

Changing profile of undergraduate level science teaching in India with special reference to biology

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In our country, undergraduate (UG) level teaching in natural sciences, has been based on two models. One of them is the three-science domain (biology, chemistry and physics) teaching model and the other, popularly called Honors involves in-depth training in one of the science domains. In some parts of India, both the models are followed. As undergraduate degree course is sandwiched between postgraduate course and the higher secondary school course, any changes in curriculum at these two levels should influence UG level training. Since the last two decades, there have been many changes in postgraduate (PG) programmes. Areas like genetics, molecular biology, biochemistry, biotechnology, ecology, limnology, etc. have been identified as independent PG courses but UG courses largely remained unchanged focusing on core disciplines like botany and zoology. At present the UG level training is being imparted in 'life sciences' than in botany or zoology. Life sciences means different things to different universities. Honors model BSc degree courses have also been started in functional areas of biology like biochemistry, genetics, etc. The debate on the relative content of basic versus applied courses within biology has been periodically swinging either way, but these days there is an increasing presence of applied courses alone like biotechnology, sericulture, etc. at the UG level.

To keep pace with such UG and PG course designs, the curriculum at higher secondary school level needs suitable restructuring. The National Curriculum Framework (NCF-2005) developed by NCERT has recommended that the learner should acquire knowledge and skill through process learning with disciplinary approach at the higher secondary level. The biology textbook at this stage has been formulated to meet the requirement of the learner at the tertiary level of education in biological sciences¹. With additional complications arising out of implementation of integrated post-school 5-year MSc courses or integrated Ph D (MSc + Ph D) courses, the nature of BSc level training in biology has again drawn

attention in academic circles. A plea is made for 3 or 4-year BSc Honors type course in integrated biology instead of botany, zoology, biochemistry etc. This can be the stepping stone to a host of vocational and higher educational courses.

UG level education in colleges and universities has always managed to draw societal attention and political debate for a number of reasons. The sad part of these debates and discussions is that the problems of the academic community, be it school teachers or working scientists, have overshadowed those of science education in all such deliberations. The consequence has been a total absence of any educational reforms or restructuring at the UG level. While some new institutions like IISER and NISER have begun functioning as part of the solution, there have been no transparent public debates through newspaper columns or seminars on this issue. The lone exception is the recent inter-academy initiative on 4-year courses, which has been discussed at various fora². It is obvious that the major stakeholders like the Government science departments and UGC have either (i) no interest, (ii) have no ideas, (iii) feel intimidated by the enormity of the situation, or (iv) clueless about the administrative means to bring about envisaged reforms. Therefore, we have to look at (i) the statement of the problem(s) in the existing systems, (ii) probable solution(s) and (iii) the administrative mechanism(s) by which reforms have to be brought into operation.

UG education has to be of good quality and also accessible to everyone. Two implications of this statement are that one, we need more colleges so that the student need not commute more than 5 km to reach the college. The college should not be of residential type. It will solve the problems of hostels in situations where supply does not meet the demand; two, it should be broad-based giving proficiency in one major natural science (physics, chemistry, earth and life sciences) or mathematics.

One of the suggested reforms to take care of quality is longer duration of for-

mal education. Currently, it takes 15 years of formal education to complete the UG degree successfully. Professional UG degrees (BTech, MBBS, BVSc, etc.) take a total of 16–17 years of formal education. If we add the years of postgraduate and research level education, one can see that a person becomes employable around 30 years of age. We therefore face a situation where two mutually exclusive forces are pulling educational reforms in two opposite directions. One of them being towards vocational courses leading to employment for lateral exit, preferably early. From demographic and socio-economic considerations, this solution is not bad. Sixty two years after independence, the starting of new institutions to impart quality science education at UG level is itself an acknowledgement of the fact that our UG and PG science education is not of good quality. Hence, longer duration of formal education is not a solution to our problems. A second reform has been in increasing the learning load to serve both quality and equity. It does not take great insight to realize that quality and equity are mutually exclusive. Experimental science, being very cost-intensive adds credence to this belief that equity and quality cannot co-exist.

The following options should be available to improve the quality of education in our country. (i) Ten years of formal school education with lateral exit towards vocationalization. Eighteen-year olds today are smarter and better informed than those of a generation or two back. (ii) A three to four year undergraduate degree ensuring a broad-based training and skill building to create socially responsible healthy citizens. However, it should be organized by clubbing two years of higher secondary school education and one or two years of present UG level degree courses. Expertise is not what we should be expecting in those students at the end of this UG education. The only quality to be assured, at the end of UG level education, is employability and/or willingness to learn. (iii) A small percentage of UG, based strictly on aptitude, talent and health can

take up integrated MPhil–PhD degree of 5–6 years duration with a provision for lateral exit with an MSc or MPhil degree. The difference between the two would be whether one has done a project (MPhil) or not (MSc). The remaining undergraduates should be able to find employment after one year of additional job specific training to become technical staff or school-level teachers. Quality is looked at from two perspectives. It can be defined as either talent and aptitude for higher academic pursuit or talent and emotional maturity for immediate employment. Moreover, if parallel restructuring is done in medical, veterinary and engineering degree courses both in duration and the pre-requisites³, the same 3- or 4-year UG degree holders can become entry pool for professional courses also. All professional courses should be of 3 years duration and of integrated type leading to MD, MTech, MVSc degrees.

Syllabus revision exercises in all universities and colleges invariably mean adding more courses but never deleting or changing or reorganizing the existing course. Let us take a look at the content of biology courses at the UG level. BSc level courses in zoology or botany were to a large extent descriptive giving details of fauna or flora classified into taxa. This was essentially reflecting the biological knowledge of those times. There was a time when taxonomy, systematics and evolution were the only areas which could be taught. The only additions as time progressed were in the areas of anatomy, histology, embryology, behaviour, ecology and a bit of physiology and microbiology. Most of the information in all these areas is acquired by observation and description rather than analytical experimentation. When experimental botany, zoology and microbiology were established, functional areas got established. These were biochemistry, biophysics, genetics, physiology, pharmacology, etc. Majority of the biology departments did not absorb this new knowledge. On the contrary, these areas gave rise to different departments. Most of them were offshoots of chemistry, physics or zoology/botany. Some biological departments however absorbed, to varying degrees, this new 'modern biology' by adding courses in biochemistry (physiological chemistry), genetics, cell biology or even molecular and developmental biology. That is when problems arose in the learning/teaching load. UG

courses got stratified into one domain 'honors' courses and three domain 'general/pass' courses. This single domain 'honors', later included functional areas like biochemistry, microbiology, etc. and applied areas like biotechnology. These developments were largely knee-jerk reactions driven by personal egos or market-demand perceptions. They did not do justice to the nature of biology. Teachers, students and parents were all confused. More confusion was created by some universities when they started PG courses in 'life sciences' or 'biosciences' or 'biological sciences', etc. In many places, this was an euphemism referring to a mixture of sub-disciplines. The mixture could be botany and zoology. It could be behaviour, immunology, molecular biology, biochemistry, microbiology, etc. It could also be cancer biology, genomics, bioinformatics, molecular biology, etc. They were mixtures without a philosophical backing. Most of them left out 'classical field biology'. There was never an organic thread or theme running through those courses. Meanwhile, most of the departments based on functional areas (biochemistry, genetics, plant molecular biology) began sensing a deficiency in their courses and incorporated teaching courses from sister departments. They coined a term 'inter-disciplinary teaching'. There are some who have taken it to such a ridiculous extent that there is no 'core course'. Every course was from some other department. Funding agencies on one hand and employers like public service commissions on the other, further contributed to the 'mess' by making strange demands on essential and desired qualifications. Meanwhile there were serious debates in certain academic communities to restructure UG courses to make them more broad-based (the bottom line was away from the single domain honors model) and in the process accept 'life science' as a single domain. Figure 1 diagrammatically represents these various models at UG level.

In model 3, life science course syllabi are written as botany plus zoology but not integrated. It is taught in IGNOU. It is partially integrated within life sciences. It has no separate courses in chemistry. In model 4, there is again partial integration but better than the IGNOU course. This is followed in Delhi University. Model 5 is not followed anywhere. It is a modification of the

IGNOU model. Model 6 has vertical and horizontal integration and is a UGC recommendation. Course titles however are sub-discipline based. Model 7 has been adopted by the S.V. College of Delhi University. The philosophical underpinnings of this course and the course titles have been discussed elsewhere⁴.

UGC CDC–Zoology has suggested that if possible BSc (Biology) course should be implemented in Indian universities and colleges. The semester system was recommended. A brief write-up on the philosophy underlying such a course was given. The duration of UG degree course recommended was 3 years. It was instructed in the form of 30 theory courses and 6 laboratory courses, each lasting a semester, i.e. 90 working days or 15 weeks. Total credits assigned were 90 for theory and 108 for laboratory work. 60% of the courses pertained to biology, 30% to non-biology sciences and 10% to non-science courses. This was the first integrated biology UG programme officially recommended in the country⁵. The syllabus was suggested in the form of sub-disciplines like biochemistry, genetics, etc. The recommended courses titles were as follows:

101	Mathematics for Biologists
102	Biodiversity-1
103	Biodiversity-2
104	English for Scientists
105	Cytology
100L-1	Laboratory course
106	Chemistry for Biologists
107	Regional Language/Sanskrit
108	Environmental Science
109	Genetics
110	Plant Anatomy
100L-2	Laboratory Course
201	Physics for Biologists
202	Biochemistry-3
203	Microbiology
204	Biostatistics
205	Ecology
200-L-1	Laboratory Course
206	Physics for Biologists
207	Chemistry for Biologists
208	Plant Physiology
209	Biodiversity-4
210	Plant development
200L-2	Laboratory course
301	Biophysics
302	Animal Physiology
303	Animal Development
304	Computer applications
305	Evolution
300L-1	Laboratory course

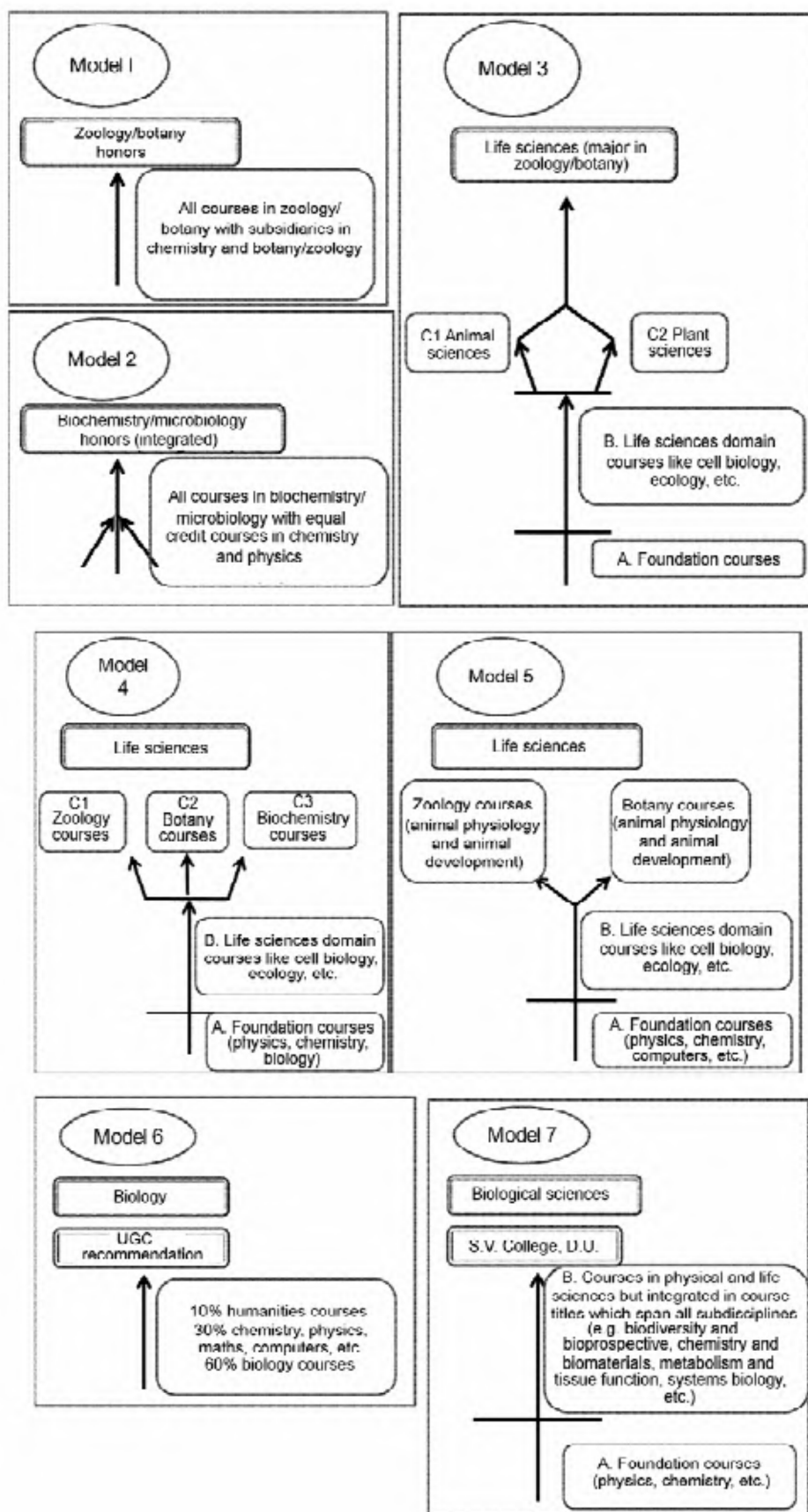


Figure 1. Diagrammatic representation of various models.

306	Biochemistry
307	Science and Society
308	Molecular Biology
309	Applied Biology
310	Cell Biology
300L-2	Laboratory Course

The inter-academy initiative on a 4-year BSc degree course can easily be structured on either the UGC recommended model or Delhi University model by including two more semesters; one for project work and another for instruction in few more papers to focus on a major sub-discipline within biology like biochemistry, physiology, genetics, biotechnology, etc. Alternatively, a true research project component can take the duration of a semester.

Conclusion

Undergraduate education in science has witnessed a range of structures and subject/disciplines such as honors degrees, pass courses, postgraduate diplomas, general degrees, etc. With regard to biology-related subjects, there are bachelor's degrees given for medicine and surgery as professional degrees; other

disciplines include zoology, botany, biochemistry, biotechnology, microbiology, biomedical science, etc. There are single subject honors courses and 3-subject general BSc courses. Some variations, like 4-subject BSc courses also exist.

However, the philosophical underpinnings both from technical (discipline-based) and from educational perspective has not been seriously enunciated or debated.

Biology is the science of life forms and living processes. Over centuries, biological knowledge has led to many technologies benefiting humans, be it in food security, health sector or national security. One can name sericulture, medical zoology, vaccines against viral, bacterial and parasite diseases, diagnostic methods for infectious diseases, pregnancy, cancer or genetic and nutritional disorders. Possibilities of application to human welfare has driven growth of biological knowledge; be it horticulture, biopharmaceuticals, or emerging technologies in communication.

Biology should be taught as a single natural science domain at the UG level. One can have many models differing in course titles and degrees of integration within biological sciences and among

natural sciences. All that is being proposed here is to integrate the natural sciences, conceptualize biology and incorporate more physical sciences, mathematics and computer applications into biology curriculum and thus present biology as an integrating natural science⁴.

1. Text Books for Class XI and XII Biology, NCERT, Aurobindo Marg, New Delhi, 2006.
2. Restructuring post-school sciences teaching programmes – a position paper, Indian Academy of Sciences, 2008.
3. Kambadur, M., Proceedings of the 9th Indian Science Congress (3–7 January, Annamalai Nagar), Part III, 2007, pp. 3–11.
4. Kambadur, M., *Resonance*, 2008, **13**, 272–276.
5. UGC Model Curriculum (Zoology), University Grants Commission, Bahadur Shah Zafar Marg, New Delhi, 2001, pp. 13–71.

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Teaching and research – a lifestyle option and a lifetime experience*

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In this article, I shall use the two terms teaching and research together to mean a single profession and for brevity, use only 'he' to indicate both genders. My aim is to (i) share with my senior colleagues the commonalities in our experiences, and debate on the differences; (ii) to advise my younger colleagues to appreciate and enjoy the positive sides of this profession, and provide them some clues and suggestions to overcome the negative sides, if they find any; and (most importantly) (iii) persuade research scholars and other students to consider teaching and research as a career or lifestyle option.

Teaching, it is said, is a noble profession, because it comprises a lot of giving, without expecting any return from the receiver. A teacher gives his best to the student, irrespective of his scope for career advancements and benefits. The teacher–student relationship is a unique one, and is non-reciprocal, because it comprises one way flow, which does not have a parallel in any other type of human relationship.

The freedom of time management is one of the most attractive features of the profession. A rough calculation shows that during any semester, the actual time needed for teaching, including preparation and assessment, hardly ever exceeds 20% of the total time available. You are free to distribute the rest of the time in any manner you like – amongst research,

innovative development, consultancy, conference participation, book writing, hobbies, etc.

A teacher should be active in research. Teaching without research is likely to make you stereotyped, outdated and stale, however good you maybe as a communicator. Updating knowledge for the purpose of teaching is not enough – it must be applied to seek and find undiscovered truths. Being active in research will also help you to innovate on teaching methods, to see and show existing knowledge in new light and inspire your students to think anew and be creative. Various awards and recognitions are available for an outstanding researcher, which are relatively easier to aim for if you are in the teaching and research profession, as compared to others, because

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