

Science Club

School of Life Sciences, University of Hyderabad

Presents

“Jawaharlal Nehru Chair Lecture Series”

on

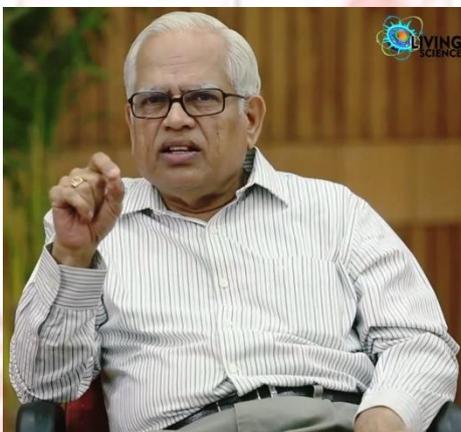
“Understanding Biology”

(A series of 12 lectures in the year 2017)

By

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Third Lecture on

“The Essence of Biology and Biology Education”

16/3/2017, Thursday, 4 to 5 pm, Seminar Hall,
School of Life Sciences

ALL ARE CORDIALLY INVITED

Host: Dean SLS and Science Club

The Essence of Biology

Biology is the science of living organisms. Natural science comprises Physics, Chemistry and Biology. The geographical space where living organisms are to be found is called Biosphere. This includes Air, Water and Soil. Whether there is life in Space outside of Earth (extra-terrestrial?) is a debatable point. The whole science of 'Exobiology' deals with this. It essentially studies rock samples from other planets and moons for signs of Life! Cyril Ponnamperna, an American scientist of Sri Lankan origin, was one of the greatest exobiologists. The origin of life on earth is still shrouded in mystery. One of hypotheses currently debated is the idea of 'Panspermia'.

Biologists, for a very long time i.e. roughly for 1700 years from Aristotle days, dating around 350 B.C. till Rene des Cartes of France, did not carry out investigative experimentation. Those were the days when the Roman Church controlled western world and was generally opposed to Science in the modern sense. Biologists, however, described flora and fauna around the world by conducting expeditions. In essence they described Biodiversity. Taxonomy was established, as the information was too much to handle, to aid remembering the life forms. With the advent of magnifying glass and later the optical microscope, biologists continued to describe living organisms, dividing them into Plants, Animals and Microbes. There was no common theme, question or purpose behind this description. Biology got divided into Botany, Microbiology and Zoology. This was the classical Biology, a descriptive and phenomenological Biology, also to be called later as Natural History.

Rene des Cartes, the French mathematician and probably the first Philosopher of Science, brought two changes in our approach to science in general and Biology in particular. The utility value of science was given more importance than merely understanding the structure and functioning of Nature. Nature included both the inanimate physical matter and the animate and organic living world. The aim of science was to control Nature and derive creature comforts for human life. He kept Man outside Nature and everything else including woman as part of Nature, thus echoing ancient Indian philosophical ideas. Secondly, he advocated the use of concepts and techniques of Physics and Chemistry to investigate and thereby understand living structures and living processes/phenomena. Anatomy, Physiology etc. and true experimental biology began and slowly dominated over all other branches of Biology. Reductionist Biology became 'The Biology' much to the annoyance of Taxonomists. Reductionist Biology culminated in Biochemistry and Molecular Biology. Ironically this did not lead to understanding of Biology. It was only 'molecular description'!

Two major events enhanced the respectability of classical Biology on one hand and Reductionist Biology on the other hand. One was the establishment and acceptance of Darwinian ideas of organic evolution by Natural selection and which elegantly explained biological phenomena at every level of the hierarchy of organization of living objects i.e. ecosystem, population, organismic, cellular and even molecular level. The essence of this theory is that living is a stochastic process and there is no room for deterministic ideas in biology. Our lives are not predetermined. That is why evolutionary direction is not

predictable. Evolution is random but Natural selection is deterministic in our perception. The second was the demonstration of 'bacterial transformation' by Cohen and Boyer in 1972. This ushered in 'Molecular Biotechnology', the useful part of Biology. Conceptual Biology as another vision of Truth about Nature was a casualty. More than a dozen departments in Universities claimed they are teaching Biology!

The third phase (or even 'face') of Biology primarily addressed the property of 'emergence' in organized living structures like molecular assemblies/sub-cellular organelles, cells, tissues, organs, organisms, populations and even ecosystems. Gaia hypothesis extends this to whole of Earth as a single living organism! While reductionist biology claimed understanding parts (or components) leads to understanding the 'whole', thus denying emergent phenomena as of external origin (God?), Systems Biology, the third phase or face of Biology, revealed that interaction among the components of a 'whole system' leads to emergent properties. Whole is more than the sum of parts! In a way they also rejected supernatural origin of 'vital force'/emergent property. As examples, we can say mind is an emergent property of intra-brain processes and evolution is an emergent property of underlying physiological processes.

Biology asks 3 questions and seeks answers for them. The most important question is: how structure sub serves function? One can pose this question at molecular, cellular, organismic or population levels. The second question is mechanistic in nature and wishes to establish proximate cause and effect in living processes (most of reductionist biology) and the last question identifying the ultimate causes of living processes and this does not have answers. Discussing the third question leads us to non-natural scientific areas like sociology and philosophy!

Suggested Readings:

01. Ernst Mayr (1997) *This is Biology* , Harvard University Press.
02. Cairns-Smith, AG (1998). *Seven clues to the origin of Life*, Cambridge University Press.
03. Taleb, NN. (2007). *The Black Swan*, Penguin Books.
04. Gadagkar, R., (1997) *Survival strategies-conflict and cooperation in Animal societies*, Universities Press (India) Ltd.
05. Bhargava, P., (1995) *Science, Philosophy & Culture in Historical Perspective* in PHISPC (Eds) DP Chattopadhyay and Ravindra Kumar, Volumes 1 and 3.
06. Kambadur Muralidhar (2008) What organisms do in PHISPC (Eds) DP Chattopadhyay and Ravindra Kumar Vol XII, Part 6 (Ed) NS Rangasawmi, *Life and Organicism*, pp117-158.
07. Brenner, S., (1997) *Loose Ends from Current Biology* Current Biology Ltd.
08. Julian Sutton (1998) *Biology*, McMillan Education Palgrave Publication.
09. Neil Campbell and Jane Reece (2001) *Biology*, Pearson Benjamin Cummins.
10. Peter Raven., Johnson, G., Mason, K., Losos, J., and Singer, S., (2016) *Biology* 11th Edition
11. Brian T White and Mischke, M.,(2006) *A Problems approach to Introductory Biology*. ASM Press.

12. Kambadur Muralidhar, (2015) *Introductory Biology*, Module 1, e-book on MSc in Biophysics, MHRD publication (Ed) M. Rajeswari.

Biology Education

The academic world consists of teachers, students, scientists, communicators, administrators, technical and non-technical supportive staff working day and night. It is located within the general society and also without the rest of the society. There should be a two-way interaction between the academic world and the rest of the society. Through colonial rule, we got the university system of education in which science education is also imparted. One should never forget that 'Learning' is the most important of all the activities of the academic world and indeed it should be 'the activity'. The system of western education in science is organized in 3 phases i.e. School, Undergraduate (UG) and Post-Graduate (PG) phases. These form not only a linear sequence but also a hierarchical sequence. Post-graduate level of education follows under graduate level which in turn follows school level education. Each level is subdivided into year-based or semester-based sub levels. As of now, 12 years of schooling is followed by 3 years of UG education which is followed by 2 or 3 years of PG education. Some students will take another 4-5 years to complete PhD level educational/research training. Unfortunately these are referred to in common parlance different levels of 'teaching' and not as levels of 'learning'. There are different combinations of these levels, in terms of number of years spent, in different parts of the world including within India. The issues to be discussed are many and those include degree of vocationalization at every level followed by exit. There are 2 mutually exclusive products of this educational system. One is an employee who carries out his/her assigned job as much professionally as possible and the other continues to be a knowledge worker in pursuit of 'TRUTH' and in the process creates new knowledge. The latter is sometimes identified wrongly as either a teacher or a scientist. Teaching and research have to be pursued together by the same person.

How should we organize this science education in general and biology education in particular given the nature of the system which is largely a colonial legacy? The profound question is how to transact human knowledge in breadth and depth and also experience it so as to enable the learner to gain wisdom and/or employability? As far as Biology is concerned, it should be part of Science & Technology at the School level. In its turn science & technology should be a part of general education which enables understanding human life, human relations and relation of Man and Environment. We have somehow to achieve both individual emancipation (the ultimate goal of education) and also participation in national development. Till the end of School phase Natural Science should be taught as a single discipline. The structure and function of Nature as an integrated system should be understood. At the UG level Biology should be taught as an integrating science discipline. Sufficient practical knowledge of Mathematics, Chemistry and Physics should be imparted. They should be presented as tools, techniques and sometimes as language and not as separate disciplines. Therefore the integrated Biology would mean:

- Integration of Botany, Zoology and Microbiology.
- Integration of structural biology (classical and modern) with functional biology i.e. internal physiology and externalized physiology or behavior.
- Integration of morphological and molecular languages.
- Integration of Mathematics, Physics and Chemistry within Biology.
- Integration of Humanities and Social Sciences within Biology.

How to achieve this at the School and UG levels? We can substitute the word Science for Biology in so far as school education is concerned. The school education should be experienced by the pupil in 2 phases. Phase 1 should be education about human relations, language and literature, society, general education, personal and public hygiene, nutrition and environmental health, love of biodiversity, values in life etc. The next phase should be dealing with Natural Science & Technology as a single discipline. Of the 5 elements of integration listed above, school and UG level of education should differ only in the relative emphasis on the 5th element vis-a vis the first 4 elements. In school stage all the listed elements should refer to Science as a whole while at UG level they will refer to Biology as a unitary discipline. Similarly one can think of Physics or Chemistry or Mathematics.

How to achieve the slated aims of UG level education in Biology? The curriculum should list course titles and content in such a way that one cannot make out whether it is Botany or Zoology. One should not be able to make out whether it is Chemistry or Physics or Cell Biology or Biochemistry. These words which represented earlier knowledge domains or even departmental names have created boundary walls within the single discipline of Biology. An example for discussion will be the BSc (Hons) in Biology which was initiated at Delhi University in Sri Venkateswara College. Even this curriculum can be improved to match the aims of UG education in Biology. Summary of all this discussion is that there should be no specialization within Biology at UG level.

At the PG level, one can specialize to any extent. In the American system PG course is part of PhD and they take few lectures on a highly specialized topic like Tumor Immunology or C-3 plants etc. In India as the teaching at UG level is not good; PG education is a must before one starts PhD. In India integrated PhD where they admit students with just BSc, is not very successful. For the same reason PhD should be on a topic but not in a subject like Biochemistry, Zoology etc.

To achieve these objectives we have to change the structure of education also simultaneously. One can think of 11+4+5 years of education for school, UG and PhD degree level education. However standards required for each of these degrees or levels should be clearly and thoughtfully delineated and set. An analysis of current structures of UG Biology education in our country shows a vast diversity but lacking any articulated philosophy.

Suggested Readings:

01. Muralidhar, K., and B.K. Tripathy (2009) *Changing profile of undergraduate level science teaching in India with special reference to Biology* Current Science Vol97 (8), 1123-1126.
02. Kambadur Muralidhar (2008) *Biology as an integrating natural science domain, A proposal for BSc (H) in Integrated Biology.* Resonance, 13, (3), 272-276.
03. Kambadur Muralidhar et al (2001) UGC Curriculum Development Committee Report for Zoology/Biology.
04. Gita Bali (2015) Recommendations of the committee set up by Karnataka Government on UG Education.
05. Indian Academy of Sciences (2012) Post school education
06. Kambadur Muralidhar and Srivastava, PK. (2006) *Integrative Biology at Undergraduate Level of Science Education.* In "Integrative Biology" Ed. S.C. Lakhotia, INSA Publications, New Delhi, pp.53-56.

