Fads and fallacies in biology research

M. K. Chandrashekaran

The classical/modern schism is a myth, but one that is reinforced by insipid research in so-called classical biology.

The editor has invited me to contribute an 'Opinion' article on the 'need of classical biology' to initiate a debate on the subject in *Current Science*. Obviously he wants 'the cause of classical biology' upheld in the face of the flourishing 'more modern' molecularly oriented branches of biology. I have in word and deed rejected this kind of meaningless schism. But I do appreciate his anxiety that in our enthusiasm for the newly sprung kinds of biology we do not neglect classical biology and throw the baby out with the bathwater. I personally know a few friends in biology who have felt for a longish while that they might indeed themselves be the baby in question. If the idea behind asking me to write is to get me to stress the importance of taxonomy, anatomy, morphology, physiology, ethology, etc., I shall gladly do so, for man doth not surely live by molecular biology alone. I am sure biologists who have made landmark contributions to these various areas will also write on the need of classical biology.

The term classical is to my mind what the *Oxford English Dictionary* says it is: standard, first class. This declaration should lighten the conscience of many classical biologists in India, who are all trying to join subdisciplines of botany and zoology suitably rechristened to sound modern. Having clearly stated my premises I would first like to describe recent historical developments in biology as a backdrop to my message.

Shifting sands of trends in biology

A myth in biological circles began making the rounds, beginning in the sixties, that certain branches of biology such as biochemistry, molecular biology, immunology and related disciplines were 'more modern' and therefore 'in'.

There soon were two kinds of biologists. The biochemically oriented biologists had chosen, with their reductionism and abracadabra, the appellation 'modern' for themselves, and the other biologists did not even seem to know any more if it was good or bad to be classical. Worse, the term classical was made to sound like the antithesis of modern, which of course is piffle of the first order. The German zoologist Hansjochem Autrum[1] observed, 'Science is either science—and therefore modern—or it is not science at all, i.e. not probing after unknown laws (of nature).' Since the translation is mine I reproduce the original: 'Wissenschaft ist aber entweder Wissenschaft und dann modern, oder es ist keine Wissenschaft, d.h. kein Fragen nach unbekannten Gesetzen.'

The botanists and zoologists, portrayed as perpetually feuding for supremacy, were once a powerful and proud lot. Here is a spirited defence of zoology by Peter Medawar[2]: '... zoology, the best fitted of all science subjects to provide its students with a liberal education, partly because of the intrinsic interest—even grandeur—of the concepts that inform it, such as evolution, heredity and epigenesis; partly because of the qualitative exactitude of the formal study of one of its principal disciplines, comparative anatomy; and partly because zoology overlaps with and irrupts into anthropology, demography and ecology. In later years I came to take the view that a person who was really good at zoology in the broad sense of the above description would be qualified to turn his hands to most things.'

The change in attitudes in biology and the going-overboard syndrome interestingly coincide with the waning of the British influence (thank heavens for that!) and the swelling influence of American science. The casualty was idealism, so prevalent in English and Central European universities. Another negative turn was the adoption here of the New World's indifference to history and precedence. The new breed of biologists (who often had no training in biology at all) were generally unaffected by the writings of Charles Darwin and T. H. Huxley; the rediscovery of Mendelism in 1900; the emotional debates of the neo-Darwinians and crypto-Lamarckians; the accidental discovery of the missing fossil link, the coelacanth fish *Latimeria* freshly dead, in a fish market in South Africa; and the writings of even modern biologists like Ernst Mayr, Theodosius Dobzhansky, J. B. S. Haldane and J. S. Huxley. The modern methods of physics and chemistry were powerful aids to the new subdisciplines of biology. But the reductionist fervour of their practitioners and their tendency to regard the rest of biology as being below contempt were awe-inspiring. Such schisms have surfaced in the past in biology. In the second half of the nineteenth century it was the comparative anatomists, 'the demonstrators of the theory of evolution'—men such as Karl Gegenbauer, Ernst Haeckel, Karl Ernst von Baer—, who were the cock of the walk. The mantle of pseudoelitism then fell upon the shoulders of the embryologists and developmental biologists—Richard Hertwig, Wilhelm Roux, Theodore Boveri. Earlier in the twentieth century the physiologists were king, and in the second half of the century 'molecular' is the boss word. All these are inevitable and welcome developments, for the major concern of biology is to understand how (mechanisms) things function in nature. But biologists with broader vision and a knowledge of the history of science know that it will be shortsighted in the long run to see only the molecular tree for the biological forest. The 'nothing else but' attitude of ontological reductionism, for which Julian Huxley coined the term 'nothingelsebuttery', is to be blind to the complexities of biology.

Classical biology at the crossroads

On the other hand the woes that have descended on the study of botany and zoology should have been anticipated. Even my generation found the zoology course deadly dull. Nothing that we learnt in the formal zoology classes was of the slightest use or had the slightest relevance to what became the subject of my scientific researches later. Having won an MSc in zoology we did not know much about animals. There were too many lectures and too much theory. We were familiar (through browsing in the library) about the contributions of Edwin Goodrich, Ray Lankester, J. Z. Young, Sir James Gray, C. F. A. Pantin, Hans Spemann, Max Hartmann, G. Haberlandt, Hugo von Mohl, Wilhelm Pfeffer, O. Renner, K. v. Frisch, K. Lorenz and N. Tinbergen. But we did not have a true feel for the biology and behaviour of the frogs we so listlessly dissected. Of course its life cycle we had learnt by rote. I did not know until much later, for example, that you cannot force-feed a frog, nor breed them in the laboratory, nor did I know its place in the food chain. We were not even aware that we were needlessly decimating free, living frogs which are beneficial to man. So a change in biology curriculum had to come and the new biology did bring in welcome changes.

The modern and the classical

The only advantage of not knowing the history of science is that it allows one to make discoveries. In Europe it is considered barbarian not to cite earlier literature. E. Bünning[3] narrates the several findings of Wilhelm Pfeffer made 100 years ago that can pass for modern today: 'It is often believed that the discovery of adaptive enzymes is one of the laurels of modern microbiology. But actually the discovery was made in Pfeffer's laboratory shortly before 1900 and continued to be a topic of research in that laboratory for several years. Pfeffer stated that three or four units should be sufficient to yield all the necessary information for an organism's development. He suggested using bacteria for studying evolution.... The results allowed Pfeffer to state (1893) that the senses of unicellulars are not poorer than those of vertebrates.' Compare this with the statement of Monod and Jacob (1961): 'Anything found to be true of *Escherichia coli* must also be true of elephants.'

Textbooks and research papers published in the first half of this century proclaimed that membrane permeability can be explained with an 'ultrafilter theory' on the one hand and a 'lipid theory' on the other. But in recent textbooks on membrane biology we can read, contrary to the alluded 'classical' views, that membranes should no longer be considered as filters or sieves. But the latter was also Pfeffer's view, only stated a hundred years ago. Pfeffer stated that the plasma membranes are active; they can select like a door-keeper. Pfeffer even mentioned the possibility of carrier molecules, as they are now called. Until a few decades ago certain chemists believed bacteria to be mere containers of certain enzymes and their substrates. Now we know better. So much for the modern and the classical.

Need of classical biology

Classicism is not the exclusive preserve of traditional biology. I am sure my colleagues in biochemistry, molecular biology and related disciplines would also want to (continue to) write classical papers. G. Padmanaban[4] has drawn up a list of the kinds of biology that can be classified as being humdrum, routine and sterile:

1. Description of a 'new species' with inadequate evidence
2. Reports of beneficial properties of plant extracts of one kind or another
3. Measurement of assayable parameters in biological systems with reference to some variable such as growth, temperature, etc.
4. Study of the effect of pesticides and other toxic compounds in a wide range of aquatic and other organisms
5. Making four short communications for *Current Science* from what could be one good paper in a specialist journal.

The author has succinctly summarized the cardinal ills of contemporary classical biology.

Matters look a shade gloomier in the area of animal-behaviour and ecology research in India. There is a widespread misconception among younger biologists that animal-behaviour work must be done with the larger mammals: black buck, deer, rhinoceros, wild dog, monkey, elephant, tiger and lion, the underlying but erroneous belief being that the behaviour of these mammals must be necessarily closer to human behaviour. This fallacy was planted in our minds by the behaviourists (mostly psychologists) of North America, who all worked on the laboratory rat.

There is a crying need of wholesome research in the fascinating areas of ethology, neuroethology, behavioural ecology, sociobiology and chronobiology. As for the choice of animals India is an ethologist's paradise. I must mention that the size of the animal is secondary. It is the questions that one asks oneself about the adaptiveness of the behaviour of the animal that are important. I shall chronicle here names of famous ethologists and the animals with which they worked. Otto Heinroth – ducks; C. O. Whitman – salamanders, leeches, pigeons; Wallace Craig – pigeons; N. Tinbergen – stickleback fish; G. P. Baerends – birds; K. Lorenz – geese; K. v. Frisch – bees; A. Manning – *Drosophila*; A. Faber – grasshoppers; W. Wickler – birds; T. C. Schneirla and E. O. Wilson – ants; P. Marler and W. H. Thorpe – birds; K. E. Schmidt-Koenig, E. Gwinner, and W. and R. Wiltschko – birds; D. R. Griffin and G. Neuweiler – bats.

Ethology was born outside the confines of universities, grew rather haltingly, and has only recently come of age. Ethology had no dearth of detractors. An eminent neurophysiologist in Oxford was asked what he thought of the researches of Niko Tinbergen and he answered: 'Ethology? Why, that's bird-watching, isn't it?' Tinbergen got the Nobel prize four years after the neurophysiologist's remark. Konrad Lorenz defined ethology as the discipline that applies to the behaviour of animals and humans all those questions asked and all those methodologies used in all branches of biology since Charles Darwin's time. That's a very perceptive definition by one of the founders of ethology.

Neuroethology is the discipline that seeks to understand the neural bases of behaviour. Unlike the practice of ethology, the practice of neuroethology calls for basic instrumentation: electrodes, oscilloscope(s), Grass stimulator, pre-amplifiers and so on. The mention of neurophysiology evokes images of rats and cats with chronically implanted electrodes. Some of the most fascinating neurophysiology work has been done with insects (electroretinograms in dipteran flies, electroantennograms in moths), spiders (mechanoreception) and scorpions (ERGs). The prospects are limitless.

What under the sun can possibly surpass the beauty of the feedback physiological principles involved in the capture of a moth by an insectivorous bat in the pitch darkness of a new moon night? What can contain greater excitement than finding out how a bat living in the deepest pockets of a labyrinthine cave knows time of sunset? There is a lot of biological and behavioural drama in the recognition by a bat mother of her own offspring, in the act of a bat relocating his 'personal space' ± 1 mm in the irregular geometry of a cave bathed in darkness, in unravelling how a mother field mouse by absence and presence gives her new-born pups information of day and night.

In this article I have been brazenly lobbying for more work in my areas of expertise and research interests. As the German proverb goes, 'the farmer does not eat anything that he does not know'. I leave it to other colleagues to hawk and commend to the reader their specializations in classical biology.

1. Autrum, H., *Verhandlungen der Deutschen Zoologischen Gesellschaft*, 1963, pp. 37–42.
2. Medawar, P., *Memoirs of a Thinking Radish*, Oxford University Press, Oxford, 1986, p. 209.
3. Bünning, E., *Annu. Rev. Plant Physiol.*, 1977, **28**, 1–22.
4. Padmanaban, G., *Curr. Sci.*, 1990, **59**, 5–6.

M. K. Chandrashekaran is in the Department of Animal Behaviour and Physiology, School of Biological Sciences, Madurai Kamaraj University, Madurai 625 021.

Biotechnology, the tip of the iceberg

M. C. Srinivasan

Good traditional-biology research underpins biology's latest success.

I consider it a privilege to be invited to contribute an 'Opinion' article on the 'need of classical biology'. I have chosen to discuss the subject in relation to microbiology and applied botany. Biology is a vast discipline and the complexity of life processes makes it multidisciplinary and necessitates expert inputs also from physical and chemical sciences for understanding the component events of bioprocesses. Biotechnology aims at harnessing this knowledge for the benefit of mankind through manufacture of useful bioactive metabolites and production of plants and animals with better qualities.

In recent years scientific advances have pushed the frontiers of biological sciences at a rapid pace, and often 'modern' developments have been quickly relegated to the 'classical' within the span of just a few years. Yet, if one looks at the advances made in biology in perspective, it is possible to identify contributions of great significance in classical biology that have laid the foundations of several modern developments. For example, Mendelian laws of inheritance established in plants proved universal and led to the interpretation of genetics and heredity in molecular terms. The Nobel prize-winning work of Beadle and Tatum on *Neurospora* genetics was a significant milestone in this progress. Likewise, elucidation of the structure of DNA followed the classical work of Avery on biological variation in capsular pneumococci which led to the prediction that DNA was the molecule responsible for transmission of hereditary characters. The dawn of the molecular-biology era and the fruitful developments in biotechnology and recombinant-DNA technology, which have led to the successful cloning and expression of even mammalian genes in microbial systems, are outstanding offshoots of these classical findings.

The questions that present-day biologists and biotechnologists should address are: (i) What role does classical biology have to play in sustaining the progress in modern biotechnology? (ii) What is the type of infrastructure that must be built up and reinforced in classical biology to ensure sustained and fruitful advances in biotechnology? I shall attempt to find answers to both these vital questions from my individual perception as a biologist involved in using knowledge in classical microbiology and botany for developing useful bioactive metabolites.

Classical microbiological studies laid emphasis on ecology, distribution, taxonomy, and physiology of growth and reproduction of diverse forms of microbes collected and investigated by specialists in each of these major areas of microbiology. Such studies have laid the foundations for appreciating the extent of biodiversity in natural populations of bacteria, actinomycetes and fungi, besides other forms of microscopic life. We have considerable insight into the distribution of microbial populations, their correct identification, and their cultivation in the laboratory environment in pure cultures for exploring their biosynthetic activities as well as biotechnology potential. Although our knowledge of several groups of microorganisms is far from complete, the studies over the years have laid strong foundations for further advances in these 'classical' areas, provided such studies are pursued with vigour in future.

Biodiversity is now recognized worldwide as a major factor in identification of novel gene pools. While only about 1.5 million species have been described by biosystematists so far, experts have calculated that we may find that 70–80 million species exist if we study invertebrates and microorganisms more exhaustively[1]. Many of these natural populations are either endangered or becoming extinct owing to natural and man-made environmental changes. Conservation of the microbial heritage in well-established germplasm banks is vital to future development in microbiology and biotechnology[2]. An appreciation of microbial biodiversity necessitates generation