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 in-
formation 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.

I. Autrum, H., Verhandlungen der Deutschen

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. Biotechn-
ology 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 off-
shoots of these classical findings.

The questions that present-day biologists and biotechnologists should ad-
dress 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 microbiol-
ogy and botany for developing useful
bioactive metabolites.

Classical microbiological studies laid
emphasis on ecology, distribution, tax-
onomy, and physiology of growth and
reproduction of diverse forms of micro-
bases collected and investigated by spe-
cialists 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, be-
sides other forms of microscopic life. We
have considerable insight into the distri-
bution of microbial populations, their
correct identification, and their cultiv-
ation in the laboratory environment in
pure cultures for exploring their biosyn-
thetic activities as well as biotechn-
ology potential. Although our know-
ledge of several groups of micro-
organisms 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 world-
wide 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 inverte-
brates and microorganisms more exhaust-
ively. Many of these natural popula-
tions 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 bio-
technology. An appreciation of micro-
bial biodiversity necessitates generation
of interest and adequate expertise in identifying the less-common genera and species from natural sources through enrichment and/or selective culture techniques. Since microbes coexist, colonize natural substrates, and are not distributed in uniform numbers, the rarer and slower-growing species can only be encountered through innovative approaches. Devising screens for such selections involves commitment to classical biology and high-level expertise in the taxonomy of selected groups and their physiology of in vitro behaviour to ensure long-term maintenance in pure cultures. Unfortunately, in recent years, focus on this vital aspect has been either very low or even absent, and, unless effective corrective measures are taken, future programmes in applied microbiology and biotechnology may be affected to a considerable extent. Adequately trained and skilled manpower as well as infrastructural facilities for ensuring in vitro conservation of microbes in accordance with established international standards are basic necessities for all countries if biotechnology programmes of the future have to be firmly established and flourish. Our own limited efforts at the National Chemical Laboratory have been very positive in that, by undertaking to screen for unusual microbial species with potential for development of novel industrially useful enzymes, we have discovered commercially promising strains of actinomycetes like *Chainia* and alkalophilic *Bacillus* species for cellulase-free xylanase production and *Comoidobolus* species yielding trypsin-like alkaline protease in submerged culture.\(^2\)–\(^5\)

Considerable attention has been given in plant biotechnology to evolving improved varieties and cultivars for enhanced yields of food crops as well as crops with better nutritional value, such as better composition of seed storage proteins. Plant cell culture today has emerged as an area of great practical importance. Fundamental contributions made over the years by botanists, embryologists and morphologists to cell biology and studies of in vitro differentiation have been a major sustaining force behind all recent developments, including protoplast isolation, plant regeneration and differentiation, and somaclonal-variation selection. The use of the *Agrobacterium tumefaciens* plasmid is a major breakthrough in effecting transfer of desirable foreign genes into plants and 'synthesizing' desirable variants. There is, however, considerable need to strengthen our basic knowledge of plants, and continued efforts in aspects related to taxonomy, ecology, physiology, genetics and traditional plant breeding are most essential. Identification of wild relatives of crop plants whose genes for pest and pathogen resistance as well as stress tolerance would involve high-level expertise in such areas of 'traditional' botany as systematics and plant ecology. Even at the more fundamental and sophisticated level of plant gene manipulation, while considerable progress has been made in gene transfer, cloning and expression of desired traits, the success has been sporadic and rather inconsistent. The only way to overcome these bottlenecks is to get better knowledge of plant biology through intensive studies on the classical aspects viewed in the light of our modern knowledge. For example, at a recent symposium in Japan, Takeshi Otani of Kirin Brewery reported the successful creation of multiple lysine and tryptophan codons by site-directed mutagenesis in the gene for \(\alpha\)-zein, the most abundant storage protein of maize. Although the engineered \(\alpha\)-zein remedied the deficiency in the essential amino acids, the new protein was not incorporated stably into its normal location in the endosperm of maize.\(^6\) Otani has suggested that further experiments using tobacco, which does not contain any zeins but where differentiation into whole plants from cell cultures is well standardized, are required for studies of the mechanisms of stable expression and accumulation. Another area of importance and concern to modern plant biotechnology is the inability of *Agrobacterium* to effect gene transfer into cereals, where such an effort would be most fruitful as well as essential. In a thought-provoking article, Potrykus\(^6\) concluded that failure to show proof of the recovery of transgenic plants among cereals despite careful and large-scale experiments using diverse established methods may 'point to a biological problem that has not been considered in previous experiments and which may also be the cause for the failure of *Agrobacterium*-mediated transformation'.

It is obvious that, whether it is with microbial systems or plants, considerable traditional or classical biological work must be done to supplement/complement the advances being made in modern biology. To establish sustainable biotechnology programmes, we must establish schools of excellence where persons skilled in the traditional and classical aspects of biology can be trained in the same manner in which we encourage research and development in the modern aspects of molecular biology and protein engineering. Under the impact of the molecular-biology 'wave', traditional biology has been a retreat, and several areas, like taxonomy, have become least-favoured areas for specialization among the upcoming generation of graduate and research students. Efforts to kindle interest in these neglected areas may have to be intensified without further delay if classical biology has to retain its rightful place in the future developments in biotechnology. A perspective view of the biological sciences must be emphasized by educational policy makers as well as funding agencies. The fact that classical biology is still the bedrock from which modern developments can spring must be firmly established at the earliest opportunity.


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