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50 Years of JBE: The Evolution of Biology as a School Subject

No inspired prophet [is needed] to foresee a great development some day of the biological sciences (H. T. Tizard, 1934) [i]

When the Journal of Biological Education was first published in 1967, biology was still very much the Cinderella of the three school sciences in many countries. Most selective secondary school biology courses readily betrayed their origins as an unconvincing coalition of botany and zoology. In England entries for A-level zoology (8,091) and botany (4,740) in1962 jointly exceeded those for biology (8,172). At sixth form level, biology curricula were dominated by the needs of intending medical students, with an emphasis on the dissection of animal 'types', together with plant morphology and taxonomy, rudimentary physiology, biochemistry and histology. In the non-selective secondary modern schools, biological education was often limited to socially- or economically- directed courses such as Human Biology, Health Education, Physiology, Hygiene, Agriculture and Horticulture. Courses of this kind were also the antecedents of the general biology programmes that developed in high schools in the USA. However, such schools have a different history and social function from their European counterparts and a curriculum structure that has led to biology being studied before chemistry or physics rather than alongside them.

Traditionally, much biology was taught and assessed in ways that did little to promote students' curiosity. In addition, the subject was perceived as being descriptive, requiring little in the way of mathematics and lacking opportunities for laboratory-based experiments. However, by the time the Journal of Biological Education made its first appearance, change was already well underway. The two decades either side of 1960 brought a world-wide interest in curriculum renewal that led to attempts at reform in both the developed and the developing world. In Anglophone Africa, the African Primary Science Project was one of three projects sponsored by the Education Development Centre based in Massachusetts in the USA. The Biological Sciences Curriculum Study, also based in the USA, was, and remains, a major initiative. One of its noteworthy features was the publication of green, blue and yellow versions of a high school biology course, focusing on ecology, molecular biology and cellular biology respectively. The Australian Science Education Project developed curriculum materials and resources for use at junior high school level in all the States of that Commonwealth. In the UK, large scale projects funded by the Nuffield Foundation, the Schools Council for the Curriculum and Examinations and the Scottish Education Department sought to reform not only the content of the school biology curriculum but the way in which the subject was taught and the means by which students were assessed.

Although many of the reforms were initially directed at selective systems of secondary schooling or at the upper levels of high school education and in many cases were only partially successful, they were of seminal importance for much that was to follow in the field of biology education, especially for elementary or primary education and for the development of courses that sought to integrate or combine the three basic school sciences. The reforms

also promoted an inquiry approach to teaching and encouraged the institutionalisation or expansion of biology education as a field of teaching and research within higher education.

Today, the school system in many countries is mainly or entirely non-selective and co-educational. In England, biology is a component of a statutory national curriculum and botany and zoology are no longer subjects for examination at GCSE or A-level. Biological topics form part of the education of all children from 5-16 and equal opportunities legislation ensures that curriculum discrimination between boys and girls is no longer permitted. School biology is now universally regarded as a subject that seeks to promote curiosity about the natural world, knowledge of the structure and function of living organisms, an understanding of genetics, evolution and the inter-relationships of living organisms, and an insight of the nature of scientific investigation including a critical approach to evidence. Students are also required to display a much wider range of competences than hitherto.

These changes have contributed to a widespread rise in the popularity of the subject among school students although many other factors are in play, notably greatly increased career opportunities. In the UK for example, 64,666 candidates entered for A-level examinations in 2015 in biology and the subject ranked third, below English and mathematics, in terms of the percentage of total A-level UK entries. At GCSE level, with 141,900 entries, biology has benefited from the resurgence of single subject entries, the highest number for sixteen years, at the expense of Dual Award entries in science. Biology will also have been studied by the 395,484 students entered for examinations in the latter. Within higher education, biology is represented by a remarkable number of specialised disciplines from microbiology, virology, genetics, embryology, biochemistry and molecular biology to ecology, human biology, parasitology, zoology, marine biology, and wildlife biology. This specialisation prompts the question of how, and by what means, teachers of biology are now best trained, given that, for at least they foreseeable future, many will also be required to contribute to the teaching of broader science courses.

Beyond the world of school, television programmes about the natural world have never been so numerous or popular and many attract an international audience. Alice Roberts' Incredible Human Journey presented a powerful illustration of human evolution, and a variety of natural history programmes has vividly revealed the extraordinary diversity and adaptability of living organisms. A variety of politically inspired movements, such as Greenpeace and Friends of the Earth, ensure that a wide range of environmental issues remain in the public eye. Science fairs, hand-on science centres and museums, wild life centres, zoos and outreach programmes are well-established in many countries and along with the burgeoning publication of popular science books enrich the world in which biological education now takes place. Stem cell therapy, GM crops, climate change and its impact on population and biodiversity are among many issues that feature prominently in public and political engagement with biology-related debates.

Research in biological education has led to important findings about children's conceptual development and offered insights into how their understanding of biological concepts, such as evolution, adaptation or genes, changes over time. The same research also presents biology

teachers with a considerable challenge since it reveals that, when erroneous, many of these ideas are remarkably resistant to change.

Reviewing the past half century of biological education thus offers much that can properly be described as progress. More biology is now being taught to more students than at any time in the past, school curricula are more in touch with developments in biological science, and the public salience of biology is high. In many countries, there has also been some easing of the gender gap. In the UK, the ratio of girls to boys sitting A-level examinations decreased between 2001 and 2015 from 1.63 to 1.45. In 1962 it was 1.56:1.0 with boys outnumbering girls, although the numbers of candidates were much smaller. There has to be some concern, however, about the consequences of a recent decision in England to change the way in which practical science is assessed at this level. Will it, as many suspect, lead to a deterioration in the practical competence of A-level students at a time when universities are already concerned about the practical skills of undergraduate entrants? At GCSE level in 2015, there was almost no difference in the numbers of boys and girls entered for either biology or Science at this level whereas in 1962, girls massively outnumbered boys by 2.87:1.0.

However, as school biology has become more mathematical, more experimental, more focused at the level of the gene, chromosome and cell, and more conceptually demanding, is there a risk that this will make biological science more difficult and less readily accessible to a wider public? The great popularity of television programmes such those presented by Sir David Attenborough derives, not simply from his skill as a presenter, but also to the focus on plants and animals in their natural settings. Natural habitats in many other countries face a variety of ongoing threats from environmental pollution to destruction as a result of housing or other development. In some countries, school field trips are not the norm and in others, including England, school budgets have often made such trips a thing of the past. At a time when the national curriculum in England requires young pupils to 'identify and name a variety of plants and animals in their habitats', is there a wider significance to the deletion by the Oxford Junior Dictionary of words such as acorn, conker, heron, wren, and willow in favour of entries such as MP3 player, celebrity, broadband and block-graph?

As with the other school sciences, biological topics and problems feature in the regular comparative international tests of student achievement such as Trends in International Mathematics and Science Study (TIMSS) and the OECD Programme for International Student Assessment (PISA). The outcomes of these tests, especially PISA, are all too often presented in the form of beguiling international 'league tables' when a much closer scrutiny of the data is needed. In the case of England, for example, the difference in the levels of performance in PISA between the highest and lowest scoring groups of pupils is substantially greater than that between England and those countries with which the country is usually compared. Biology teachers are not alone in facing the challenge of overcoming this problem which reflects the more general difficulty of providing a biological education that meets the needs of the overwhelming majority of pupils. The requirement that in the future students must remain in education or some form of training or apprenticeship until the age of 18 offers both new challenges and fresh opportunities for biology educators within both formal and informal education.

PISA exerts a powerful globalising and normalising influence on curricula since many countries adjust elements of their school curricula in response to national or regional test results. This raises an important question. To what extent should biology curricula in schools in the developing world mirror those offered to pupils in more advanced societies? This question is important not least because PISA does not seek to measure what 15 year old pupils know as a result of being taught, but to assess how well the school curriculum has prepared them for their future role as 'potential and constructive citizens' in the world in which they will live and work. To point out that such a role differs from country to country or even within a given country is to state the obvious. Is there therefore a need for more courses that prioritise the social, health and psychological aspects of biology rather than its more academic aspects?

Rather different types of survey reveal other issues of concern to those seeking to promote biology education. Data from many countries suggest that too few citizens have an adequate grasp of relationships such as causality and probability, of what it means to think scientifically and of many basic scientific concepts. The Science and Engineering Indicators published by the National Science Board in the USA reported in 2014 that only 48% of US citizens agreed with a statement that human beings as we know them today developed from earlier species of animals, although adding the phrase 'according to the theory of evolution' increased significantly the proportion of correct responses. Creationism and intelligent design hold sway in many parts of the world and the teaching of evolution continues to be forbidden in several education systems, usually because it is seen as in conflict with long-held revealed truths. The 2012 Eurobarometer survey indicated that most EU citizens were opposed to the introduction of GM food and believed that scientists could not be trusted to tell the truth about controversial scientific and technological issues because of their growing dependence on industrial and commercial sources of funding.

Thus while the 'great development' of the biological sciences envisaged by Tizard has unquestionably taken place, much work remains to be done to promote public understanding of the biological sciences and of biology related issues.

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[i] Tizard, H. T., Science at the Universities: Some Problems of the Present and the Future, *Report of the British Association for the Advancement of Science, 1934,* London, John Murray, 1935, p. 216.