Cambridge University Press
978-0-521-57201-9 - The Cambridge History of Science, Volume 6: The Modern Biological and Earth Sciences
Edited by Peter J. Bowler and John V. Pickstone
Excerpt
More information

1

INTRODUCTION

Peter J. Bowler and John V. Pickstone

Preparation of this volume has been a daunting task for both editors and authors. We have had to create a workable framework through which to present an overview of the development of a diverse range of sciences through a period of major conceptual, methodological, and institutional changes. Equally problematic has been the need to ensure that the presentation takes note of both the enduring traditions within the history of science and the major historiographical initiatives of the last few decades. We have tried to ensure adequate treatment of both the sciences themselves and historians' concerns about how they should be studied. Some sacrifices have had to be made to create a viable list of topics. The result is, we hope, representative, but it is by no means encyclopedic. Topics that might have been expected were dropped either because there was not enough space to cover them adequately or, in a few cases, because the editors could not find authors willing to synthesize vast ranges of information and insights in the space that could be allowed. We are particularly conscious that agriculture and related sciences are barely present and that some areas of the environmental sciences could not be covered, including oceanography and meteorology.[1] Delays have been inevitable in the production of so complex a text, and although some efforts have been made to update the references in the chapters, we and the authors are conscious of the fact that what we are presenting will not always reflect the very latest developments and publications.

We have sought to achieve a balance between the earth and the life sciences, the traditions of natural history and the biomedical sciences, the "old" and "new" sciences, and between the development of particular sciences and more general perspectives and techniques. We have also tried to alert the reader to new developments in the historiography of science and to current interests

[1] See Peter Bowler, *The Fontana/Norton History of the Environmental Sciences* (London: Fontana; New York: Norton, 1992). For useful notes on the agricultural sciences, see Harwood, Chapter 6, this volume.

in the relationship between the history of science and broader social and cultural history. This introduction seeks to provide an outline of these issues for the reader who needs a first introduction to the history of the life and earth sciences in the modern period.

The history of science has come a long way since the editors first came into the field. Scientists have often worried about initiatives that explore the social dimension of how scientific knowledge is created, fearing that the search for social context ends up treating science as no more objective than any other belief or value system. Some historians worry that strongly relativist approaches may alienate the history of science from one of its natural constituencies – the scientists themselves. At the same time, however, virtually all professional historians of science have found it necessary to distance themselves from the kind of history that is often done by the scientists who take a passing interest in the development of their field. Such history is invariably done by hindsight, using modern interests to determine the value of past science, often thereby doing violence to what the historian sees as crucial within the very different cultural and social contexts of past eras. We need a balance between the need to contextualize science, so that we can see it as a human activity, and the scientists' feeling that – whatever the human dimension – there is something special about scientific knowledge even if it cannot be regarded simply as facts about nature.

By the 1960s, the history of science had emerged as a recognized academic discipline with a central core of interests and techniques. At this time, it was still widely assumed that the study of how science develops should be concerned principally with the scientific theory. The history of science was routinely linked with the philosophy of science – the study of the scientific method and the epistemological problems generated by the search for objective knowledge of nature. No doubt the generation of scientific knowledge had philosophical, religious, and practical implications, but these were of interest to a rather different group of "externalist" historians who concerned themselves with the engagement between science and the outside world. Few "internalists" would have conceded that the external factors played a role in shaping the *knowledge* that was generated.

At the same time, no internalist historian would have pretended that science was merely the steady accumulation of factual information as implied by the old method of induction. Indeed, much attention was already focused on areas where science seemed to have advanced by new theories that required the reinterpretation of all existing knowledge in the field. In this sense, the history of science was part of the history of ideas, and the creation of major new theories was seen as integral to the emergence of new worldviews that had transformed Western culture. Concepts such as heliocentric astronomy, evolution theory, or the germ theory of disease were accepted as a defining feature of the modern world. But such conceptual revolutions were still seen as being initiated by puzzles or opportunities created by the accumulation of factual observations. The search for a better way of describing the world in objective terms was still paramount, and the broader implications of the resulting theoretical revolutions were still seen as a secondary phenomenon. There was a one-way flow of influence between theoretical innovation within science and the wider domains of Western science and culture. Everyone simply had to adjust themselves to the new ideas generated by scientific progress.

This model of the history of science, often associated with the philosophy of science promoted by Sir Karl Popper, was broadly acceptable to the scientists themselves because it preserved the claim that new initiatives could be explained simply as attempts to gain better descriptions of the natural world. But already by 1962 Thomas S. Kuhn's *Structure of Scientific Revolutions* had challenged that consensus by arguing that the scientific community had to be understood in sociological terms. Social pressures helped maintain scientific conformity, and most research was done within paradigms that predetermined the projects that were relevant and the innovations that were acceptable. Radical new insights were resisted, even when old theories were visibly failing to account for new observations – the anomalies were swept under the carpet until a crisis was reached, and only then did a scientific revolution become possible. Here was a radical, and at the time highly controversial, challenge to the objectivity of science. It was also a challenge that encouraged internalist historians to take an interest in the workings of scientific communities. And it soon became clear that innovations in scientific theory did not necessarily originate within the field concerned; some spread from related fields or were prompted by new instruments or by new arrangements for professional education or practice. To get a rounded view of the production of knowledge, historians had to understand the social and economic features of the period – its institutions as well as its ideas.

From this point onward, the history of science became steadily more sociological, more interested in what scientists actually do than in what the armchair philosophers say they ought to be doing. Attention has increasingly switched from the theories themselves to the professional groupings that define the way science is actually done. Historians now pay much greater heed to the emergence, maintenance, and transformation of research schools and disciplines.

Historians' growing interest in the practice of science has led to a spread of interests away from the classic theoretical revolutions. Where theoretical revolutions did not map directly onto the emergence of new disciplines, the new approach has tended to deflect attention away from theoretical innovations as the main punctuation marks in the development of science. For example, though the Darwinian revolution of the 1860s undoubtedly had major effects on how scientists thought within established areas of natural history and the life sciences, evolutionary biology became established as a recognizable branch of the field only much later, in the mid-twentieth century, and then only with much difficulty. We should not assume any simple mapping of ideas and structures, and still less that evolution was a major determinant in all biological sciences. Much of late nineteenth-century biology can be profitably studied in terms of the changing patterns of work within established areas such as morphology or physiology, and this is obviously true for medicine, where the impact of Darwinism was minimal except via eugenics.

And yet, seen from another perspective, Darwinism retains its importance – as transforming or threatening common understandings of the world. Through studies of evolutionary theory or through analyzing the ways in which individuals and communities see disease or epidemics, we can investigate the interplay of technical knowledge and more general, shared cosmologies. Was man a unique creation? Was disease a punishment? Or are we to reconcile ourselves to a world where the emergence of humans or the occurrence of epidemics have natural causes rather than meanings? We no longer take for granted that the flow of influence is one-way only, from scientific insights to broader social and cultural developments. The fact that science is embedded not only within its own social structures but also within society as a whole is now seen as shaping the way in which scientific innovations are made.

Scientists have religious beliefs and philosophical opinions; they may in addition have political views, both consciously expressed and reflecting the less tangible influence of broader ideologies embedded within the societies within which they live. They also have practical concerns, both about their professional positions and the ways their work can be exploited in medicine and technology. Historians now routinely expect to find that these factors influence scientists' choice of research projects and the kinds of theories they are inclined to support or develop. Without necessarily wanting to go down the route of radical social constructivism, few historians would deny that accounts of brain functions in the early nineteenth century were related to social class or that Darwin's theory shows the influence of the individualistic social philosophy within which he was raised. Indeed, the best modern historiography seeks to integrate the ideological contexts with the detailed, technical work.

A further spin-off from this willingness to concede the effect of the local professional environment has been the recognition among historians that our own perception of the past is shaped by our viewpoint in the present. To some extent, English-speaking historians have defined the great scientific revolutions of the past in terms of concerns and values still current in their own national scientific consciousness. The amount of attention focused on Charles Darwin by historians of evolutionism, for instance, reflects English-speaking scientists' greater commitment to the genetical theory of natural selection as the defining feature of their field. Darwin's impact would be seen in a very different light by French or German historians of science seeking to describe the role played by evolutionism in their own countries. They are much more likely to focus on museums and universities – rather than natural history, field geology, and exploration – and more likely to see cell theory and morphology as the main business of nineteenth-century "biology." As a consequence, they are also more likely to stress the links between biology and medicine.

The intense focus on the impact of Darwinism among Anglo-American historians of biology also has "knock-on" effects in other areas. The decision to treat the debate over Charles Lyell's uniformitarianism as a defining feature in the emergence of scientific geology is almost certainly a product of the sense that his methodology marked an important step on the way to Darwinism. But continental geologists paid much less attention to Lyell and would thus dismiss this debate as a sideshow. Most of the chapters in this volume have been written by historians trained within the Anglo-American community. Yet because the chapter titled "Geology" has been written by a specialist in the development of continental European geology, the impact of Lyell has been played down in accordance with that tradition.

Readers should also be aware that much of the recent writing on biomedical sciences comes from historians who are interested in medicine and its practice, as well as in the sciences. They tend to stress the ways that "scientific practices" are related to diagnosis, and they have to be aware of the complex, ever-changing social and institutional environments in which most medical experts have worked. As a result, the chronologies of the history of medicine tend to be different from those of the history of science.

Histories of the physical sciences have tended to focus on the scientific revolution of the seventeenth century, and some historians of biology tried to follow them by stressing mechanistic biology, quantification, or the experiments of William Harvey. Other historians of biology focus on Darwinism, or evolution more generally, in the belief that this defining concept made biology scientific. But historians of medicine have usually focused on the establishment of clinical medicine in the hospitals of post-Revolutionary Paris, seeing there not just a new concept of disease as tissue lesion but an associated set of practices through which the "gaze" of the clinical examination (and autopsy) displaced the patients' narrative in defining the nature of the illness. Some historians would see the focus shifting later to laboratories, where medical scientists created new tests and new forms of experimentation, so that by the end of the nineteenth century, physiology and bacteriology increasingly defined the understandings to which clinicians aspired.

But, in general, we do well to see such methodological shifts not as replacements but as displacements by which new concerns and procedures are added to the repertoire, often through arguments about their importance compared to the longer-standing (and persistent) practices. Thus patients' narratives and clinical examinations remain important in most areas of medicine, and in some (e.g., psychoanalysis), they remain central. So, too, in the development of the biological sciences, taxonomy and natural histories of particular localities remain important, even when most biologists may be more concerned with analyzing bodies into patterns of cells, proteins, or DNA or with experimenting on physiological or biochemical systems.[2]

So perhaps medicine can teach historians of science to be rather less "linear" and rather more pluralist in their accounts of scientific work. Certainly we can see how a concern with scientific and medical work within institutions has provided a sociohistoric framework in which we can map the development of biomedical theories and practices over the nineteenth and twentieth centuries. It is a framework that connects and compares the leading and imperial nations of the West, especially through their educational policies and economic activity. It seems worth sketching that framework in the hope that it will serve to connect and ground the chapters that follow in this volume.[3]

Few historians would now try to understand the zoology of Georges Cuvier and Jean-Baptiste Lamarck, or the medical science of Xavier Bichat and François Magendie, without reference to the new or reformed institutions created by the government of France after the Revolution. These provided financial support and institutional power for intellectuals who saw themselves as reformers of their subjects and as creators of textbooks, journals, and definitive collections. That the prestige institutions of early nineteenth-century France were state museums, hospitals, and professional schools – rather than universities – helped create a tradition of elite technocrats close to government and a long-standing opposition between state-supported intellectuals and the Catholic Church. Those early nineteenth-century institutions were the context for major developments in analytical zoology, botany, stratigraphy, and general anatomy, and of various applications of chemistry to plants, animals, and humans. That was also the context *outside* of which Claude Bernard and Louis Pasteur found ways of developing their experimental laboratories in the latter half of the century. In the twentieth century, and especially since the 1960s, prestigious French research has mostly been supported by institutes with direct state support rather than through the universities.

German science, by contrast, was shaped beginning in the 1820s by new or reformed universities that enjoyed considerable autonomy and competed for staff and students through the promotion of "research." Recent evidence that the motives of German states were often economic as well as educational and cultural should not hide the long-standing global importance of this new idea of a university – as a community of researchers bent on developing their "disciplines," with students who themselves were potential researchers. Here was a machine for the multiplication of knowledge that bears comparison with the reproductive capacities of modern capitalism. And it was in

[2] For this way of looking at the sciences, see John V. Pickstone, *Ways of Knowing: A New History of Science, Technology and Medicine* (Manchester: Manchester University Press, 2000; Chicago: University of Chicago Press, 2001).

[3] See also the chapters herein on institutions, especially universities, and see the national histories of science in Volume 7 of this series.

Germany, beginning about 1860, that systematic linkages were made between university scientists (especially chemists), industrial companies looking for new products, and governments keen to promote (late) industrialization. By the 1890s, Germany led the world in organic chemistry, dyestuffs, and new pharmaceuticals and was a major player in the new electrical industries. German science, like much of German culture, set the standard for "civilized nations." Germany was the fatherland of cell theory and medical bacteriology, agricultural chemistry and forestry, morphology and embryology, and the application of experiment within the biological and medical sciences. Experimental physiology, for all its French roots, had been largely developed in German universities; there, too, it spread to plant physiology and to clinical science. In 1890, a science-minded British doctor would try to spend time in a German laboratory (though a cautious patient might prefer the bedside empiricism celebrated by the Harley Street elite).

German university science was imitated with more or less success in the capitals of Northern and Eastern Europe and in the better state and private universities of the United States after the Civil War. But in the United States and especially in Britain, Germanic imports coexisted with more traditional forms of higher education aimed at the gentry and would-be clergy, and with scientific communities in which gifted amateurs were prominent. Wealthy amateurs continued to play a significant role in the scientific elite through the last decades of the nineteenth century, and in some areas of natural history there was significant liaison between the elite and a host of amateur collectors. Although Scottish medical education was university-based, most medical education in England and the United States was based on charity hospitals or proprietary medical schools run by clinicians. Proprietary medical schools were especially prominent in the United States until after the Great War.

In Britain, the older model of scientific education coexisted with a tradition of scientific exploration and surveying appropriate to a great imperial power. In North America, too, the opening up of the American West generated a cultural imperative in which surveying was central to the scientific enterprise. The early nineteenth century saw the foundation of numerous geological surveys, and although these did important scientific work, the intention of the governments that funded them was always utilitarian – they wanted to know what mineral wealth was there to be exploited. Field stations and botanical gardens were founded both in Europe and in colonized territories, again with a view toward understanding how the animals and plants of the various continents could be exploited commercially. Local institutions might also test the potentiality for imported species to be grown commercially in a new environment. The great natural history museums founded in many European and American cities were certainly part of the process by which natural history became professionalized, but they were also "cathedrals of science" that symbolized the West's dominance over the countries whose animals, plants, and fossils were displayed there.

Starting about 1850, and especially from the 1870s, university and medical reform, plus the founding of new kinds of institutions, allowed the upgrading of "academic science" – often using German models adapted to local conditions. In the United States, "German" research schools coexisted with programs of professional education that sought to instill the principles of practice, including those of engineering and the other "applied sciences," which in Germany were left to the polytechnics. In Britain, the research ideal was variously taken up for chemistry, physics, and physiology, especially in the universities of Glasgow, London, and Manchester. In Cambridge, research flourished in physiology and physics – alongside natural history and the peculiarly strong mathematical tradition. But not until the 1890s did "research" become central to the development of all the major universities. Oxford attained scientific eminence in the early twentieth century, often by importing established professors from the provinces.

By the opening of the twentieth century, France, Britain, and the United States were "catching up" in the biomedical sciences, which were also developing in Japan as it "Westernized." Like most other sciences, biomedicine was favored by a new stress on economic development as nations competed for trade and empire. The imperial connection was particularly important for the biological and agricultural sciences because in the 1890s science began to be seen as a key to the success of empires. "Tropical medicine" would make the colonies safe for Europeans and might improve the health of native workers; scientific agriculture would make for profitable crops and husbandry. Humans, too, might be better bred, multiplying the strong and reducing the reproduction of the weak; in the early 1900s, genetics as a new science was closely tied to eugenics as social prescription. In all such fields, including child rearing, reliance on tradition now seemed inadequate for social progress; science held the key to better practice, and its messages were to be spread through schools, clinics, and popular lectures.

At much the same time, and again across all the leading nations, bacteriology promised the conquest of infectious diseases at home, and new state and charity institutes were established for medical research. These were loosely linked with universities, whose medical schools were becoming more scientific as the professions and governments, especially in the United Kingdom and the United States, pursued a university-based model of medical education. The generation before the Great War was formative for the institutions and disciplines of biology and medicine, both in "applied areas" and in the "pure sciences" dominated by experimental physiology, then seen as a model of scientific medicine and as a bridge between the medical and science faculties.

The interwar years were difficult for the European nations damaged by defeat or victory. Although the war had increased state investment in research, and though that effort continued, the pace of educational expansion seems to have slowed in France, Germany, and the United Kingdom. The American economy was stronger, and new subjects such as biochemistry and genetics were institutionalized there partly because American universities were more open and "applied" in their structures. The German hegemony was gone; some American researchers still went there, but they also came to Britain, and the Anglo-American scientific community became more important.

At the same time, the decline of infectious disease in the West and the emergence of chronic causes of mortality, especially cancer, gave new focus to medical research and charity. By the 1930s, the world's leading pharmaceutical companies all had laboratories for research and product development (not just for quality control). Infectious disease in the tropics remained important for the British and French empires, and the Rockefeller Foundation funded American studies – for the southern states as well as for countries in which the United States had a growing economic interest. The Rockefeller Foundation also emerged as a major player in fundamental science, supporting a program in what became molecular biology.

Since 1940, the world of biomedical sciences has been transformed by the two forms of investment that had emerged strongly by the end of the nineteenth century – from governments and from industry. The third quarter of the twentieth century was dominated by state investment as Western and Soviet bloc governments poured huge resources into war-related research, space programs, medical services, agricultural intensification, and overseas development. In the earth and environmental sciences, these investments created new opportunities for scientists and led to the transformation of some disciplines. Opportunities to study the deep-sea bed, generated by the concern for submarine warfare, boosted the prestige of geophysics at the expense of traditional geology and made possible the emergence of the theory of plate tectonics and continental drift. Space exploration offered new methods of monitoring the earth's surface. Almost all countries saw a substantial increase in university-level science and in technical manpower, often financed directly or indirectly by military and industrial resources.

Similar developments took place in those areas of the life sciences that could be associated with medicine. Heart disease, and especially cancer, became objects of investment and prestige comparable to the space race, and researchers presented themselves as "biomedical" to capitalize both on the intellectual prestige of science and the intended benefits of medicine. The pharmaceutical firms expanded their product ranges to include the new antibiotics and new kinds of molecules acting on the nervous and cardiovascular systems; traditional remedies were marginalized, especially in the hospitals, which now dominated health care.

In the decades after World War II, biological sciences in universities were reconfigured, partly in response to the successful analyses of DNA, RNA, proteins, and the relations between them – all made possible by sophisticated analytical methods, including isotopes, x-ray crystallography, and the creative use of specific enzymes. After the Cambridge discoveries of Watson

Cambridge University Press
978-0-521-57201-9 - The Cambridge History of Science, Volume 6: The Modern Biological and Earth Sciences
Edited by Peter J. Bowler and John V. Pickstone
Excerpt
More information

and Crick in 1953, the genetic code came to define a "molecular" biology – pulling together the various life sciences at a level below cells and genes. The old configurations of disciplines based on botany and zoology (in the science faculties) and the medical sciences (as taught to medical students) variously gave way to a vertical division between ecological sciences concerned with environments and biomedical sciences, which focused on subcellular structures and happenings in man or any other organism. That is simplistic – some new configurations, such as neurosciences, were system based, spanning from coelenterates to cerebral dysfunctions in man – but one way or another, the disciplinary structures of the early twentieth century gave way to new formations whose inhabitants were sufficiently numerous and confident to rival the prestige of the physical scientists and the relevance of the clinicians. The biomedical sciences were the new frontier and the motor of change in medical practice; the environmental sciences, on a much smaller scale, held the key to a newly emergent challenge – environmental damage and species loss on a global scale.

This restructuring of biology and medicine gained force in the last quarter of the century as molecular biology and the new genetics moved from analytical acumen to experimental syntheses and came to be linked more closely with the large pharmaceutical and agricultural companies that, partly through repeated mergers, had come to shape medical and agricultural practices worldwide. These companies invested in genetic engineering – directly, by buying up the small companies founded by academics, or through supporting university research.

One should not, of course, forget the large quantity of university research that continues to be funded by research councils and others according to the disciplinary priorities of academics, or indeed the massive "development" work that is characteristic of the industries and of relatively little interest to academics. But nor can one ignore the extension of the "technoscientific" interplays across much of the biomedical research scene. The ties of research to commerce were further enhanced, in various countries, by the privatization of the laboratories and agricultural stations once paid for by the state and by the tendency of governments to see science as a direct part of the infrastructure of national industries rather than a form of cultural investment.

That these general patterns of development can be described across nations, especially for the twentieth century, should not, however, hide the continuing importance of local and national differences. Although fully comparative histories are rare, many sociohistoric studies are enhanced by partial or implicit contrasts between locations. As we have hinted, one important consequence of focusing on the practice of science has been recognition of the local variations in how fields are organized and defined. For example, neither the conceptual revolution nor the disciplinary specialization that led to the creation of genetics in Britain and especially the United States worked out the same way in France and Germany. Nor could one fully account for patterns