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science, history and culture: evolving perspectives

This chapter could be entitled 'the present and future of history of science'. As the previous chapter suggests, history of science has increasingly been re-examined 'from the inside'. But not only have historians revisited the subject: so too have philosophers, sociologists and the wider public. Together, these visions of the subject have reworked its goals, its methods and its audiences. The aim in this chapter, then, is to explore behind the scenes to illustrate how scholars have drawn meaning from the history of science.

philosophers and failure: disputing how science works

From the early nineteenth century, the history of science became closely associated with philosophy, although, as historian Simon Schaffer (b. 1955) and others have argued, the writing of scientific history also developed from biographies of exemplary practitioners. Both connections were only to be expected. Mediaeval categories had defined scientific knowledge as part of natural philosophy, an understanding traceable to Aristotle; and big names like Aristotle provided authoritative answers. The narrower term *physics* – dropping the philosophical association – was substituted increasingly during the late nineteenth century, but there were some holdouts. Scottish universities largely retained the term *natural philosophy*, with Glasgow University's department being reorganized to become the Department of Physics and Astronomy as recently as 1986.

Elaborated by William Whewell, the history of science served as raw material to construct philosophical understandings of the universal nature of knowledge. He categorized branches of scientific knowledge, traced their histories, and coined new words (such as *physicist*, *anode* and *uniformitarianism*) to describe them. Whewell's *History of the Inductive Sciences* (1837) was followed quickly by *The Philosophy of the Inductive Sciences, Founded Upon Their History* (1840). The twinned books argued that the successful advance of scientific knowledge relied on *induction*, the generalization of concepts and laws from particular examples.

Whewell's French contemporary (and rival) Auguste Comte, introduced in chapter four, also categorized the sciences via a historical survey. Unlike Whewell, Comte suggested that the advance of knowledge could be accelerated by a rigorous methodology that relied only on observable facts. 'Positive' knowledge extended only to what could be experienced directly (empirical evidence). And, as singer Bing Crosby put it, in addition to accentuating the positive, it was equally important to eliminate the negative: theorization about hidden or abstract entities, Comte claimed, was pointless.

Ironically, while the history and philosophy of science became closely allied, practicing scientists drew away from both fields around the turn of the twentieth century. Now increasingly professionalized and goal-oriented, scientists delved into the philosophical justifications of their work less often. Perhaps the last influential scientist-philosophers were Ernst Mach (1838-1916) and Pierre Duhem (1861-1916). A confirmed positivist, Mach argued that scientific laws are merely short-hand for collections of experimental findings. His book *The Economical Nature of Physical Inquiry* (1882) suggested that 'the law always contains less than the fact itself', and promoted the trimming of scientific claims to only what was strongly supported by evidence. This rather fundamentalist approach led him to reject the atomic hypothesis at the turn of the century on the grounds that direct observations were impossible, and the indirect evidence was 'uneconomical'.

French physicist and philosopher Pierre Duhem, on the other hand, investigated the problem of constructing scientific theories. His position, known as the Quine-Duhem thesis or the problem of *under-determination*, is that for any set of data a large number of theories can be convincingly applied. In any experiment then, the results will not provide sufficient evidence to force revision of a theory (this came up in Chapter 5 in the discussion of the Michelson-Morley experiment). Duhem's unsettling conclusion raises questions that were reviewed by historians and sociologists of science half a century later: how can empirical evidence be related to theories at all, and (more fundamentally) what confidence can we have in scientific realism – the notion that it is possible to discover the true nature of things?

Philosophers, too, were stimulated (and disturbed) by the elaboration of new scientific theories such as relativity and quantum mechanics. One outcome was the influential *logical positivist* movement which sprang up in 1920s Vienna and came to dominate American philosophy of science into the 1960s. Inspired by Comte's positivism, its members questioned the proliferation of concepts that could be only indirectly inferred. How, for example, do we know that 'electrons' and 'energy levels' truly exist? They argued for a more logically-based scientific method, and could turn to historical episodes to illustrate how successful science had operated in the past.

While scientists themselves were turning away from philosophy, then, history of science developed in close association with it. Early twentieth century historians of science emphasized the evolution of concepts and the accumulation of factual knowledge – intellectual history and its philosophical significance. The label 'History and Philosophy of Science' (HPS) identified a successful proto-discipline at prominent institutions such as Cambridge. Part of the reason of the success there can be attributed to its location within the Faculty of Natural Science. Academic affiliations were also tight elsewhere: the History of Science Division at the University of Leeds, for example, was founded in the mid 1950s within its Department of Philosophy.

More frequently, though, Philosophy departments pursued the philosophy of science without explicit links to the history of science. Notable contributors – each with well established explanations and followers – included Karl Popper (1902-1994) at the London School of Economics and Thomas Kuhn at the University of California, Berkeley. Both rejected the positivist philosophy that was becoming the orthodox explanation for how science works, but for distinct reasons. Popper emphasized insights about the scientific method. Importantly, he demonstrated that scientific theories can never be wholly proven: at best, they are conditionally confirmed by mounting evidence. In essence, this is a critique of induction. He proposed instead the notion of *falsificationism* to explain the advance of knowledge. Facts, he argued, could never be confirmed to be true in general, but they could be proven false. For example, the claim 'all swans are white' cannot be proven true unless we examine every swan that exists or has existed, but it can be proven false merely by finding a single example of a black swan. Swans aside, the same imbalance affects many modern claims: we could prove that UFOs or ghosts exist by capturing just one, but we can never disprove their existence; we may be failing to find them because we are looking in the wrong places or at the wrong times! Science advances, said Popper, by testing falsifiable hypotheses. The remaining set of hypotheses not yet proven false represents our working body of knowledge. Some historians argue that there are few examples of this method in practice.

On the other hand, Kuhn, as we have seen, claimed a different use for historical evidence, demonstrating that it did not support the notion that science accumulated knowledge inexorably; periodically, he showed, there were ruptures of knowledge, and new frameworks of understanding (or worldviews) were constructed. The revolutions discussed in chapter three are evidence of such periodic convulsions. Both Popper and Kuhn emphasized the importance of theory-making, and so reduced the stress on fact-collecting and empirical observation.

Imre Lakatos (1922-1974) and Paul Feyerabend (1924-1994), both junior associates of Popper, provided their own distinct approaches to the philosophy of science. Lakatos sought to reconcile the views of Popper and Kuhn. Feyerabend's *Against Method* (1975) argued that science is not a unified body of knowledge with any identifiable universal method; instead, it is an incoherent patchwork of particular techniques and procedures that isolate pockets of knowledge.

As this outline suggests, the history of the philosophy of science has interesting parallels with history of science itself. A series of contributors (including Whewell, Comte, Popper, Kuhn, Feyerabend and their successors) have reformulated the bases of the subject. As a result, the worldviews of philosophers of science have been shaken periodically.

science in the post-modern world

As sketched in chapter six, the close alliance between the history and philosophy of science has been broadened to other disciplines during the late twentieth century. There has been a flourishing of approaches to writing the history of science, and to understanding science itself. These new viewpoints have resulted from studies of science 'from the outside': from other disciplines and even from other belief systems. This gradual process, developing after the Second World War, can be described as waves of reorientation for the history of science.

Two such changes of direction have been described as the 'linguistic turn' and the 'social turn'.

The linguistic turn

The phrase 'linguistic turn' refers to a shift in the history of science towards studies of language and discourse – i.e. research into the ways that scientific findings have been described, communicated and perceived. This refocusing of attention towards language began in Humanities subjects (history, literature, cultural and media studies) during the 1960s. These ideas amalgamated developments by philosophers such as Ludwig Wittgenstein (1889-1951) and literary theorists such as Jacques Derrida (1930-2004). Wittgenstein had argued that philosophical concepts are intimately tied up with language. A separate development was the method of *structuralism*, conceived first for the study of linguistics but spreading to other fields during the 1950s. Structuralism seeks to find abstract patterns or structures within social events, and to determine their rules of combination. Anthropologists such as Claude Lévi-Strauss (1908-2009), for example, sought to discover the 'deep grammar' of societies by studying their rituals, kinship associations and mythology.

By contrast, the next generation of philosophers and critical theorists, particularly in France, developed a critique of structuralism that, logically enough, has been dubbed *post-structuralism.* Derrida, Michel Foucault (1926-1984) and others argued that various radical philosophies that were critical of Western philosophies illustrated the degree to which Western culture itself had defined ways of thought. Post-structuralists argued that the underlying 'structures' of society identified by structuralists are not universally observable characteristics but are, in fact, conditioned or created by culture. As a result, the attempt to apply a scientific approach to social processes is inherently biased. They seek, instead, to understand the world by investigating multiple viewpoints or perspectives. Such a position clearly challenged the interpretations of the history of science that had been developed up to the 1960s. It also challenged the traditionally privileged position held for scientific knowledge itself.

While its origins are diffuse and definitions are spurned, at the heart of the linguistic turn is the conviction that our understanding of the world is strongly filtered and shaped by language. Rhetoric, it is argued, can create a vision of the world by defining terms and corresponding concepts. This highly-constrained perspective can limit or distort our perceptions about the natural world. Taking up this approach, historians of science began to study scientific texts in relation to other kinds of discourse, such as religious and political. They sought to discover how scientists' discourse affected the presentation of their findings and how texts had been used to persuade audiences of their explanations. This approach probed the motivations for scientific accomplishments and related them more clearly to the context of their times and to other varieties of historical study. Science, previously explained mainly by the logic of reasoning, was now more fully explained in terms of ideologies and interests. One might ask, for example, how we can characterize Isaac Newton, Robert Boyle or Louis Pasteur by the books they read and wrote. The attention to scientific rhetoric led naturally to wider interest in historical context that created these texts. It also opened the door to the study of different national settings for science. Studies of articles on science in popular journals, for example, embedded the field more firmly in the scholarship of Victorian culture, and revealed differing perceptions of science in the countries of Europe and America.

The social turn

As suggested by the linguistic turn, growing numbers of historians of science began to focus on the rhetorical and human factors underlying scientific knowledge. A closely-related shift in attention from the 1970s was the so-called 'social turn'. Here, too, the roots of change can be found in the ideas of other disciplines.

Social history, a branch of historical studies that had been growing since the 1950s, called attention to 'history from below'. Its proponents argued that social norms and beliefs could arise from, and be sustained by, the masses rather than from figures of authority. Applied to the history of science, social history focused on audiences and different portions of the public – by class, education, occupation or national origin – rather than on men and women of science. Histories of science could now be devoted to the *reception* of scientific ideas instead of merely to their *creation*. Indeed, social history has more recently extended to *cultural* history of science. This approach focuses on the relationship between science and culture, a subject that makes sense only if the historian appreciates that knowledge may have different cultural expressions or be subject to cultural shaping. For instance, the national preference for the concepts of Descartes in France was diminished after the French translation and commentary of Newton's *Principia* by woman of science Émilie du Châtelet. The fruit of this approach is the broader understanding of science as a social process: a collective human activity fraught with human emotion, motivations and mistakes as well as successes.

A second outcome of the social turn was a new attention to craft skills and artisanal knowledge as drivers of science. As suggested by philosopher Jerome Ravetz (b. 1929) during the early 1970s, this approach counteracted the traditional interest in intellectual history for the field. Rather than focusing on concepts and their mutation, historians of science increasingly investigated the importance of process skills. Historian Myles Jackson (b. 1964), for example, has argued that the development of spectroscopy by Joseph von Fraunhofer in early nineteenth century Germany owed much to his artisanal expertise in precision optics.

But just as post-structuralism had influenced 'the linguistic turn', it provided a more radical slant for the 'social turn' than did social history. The relationship between social activities and scientific findings can be explored one step further: can society not merely constrain or filter our scientific practices, but also shape our scientific beliefs? An example of this possibility is the investigation of N-rays discussed in chapter five. The N-ray studies and claims of René Blondlot had been conditioned by his working environment. The contemporary discoveries of x-rays and radioactivity, along with state-of-the art practices of measuring the brightness of light and detecting radio waves, had made him and his scientific collaborators receptive to interpretations that might have seemed improbable in other social contexts. The data reported in papers by several laboratories were later judged to be illusory and misguided. On a much larger scale, it can be argued that the Aristotelian understanding of the heavens – the Western orthodoxy for nearly 2000 years – was supported by prevailing theological ideas and trust of ancient authority.

An extension of such anecdotal cases suggests that, at least sometimes and for certain periods, scientific facts can be *social constructs*.

Social constructivism: the view that knowledge is a human product that is socially and culturally shaped, rather than being based primarily on discoverable physical reality.

This new approach had at least two clear consequences. First, it brought scholarship in the history of science closer to other fields such as literature, anthropology and sociology. This new cluster of scholarly interests has been described by labels such as *science studies*, *science and technology studies* (STS) or *science-technology-society* (also abbreviated STS).

The second consequence of these turns has been that they diminished the perceived separation between scientific knowledge and other forms of human belief. Another intellectual current for historians of science during the late twentieth century came once again from philosophy and sociology. So-called *sociology of scientific knowledge* (often referred to by its abbreviation, SSK) was the product of interdisciplinary studies from the 1970s. One of its principal founders, David Bloor (b. 1942), argues that sociological factors influence all aspects of science, from the selection of problems to funding, from categorization of results to dissemination, and from observation to theory construction. Members of the so-called Edinburgh School (the Science Studies Unit at the University of Edinburgh from the late 1960s) distinguished two versions of this viewpoint. The 'Weak Program', they argued, applies discussion of social factors merely to erroneous beliefs. Thus Blondlot's N-rays would be attributed to the social considerations that flavored his scientific work, while the successes of his critics would be attributed solely to intellectual factors and rational, objective judgment. As suggested by the pejorative label 'weak', the members of the Edinburgh School favored a different approach, which they dubbed the 'Strong Program'.

According to the Strong Program, historical, sociological and philosophical investigations of scientific practice should strive to be neutral with respect to our current beliefs about the truth or falsity of claims. This approach, known as *symmetry* or *methodological relativism*, gives equal attention to historical episodes that today are seen as 'successes' and 'failures'. The history of science is thereby broadened to document and analyze not just how we came to hold our present scientific beliefs, but also the numerous blind alleys, failed initiatives and errors of the past. This is not merely a matter of being 'fair' to the collection of historical actors, but also to better understand the strategies and philosophies of knowledge pursued by our forebears. It also extends history of science into the present and, indeed, the future: the scientific practices and strategies of the past inform those of the present, and so historians, anthropologists, philosophers and policy-makers have much to teach each other.

A more radical position of the Strong Program, however, is its commitment to social constructivism. The original expositions set out to investigate the hypothesis that *all* scientific knowledge is socially constructed to some extent, and possibly entirely so constructed. This claim certainly opposed most scholarship in history of science up to that time, but members of the Edinburgh School and others employed historical case studies as the basis of such research.

An early and highly influential example is the still controversial historical hypothesis put forward in 1971 by American historian of science Paul Forman (b. 1937). The 'Forman thesis' argues that the content of early quantum mechanics was shaped by the culture in which it developed, interwar Weimar Germany. The unexpected defeat of Germany in the First World War, it is claimed, caused a loss of confidence among the educated elite in rationality, deterministic processes and even causality itself. In this cultural environment, Weimar physicists opted to support the uncertainty principle proposed by Werner Heisenberg rather than alternate interpretations of quantum mechanics. As a result of these cultural pressures actively shaping the subject in the German context and its rapid international spread, the Copenhagen interpretation became the new orthodoxy. Forman's claims were followed by a generation of historical studies to further explore the social and cultural mechanisms that could influence the content of science.

Other variants of the sociology of scientific knowledge, notably attributed to French scholar Bruno Latour (b. 1947), argued from the 1970s for more radical understandings of science, technology, knowledge and technical products. His early work *Laboratory Life: the Social Construction of Scientific Facts* (1979, co-written with sociologist Stephen Woolgar (b. 1950)) unconventionally explored science by applying the methods of anthropology to a biology laboratory. These perspectives are beyond the scope of this book, but they, too, continue to motivate current research by some historians of science.

Such theorizing about the scientific enterprise may appear arid and divorced from the concerns of previous generations of historians of science, who more frequently adopted a narrative style (that is, constructing carefully-researched stories of scientific episodes and historical figures). They may also fail to tempt the casual reader with their intellectual vistas. However, these radical positions, during the early 1990s, assumed a public and even political dimension. Dubbed the 'Science Wars' by the American media, the differences in viewpoint between radical constructivists and practicing scientists were played out in magazine articles, campus debates and television interviews. In their crudest form, they illustrated a polar division between so-called 'relativists' and 'realists'. The relativists argue, with varying degrees of compromise, that scientific belief is influenced, shaped or determined by the society in which it is practiced. The realists, calling upon older and still widely accepted philosophical foundations, argued that human knowledge based on rational scientific approaches is ultimately unlimited in its accuracy and power to describe the natural world. Both extremes accommodate nuanced approximations, making the 'wars' more a spectrum of discord. While the 'Science Wars' cooled down, they are a potent illustration of the relevance of history of science in contemporary culture.

anti-scientific movements and popular belief

The section above limited itself to changing scholarly opinion since the Second World War. But, as discussed in chapter five, one of the most dramatic features of science over that period was the rise and fall of public confidence in scientific authority. So, alongside the scholarly turns, we can track changing understandings of science in popular culture.

Popular criticisms of science have roots as old as the scientific revolution and have been supported by a range of scholars.

During the second half of the eighteenth century, the grand aspirations of the Enlightenment were criticized by scholars such as Jean-Jacques Rousseau (1712-1778). Rousseau criticized the power and adequacy of rationalism to create the better world, and argued that humans inevitably were corrupted by society. He suggested that the advancement of knowledge had concentrated power in the hands of governments to the detriment of individual liberty.

Supported by such ideas, *Romanticism* became an important cultural and intellectual force influencing literature, art and music through the mid nineteenth century. The movement represented, in part, a resistance to Enlightenment claims. It stressed direct individual experience, imagination, emotion and intuition over cold rationality. While no consensus can be identified, Romanticism challenged the scope of reason and emphasized subjective human qualities. By extension, this challenged universal laws and scientific methodologies such as reductionism and quantification as means of describing and explaining the complexities of the natural world. Incidentally, such perspectives inform some contemporary scientific concerns, too: environmentalism and so-called 'deep ecology' owe much to the Romantic movement, in opposition to technologically-oriented solutions that can be linked more closely to the worldviews of the mechanical philosophers and many of the other practitioners that have been the focus of this book. In exchange for the expanding methods of science, proponents of Romanticism offered holistic, multi-layered description founded on particular experience.

Reductionism: the breaking down of a problem into more easily explainable parts, or the simplification and generalization of an explanation in terms of a more fundamental one (note: there is a distinct definition that may be encountered: in biology, where reductionism can refer to a materialist explanation of life).

Holism: the consideration of multiple scales and interconnected contributions making up an effect.

The most influential scientific expression of this was *naturphilosophie*. Most widely supported in the German-speaking world by exponents such as Johann Wolfgang Goethe (1749-1832), this philosophy emphasized the interconnectedness of nature. Its approach promoted alternatives to the 'new science' of the seventeenth and eighteenth centuries, rejecting the procedure of dividing problems into more easily manageable portions. Goethe, for example, championed explanations of light and color that were distinctly at odds with those of Newton a century earlier. A drawback of his color theory was that, unlike Newton's, it was difficult to make predictions from it.

While the late nineteenth century witnessed a growing popular acceptance of progress as discussed in chapter four, the pace of scientific and technological change provoked varied critical responses. Romanticism had offered an early alternative, but quite distinct counter-forces emerged in the twentieth century. Emerging in Switzerland during the First World War, *Dadaism* was a cultural movement that expressed a rejection of logic and reason. Through art, theatre, manifestos and design, Dadaists expressed irrationality and chaos as a reaction to the conformity and perverse 'logic' that they argued had led to war. Within a decade the movement had fostered *surrealism*. Surrealist artists, writers and performers juxtaposed unrelated and dream-like images, communicating a rejection of logic and orderly sequential thought.

In their very distinct ways, the Romantic, Dadaist and Surrealist movements were important examples of opposition to the techno-scientific basis of modern culture that was expanding during the nineteenth and early twentieth centuries. They challenged the completeness of scientific explanation and offered multiple perspectives in place of general explanation. Although Dadaism and surrealism were relatively elite and narrow in membership, they affected the wider public at least peripherally and temporarily.

A more direct expression of popular anti-scientific sentiments was through the adoption of non-western religious, medical and metaphysical ideas. The New Age movement, for example, can be characterized as an individualistic approach to spiritual exploration and consciousness. Like the artistic movements described above, it criticizes the constraints and limitations of the scientific approach, and argues for a holistic understanding of the natural world. Although the term *New Age* circulated from the early 1970s, there are identifiable links with ideas that developed during the late nineteenth century, such as spiritualism and alternative medicines. Here, again, universal definitions cannot be constructed but the body of ideas draws upon a wide range of religious concepts from many cultures. Some concepts, such as meditation and reincarnation, have links to Eastern religions. An attention to mystical and mysterious dimensions of knowledge has roots in a number of world religions, including Christian and Jewish sects and Shamanism. The collection of practices may also amalgamate a variety of medical traditions from other cultures. Some of these are ancient and widespread, such as acupuncture (China) and Ayurvedic medicine (India). Others represent new interpretations of old concepts, such as aromatherapy's adoption of ideas traceable to alchemy. Admittedly this sparse survey cannot do justice to the forms of knowledge that challenge science; this book highlights the twists and turns of the scientific perspective and can only sketch a background against which to contrast it.

There is one further aspect of these alternatives that can be mentioned, though. Some critical perspectives do not merely challenge conventional science: they sometimes have sought to incorporate and extend it. Some alternative medicines have recognizable scientific links, such as therapies based on magnets or light. New Age thinking is informed by certain sciences, notably aspects of psychology and ecology. Its interpretations of quantum mechanics, for example, draw connections between consciousness, causality and spirituality. New Age claims promote notions of knowledge (epistemologies) that extend beyond the methods and theories of science, but frequently make reference to them. Like spiritualism, one of its disparate roots, some New Age beliefs borrow from the terminology of science. Where spiritualists detected 'vibrations' from the spirit world, promoters of 'crystal therapies' may invoke 'resonances', 'energy levels' and 'recharging'; alternative therapists may refer to 'toxins'. Such adoption of scientific jargon with unconventional meanings has been described as *pseudo-scientific*. The criticism of practicing scientists usually focuses on the lack of reliable evidence for such claims, and the lack of precision of their foundational ideas.

Pseudoscience: a body of knowledge that claims scientific authority without appropriate scientific methodology.

Not all of the counter-forces to modern science are to be found in older or non-western traditions. Stalwart opposition to Darwinism, for example, has in recent decades been buttressed by (piecemeal) arguments drawn from the history and philosophy of science. Rather like supporters of phrenology in the early nineteenth century, certain supporters of creationism have attempted to construct a 'creation science' that adopts some features of scientific methodology. They may cite certain scientists as figures of authority for their claims (although most have credentials outside biology) or may point to inadequately explained observations as crucial refutations of evolutionary theory. The work of historians to reveal the complex history of many scientific claims may be used by creationists to hint that no scientific orthodoxy is safe and authoritative. Such pick-and-mix scholarship nevertheless is inevitably patchy and underlain by a clearly non-scientific foundation: that one particular theory – the Biblical account of creation – is beyond critical investigation and adjustment. By contrast, Darwinian evolution and Mendelian genetics have adapted to new empirical evidence.

The most serious challenge to the consensus of biologists was probably the set of claims made by Ukrainian agronomist Trofim Lysenko (1898-1976), who argued during the 1940s and 50s for the inheritance of acquired characteristics (rather similar to the ideas of Lamarck some 150 years earlier). His methods of mutating crops by *vernalization* (acquisition of spring-hardiness of crops by exposing young plants to winter conditions) were carefully tested in other countries and found to be irreproducible. The rise of Lysenkoism, which promised higher crop yields, was supported in the Soviet Union by active suppression of Mendelian genetics until 1964. What had, for a time, been Soviet science was recast as pseudoscience.

Having distinct aims and memberships, other forms of opposition to specific scientific claims have become increasingly visible from the late twentieth century. The case of British opposition to the mumps-measles-rubella (MMR) inoculation during the late 1990s is a typical example. The case is interesting beyond the British context precisely because it became controversial only there; it begs the question of what conditions were remarkable at that time in that particular country. A small-scale study by a doctor suggested that the MMR injection could be correlated with subsequent emergence of autism in a small number of inoculated children. Unswayed by large-scale trials and statistical analysis – the methodology of modern medicine – many anxious parents rejected the perceived dangers of inoculation in the face of unverified anecdotal claims. This did not necessarily represent a blanket rejection of science and medicine, but often a construction of seemingly more acceptable explanations: for instance, that the vaccine would be safer if divided into three separate inoculations for mumps, measles and rubella, respectively; that the British Medical Association, National Health Service and Department of Health responded directly and unanimously to demands of their political masters, and so were suspect; or that 'rogue' doctors would routinely be attacked when they threatened industrial, institutional and professional establishments. Even for rational audiences, conspiracy theories may prove more compelling than plodding, and increasingly invisible and incomprehensible, science. Such claims are generally challenged by practicing scientists who argue that, even taking political, social and cultural factors into account, bodies of expert and independent peers (operating in different countries under distinct political and religious systems, for example) tend, in the long run, to agree on questions of scientific fact.

These very recent challenges to scientific knowledge and practice are not unprecedented: as this book suggests, different approaches to knowledge have always coexisted. What makes them remarkable is their increased visibility in the past few generations after a long decline in the west since the scientific revolution. Old and new, they are topics of direct relevance to historians of science. Not only are they linked to ideas as old as modern science itself, but they can be expected to influence twenty-first century thinking about science and its integration into wider culture. The history of science, therefore, is firmly embedded in analysis of the present-day.

between the universal and the particular

We live in interesting times, to paraphrase an ancient Chinese blessing. History of science today is more vibrant and relevant than ever in the past. It is enriched – and made contentious – by other disciplines and perspectives. The debates of the 'science wars' have diminished considerably, but proponents of both extremes continue to lob volleys through historical studies. As a result, the hot spots in the history of science are equally changeable and multi-dimensioned. The field offers timely opportunities for research and exploration based on every type of human scholarship.

This beginner's guide has suggested that the observation, innovation in technique, logical reasoning and application of knowledge so characteristic of science are widely-shared human attributes readily discernible across human societies. It has argued that natural phenomena are an inexhaustible resource to motivate human curiosity and research. Equally universal are the drives to explain patterns and to apply knowledge in the pursuit of power and control. The history of science focuses on the myriad contexts in which these human attributes have been expressed and shaped.

Alongside this seemingly ubiquitous drive, though, are dramatically different cultural expressions. The activities we call 'science' have emerged and mutated at particular times and places and been shaped and applied in those environments. The techniques of how best to recognize and weigh up these events and contexts have motivated – and sometimes divided – historians and scientists. The challenging and continuing goal for history of science is to detect and explain the subtle intellectual and cultural interactions of this diverse human enterprise.

further reading

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