"Scientific Culture"

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1. Modern Scientific Culture

All human societies develop knowledge about their natural and social worlds. Even hunter-gatherers possess remarkable local knowledge about plants, animals, and climate. The great world civilizations had a more complex division of labor that allowed priests, doctors, smiths, farmers, and other specialists to develop more elaborate and less local knowledge systems about astronomy, psychology, medicine, metallurgy, agriculture, and other fields. Researchers tend to reserve the term 'science' for the elaborated, written knowledge systems of the great world civilizations—such as ancient Greek or Chinese science—and they tend to describe other, more local knowledge systems as ethnomedicine, ethnoastronomy, ethnobotany, and so on.

Many attempts have been made to describe the distinctive features of the type of science that emerged in Western Europe around 1500–1700 (Cohen 1997). The term 'modern science' is somewhat clearer than 'Western science,' not only because Western science was built up in part from non-Western sources, but also because Western science rapidly became globalized. However, two clarifications are in order. First, the term 'scientist' did not emerge until the nineteenth century; in earlier centuries the term 'natural philosopher' was more common. Second, the term 'modern' is used here to refer to a society characterized by a family of institutions that includes modern science, constitutional democracy, capitalism, religious pluralism, social mobility, and a universalistic legal system. Although some of those institutions can be found in some of the world's societies prior to 1500, their development as a system occurred in the West and accelerated after 1500. As an institution, science soon found a niche in modern societies by providing research and or ideological support for the emerging capitalist industries, the state, and the churches (e.g., ballistics, mining, navigation, taxation, public health, critiques of magic).

Modern societies provided more than financial resources that supported the growth of modern science as an institution; the culture of modernity provided intellectual resources that contributed to the emergence of modern scientific inquiry. Three of the central values of modern scientific culture are empiricism, formalism, and mechanism. Although each of the distinctive features of modern scientific culture can be found in other scientific cultures (and may not be found across all modern scientific disciplines), as a family of features they have some value in characterizing modern scientific culture, and in showing its points of confluence with the cultures of modernity more generally.

Empiricism refers to the value placed on observations as a means for resolving disputes about natural and social knowledge. In some sciences, empiricism was developed as experimentalism; in other words, observations could be brought into the laboratory and subjected to experiments that were, in principle, reproducible by competent members of the scientific community. However, other fields remained non-experimental, such as the fieldwork-based sciences. Because observations are always subject to interpretation, their use as a resource for dispute resolution was in turn rooted in broader societal cultures. Scientists had to trust each other not to lie (Shapin 1994), and they required societies and journals in which they could debate and share results. Those requirements were met in the European societies that fostered the emergence of a 'relatively autonomous intellectual class' (Ben-David 1991, p. 304) and a public sphere of open debate (Habermas 1989).

The relationship between empiricism and the broader society went beyond institutional requirements; other sectors of society were also characterized by an empirical cultural style. For example, constitutional democracies and markets were based on the 'empiricism' of elections and consumer purchases. Likewise, some Protestant churches replaced church dogma with the empiricism of direct interpretation of Bibles, and they emphasized knowledge of God through study of his works (Hooykaas 1990, p. 191, Merton 1973, Chap. 11). In this sense, the empiricism of science emerged as part of a more general way of resolving conflicting opinions about the world through recourse to data gathering and evidence.

Formalism refers to the value placed on increasingly higher levels of generalization. As generalization progresses in science, concepts and laws tend to become increasingly abstract and_or explicit. In some fields, the generalizations took the form of mathematical laws that encompassed a wide range of more specific observations. In physics, for example, it became possible to apply the same set of formal laws to the mechanics of both terrestrial and celestial objects, and space and time were analyzed in terms of geometry (Koyre_ 1965). In other fields, the generalizations took the form of increasingly formal and abstract taxonomies and systems of classification, as in early modern biology (Foucault 1970).

Again, broader institutions and values contributed to the emergence of this specific form of inquiry. When researchers found support for societies that published journals where an archive of research could be located, they found the institutional resources that allowed them to conjugate their work with that of others. Likewise, as Western colonial powers expanded, they sent out scientific expeditions that incorporated local knowledges and new observations into existing research fields. As 'Western' science became increasingly cosmopolitan, it also became more abstract. Again, however, the relationship with the broader society went beyond institutional influences to shared values. For example, scientific formalism developed in parallel with modernizing, Western political systems and social contract theories that emphasized the abstraction of general laws from particular interests, or of a general good from individual wills.

A third common feature is the value of mechanism as a form of explanation. Over time, modern science tended to rule out occult astrological forces, vitalistic life forces, and so on. When the concept of force was retained, as in Newton's gravitational force, it was subjected to the restraints of a formal law. Again, general social and cultural resources supported this development. The attack on occult forces was consistent with reformation campaigns against popular magic (Jacob 1988), and the disenchantment of the world that mechanistic models depended on was both supported by Christianity and intensified by some forms of Protestantism. The development and spread of clocks and constitutions provided an early metaphor of mechanism, and as new technologies and social charters were developed, new metaphors of mechanism continued to emerge (Kammen 1987, pp. 17–8, Shapin 1996, pp. 30–7). Sciences that violate the cultural value of mechanism, such as parapsychology (the study of claimed paranormal phenomena), are rejected. Likewise, the incorporation of local sciences has tended to occur after filtering out occult or vital forces. For example, in response to demand from patients and cost efficiency concerns, acupuncture and Chinese medicine are being incorporated into cosmopolitan biomedicine. However, even as the practices are being incorporated, the vitalistic concept of 'chi' and Chinese humoral concepts are being translated into mechanistic concepts consistent with modern biology and physics.

Just as values such as empiricism, formalism, and mechanism have been used to describe the intellectual culture of modern science, so a related family of concepts has been used to describe its institutional culture. Most influential was sociologist Robert Merton's (1973, Chap. 13) list of four central norms. Although subsequent research suggested that norms were frequently violated and better conceptualized as an occupational ideology (Mulkay 1976), Merton's analysis did have the advantage of pointing to the fundamental preconditions for the existence of modern scientific culture. Perhaps the basic underlying institutional value is autonomy. In other words, there is a value placed on leaving alone a certified community of qualified peers to review and adjudicate the credibility of various claims of evidence and consistency, rather than have the function ceded to the fiat of kings, dictators, church leaders, business executives, and others who do not understand the research field. The value of autonomy creates an interesting tension between science and another modern institution, constitutional democracy. Although scientific communities have suffered greatly under nondemocratic conditions, their demand for some degree of autonomy based on expertise also entails a defense of a type of elitism within a modern, democratic social order that values egalitarianism. The tension is reduced by valuing egalitarianism within the field of science, that is, by reserving it for those persons who have obtained the credentials to practice as a scientist.

2. Variations in Scientific Culture(s)

Going beyond the focus on modern science as a whole, much research on scientific culture has been devoted to its variations over time and across disciplines. Historians occasionally use the concept of periods as a way of ordering cultural history, for example in the divisions of music history from baroque to classical to romantic. Although periodization is very approximate and relatively subjective, it nonetheless helps to point to some of the commonalities across scientific disciplines within the same time period, and some of the disjunctures in the history of science over time (Foucault 1970). Changes in conceptual frameworks and research programs across disciplines within a time period usually are part of broader cultural changes. For example, in the nineteenth century political values were frequently framed by grand narratives of progress (shared with the ‘white man’s burden’ of colonialism among other ideologies), and likewise new scientific fields such as cosmology, thermodynamics, and evolutionary biology evidenced a concern with temporal issues. In the globalized information society of the twenty-first century, concerns with complex systems have become more salient, and scientists in many disciplines are developing research programs based on ideas of information processing and systemic complexity.

Science is to some extent universal in the sense that, for example, physicists throughout the world agree upon the basic laws and empirical findings of physics. However, there are also significant cultural variations in science across geographic regions. The variations are more salient in the humanities and social sciences, where distinctive theoretical frameworks often have a regional flavor. For example, one may speak of French psychoanalysis or Latin American dependency theory. The variations are also obvious for the institutional organization of scientific communities, laboratories, and university systems (Hess 1995).

Furthermore, variations in the institutional organization are sometimes associated with differing research traditions in the content of a field. For example, the salary and power structure of German universities in the first third of the twentieth century favored a more theoretical approach to genetics and a concern with evolution and development. In contrast, the relatively collegial governance structures of the American universities, together with their location in agricultural schools, contributed to the development of American genetics in a more specialized, empirical, and applied direction (Harwood 1993). Sometimes variations in institutional structures and conditions are also associated with differences in laboratory technologies, which in turn restrict the selection of research problems. For example, in Japan, funding conditions for physics have in part shaped the emergence of detector designs that differ substantially from those in the USA (Traweek 1988).

In addition to the temporal and national cultures of science, a third area of variation in scientific cultures involves disciplinary cultures. For example, both high-energy physics and molecular biology are considered ‘big science,’ but their disciplinary cultures are substantially different (Knorr-Cetina 1999). Regarding their intellectual cultures, in high-energy physics data are widely recognized as heavily interpretable, whereas in molecular biology the contact with the empirical world is much more hands-on and direct. Regarding the institutional cultures of the two fields, laboratories in high-energy physics are very large-scale, with the individual’s work subordinated to that of the co- operative team, even to the point of near anonymity in publication. In contrast, in molecular biology the laboratories are smaller, even for the genome project, and competition among individual researchers re- mains salient, with frequent disputes over priority in a publication byline.

3. Multiculturalism and Science

A third approach to the topic of scientific culture involves the ongoing modernization of scientific cultures. Although modern science is increasingly international and cosmopolitan, its biases rooted in particular social addresses have constantly been revealed. Science has been and remains largely restricted to white men of the middle and upper classes in the developed Western countries (Harding 1998, Rossiter 1995, Schiebinger 1989). As scientific knowledge and institutions have spread across the globe and into historically excluded groups, they have sometimes undergone changes in response to perspectives that new groups bring to science. For example, in the case of primatology, humans and monkeys have coexisted for centuries in India. Consequently, it is perhaps not surprising that Indian primatologists developed new research programs based on monkey–human interactions that challenged the romanticism of Western primatologists’ focus on natural habitats (Haraway 1989). More generally, as scientific disciplines become globalized, different national cultural traditions intersect with the globalized disciplinary cultures to reveal unseen biases and new possibilities for research.

As women and under-represented ethnic groups have achieved a place in scientific fields, they have also tended to reveal hidden biases and develop new possibilities. Although the reform movements of multiculturalism in science can be restricted to the institutional culture of science (such as reducing racism and sexism in hiring practices), they sometimes also extend to the intellectual culture or content of science. Theories and methods—particularly in the biological and social sciences—that seem transparently cosmopolitan and truthful to white, male colleagues often appear less so to the new groups. Whether it is the man-the-hunter theory of human evolutionary origins (Haraway 1989), the ‘master’ molecule theory of nucleus to cytoplasm relations (Keller 1985), or biological measures of racial inferiority (Harding 1993), scientific disciplines find themselves continually challenged to prove their universalism and to modify concepts and theories in response to anomalies and new research.

In some cases the members of excluded groups do more than replace old research methods and programs with new ones; they also create new research fields based on their identity concerns. A prime example is the work of the African American scientist George Washington Carver. Although best known in American popular culture for finding many new uses for the peanut, Carver’s research was embedded in a larger research program that was focused on developing agricultural alternatives to King Cotton for poor, rural, African American farmers (Hess 1995).

4. Conclusions

It is important not to think of the embeddedness of scientific cultures in broader cultural practices as a problem of contamination. The broader cultures of modern science provide a source of metaphors and institutional practices that both inspire new research and limit its possibilities. For example, if evolutionary theory could not be thought before the progressivist culture of the nineteenth century, it cannot help but to be rethought today. Not only have new research findings challenged old models, but the broader cultural currents of complex systems and limits to growth have also inspired new models and empirical research (DePew and Weber 1995). In turn, today’s concepts and theories will be rethought tomorrow. The broader societal cultures are not weeds to be picked from the flower bed of scientific culture(s) but the soil that both nurtures and limits its growth, even as the soil itself is transformed by the growth that it supports.

See also

Academy and Society in the United States: Cultural Concerns; Cultural Psychology; Cultural Studies of Science; Culture in Development; Encyclopedias, Handbooks, and Dictionaries; Ethics Committees in Science: European Perspectives; History of Science; History of Science: Constructivist Perspectives; Scientific Academies in Asia

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