6

The Social Construction of Scientific and Technical Realities

What Does "Social Construction" Mean?

The term *social construction* started to become common in STS in the late 1970s (e.g. Mendelsohn 1977; van den Daele 1977; Latour and Woolgar 1979). Since then, important texts have claimed to show the social construction (or simply the construction) of facts, knowledge, theories, phenomena, science, technologies, and societies. Social constructivism, then, has been a convenient label for what holds together a number of different parts of STS. And social constructivism has been the target of fierce arguments by historians, philosophers, and sociologists, usually under the banner of *realism*.

For STS, social constructivism provides three important assumptions, or perhaps reminders. First is the reminder that science and technology are importantly *social*. Second is the reminder that they are *active* – the construction metaphor suggests activity. And third is the reminder that science and technology do not provide a direct route from nature to ideas about nature, that the products of science and technology are *not themselves natural*. While these reminders have considerable force, they do not come with a single interpretation. As a result, there are many different "social constructions" in STS, with different implications. This chapter offers some categories for thinking about these positions, and the realist positions that stand in opposition to them.

The classification here is certainly not the only possible one. For example, one of Ian Hacking's goals in his book on constructivism (Hacking 1999) is to chart out the features of a strong form of social constructivism, to provide the sharpest contrast to realism. The features he identifies are: the contingency of facts, nominalism (discussed below) about kinds, and external explanations for stability. On his analysis, a social constructivist account of, say, an established scientific theory will tend toward the position that: the theory was not the only one that could have become established, the categories used in the theory are human impositions rather than natural kinds, and the reasons for the success of the theory are not evidential reasons.

The goals of this chapter are somewhat different. Rather than providing a single analysis or a sharp contrast to realism, the chapter pulls social constructivism apart into many different types of claims. Some of these are clearly anti-realist and some are not. While there are some general affinities among the claims, they also have unique features.

Although most of the forms of constructivism described below are opposed to forms of realism, there is less need for an analogous list of realisms. This does not mean that realism is any more straightforward. Realism typically amounts to an intuition that truths are more dependent upon the natural world than upon the people who articulate them: there is a way that the world is, and it is possible to discover and represent it reasonably accurately. Realists disagree, though, over what science realistically represents, and over what it means to realistically represent something. They disagree about whether the issue is fundamentally one about knowledge or about things. And there is no good account of the nature of reality, the conditions that make real things real – for this reason, realism is probably less often a positive position than a negative one, articulated in opposition to one or another form of anti-realism.

1 The social construction of social reality

Ideas of social construction have many origins in classic sociology and philosophy, from analyses by Karl Marx, Max Weber, and Émile Durkheim, among others. STS imported the phrase "social construction" from Peter Berger and Thomas Luckmann's *The Social Construction of Reality* (1966), an essay on the sociology of knowledge. That work provides a succinct argument for why the sociology of knowledge studies the social construction of reality:

> Insofar as all human "knowledge" is developed, transmitted and maintained in social situations, the sociology of knowledge must seek to understand the processes by which this is done in such a way that a taken-for-granted "reality" congeals for the man in the street. In other words, we contend that *the sociology of knowledge is concerned with the analysis of the social construction of reality*. (Berger and Luckmann 1966: 3)

The subject that most interests Berger and Luckmann, though, is social reality, the institutions and structures that come to exist because of people's actions and attitudes. These features of the social world exist because significant numbers of people act as if they do. Rules of polite behavior, for example, have real effects because people act on them and act with respect to them. “Knowledge about society is thus a realization in the double sense of the word, in the sense of apprehending the objectivated social reality, and in the sense of ongoingly producing this reality” (Berger and Luckmann 1966: 62). Yet features of the social world become independent because we cannot “wish them away” (1966: 1).

The central point here, or at least the central insight, is one about the metaphysics of the social world. To construct an X in the social world we need only that: (a) knowledge of X encourages behaviors that increase (or reduce) other people’s tendency to act as though X does (or does not) exist; (b) there is reasonably common knowledge of X; and (c) there is transmission of knowledge of X. Given these conditions, X cannot be “wished away,” and so it exists. For example, gender is real, because it is difficult not to take account of it. Gender structures create constraints and resources with which people have to reckon. As a result, treating people as gendered tends to create gendered people. Genders have causal powers, which is probably the best sign of reality that we have. At the same time, they are undoubtedly not simply given by nature, as historical research and divergences between contemporary cultures show us.

Box 6.1 The social construction of the discovery of the laws of genetics

Discoveries are important to the social structure of science, because more than anything else, recognition is given to researchers for what they discover. This motivates priority disputes, which are sometimes fierce (Merton 1973). Yet it is often difficult to pinpoint the moment of discovery. Was oxygen discovered when Joseph Priestley created a relatively pure sample of it, when Antoine Lavoisier followed up on Priestley’s work with the account of oxygen as an element, or at some later point when an account of oxygen was given that more or less agrees with our own (Kuhn 1970)? Such questions lead Augustine Brannigan (1981) to an *attributional* model of discoveries: discoveries are not events by themselves, but are rather events retrospectively recognized as origins (see Prasad 2007 for a similar model of inventions).

The history of Mendelian genetics nicely illustrates the attributional model. On the standard story, Gregor Mendel was an isolated monk who performed ingenious and simple experiments on peas, to learn that heredity is governed by paired genes that are passed on independently, and can be dominant or recessive. His 1866 paper was published in an obscure journal and was not read by anybody who recognized its importance until 1900, when Hugo de Vries, Carl Correns, and Erich Tschermak came upon it in the course of their similar studies. Against this story, Brannigan shows that Mendel's paper was reasonably well cited before 1900, but in the context of agricultural hybridization. In that context, its main result, the 3:1 ratio of characteristics in hybrids, was already known. Mendel was read as replicating that result, and offering a formal explanation of it. Indeed, judging by his presentation of them, Mendel did not seem to recognize his results or theory as a momentous discovery.

Though de Vries had read Mendel's paper before 1900, the first of his three publications on his own experiments and the new insights on genetics makes no mention of it. Correns, pursuing a similar line of research, read de Vries's first publication, and quickly wrote up his own, labeling the discovery "Mendel's Law." Recognizing that he had lost the race for priority, Correns assigned it to an earlier generation – though had Correns read papers from one or two generations earlier still, the title could have gone to any of a number of potential discoverers. De Vries's second and third publications accept the priority of Mendel in awkward apparent afterthoughts, but grumble about the obscurity of Mendel's paper.

Mendel, then, became the discoverer of his laws of genetics as a result of a priority dispute. His work on hybridization was pulled out of that context and made to speak to the newly important questions of evolution. Mendel discovered his eponymous laws in 1866, but only as a result of the events of 1900.

For STS, knowledge, methods, epistemologies, disciplinary boundaries, and styles of work are all key features of scientists' and engineers' social landscapes. To say that these objects are socially constructed in this sense is simply to say that they are *real* social objects, though contingently real. Ludwik Fleck, a key forerunner of STS, already makes these points in his *Genesis and Development of a Scientific Fact* (1979 [1935]). A scientist or engineer who fails to account for a taken-for-granted fact in his or her studies may encounter resistance from colleagues, which shows the social reality of that fact. To point this out is in no way to criticize science and technology. The social reality of knowledge and the practices around knowledge is a precondition of progress. If nothing is reasonably solid, then there is nothing on which to build.

STS has tended to add an active dimension to this metaphor, studying processes of social construction. Claims do not just spring from the subject matter into acceptance, via passive scientists, reviewers, and editors. Rather, it takes work for them to become important. For example, Latour and Woolgar (1979) chronicle the path of the statement "TRF (Thyrotropin Releasing Factor) is Pyro-Glu-His-Pro-NH_2" as it moves from being *near nonsense* to *possible* to *false* to *possibly true* to a *solid fact*. Along the way, they chart out the different operations that can be done on a scientific paper, from ignoring it, citing it positively, citing it negatively, questioning it (in stronger and weaker ways), and ignoring it because it is universally accepted. Scientists, and not just science, construct facts.

2 The construction of things and phenomena

Not only representations and social realities are constructed. Perhaps the most novel of STS's constructivist insights is that many of the things that scientists and engineers study and work with are non-natural. The insight is not new – it can be found in Gaston Bachelard's (1984 [1934]) concept of *phenomenotechnique*, and even in the work of Francis Bacon written in the 1600s – but it is put forcefully by researchers writing in the 1980s.

Karin Knorr Cetina writes that "nature is not to be found in the laboratory" (Knorr Cetina 1981). "To the observer from the outside world, the laboratory displays itself as a site of action from which 'nature' is as much as possible excluded rather than included" (Knorr Cetina 1983). For the most part, the materials used in scientific laboratories are already partly prepared for that use, before they are subjected to laboratory manipulations. Substances are purified, and objects are standardized and even enhanced. Chemical laboratories buy pure reagents, geneticists might use established libraries of DNA, and engineered animal models can be invaluable.

Once these objects are in the laboratory, they are manipulated. They are placed in artificial situations, to see how they react. They are subjected to "trials of strength" (Latour 1987) in order to characterize their properties. In the most desirable of situations scientists create phenomena, new stable objects of study that are particularly interesting and valuable (Bogen and Woodward 1988) – "most of the phenomena of modern physics are manufactured" (Hacking 1983).

The result of these various manipulations is that knowledge derived from laboratories is knowledge about things that are distinctly non-natural. These things are constructed, by hands-on and fully material work. We will return to this form of construction in Chapter 14.

In terms of technology, there is nothing the least striking about this observation. Whereas sciences are presumed to display the forms of nature exactly as they are, technology gives new shape and form to old materials, making objects that are useful and beautiful. The fact that technology involves material forms of construction, leaving nature behind, is entirely expected.

3 The scientific and technological construction of material and social environments

Scientific facts and technological artifacts can have substantial impacts on the material and social world – that is the source of much of the interest in them. As such, we can say that science and technology contribute to the construction of many environments.

The effects of technology can be enormous, and can be both intended and unintended. The success of gasoline-powered automobiles helped to create suburbs and the suburban lifestyle, and to the extent that manufacturers have tried to increase the suburban market, these are intentional effects. Similarly, the shape of computers, computer programs and networks are created with their social effects very much in mind: facilitating work in dispersed environments, long-distance control, or straightforward military power (Edwards 1997).

Science, too, shapes the world. Research into the causes of gender differences, for example, has the effect of naturalizing those differences. And there is tremendous public interest in this area, so biological research on genes linked to gender, on the gender effects of hormones, and on brain differentiation between men and women tends to be well reported (e.g. Nelkin and Lindee 1995). More often than not, it is reported to emphasize the inevitability of stereotypical gendered behavior. There is good reason to expect that this reporting has effects on gender itself.

Science also shapes policy. Government actions are increasingly held accountable to scientific evidence. Almost no action, whether it is in areas of health, economy, environment, or defense, can be undertaken unless it can be claimed to be supported by a study. Scientific studies, then, have at least some effect on public policies, which have at least some effect on the shapes of the material and social world. Science, as well as technology, then, contributes to the construction of our environments.

4 The construction of theories

The most straightforward use of the social construction metaphor in STS describes scientists and engineers constructing accounts, models, and theories, on a basis of data, and methods for transforming data into representations. Science is constructive in a geometrical sense, making patterns appear given the fixed points that practice produces.

Box 6.2 Realism and empiricism

Whether one should believe scientific theories, or merely see them as good working tools, has been one of the most prominent questions in the philosophy of science since the early twentieth century. Most philosophers agree that science's best theories are impressive in their accuracy, but they disagree about whether that empirical success is grounds for believing the theories are true.

The classic *empiricist* argument against truth starts from the claim that all of the evidence for a scientific theory is from empirical data. Therefore, given two theories that make the same predictions, there can be no empirical evidence to tell the difference between the two. But any theory is only one of an infinite number of empirically equivalent theories, so there is no reason to think that it is true. Truth in the standard sense is superfluous (e.g. van Fraassen 1980; Misak 1995).

Scientific realists can challenge empiricists' starting assumption, and argue that data is not the only evidence one can have for a theory. For example, it is desirable that theories be consistent with metaphysical commitments. As a result, realists can challenge the assumption that there are typically an infinite number of equivalent theories, because only a few theories are plausible. And they can argue that there is no way to make sense of the successes of science without reference to the truth or approximate truth of the best theories (see, e.g., Leplin 1984; Papineau 1996). One of the best-developed versions of the latter argument is due to Richard Boyd (e.g. 1985). Boyd argues that we have good reason to believe "what is implicated in instrumentally reliable methodology" (Boyd 1990: 186). The truth of background theories is the best explanation of the success of scientific methods. The strategy is to focus not on how successful theories are at making predictions or accounting for data, but on how successful background theories are in shaping research, which then produces reliable theories.

That science constructs representations on top of data is roughly the central claim made by logical positivism (Chapter 1). For positivism, there is an essential contingency to scientific theories and the like. For any good scientific theory, one can create others that do equally good jobs of accounting for the data. Therefore, contrary to realist accounts (Box 6.2) we should not believe theoretical accounts, if to believe them means committing ourselves to their truth. Bas van Fraassen, whose work is positivist in spirit, says of the metaphor, "I use the adjective 'constructive' to indicate my view that scientific activity is one of construction of rather than discovery: construction of models that must be adequate to the phenomena, and not discovery of truth concerning the unobservable" (van Fraassen 1980: 5). However, for positivists, the contingency of scientific representations is largely eliminated by prior decisions about frameworks; *logical* positivism adopted the assumption that scientists first make decisions about the logical frameworks within which they work, before they operate within those frameworks.

Given the problems of induction we have seen, this process cannot be a purely methodical or mechanical one. There is no one way to develop good theoretical pictures on a basis of finite amounts of data, no direct route from nature to accounts of nature. When Knorr Cetina, under the rubric of "constructivism," explains why particular theories are successful, she looks to established practices, earlier decisions, extensions of concepts, tinkering, and local contingencies (Knorr Cetina 1977, 1979, 1981). Representations of nature are connected to nature, but do not necessarily correspond to it in any strong sense.

Controversies show the value of bottom-up accounts of contingency (Chapter 11). By definition, scientific and technical controversies display alternative representations, alternative attempts to construct theories and the like. They can also display some of the forces that lead to their closure. For example, a choice between Newton's and Leibniz's metaphysics may have been related to political circumstances (Shapin 1981). Or, the particular resolution of the dispute between Louis Pasteur and Félix Pouchet over spontaneous generation was shaped by the composition of the prize committee that decided it (Farley and Geison 1974). Scientific and technological theories, then, are constructed with reference to data, but are not implied by that data.

5 Heterogeneous construction

Successful technological work draws on multiple types of resources, and simultaneously addresses multiple domains, a point that will be developed in Chapters 8 and 9. The entrepreneurial engineer faces technical, social, and economic problems all at once, and has to bind solutions to these problems together in a configuration that works. In helping to develop an artifact, then, the engineer is helping to produce knowledge, social realities, and material and social things. While the various constructions can be parceled out analytically, in practice they are bound together.

Builders of technology do *heterogeneous engineering* (Law 1987). They have to simultaneously build artifacts and build environments in which those artifacts can function – and, typically, neither of these activities can be done on their own. Technologists need to combine raw materials, skills, knowledge, and capital, and to do this they must enroll any number of actors, not all of whom may be immediately compatible. Technologists have the task of building stable networks involving diverse components.

Scientific work is also heterogeneous. Actor-network theory (Chapter 8) is a theory of "technoscience," in which scientists and engineers are separated only by disciplinary boundaries. Like engineers, scientists construct networks, the larger and more stable the better. They both construct order, because stable networks create an orderly world. These networks are heterogeneous in the sense that they combine isolated parts of the material and social worlds: laboratory equipment, established knowledge, patrons, money, institutions, etc. Together, these create the successes of technoscience, and so no one piece of a network can determine the shape of the whole.

What we might call *heterogeneous construction* is the simultaneous shaping of the material and social world, to make them fit each other, a process of "co-construction" (Taylor 1995). Heterogeneous construction can involve all of the other types of construction mentioned to this point,

Box 6.3 The heterogeneous construction of the Pap smear

Monica Casper and Adele Clarke (1998) show how the Pap smear became the "right tool for the job" of screening for cervical cancer through a process that we could see as heterogeneous construction. It has its origins in George Papanicolaou's study, published in 1917, on vaginal smears as indicators of stages in the estrous cycle of guinea pigs. Over the following decade, Papanicolaou investigated other uses of the smears, eventually discovering that he could detect free-floating human cancer cells. His presentation of that finding, in 1928, was met with little enthusiasm: the results were not convincing, pathologists were not used to looking at free-floating cells, and gynecologists were uninterested in cancer. Papanicolaou abandoned the smear as a cancer test for another decade.

New powerful actors, such as the American Cancer Society, took up the test and created an environment that could support the tinkering necessary to address its problems. The Pap smear faced, and faces, "chronic ambiguities" regarding the nature of cancer, the classification of normal and abnormal cells, and the reading of slides. As a result it has a false negative rate (it fails to detect cancerous and precancerous cells) of between 15 and 50 percent of cases, depending upon the circumstances. Given its initial poor reception, and the problems with even established versions of the test, what social and material adjustments allowed it to become successful, and to play a role in saving the lives of thousands, and perhaps millions, of women?

The test became less expensive by gendering the division of labor. Technicians, mainly women, could be paid less than the (predominantly male) pathologists. Technicians could even be paid on a piecework basis, and do some of their work from home. These innovations allowed the volume of testing for it to become an effective screening test. Volume, however, meant that technicians suffered from eyestrain, and from the combination of low status and high levels of responsibility on matters of life and death. Meanwhile, automation of record keeping helped to reduce the cost of Pap smears, and also to make them more useful as screening tests for large populations of women (Singleton and Michael 1993). High rates of incorrect readings of the tests have created public pressure for rating and regulating the labs performing them. Women's health activists have prompted governments to take seriously the conditions under which Pap smears are read, and the number of smears read by a technician each day, reducing the number of "Pap mills." High rates of incorrect readings have also prompted the negotiation of local orders: Rather than strictly following standard classification schemes, labs sometimes work closely with physicians and clinics, receiving information about the health of the women whose smears they read. Out of this information they develop local techniques and classifications, which, in clinical tests, appear to have better success rates.

Many material and social aspects of the test had to be constructed in order for it to be a success.

combining the construction of accounts and social reality and phenomena and the broader environment.

Many contributions to STS have converged on this point. Science and social order are "co-produced" (Jasanoff 2005). The criteria for good climate science are shaped by policy concerns, and the criteria for good policy are being shaped by climate science, in a process of "mutual construction" (Shackley and Wynne 1995). In a different way, ideas and practices concerning health and disease are bent around standardized classifications of diseases and medical interventions (Bowker and Star 2000). Assisted reproductive technologies seem miraculous, but their miracles are performed through much mundane work that integrates political, social, legal, ethical, bureaucratic, medical, technical, and quintessentially personal domains. Patients, eggs, sperm, equipment, are "choreographed" to make pregnancies, babies and parents (Thompson 2005).

6 The construction of kinds

It has been a longstanding philosophical question whether natural kinds are part of the non-human world or are only part of human classification. (The debate is usually put in terms of "universals," the abstractions that range over individual objects, like redness.) *Nominalists* believe that kinds are human impositions, even if people find it relatively easy to classify objects similarly. *Realists* believe that kinds are real features of the world, even if their edges may be fuzzy and their application somewhat conventional. For nominalists, individual objects are the only real things. Given how difficult it is to make sense of the reality of general properties – Where do they exist? How do they apply to individual objects – nominalists prefer to see them as entirely mental and linguistic phenomena. For realists, the world has to contain more than mere concrete objects. Given how difficult it is to make sense of a world without real general divisions – Do we not discover features of the world? If they were not real, why would kinds have any value? – realists see kinds as external to people.

In STS, nominalism is one way of cashing out the construction metaphor. If kinds are not features of the world, then they are constructed. To the extent that they are constructed by groups of people, they are socially constructed. Since science is the most influential institution that classifies things, science is central to the social construction of reality. We can see statements of this in works by Thomas Kuhn (e.g. 1977) and proponents of the strong programme (e.g. Barnes, Bloor, and Henry 1996): sociological finitism (Chapter 5) could be considered a version of nominalism.

7 The construction of nature

It is only a short step from nominalism to the strongest form of the social construction metaphor in STS, the claim that representations directly shape their objects. According to this form of constructivism, when scientists agree on a claim, they literally make the claim true. The world corresponds to agreement, not the other way around. Similarly, when engineers create agreement on what the most efficient solution to a problem is, they literally make that solution the most efficient one. Mind, in this case a social version of mind, is prior to nature; the way it classifies and otherwise describes the world becomes literally true. The position bears some similarity to Kant's idea that humans impose some structures on the world, so we can call it *neo-Kantian constructivism*. This constructivism has been called "the spontaneous philosophy of the critics," its popularity stemming from, among other things, the lack of institutional power of the social sciences and humanities (Guillory 2002).

Neo-Kantian constructivism gains its plausibility from two facts. First is the fact that the natures of things are not directly available without representations, that there is no independent access to the way the world is. When scientists, or other people, agree about something, they do so only in response to sense experiences, more mediated information, and arguments. Since even sense experiences are themselves responses to things, there is never direct access to the natures of things.

Second, detailed studies of science and technology suggest that there is a large amount of contingency in our knowledge before it stabilizes. Disagreement is the rule, not the exception. Yet natural and technological objects are relatively well behaved once scientists and engineers come to some agreement about them. Einstein says, "Science as something already in existence, already completed, is the most objective, impersonal thing that we humans know. Science as something coming into being, as a goal, is just as subjectively psychologically conditioned as are all other human endeavors" (quoted in Kevles 1998). We need to account for this change.

Because of the contingency of representations, we cannot say that there is a way the world is that guarantees how it will be represented. And therefore, we might question the priority of objects over their representations. Steve Woolgar probably comes closest to the neo-Kantian position in STS, when he argues that contingency undermines realist assumptions:

> The existence and character of a discovered object is a different animal according to the constituency of different social networks. . . . Crucially, this variation undermines the standard presumption about the existence of the object

> prior to its discovery. The argument is not just that social networks mediate between the object and observational work done by participants. Rather, the social network constitutes the object (or lack of it). The implication for our main argument is the inversion of the presumed relationship between representation and object; the representation gives rise to the object. (Woolgar 1988: 65)

Neo-Kantian constructivism is difficult to accept. The modest version of its central claim that was put forward by Immanuel Kant was attached to an individualist epistemology: individuals impose structure on the world as they apprehend it. For the Kantian, if the individual is isolated from the material world then it makes no sense to talk of anything lying beyond phenomena, which are in part constituted by people's frameworks and preconceptions. However, STS's neo-Kantianism should not be so modest, because STS emphasizes the *social* character of scientific knowledge. If what is at issue are the representations made by groups of people, the neo-Kantian claim appears less motivated. How does consensus affect material reality? Or how do the convictions of authorities carry weight with the world that the convictions of non-authorities do not? How does it *cause* changes in the material world?

If neo-Kantian constructivism were true, for example, then representation would act at a distance without any mediators. Successful representation would change, or even create, what it represents, even though there are no causal connections from representation to represented. Neo-Kantian constructivism therefore violates some fundamental assumptions about cause and effect. For this reason authors like Latour argue that social constructivism is implausible "for more than a second" (Latour 1990).

There are also political concerns about neo-Kantian constructivism. Feminists point out (Chapter 7) that science's images of women are sometimes sexist, particularly in that they are quick to naturalize gender. If neo-Kantian constructivism were right, then, while feminist critics could attempt to change science's constructions of women, they could not reject them as false – scientific consensus is by definition true. Similarly, environmentalists have a stake in the reality of nature aside from constructions of it. While they can attempt to change dominant views on the resilience of nature, they could not reject them as false (Grundman and Stehr 2000; Takacs 1996). It may also be that constructivism places too much emphasis on contingency and the social processes of knowledge creation (Crist 2004). Scientific knowledge, the meaning of nature, environmental values, and even "natural" spaces may be shaped socially, but they are also shaped by nature.

Box 6.4 Constructivism and environmental politics

Within environmental studies, some people argue that constructivism's focus on science's social processes tends to undercut scientific knowledge (e.g. Crist 2004; Soulé and Lease 1995). STS shows that other circumstances would have produced different knowledge, yet trust in science is based on an image of science as having formulaic methods for uncovering truths of nature. Constructivism, then, appears to cripple the ability of science to serve as a solid foundation for environmental politics.

Yet that may be a misdiagnosis. Environmental politics often pits experts against each other. Experts typically try to present their own views as entirely constrained by nature and rationality, so that there is no room for disagreement. Yet those same experts find ways in which opposing arguments are open to challenge (see Chapter 11). The fact that scientific knowledge is laden with choices is not hidden, seen only by people working in STS, but is regularly rediscovered in disputes (e.g. Demeritt, 2001).

If this is right, then for science to play a larger role in politics, its knowledge should be constructed with controversy already in mind. Science's authority should not depend heavily on an incorrect formal picture of itself, at the risk of being rejected when that picture proves wrong. The constructivist view brings to the fore the complexity of real-world science, and therefore can potentially contribute to its public success. Successful science in the public sphere can be the result of the co-production of science and politics. Science can more easily solve problems in the public domain if scientific knowledge is carefully adjusted to its public contexts, and attuned to the different knowledge of others (see Chapter 16).

However, in light of the obvious truth of at least some of the other versions of constructivism described above, neo-Kantian constructivism may be a decent approximation, and may be methodologically valuable, even if it is wrong in metaphysical terms. So while claims about the "social construction of reality" can sometimes look suspect, they may amount to little more than metaphor or sweeping language. Even the political problems with neo-Kantianism may be unimportant, if the language is understood correctly (Burningham and Cooper 1999). Claims about the "social construction of reality" may draw attention to contingency in science and technology, and therefore lead researchers to ask about the causes of contingency. As a metaphor, this strong neo-Kantianism can be a valuable tool.

Richness in Diversity

At the same time that the term became common in STS, social construction talk took off in the humanities and social sciences in general, so much so that the philosopher, Ian Hacking, asks in the title of a book, *The Social Construction of What?* (Hacking 1999). Genders, emotions, identities, and political movements are only a few of the things to which social construction talk has been applied.

STS is partly responsible for this explosion of social construction talk. Because scientific knowledge is usually seen as simply reflecting the natural world, and scientists must therefore be relatively passive in the creation of that knowledge, the claim that scientific realities are socially constructed is a radical one. As a result, STS's constructivist claims have been influential. This can be seen in the explicit use of constructivist texts and ideas from STS in such fields as psychology, geography, environmental studies, education, management, cultural studies, and even accounting.

However, the diversity of claims about the social construction of reality means that constructivism in STS cannot be any neat theoretical picture. Instead, it reminds us that science and technology are social, that they are active, and that they do not take nature as it comes.

Some of the above forms of constructivism are controversial in principle, and all of them are potentially controversial in the details of their application. But given their diversity it is also clear that even the staunchest of realists cannot dismiss constructivist claims out of hand. Constructivism is the study of how scientists and technologists build socially situated knowledges and things. Such studies can even show how scientists build good representations of the material world, in a perfectly ordinary sense. As recognized by some of the different strains of constructivism, science gains power from, among other things, its ability to manipulate nature and measure nature's reactions, and its ability to translate those measurements across time and space to other laboratories and other contexts. Laboratory and other technologies thus contribute to objectivity and objective knowledge. Constructivist STS may even *support* a version of realism, then, though not the idea that there is unmediated knowledge of reality, nor the idea there is a single complete set of truths.