SCIENCE, TECHNOLOGY, AND SOCIETY

AN ENCYCLOPEDIA

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duced humans have been around a lot longer than molecular genetics. Such stories, such as Mary Shelley's *Frankenstein,* still play a role in current understandings of cloning technology.

So for the sociologist the question is not "Can a human be cloned?" but "Can a social environment be cloned?" Organisms develop in specific contexts, during specific times at specific places. Taken out of those contexts, identity changes. For example, the social context of agriculture, family, economics, individuality, creativity, and procreative liberty changes through time and among disciplines and thus can change the meanings of these concepts. When a plant physiologist says the word *clone,* she can mean a plant cutting, whereas a member of the Raelian sect who believes that Jesus was resurrected by aliens with cloning technology may attach a very different meaning to the word. A "clone" represents a category of life, recognized as a copy of a part or whole organism, but social contexts give this category applications and uses that drive cloning debates.

See also **Bioengineering; Biomedical Technology; Biotechnology**

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COMMUNICATION IN THE SCIENTIFIC COMMUNITY.

The deeply social endeavors of science and technology are held together by communication that is both cooperative and competitive. To carry out their work, scientists and technologists need the knowledge, thought, and techniques developed by others, but to contribute to knowledge and advance technology they must identify, develop, and argue for some novelty of discovery, thought, or invention, distinctive from prior advances. Furthermore, they must make their novelty visible, persuasive, and useful to others—enlisting those others in the propagation of their thought. This work is carried out through communication.

Communication in Knowledge Creation and Dissemination

Formulating knowledge is itself a process of articulating a communicative statement, by which our knowledge is crystallized and shared. Studies of laboratory interaction have repeatedly observed how, through talk and gesture, scientific teams looking at a representation of data notice, identify, label, and attribute meaning to an interesting phenomenon. Natural phenomena, as they are observed or manipulated, are inscribed into data by the recording scientists or by various instruments that serve as inscription devices. Sociologists Bruno Latour and Steve Woolgar describe the work of a biological laboratory as a process by which living specimens are labeled and turned into samples, which are then, for example, centrifuged and assayed, resulting in graphic representations of the contents. These graphic representations are then numerically valued and charted into graphs and tables, which are in turn analyzed and embedded into scientific papers. Although much work is done through the physical manipulation and observation of objects in the laboratory, the results of this material experience are transcribed into communicative symbols that continue to be transformed in the world of calculation and communication.

But the story does not end with the production of papers. Papers are presented to audiences of scientists at conferences and seminars, where they are the topic of discussion. Articles are submitted to journals, where they are read and evaluated by referees and editors, who communicate their evaluations back to the authors, who, if so requested, may then revise. Articles, once published, go to libraries and private subscribers. Readers then search journals for findings that will help them advance their own knowledge and research. Further research articles then cite previous work to build on them, and review articles sum up earlier findings to point to new research directions. An article may become so associated with a particular idea that reference to the article comes to represent the idea. People whose work is closely related to each other's cite many of the same people as well as each other's work. Analysis of shared patterns of citation, called *cocitation analysis,* can identify emerging areas of scientific work.

Further from the research front, articles may be cited in handbooks and textbooks that help familiarize students with areas of research. If the knowledge claim presented in the original article becomes widely accepted and relied on, it may become a shared piece of common knowledge that it is no longer identified with any article or author. As it has become fully incorporated into shared scientific knowledge, its origins have become obliterated. Textbooks themselves then become embedded within the complex communicative systems of the classroom with syllabi, discussions, lectures, other readings, assignments, and exams. Further dissemination of scientific knowledge may occur through journalism and other forms of popular science writing, sometimes to provide practical knowledge, sometimes to satisfy public curiosity, and sometimes to help increase public support for scientific programs.

Funding and support for science foster additional systems of communication. The most visible edge of this is the proposal and reviewing process, but there are many other documents by which proposals are called for, support solicited, capabilities of research teams represented, and grants and contracts administered and monitored. This communication may be as much legal, budgetary, and bureaucratic as it is overtly scientific, but all of it is the communication that makes science possible. There are differences among the sciences in the groups of people with whom they communicate. People in the environmental sciences, for example, often communicate with government agencies and community groups; people in geological sciences often have regular connections with extractive industries and their regulators as well as groups concerned with monitoring and preparing for volcanic and earthquake disasters. Engineers and other developers of technology may have even more complex patterns of communicative patterns. Their work often circulates within corporations and must be attentive to legal, regulatory, risk, financial, production, sales, and consumer issues, which are often mediated by other specialists such as patent lawyers, consumer relations and marketing departments, managers, and technical writers. As the development and deployment of technology regularly involve mobilizing many forms of interest and power, power relations are typically enacted within communications surrounding technology.

Spoken, Written, and Electronic Communication

Much of communication within science and technology is spoken. Ideas are shared, interpreted, and argued, and experiments designed, over informal chat. Technology design teams thrash through ideas and alternative models; development teams communicate to turn design ideas into workable practice. Over the lab bench, people coordinate through talk to make the experiment work, identify and interpret phenomena visible in data traces, and consider the implications and uses of their projects. Conference and seminar presentations are also often more talked than written, supported by outlines of key points, data charts, graphs, and other visual displays.

Informal communication can also extend into written text. From the earliest periods of natural philosophy, investigators shared their results through letters. Scientist and inventors as early as Leonardo da Vinci (1452–1519) recorded their ideas, designs, observations, and results in notebooks. As collaboration became more common, particularly in the later nineteenth century, notebooks and other laboratory records served as well to coordinate work and attention.

Laboratory notebooks also have an archival function: to substantiate findings and claims that appear in the public literature. As industrial laboratories grew, the coordinating function of laboratory notebooks became increasingly important, along with other internal reports and records. With the nineteenth-century elaboration of patent laws, notebooks also came to serve as legal evidence for priority of invention.

In the twentieth century, as technology for duplicating papers became convenient, informal circulation of drafts, or *preprints,* of scientific articles to colleagues became common. The Internet now supports the distribution and archiving of preprints along with sharing of large data sets. Through communications technologies, scientists in different locations can even work simultaneously, observing data being collected in real time at a third location. The groups of people who regularly communicate with each other informally have been called "invisible colleges," a term first applied to the seventeenth-century membership of the Royal Society.

However, the more enduring and formal communications of published work in journals and books are reproduced many times, shipped to distant places, and archived in research libraries. Although laboratory talk accompanies experiments, data collection, and interpretation, and although informal documents help coordinate complex, multiperson, multisite projects, formal written documents are significant in the social presentation of knowledge, development of extended argument, creation of shared knowledge and archives, and structuring science as communal activity.

The Resources of Language

Because knowledge emerges within communication and takes on the form of communication, it employs the many resources of language, although with a particular selection. One of the most obvious elements is the emergence of scientific terms and words. The linguist Michael Halliday has examined the nominalization process, whereby actions are turned into nouns, which then become more abstract and combine with other abstractions in multiword noun phrases (an example is the phrase "nominalization process" itself). This process occurs both within the course of a single text and over the history of research areas. Another linguistic feature often associated with scientific writing, the avoidance of the first person by the use of the third person and passive voice, upon closer investigation turns out not to be so simple. Although objects of investigation and theory-based abstractions are often the subjects of sentences, the first person appears regularly to indicate roles appropriate to the work of the scientist, such as choosing and carrying out procedures, adopting assumptions, and drawing conclusions. Disciplines also vary in the use of the first person. Douglas Biber, Dwight Atkinson, and Kok Cheong Lee have each examined the linguistic resources used in scientific writing more comprehensively.

From the earliest period of modern science the difficulties of using language to carry out the work of science have been recognized. The Renaissance philosopher Francis Bacon (1561–1626) noted that language was plagued by four kinds of idols. The "idols of the tribe" are the limitations of human mind, sense, and perception. The "idols of the cave" are the idiosyncrasies of each person's separate experience, character, education, reading, and experience, which lead us each to perceive things differently. The "idols of the marketplace" are the word meanings and associations that grow out of common experience rather than philosophic investigation. Finally, the "idols of the theatre" are the residue of the philosophic dogmas that have influenced people's minds and perceptions. Bacon never suggests that we can totally expunge these idols from our minds and discourse, but only that we attempt to address their ill effects.

Some of Bacon's followers in the later seventeenth century more optimistically thought. as did Thomas Sprat (1635–1713), that they could fully cleanse language of the ornamental colors of rhetoric or, as did Bishop John Wilkins (1614–1672), that they could develop a more philosophic language with a univocal correspondence between things and signs. Such a total cleansing of the language proved impossible, however, for the tools of language are what make communication possible. Metaphor, for example, uses similarities to communicate new ideas and experiences to audiences, building on what they are already familiar with. Even more, it allows investigators to draw on what they know as they attempt to discover and formulate knowledge about the previously unknown. Metaphor is an invaluable cognitive tool and is inescapable in language, for new meaning grows by building on former meanings. Scientific writing, similarly, uses many of the other traditional figures of speech and thought (though they may be subsumed into scientific analytic method), such as antithesis, serial or graded ordering, and repetition.

The practice of hedging and modulating claims is also central to making arguments and assessing certainty about claims, as well as protecting the integrity of arguments against overgeneralization or unwarranted certainty. In addition, scientific writing, because it requires constantly challenging the views of others in order to advance new or competitive claims, has been found to use the linguistic mechanisms of politeness.

Scientific Communication as Argument

Even more fundamentally, science has not been able to escape rhetoric, argument, and advocacy, because each scientific paper, when first written, is not immediately an unquestioned truth. In a scientific paper an author attempts to convince colleagues of some claim or set of related claims. At issue may be the identification of a phenomenon, the accuracy and veracity of data, the appropriateness of method, the general usefulness of a set of methods, the interpretation of data, or a new theoretical position. Scientific claims and methods must present themselves in competition with other claims, so an article must present good reasons why the its claims should be taken as more accurate and more important than other claims in other articles. Although standards of scientific argument have been refined over the ce turies, they are always directed at makir claims persuasive. Standards of argume are often identified as methodological rath than rhetorical, because they have to do wit finding and producing the most relevar and precise data or making the connectio between data and ideas, but these nonethe less are issues of persuasiveness. The cur rent standards have emerged because they have proven to be the most persuasive, trumping weaker arguments resting on less powerful data and reasoning.

The life of a scientific claim also lies in its usefulness to others so that it gets cited and regularly repeated. The great majority of articles get few or no citations, so, whether they are true or false, they lie unused on the back shelves of a library. A smaller number of works, however, greatly influence methods, problem formulations, and theoretical explanations, as well as our knowledge of phenomena.

History of Scientific and Technical Communication

The history of science and technology goes hand in hand with the history of communicative technologies and practices along with the emergent social organization built on communication. The introduction of the printing press into fifteenth-century Europe facilitated the precise reproduction and distribution of observations and knowledge, allowing for comparison and collection at many sites, advancing the communal character of science. The printing press also fostered the recording and distribution of craft knowledge, so that technology spread more widely and accumulated more rapidly. Much of the practice and craft of science and technology, nonetheless, required (and continues to require to today) direct personal transmission, particularly in laboratory skills of manipulating physical objects and events and in developing the habits of thought to produce, elaborate, and substantiate innovations. Nonetheless, the shared knowledge and practical guidelines available in books helped to align and expand attention to common practices and problems.

The colonial expansion of Europe during the fifteenth to nineteenth centuries, facilitated by advances in maritime, military, and navigational technology, fostered new practices and forms of information gathering and communication. Governance and economic exploitation of distant lands required extensive transmission of information about geography, climate, mineral wealth and extraction, and flora and fauna.

In the latter half of the seventeenth century the development of scientific societies, along with journals, represented another major step forward in scientific communication. The Royal Society of London, founded in 1660, and the Académie Royale des Sciences, founded in 1666, were early associated with journals to spread more widely the presentations, demonstrations, and arguments that occurred at their meetings. *The Philosophical Transactions of the Royal Society* and *Le Journal des Sçavans* were both founded in 1665.

The founding of journals raised many social, intellectual, and communicative issues whose solutions set precedents that would influence the operations of scientific journals that followed. The editor of the journal had a strong shaping hand in soliciting, selecting, and setting standards for articles; but within a century the modern system of expert referees emerged to make publication decisions. Whereas *Le Journal des Sçavans* presented articles anonymously as the product of a collective enterprise, individual authorship was prominent in the *Philosophical Transactions* from the beginning. Publication allowed scientists to claim priority and credit for their discoveries. This individual credit model came to dominate publication practice.

Also, the various genres of scientific article needed to emerge gradually from prior genres. The earliest issues of the *Philosophical Transactions* were written in the voice of the editor reporting on correspondence he had received. Soon, however, the letters themselves were published directly. Over time the articles lost the trapping of letters and became accounts of what was observed, in increasing detail. Challenges led to quantification of detail, detailed presentation of circumstances of observations, and substantive accounts of experimental and observational methods. By the mid-eighteenth century, articles in English journals turned into narratives of inquiry, and by the end of the century articles were organized around general claims supported by experimental or observational evidence. Modern practices of citation and reviewing the literature became standard practice only in the nineteenth century. French articles from the beginning were more object-oriented, theoretical, and argumentative than English articles. German journals, on the other hand, emerged later and seemed to lag behind stylistic and theoretical tendencies in English and French journals. In the twentieth century English-language journals came to dominate science, and now most major journals in most fields are published in English, disadvantaging scientists and scientific communities in non-English-speaking countries, particularly less developed countries.

The increasing number of journals and professional societies communicating knowledge escalated rapidly in the nineteenth century, supported by social and technological changes, including less expensive printing and paper, regularized mail services, increasing economic importance of technological practice, increasing literacy, and expanding schooling. In the latter nineteenth century, universities became associated with scientific research, and technological professions became associated with university training. As research and training became more specialized and academic, scientific publications became more esoteric, theoretical, and filled with specialized vocabulary. Currently the Web of Science, a major indexing service, reports on over 5700 major scientific journals.

This enclosure of science required substantial rhetorical work to define and maintain the social boundaries of science that allowed science to be internally regulated, to gain public authority over its areas of interest, and to garner public and commercial support for its endeavors. To convey the esoteric work of science to popular audiences, new journals emerged. As science and technology also became more important for other social, economic, and governmental institutions, many other new genres and pathways of communication developed, from the environmental impact statement and testimony before Congressional committees to pharmacological advertisements touting the latest drug breakthroughs and online instruction manuals embedded within computer programs. To assist technologists in communicating with their peers, their corporate co-workers, and the public, technical writing instruction emerged as a university field in the twentieth century, and the technical writer became a major employment title in many organizations. As newspapers increased reporting on science and technology in the latter twentieth century, scientific journalism also became a recognized specialty.

The rise of the Internet and other electronic communications technologies have facilitated the rapid and extensive transmission and availability of communication of science at the research front, including preprints (early versions of articles presented for discussion), electronic journals, and virtual forums and online conferences. The Internet has also facilitated new means of carrying out the internal business of journals, societies, and research projects as well as the popular dissemination of scientific knowledge and educational communications. These new opportunities are serving to reorganize both the social arrangements and the form and content of communications. Many ideas and arrangements are being tested out, but their implications are unclear. Whatever will emerge as the next set of regularized communicative practices will no doubt use the Internet in conjunction with talk, informal text, print, electronic file, and other emergent communication technologies.

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COMMUNITY AND TECHNOLOGY.

One of the apocryphal tales in the science and technology studies literature is the story of a communal water pump in the village of Ibieca, Spain, told by Richard Sclove in *Democracy and Technology.* According to Sclove, the village lived a peaceful and harmonious existence so long as the women of the community assembled at the communal water supply to participate in the daily social exchanges that sustained the community's solidarity. However, in succumbing to the myth of technological progress, the male elders of the village replaced the communal water pump with a new municipal water supply that brought water to individual homes. While this project supposedly made the women's work easier, it unintentionally disrupted the social fabric of the community.

There is reason to doubt the veracity of this tale—the social networks that constitute our perceptions of community are often more extensive, and fragmented, than in Sclove's story. The tale also seems to speak more to the myth of the isolated, American suburban housewife rather than from the historical realities of a rural village in Spain. Nevertheless, the story raises several issues of direct significance to this essay, including how civic concerns are embedded in technological choice and design; that technology is integral to a sense of community; that gender and other cultural identities mediate this relationship; and that the mundane technologies of everyday life contribute as much to a sense of community as the latest information and communication technologies. This last point is especially important, given the hope people place in the Internet for reviving communities, both virtual and real. If the extensive literature in science, technology and society says anything, it is that all of these issues must be held in careful balance if we are to assess a complex relationship such as that between technology and community.

Given the very different ways in which people use the word *community*—the "community of West Philadelphia," the "gay and lesbian community," or even the "American community" (Putnam, 2000)—it is important to begin with a precise definition of the term, along with an account of the relationship between community and civil society. Formally, a community can be defined as any identifiable group that has a shared set of values and interests, where this commonality is sustained through some form of social interaction. (Though this definition is sufficient as a sociological definition, some also add that a community must have members who work actively to uphold the values of the community.) However, other characteristic differences in a community can affect how technology mediates its interactions. Thus, communities may refer, at one level, to physically contiguous communities, such as the Italian-American neighborhood in North Boston or the African-American community in West Philadelphia. It may also refer to less contiguous groups, such as the gay and