SCIENCE AND TECHNOLOGY:

WHO GOVERNS?

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University of Houston Law Center/Institute for Higher Education Law and Governance (IHELG)

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Science and Technology: Who Governs?

The reasons typically cited for external regulation of science and technology in our society are both obvious and compelling. Science and technology are pervasive forces in modern western society and it is impossible to read the daily newspaper without encountering articles documenting both their benefits and risks. No society should or would be willing to put into the hands of a small group of scientists and technologists the unchecked and unrestrained power to affect its environment and the lives of all its members.

A second reason for some form of external regulation lies in the character of democratic society. We accept the principle that all power in a democracy flows from the people to and through their elected representatives. The people of a democratic society reserve to themselves the power, both directly and through their representatives, to influence public policy decisions and ultimately to govern the conduct of all social institutions which impinge on their lives.

Finally, since a major share of science and technology is either directly or indirectly supported with public funds, the simple principle of accountability demands that those engaged in publicly funded enterprises be responsible and accountable for their actions to those who pay the bill.

Because of the virtually unanimous acceptance of these principles, we have already created a wide variety of both formal and informal mechanisms which regulate and restrain science and technology. The real question we must face, therefore, is not so much whether or not there should be external regulation and governance of science as whether or not the present mechanisms of regulation work for the most part, and if they do not, what modifications are necessary to make them work.

It is basic, in launching this whole discussion, to understand and accept the premise that, by its very nature, scientific research is an essay into the unknown, and that some of the generally used principles of risk assessment and evaluation are less effectively applied to this
sort of activity than to such technologies as automotive or air transportation, in which both the character and the extent of risk can be more easily defined and measured.

As might be expected, the existing mechanisms for governing science and technology in our society share some of the ad hoc, improvisational and unintegrated qualities of many of our political institutions. For more than twenty-five years political scientists have been writing articles with titles like Ten (or Twenty or Thirty) Billion Dollars in Search of a Policy. Well organized scholars have sometimes found it difficult to accept the decentralized, fragmented, sometimes adversarial, free marketplace approach to support of science which has characterized many of the agencies of our government since the end of World War II. Many have advocated tighter, more centralized, more rational, more highly organized, more coherent, and more effectively integrated long-range plans for public support of research, conceived and implemented by a more efficiently institutionalized planning structure.

Since our mechanisms for governing, regulating, and restraining science resemble our science funding mechanisms, they too seem both redundant and inefficient by organizational standards. This paper will, therefore, be concerned, among other issues, with the following question: would a set of better designed formal and institutionalized regulatory mechanisms be likely to confer greater costs or benefits on our society, compared to the unsystematically developed machinery now in existence?

Types of Regulatory Mechanisms

Basically, there are some five types of restraining and regulatory mechanisms which can be imposed at various stages of the research and development process.

1. The legislative power of appropriation. The Congress has the power to control appropriations to the various mission-oriented and other scientific agencies of government. While withholding funds does not necessarily mean cessation of research, the lack of public funding for any program or specialized area of research or development has a profoundly inhibiting effect upon work in the area.
2. The power of a variety of federal, state, and local statutes which are designed to limit or check the negative impacts of technology.

3. The investigatory and enforcement power of a variety of federal and state regulatory agencies, many of them established by these statutes. Among these agencies are the Environmental Protection Agency, the Nuclear Regulatory Commission, the Food and Drug Administration, the Federal Communications Commission, the Occupational Safety and Health Administration, state Environmental Protection Agencies, and a number of others.

4. The power of committees and boards of approval in research institutions themselves. These Institutional Review Boards and Committees on the Use of Human Subjects must give administrative approval to protocols of proposed research which makes use of human subjects. In addition, most institutions oversee the facilities in which research animals are housed and the experimental procedures in which they are used.

5. The power of the judicial system at every level to issue injunctions restraining activities perceived to violate statutes or the rights of individuals, and to hear cases, judge compliance with the law, and impose penalties.

The very considerable influence of all these restraining and regulatory mechanisms seems sometimes to be overlooked by proponents both of scientific self-regulation and of more highly institutionalized external control. The nature and extent of this influence will be explored later in this chapter; an evaluation should first be made, however, of the expressed fears of some scientists that any external regulation poses the threat of extinguishing freedom of scientific inquiry and imposing on the scientific community the dogmas of particular civil authorities. The cases of Galileo and the Roman Catholic Church and of Soviet genetics during the Lysenko period are commonly invoked to illustrate the dangers of this sort of external governance. Leonard Cole analyzes these cases in the context of their times and cultures and argues convincingly that the ecclelitical and political institutions and precedents responsible for these suppressions of free scientific inquiry are simply not present in contemporary American life and that, therefore, we run virtually no risk of this sort of repressive control. Further, he asserts that
careless analogy which blurs the distinctions between appropriate social
controls on science and technology and heavy-handed political or theological
domination of science creates risk for both science and the general
public.¹

This argument, coupled with the accepted influence of a variety of
existing regulatory mechanisms, makes irrelevant or purely theoretical
the case for completely untrammled and unconstrained freedom of the
researcher. The real issue, therefore, is not one of simplistic contrast
between scientific autonomy and a smothering blanket of external control.
Rather, consideration of both history and contemporary science demand
answers to a more complicated set of questions, namely, just what scientific
activities are regulated, in what ways, by whom, under what circumstances,
and to what ends?

The Relations of Science and Technology

Many discussions of this question use the terms science and technology
in tandem, and appear to recognize no significant distinction between
the two. The fact that two separate terms are used suggests, however,
that there is a difference between them and that it should be understood.
Weingart makes the case that despite their apparently disparate roots in
pre-history--science being grounded in the explanatory role of the
priest and the magician and technology in the accidental and trial-and-
error empiricism of the craftsman and artisan--the two had become virtually
indistinguishable in the pre-paradigmatic period of modern science.²
The amateurs who belonged to the newly established scientific societies
of the 17th century were equally concerned with theory and practice, and
were as avid to discover how mechanisms worked in practice as to understand
more fundamental scientific principles.³ According to the charter of
the Royal Society, it was the business of the Society to "improve the
knowledge of natural things and all useful Arts, Manufacture, Mechanic
practices, Engynes and Inventions by Experiment...for explication (of)
all phenomena produced by nature or art..."⁴ The absence of any institutional
separation between science and technology, as illustrated by these words
of the charter, persisted for the better part of a century. With the
gradual development in the late 18th and the 19th centuries of paradigmatic
science, however, especially as conceived and practiced by the German
universities, the streams of science and technology began to diverge,
with science seeking to develop conceptual principles and fundamental understanding of nature, and technology both reducing these principles and this understanding to practice and operating independently of science, in traditional empirical fashion. University science, which became concerned with methods of learning and creation of general principles of knowledge, viewed technology as subsequent to science and concerned only with specialized application of scientific concepts to production of useful mechanisms, devices and practices.

Although this period of divergence between science and technology extended into the early years of the twentieth century, the greater part of this century has witnessed a reconvergence of the two. The causes of this reconvergence were several: the exhaustion of the possibilities of further basic research in certain scientific areas, the obviousness of technological applications in others, and, because of the continuing accumulation of theoretical knowledge, the scientification of many areas of technology. Illustrating the first cause, Weingart points out that the National Academy's 1973 evaluation of eight subfields of physics characterized such areas as optics and acoustics as "high in their potential for contribution to technology" rather than having potential for discovery of fundamental laws. An example of the second cause is recombinant DNA research which, while still extraordinarily rich in potential for further fundamental research, has such obvious applicability to a variety of applied and technological biomedical issues that the simultaneous conduct of basic research and technological application is almost inevitable.

Finally, the accumulation of fundamental physical, chemical, and biological theory has been so great that there is great impetus to scientize and rationalize many areas of applied technology. In other words, rather than following more traditional trial-and-error empirical techniques in developing new technologies, there is an increasing tendency to refer technological problems to a context of theoretical understanding for solution. For example, a cancer chemotherapy program, involving routine brute force, trial-and-error testing of vast numbers of chemicals, yields inevitably in today's more theoretical and "scientific" environment to an approach in which our conceptual understanding of chemical-biological system interactions increasingly directs and controls experimental
rationale and procedures. In the same way, Ziman points out that, in doing research on the phenomenon of 'fatigue' in metals, "we are almost forced into the position of saying that on Monday, Wednesday and Friday we are just honest seekers after the truth, adding to our understanding of the natural world, etc., while on Tuesday, Thursday and Saturday we are practical chaps trying to stop aeroplanes from falling to pieces," so intimately related to basic physical and chemical theory are many contemporary issues of technological investigation.

As a result of this reconvergence of science and technology, the most important contemporary distinction between science and technology may involve their social context, rather than the subjects of their research or their experimental methods. It is the character and the organization of those to whom the investigator directs his communications which increasingly determine whether what is done should be called science or technology. If the communication is directed to an invisible college of peers, if few or no constraints are imposed on the dissemination of this information, if the typical medium of communication is, first, the scientific meeting and then the scientific journal, we can judge that it is science which is being done. If, on the other hand, the audience for the investigator's communications exists at another level in an organizational hierarchy of which the investigator is part, if reports must be reviewed and cleared before being released, if limits on communication must be imposed to protect the information and permit its exploitation, we can call what is being done technology. Even in the university, the traditional sanctum for "pure" research, the interest in patents and copyrights and their licenses, in spinoff companies, and in university-industry joint ventures is causing a change (though so far, a relatively modest one) in traditional scientific communication patterns.

Technological Basis of Most Risk

When we consider the issue of the social costs and risks of research in the light of this new and developing relationship between science and technology, virtually all of them seem rooted in technological rather than scientific enterprises. The problems of siting nuclear power plants and handling and disposing of radioactive and toxic chemical wastes, of dealing with acid rain, of air, water and land pollution, of energy generation and its environmental impact, human nutrition, carcinogenesis,
and a host of others, all relate to activities most vigorously pursued in what we define as technological organizations. The only widely identified potentially high risk activity which is at least as strongly pursued in basic research environments as in technological institutions is recombinant DNA research - and even that is moving at an increasing pace into a more technological mode.

To elaborate this issue, we may examine Cole's illustrations of scientific abuse in the Tuskegee syphilis study, CIA Mind Control experiments and Army Germ Warfare tests. While the argument is certainly valid that the scientists engaged in these experiments should have protested against the unethical treatment of research subjects and against the unwarranted risk to which non-consenting members of the public were exposed, the fact is that all of these--as well as other similar risk-engendering research--were programs sponsored by agencies of government in pursuit of their institutional goals rather than the products of disinterested, independent scientific inquiry. In other words, these ethical breaches were committed by what are, in terms of our definition, technological organizations. It is true, of course, that these experiments were not all necessarily statements of national policy nor parts of a national scheme condoning abuse of research subjects (as, for instance, were the Nazi experiments on human subjects), but they certainly did not stem from the pure scientific curiosity of the investigators alone.

Risks and Abuses of Science and Technology

Accepting this distinction between science and technology, and freely granting the general principle of accountability of scientists, whether functioning in basic scientific or technological organizations, let us more systematically explore the range of scientific abuse that societal oversight should identify, characterize the controls imposed by existing mechanisms of regulation, and judge what, if anything, might be accomplished by the creation of additional echelons of governing mechanisms. All abuses created by and risks engendered by science appear to fit one of the following five categories:

1. Incompetent science: inadequacy of design, ignorance of the literature, inappropriateness of methods to the problem and similar faults.
2. **Fraud**: deliberate theft of information, plagiarism, distortion, misrepresentation, or fabrication of results.

3. **Abuse of research subjects**: deception, failure to obtain informed consent, or withholding proper care from subjects.

4. **Imposing first order risks on the public**: for example, creating new pathogens or chemicals for which adequate safeguards do not exist and which could directly harm the public.

5. **Imposing second order risks on the public**: doing research which, though presenting no immediate risks, may introduce technologies which could have significant negative impacts on social, economic, political, or ethical institutions or norms.

What protections against these abuses are already offered by existing regulatory institutions and procedures? Can additional constructive safeguards be anticipated by creating new governing mechanisms? Consider each category by itself.

The first area of abuse--incompetence--does not really pose significant risk to the public except insofar as it may waste funds better expended elsewhere. Furthermore, there appears to be no way in which non-specialists can effectively identify it. It is in this area that peer review functions to prevent incompetent research from being funded and, if it is performed, to prevent its results from appearing in the scientifically sanctioned archival literature.

The second area of abuse--fraud--is likewise not identifiable in advance. No prior announcement is made of the intent to fabricate, misrepresent, or steal results, and only those acquainted with the research area and capable of replicating suspicious studies can identify fraud. Once more, peer review is the means most likely to identify fraud. Recent disclosures of fraud suggest that the scientific establishment is reasonably effective at policing this kind of abuse and, further, that scientists find it very much in their interest to detect and expose it.
The third kind of abuse is indeed a serious public concern, and a sufficient number of horrible examples exists to give us pause. On the other hand, wide public discussion about the use of human and animal subjects has clearly sensitized the scientific community to the potential for abuse. While it is true that external pressures have been important in improving the situation, the extent of abuse, even in the past, is probably not very great. Further, as has been pointed out, the most widely cited examples of the abuse of human subjects have occurred, not merely in programs supported or directed by government agencies, but specifically in those programs in which government agencies have had a distinct policy interest: nuclear testing in Utah by the Atomic Energy Commission, Army Germ Warfare tests, CIA Mind-Control experiments. In all of these, to be sure, the involved scientists have been compliant and have tended to acquiesce in the methods employed, but this compliance has been premised on over-riding concern for policy issues of national security and the like. If the abuses stemmed from the policy goals of government agencies rather than from the pure scientific curiosity of the investigators, and if government is to be the watchdog of science, who is to be the watchdog of government in such cases? Quis custodiet ipsos custodes?

In spite of the notoriety of a few specific cases, the fourth area of potential abuse actually occurs relatively rarely in basic scientific research. It happens only when a conceptual or methodological breakthrough opens a new general area of investigation. In recent decades, recombinant DNA research in the life sciences and nuclear fission research in the physical sciences are the paramount examples. By now, of course, the issue of nuclear fission has become almost entirely a technological one, and a number of the potential hazards attributed to DNA research are at least as likely to be associated with its technological applications as with fundamental laboratory investigations.

Other research programs creating first order risks for society are far more likely to be the result of technological development or application in already well-established areas than of scientific laboratory research. Such work is likely to deal with agricultural or industrial chemicals, pharmaceuticals, or energy generation and is not characterized by the imponderability of risk related to genuinely new areas of fundamental research.
The fifth area--creation of second order risks--seems almost too massive and unknowable even to consider in this context, and yet it is the impacts in this broad area which seem responsible for much of the increasing ambivalence in public attitudes towards science. If concern over these impacts should prompt development of governing mechanisms, it would be almost impossible to set limits on control. Even accepting the general principle of accountability, it is hard to think that basic science, especially life science, is in any way unique in requiring a kind of control not normally applied to the wide range of enterprises which possess comparable potential for affecting our lives.

Two problems beset us in trying to impose regulation on this sort of research. First, the character of second order impacts is almost completely imponderable. One hundred years ago, for example, it would have been impossible to predict to any approximation the enormous social, economic, political and environmental impact on the life of modern man of the invention of the automobile. In view of the inadequacy of our attempts to assess first order impacts of technology, our second order impact predictions are surely virtually worthless.

Even specifically in the life sciences, consideration of second order impacts could probably not be permitted to precipitate decisions on what research to do and what to reject. For example, life-extending research for septuagenarians and octogenarians, while certainly not directly threatening to the rest of society in a biological sense, might certainly, if highly successful, be socially and economically disastrous. Imagine the impact on the economy of having a large proportion of the population over 80 years of age, forcing a productive minority to bear the upwardly spiralling cost of their subsistence and health care. Yet, who would suggest that life-extending or maintaining research should be controlled or halted because of these possible results?

It seems clear that our judgments about the gravity of second order consequences of research and our decisions about whether or not, and to what degree, to control it are based on a confusing blend of precedent, custom, habit, social preference, economic interest and political power, and that no single system of assessment and evaluation can or should be permitted to limit choices based upon these shaky estimates of long range consequences.
How Science and Technology are Governed

Now, having enumerated the five categories of risk, let us examine two questions: Who governs science and technology? What are some of the implications of this governance? The principal mechanisms of regulation lie in the powers of appropriation, of peer review, of statute, of regulatory agencies, of institutional review boards and of judicial review.

Regulation by Appropriation

The first of the regulating, stimulating or inhibiting mechanisms is the power of appropriation. In general, the role of appropriation is rather to stimulate than to inhibit research. It is largely because of administrative commitment to specific scientific goals (space exploration, national security, elimination of specific diseases, etc.) as reflected in legislation, that the impact of appropriations decisions tends to be positive and productive. ¹¹ The negative impact of appropriations decisions appears normally to come by default rather than by conscious decisions to limit or inhibit research in a given area. In other words, low priority goals simply get leftover dribbles of support. The exception occurs, of course, when a specific project or program of research or development is singled out for reduction or elimination. Congressional refusal to subsidize the design and construction of an American supersonic transport is one of the rare occurrences of this sort.

When administrative proposals are forwarded to the Congress for review and action, many pressures and forces are unleashed. Although Congress seeks to acquire independent expert information and advice, its record of doing so is at best uneven. The mission-oriented agencies and the experts they supply provide vigorous defenses of agency activities and decisions, and frequently their only antagonists are self-appointed science and technology critics who, whatever their "bona-fides," are frequently viewed as outsiders, incompetents or single-interest lobbyists.

To improve its ability to get solid and responsible technical and fiscal advice, the Congress in the 1970's created two agencies, the Congressional Budget Office (CBO) and the Office of Technology Assessment (OTA). While the adequacy of these two, especially the OTA, is still open to question, ¹² the move is clearly in the direction of balancing special interest and agency testimony with unbiased evaluations of technological issues and their economic and other impacts.

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One characteristic of the legislative appropriation process is that even the relatively modest changes from session to session in the makeup of congressional committees, may limit somewhat our long-term planning abilities. Another characteristic is that since chairpersons tend to work closely with agency heads to guide budget authorizations and appropriations, many appropriations decisions seem to rest on personal politics and the economic climate, and that the role of purely technical advice is strictly circumscribed by political necessity and strategy. Further, timetables for congressional elections and for R&D planning and performance have little in common, putting the legislative calendar out of sync with the normal research and development process. Finally, the criteria for independent technology assessment are really unknown and there are no guarantees concerning the competence, honesty, objectivity, and impartiality of technology assessors.13

Since federal policy decisions are in many cases carried out under contract by private enterprise, significant sectors of the private economy are affected by public policy decisions concerning directions and funding of scientific and technological enterprises. Threat of major economic or social consequences of appropriations decisions, for example, labor dislocation at large space or defense installations, can have as great an influence on funding policy as does the intrinsic character of the research itself.14 This may well be among the causes of the complaint, widespread over the past twenty years, that, because it is widely dispersed and relatively weak politically, the basic research community has consistently failed to receive from the federal government its appropriate share of research funds.

In sum, the appropriation process has tended to be a highly politicized, decentralized, fragmented, and entrepreneurial activity. On the face of it, less political and more highly centralized, coherent, and goal-based administrative planning procedures would seem a far more attractive alternative. On the other hand, a more highly structured and formalized science and technology review and appropriation procedure might well ultimately put too much governing and controlling power into the hands of technology czars whose institutionalized delegation of power would put them a step further removed from the people and their elected representatives. These mandarins would, therefore, be less responsive to public attitudes
and pressure. Ultimately, the source of expert advice under any governing and regulatory system would be the same, but it may be that the "pulling and hauling" of adversarial free market-place politics is a more sensitive and salutary, if less efficient, mechanism of control than would be a more highly organized and more centralized system of planning and appropriation. This competitive and adversarial process may well permit more sensitive shortrun responses to real world issues than would a deliberately and consciously forged, well-developed, centralized and more efficient long term plan for resource allocation. For example, the refusal of the Congress to support funding for an American SST reflects a responsiveness to economic and environmental issues that were raised by a variety of interest groups. If development of an SST had been part of a well-developed long-term research and development plan, it would have been much more difficult for policy members to be responsive to these demands.

While this approach may seem like tacking into the wind, taking a long and indirect way to achievement of goals, and making the science and technology establishment subject to every vagary of popular opinion and unable to count on long-term sustained support, it may also offer optimal opportunities for oversight of activities perceived to pose risks to society.

Obviously, however, cutting off or limiting resources is at best an indirect form of external control for all but the most expensive research—that which depends absolutely upon such costly equipment as particle accelerators, mahole-type seagoing vessels and the like, which are available only through government appropriation. More modest programs of research in other areas can be carried out with local and far more limited sources of funding and not be dependent upon the approval of the federal legislature. Many of these day-to-day decisions about funding are made on the basis of peer review procedures. The character and extent of peer review differ from agency to agency, with the National Science Foundation and the National Institutes of Health having the most formalized and extensively developed systems and various units of the Department of Defense and other agencies depending to a far greater degree on in-house evaluations of responses to requests for proposals. While the agencies using in-house evaluations are, in some sense, using peer review, their reviews are not provided by disinterested experts but
rather by those who are part of and have a stake in the programs of research being supported. In general, the agencies involved in support of more basic research tend to depend more on peer review; those involved in technological development on in-house evaluation.

Although peer review is the traditional and esteemed method of maintaining standards of scientific performance, a number of questions have been raised in recent years about its efficiency. The charge is made that some reviewers are unduly influenced by the professional standing of authors or proposals and articles or by the eminence of their institutions. Hence, some advocate more widespread use of blind reviews, in which the identity of the author is unknown. On the other hand, some commentators believe that a track record of high performance in an eminent institution is evidence of value to reviewers. 16

Whether or not peer review is more objective than and superior to in-house review as a system of evaluating the quality of proposals, it is clear that many of the specific decisions concerning which proposals to fund or not fund are made, not on the basis of legislative appropriation but as a result of a highly diffuse and decentralized process involving the judgments of many independent referees. In general, however, these judgments are made on the basis of perceived scientific quality of the proposals and not for the purpose of limiting scientific work thought to involve risk. A number of other mechanisms exist, however, which are specifically designed for the purposes of restraint and regulation, chiefly to risk-posing technologies.

Regulation by Statute

At the federal, state and local levels there exists a fabric of statutes governing a wide variety of science and technology-related activities. Examples are environmental protection laws, pure food and drug laws, food and chemical labelling laws, laws governing nuclear power plant siting, toxic chemical and nuclear waste transportation and disposal, pesticide use, asbestos use, tobacco product labelling, and many more. As in any layered federal system, the character of the laws and the integrity and intensity with which they are enforced may vary from jurisdiction to jurisdiction, but the statutory basis for protection of the public from identified technological hazards does exist.
In addition to this body of statute, there are several types of administrative regulation which are binding upon recipients of federal grants and contracts for research. Where the statutes are designed primarily to protect the general public from risks associated with applications of technology, (the fourth category of risk) the administrative regulations are more specifically oriented to the conduct of research in the laboratory itself and are designed to assure ethical treatment of human subjects of research and humane treatment of animals. Again, abuses and violations occur; but failure to identify and correct them is typically a fault of inspection and enforcement rather than of absence of regulatory mechanisms themselves.

It is rare that a new thrust in science will create a hazard, either within the laboratory or to the public at large, which is so novel that it does not fall under general protective provisions of the body of statute and regulation or within the jurisdiction of the bodies established to enforce the rules. Once more, the emergence of recombinant DNA techniques is the only significant such development in recent years.

Regulatory Agencies

A third mechanism for governing scientific and technological activities is intimately related to the body of regulatory statutes. Legislation designed to impose controls on technological applications in areas of risk frequently mandates establishment of governmental agencies or bureaus charged with the responsibility of overseeing the area, enforcing the provisions of the law, and developing administrative regulations which facilitate this oversight and enforcement. Among these agencies are the Nuclear Regulatory Commission, The Food and Drug Administration, The Environmental Protection Agency, The Occupational Safety and Health Administration, and The Federal Communications Commission, as well as a variety of state and municipal agencies, responsible for surveillance and enforcement at these levels. Once more, the overwhelming majority of activities regulated by this network of agencies consists of technological applications in nuclear, chemical and other areas which are institutionally far removed from the basic research laboratory.

There are, of course, numerous reports of inadequacies, incompetence and malfeasance in regulatory agencies. Whatever the reasons for these
breakdowns in regulatory activities, the solution would appear to be a shoring up of their authority, the appointment of more competent, more disinterested or less corruptible members and, when necessary, statutory modification of their charges in order to cover areas which may have been inadvertently excluded from their areas of jurisdiction, rather than creation of yet another review echelon.

Local Review Boards and Committees

While these various agencies of government are designed principally to cope with hazards to the general population which stem from a variety of scientific and technological activities, another group of mandated boards has been established within scientific research institutions to deal with the issue of risk to subjects of experimentation (the third category of risk). These Institutional Review Boards and Committees on the Use of Human Subjects exist in every institution which receives National Institutes of Health and National Science Foundation support for programs of research. For practical purposes, this includes every significant research university in the United States. These bodies are empowered to demand and routinely review detailed research protocols from investigators proposing to perform research involving human subjects. In general, the term "use of human subjects" is construed so broadly as to include populations being asked to complete questionnaires and take standardized psychological and other tests, so that every possible risk of damage—emotional and psychological as well as physical—is taken into account. These boards have the power to recommend modification in protocols in the interest of protecting human subjects of research and may withhold approval from programs of research which fail to meet appropriate standards.

The Role of the Judicial System

The final existing mechanism for controlling and regulating risks engendered by scientific and technological activities is the judicial system itself. The judiciary is equipped both to enjoin the performance of activities which it contemplates may pose substantial or unwarranted risks and to hear cases brought by parties alleging that they have incurred harm from scientific and technological activities. Judge David L. Bazelon has incisively explained the role of the courts as well as that of other governing and regulatory bodies. The central issue, he points out, is not whether or not society shall accept some level of
risk associated with developments in science and technology (it shall), but rather how much risk is acceptable, what individuals or groups should be exposed to this risk, and who is finally empowered to make society's decisions concerning acceptability of risk.\textsuperscript{17}

Quite clearly, society has a variety of ways, formal and informal, by omission and commission, of making decisions concerning risk, without ever having the issues adjudicated in the courts. The American public has emphatically decided in the market place, for example, that 50,000 deaths a year is not an exorbitant price to pay for the benefits of automotive transportation. Yet it has on occasion fairly compliantly accepted the banning of one artificial sweetner or another, which arguably cause no deaths a year, undoubtedly because a different benefit-cost calculus is involved.

Many disputes involving risk, however, are ultimately referred to the courts because the agencies responsible for appropriation, legislation, and regulation decisions are faced with conflicting expert advice, frequently offered in the context of different value systems. In many cases, equally reputable experts will draw from the same body of data widely differing inferences concerning level and acceptability of risk. Even in those cases where there is consensus on technical data, diverse political, economic and ethical contexts and standards can lead to different conclusions concerning the risk's acceptability. Value systems--those of experts and the general public alike--which determine their assessments of acceptability of risk, are rooted in grounds far removed from the scientific and technological issues themselves. For example, even if technical experts agreed on the certainty of radiation at certain levels reaching a certain proportion of the population if nuclear power plant development continued, judgment on the acceptability of that risk would very likely be quite different for someone convinced that the future of the nation was absolutely dependent upon development of nuclear resources and for someone whose political and economic values create a commitment to soft energy development. An individual's vision of the ends of human existence, of man's place in the world, of the proper role of this nation in the international community, and of the way it should wield its economic, political, and moral influence obviously
Although the courts cannot change or make uniform the individual and group contexts of values in which disputes develop, they can at least help make sure that decision makers articulate the basis for their decisions both in terms of data and value systems. They can insist that ignorance be confessed where it exists, that arguments for acceptability or unacceptability of certain risks be explained in terms of tradeoffs for society, and that all this should be done in language comprehensible to the general public. 18

Since "common law is one means to control the consequences of technological development,"19 the role of courts is of special importance. They are equipped both to adjudicate scientific and technological disputes between private parties and to counteract the actions of executive agencies which are outside the law. To these roles may be added the enjoining power of the courts to prohibit scientific and technological activities which appear to pose unwarranted threats. Further, "by dramatizing injustices and reflecting public values a law suit can also cause the public to exert pressure for more responsible technology". One serious problem, in spite of their power of injunction, is that the courts can generally only respond to complaints and not really anticipate them. 20

The experience of recent years suggests that torts cases dealing with product liability, nuclear risk, recombinant DNA, experimentation with human subjects, environmental protection and a host of other science- and technology-related issues will demand ever increasing scientific sophistication on the part of the courts. To deal with issues of this sort, Kuehn and Porter suggest the possibility of establishing within the context of the legal system special appeals courts, on the model of the U.S. Patent or Maritime Courts. 21

For those individuals or classes who believe that scientists and technologists are engendering unacceptable risks or that responsible regulatory agencies are failing properly to evaluate and control risk-producing conditions and activities, the courts are the logical and appropriate ultimate forum for adjudication. One particular advantage which existing judicial structures and remedies offer is that they have
The Unsystematic System of Government

The complex web of social, political and economic institutions and procedures available for evaluating and controlling risk-producing scientific and technological activities is nothing less than a microcosm of the American governmental system itself. It operates at many levels, in both formal and informal ways. It has a variety of overlapping areas of jurisdiction. It is certainly more disorderly than any system established by an authoritarian and centralized government. On the other hand, its openness, its many pressure points, and the opportunities it offers for both deliberative and adversarial proceedings at many levels make it perhaps more sensitive and more responsive to a variety of public inputs than would be a more highly institutionalized and hierarchical set of structures.

This complex system of legislative, administrative, and judicial machinery, while perhaps largely reactive in exercising control, has developed certain patterns by which potential or actual risks are brought to its attention for appropriate action. If any novel regulatory machinery should be created, the question would have to be addressed of how such machinery should be used. Should it be employed routinely to review and monitor all scientific and technological activities for potential risk? Should it be used when its personnel have some prior perception of risk? Or should it be called into action only upon complaint of a victim or class of victims, a whistle blower or a public interest group? If the first of these is true, we might be launching an enormously cumbersome, complex, and time- and effort-consuming system which would slow or inhibit the conduct of all research, the greatest share of which poses no conceivable risk. If the second were true, its use might well depend on the intuitive, idiosyncratic or biased perceptions of its members. If the third were true, it would have no function different from the existing judicial system.

The nature of the relatively unsystematic body of controls which we possess inevitably results in some ambiguity concerning the scope and function of the various levels of governance as well as some inconsistency
in interpretation and enforcement of statute from agency to agency and institution to institution. Even so, the redundancy of the system offers a reasonable measure of protection to society. More important, the risk of unethical and socially hazardous behavior on the part of science must be balanced against the risk of having tighter, more cumbersome, more time consuming, more elaborate, and more inhibiting rules and regulations. In general, it has not been demonstrated that the overwhelming majority of practicing scientists is so devoid of basic ethical concern and a sense of social responsibility that they would deliberately and malevolently undertake research patently dangerous to society.

Role of the Press

One final protective mechanism must be mentioned: the press. It must be acknowledged that press coverage of science and technology over the years has been at best uneven. Accused of sensationalism and oversimplification in dealing with complex materials, press treatments of science and technology have been specifically criticized because of their tendency:

1. to be highly selective in choice of materials and to use a variety of questionable selection criteria;

2. to oversimplify, and hence to misrepresent, the methods and the character of scientific inquiry;

3. to treat scientific news as discrete events and hence to create another false conception of science;

4. to draw undue inferences about the meaning and significance of particular lines of research;

5. to report on inadequate, incomplete, and poorly designed research as readily as on competent research, as long as the subject matter is relevant to immediate popular concerns;

6. to raise false expectations of what science is capable of doing; and
7. on occasion, to create stress among readers more damaging than the real risks being reported on.22

Even if we accept the validity of this list of criticisms and grant that it has a frequent tendency to cry wolf, the press does play one absolutely crucial role: it publicly calls society's attention to the possibility of scientific and technological risk. Many of these calls will be exaggerations; a few will not. In a political democracy which is at the same time the most technologically sophisticated society in the world, it is probably worth having several false alarms registered for every one that signals genuine risk to subjects of research or to the general public.

Without the press to signal the existence of probable risk and without the knowledge by the scientific and technological community that the press is always prepared to perform this warning function, the probability of abusive actions and the likelihood of their going undetected might well be greatly increased.

As in the cases of other protective mechanisms, the behavior of the press is, of course, flawed. Like the legislative and executive bodies responsible for appropriation and regulation, the press is susceptible to improper pressure and can be misled by incompetent or biased "expert" advice. In addition, like many other institutions in our society, the press is moving toward greater centralization in administration, with decreasing opportunity for individual initiative to identify and develop stories. This is especially true in science, where the pressroom agenda can be controlled by scientific societies23 and where a small group of inner circle science writers tends to set the pattern for selection of items for coverage.24 In spite of these flaws, the press remains a most valuable informational and signalling resource for the Congress and for regulatory agencies as well as for the general public.

In some sense, the press's greatest contribution is its service as a watchdog of government science itself. It should be reemphasized that some of the most flagrant documented abuses of science have been perpetrated in pursuit of political and governmental policies rather than as a result of the disinterested curiosity of scientists themselves. The
whole issue of nuclear policy, for example, has been bound up with a broadly-based federal policy toward atomic energy. It is certainly true that scientists are involved with federal agencies in pursuit of both their scientific and the government's political and economic goals, but the abuse seems to originate chiefly in policy rather than in science. For example, Cole points out "how single minded and duplicitous" the Atomic Energy Commission had become when it publicly announced that radioactive fallout from nuclear tests in Nevada posed no threat to people in the area. It was the imperative of national policy rather than of scientific curiosity which caused an AEC Commissioner, Thomas Murray, to say in 1955, "We must not let anything interfere with this series of tests--nothing," and which prompted commissioner Willard Libby to decide that "people would have to 'learn to live with....fallout,' even if they did not know they were receiving it."\(^{26}\)

The ability of the press to identify and focus on issues of this sort probably represents its most positive contribution to the protection of the public from unethical and dangerous scientific and technological practices.

A The Role of Public Opinion

A final informal control of science and technology is public opinion. Obviously, as an instrument of stimulation or restraint of research, the role of public opinion is closely related to that of the press, with which it functions reciprocally. In its reporting and editorializing about scientific and technological subjects, the press is highly instrumental in shaping public opinion. At the same time, the press reports on various expressions of public opinion and so, in addition to shaping opinion, reflects and sometimes amplifies attitudes held by specific attentive and interested publics. In this reciprocal relationship, the two make mutual use of one another. Interested publics try to use the columns of the paper in order to broadcast their views more widely, while the newspaper, in its search for stories which are interesting and novel or which report on conflict, use these groups as sources of information. The entire issue of the relations between the press and public opinion is, however, not one which can been explored at this time. Suffice it to say that the combination of the voices of the public and the press plays a significant role in affecting both the attitudes and the behavior of the individuals and institutions charged with more formal responsibility
for the governance of science.

Specifically, legislative bodies responsible for appropriations decisions, especially in areas about which there is public controversy, have developed a variety of hearing procedures in order to permit interested publics to express their views as they try to affect levels of support for research and development enterprises. While federal regulatory agencies, various national and state, commissions and institutional review committees and control boards are typically more insulated from public opinion than are legislative bodies, there is no question that the intensity with which these bodies enforce regulations is related to public and journalistic expressions of concern about such issues as environmental pollution, nuclear risk, hazards related to use of various foods and drugs, etc.

Conclusion

This survey of the kinds of risk imposed on society by scientific and technological activities and the response to these perceived risks by a variety of formal and informal political and social institutions yields a picture of widespread but decentralized restraining mechanisms. Our society's approach to governance and restraint of science and technology is characterized by a relatively high degree of redundancy and overlapping authority and a low level of coherence and coordination. Nonetheless, all of this rather cumbersome and unwieldy machinery seems to be able to respond reasonably effectively to the emergence of major new risks and to public attitudes concerning these risks. The adversarial character of much of the deliberation concerning these risks seems to guarantee that our society is unlikely either to underreact or overreact in any major way to perceived risks over an extended time, although disproportionate responses may well emerge in the shortrun. While the case can be made that a much more highly centralized, hierarchical and coordinated structure might be a desirable alternative to the present system, there is simply no chance that such a major overhaul of our political institutions will take place. If this assumption is accepted, we should probably entertain serious doubts about creating and developing yet additional mechanisms of governance and control which will almost inevitably complicate the already overlapping jurisdictional structure of the existing machinery. A better course might well be to attempt to clarify and strengthen the authority of the mechanisms we have.
NOTES FOR CHAPTER 2


2. This is the early period of modern science, when the Baconian quest for empirical knowledge prompted a largely non-theoretical search for descriptive information about the whole range of natural and man-made phenomena which lent themselves to this sort of investigation. This search is typically not directed and limited by a set of general principles expressed in the form of a controlling theory or paradigm.


Both subjective and objective evidence exists to suggest this ambivalence. For one thing, we see an increasing number of publications concerned with assessing the costs as well as the benefits of science and technology as compared with two or three decades ago, when much of the literature emphasized the concepts of progress, growth and human betterment as the consequences of research. For example, Robert S. Morison, in the Introduction to the volume entitled "Limits of Scientific Inquiry" Daedalus, 107, 2 (Spring, 1978) vii, writes:

In the last few years, several different kinds of unease have led to a questioning of the status of new knowledge and the effectiveness of society's arrangements for encouraging or restraining the growth of knowledge. In practice, the controversy changes rapidly from one level to another, and it is often difficult to be sure of the particular concerns and motivations of the principal protagonists. For purposes of preliminary analysis, however, several sources for this new anxiety may usefully be distinguished. The most elementary, perhaps, is a concern for the harm that may be done to individuals in the simple pursuit of knowledge. Closely related is the concern for the possible damaging effects of new technologies that may result from new knowledge. Next, come the long-term hazards, hard to foresee except rather dimly, that carry some finite possibility of serious perturbations in our current way of doing things.... The fourth source of anxiety is somewhat more remote from everyday affairs and concerns the possibly unsettling effects of new knowledge on man's concept of his relations to society or the rest of the natural world. This last concern may take the form of a deep-seated and not always clearly verbalized anxiety about the possible limitations and bases of scientific knowledge itself.

Similarly, Philip Handler recently called for scientists to reverse the trend of increasing public skepticism toward science ("Public Doubts about Science," Science 208 (4448) 1093.)
The results of a number of public opinion polls confirm this sense of unease or ambivalence. Examples of these results:

One poll showed 56% of the respondents agreeing that "science and technology do as much harm as good," and 77% agreeing that "science and technology often got out of hand, threatening society instead of serving it."

Compared with only 2% of respondents in 1957-8, 7% of respondents in 1976 felt the world was worse off because of science, while those who believed the world was better off decreased from 83% in 1957-8 to 71% in 1976. The number feeling ambivalent increased from 8% to 15% (cited in Pion, E.M. and Lipsey, M.W., "Public Attitudes Toward Science," Public Opinion Quarterly 45 (1981) 303-316).

Many other public statements and opinion polls confirm this modest but consistent trend toward increasing ambivalence about the social impact and consequences of science and technology.


16. For a discussion of this issue, see the symposium in The Behavioral and Brain Sciences, 5, 2 (June, 1982): 187-255.

In the key article of this symposium, Peters and Ceci offer experimental evidence that changing the name and institutional affiliation of authors of articles dramatically affected their acceptance rate. But in an accompanying article, Yalow offers full sympathy to the practice of "rejecting papers from unknown authors working in unknown institutions."

In another study, Cole, Cole and Simon (Chance and Consensus in Peer Review," Science 214 (1981) 881-886) find no systematic bias in the evaluations of proposals by NSF reviewers, but they do find that success in getting a grant depends to a significant extent on chance, because of the high level of disagreement which exists within the population of eligible reviewers. This study has elicited numerous comments, both agreeing and disagreeing with its conclusions.


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