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# BIOLOGY AND LAW: CHALLENGES OF ADJUDICATING COMPETING CLAIMS IN A DEMOCRACY

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In 1995 and 1996, thirty-two scholars from biology, law, science studies, history, philosophy, and political science met at Arizona State University to discuss issues arising from interactions between biology and law in democratic political systems. Their report to the National Science Foundation (NSF), which sponsored the workshops,[1] suggests ways to study the relations of biology and

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1. This entire project would never have occurred without the support of Allan Kornberg, Ron Overmann, Ed Hackett, Neal Tate, and especially Rachelle Hollander at the NSF. Among the 27 other invited scholars who participated in the two workshops, Sheila Jasanoff and John Beatty offered especially helpful support at various stages. David Kaye also offered valuable suggestions. Joseph Graves made very helpful contributions to the genetics materials.

law in the context of several NSF-sponsored initiatives.[2] In addition, the report presents case studies in the areas of environmental policy, "bioprospecting," and genome control. Here, we offer a modified version.[3]

Recent decades have seen tremendous worldwide political, social, and economic upheaval. Political units are shifting, and increasing democratization is held up as an ideal. Science and technology sometimes are seen as particularly valuable in promoting progress and are accorded, therefore, a special status by many political leaders.

Yet, science and technology have undergone dramatic changes as well, raising new questions for the law, as well as legal and political institutions. Furthermore, science does not always provide clear, uncontested facts; the interface of science and law requires adjudicating many competing claims to knowledge. The biological sciences, in particular, have virtually exploded with new knowledge, notably in genetics, the environmental sciences, and human biology and behavior. This new knowledge has challenged our views of nature, life, and human identity. It also has produced new and different types of scientific expertise.

While researchers have investigated selected aspects of biology and the law, work on most of the important connections has just begun. Traditionally, scholars in such areas as science studies, law, philosophy, history, and political philosophy have examined separate disciplinary pieces of the larger picture. Moreover, because they have different conceptions of evidence and different approaches to addressing questions, it is difficult to integrate their research findings. Yet, a host of recent political actions have raised complex questions that call for more multidisciplinary research involving the social, behavioral, economic, and biological sciences. For example:

- In *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*,[4] the Supreme Court upheld an interpretation of the 1973 Endangered Species Act that prohibits not only direct harms to members of protected species, but also habitat degradation leading to their death or injury. Thus, even private land owners cannot destroy critical timberland habitat for spotted owls. The decision legitimizes a policy implemented by the Secretary of the Interior: habitat may be essential for species' survival.
- Certain religious leaders have argued that the U.S. government ought not to grant patents on living things or their parts, including DNA fragments.[5] Scientists have not created life and thus should not own it, they argue. Some scientists disagree, asserting that isolated or purified gene fragments are as much a product of human ingenuity as are the products of any other technology.
- In *Daubert v. Merrell Dow Pharmaceuticals, Inc.*,[6] the Supreme Court instructed federal judges to assume an expanded role in deciding whether proffered expertise is scientifically valid and, therefore, sufficiently reliable to be admitted into evidence—even though judges often have little training in science.
- In *Sierra Club v. Marita*,[7] environmentalists contended that the Forest Service, in developing forest management plans to protect diversity of plant and animal communities, should be required to apply scientific principles of conservation biology. The courts, however, upheld the agency's failure to do so.
- Some school boards have accepted arguments by religious groups that evolution ought not to be mandated as part of the curriculum.[8] They either question the importance of evolutionary theory in modern biology or deny that the theory of evolution is good science.
- Some critics argue that genetically engineered foods, drugs, and pesticides may be unsafe, while scientific experts maintain that the scrutiny to which such products are subjected assures safety beyond that required for many "natural" products, including those modified through conventional breeding techniques.

New scientific knowledge frequently challenges both our established political practices and our legal system. That system, through its judicial, administrative, and legislative branches, relies on testimony from scientists and representatives of various points of view to resolve disputes and make policy. Many recent biological advances raise questions about which experts do not agree. What happens when there is a conflict of expert testimonies or conflicting claims about the quality or probative value of evidence? What is to count as evidence? How are conflicting claims to be adjudicated? How are conflicts between local, national, and international participants with different interests to be resolved? Some members of the scientific community suggest that scientific claims should always be resolved in the scientific arena and that political, social, and legal forces should be irrelevant. Who will decide how to import those scientific claims into political action and legal interpretation? How are decisions to be made in areas of uncertainty, at the borderline of science and policy? Whose rules will take precedence when law and science have different approaches and standards for evaluating evidence?

2. These include initiatives addressing human capital, biotechnology, genome diversity, civil infrastructure, and human dimensions of global change.

3. For copies of the version of the report submitted to NSF, contact Rachelle Hollander, National Science Foundation, at (702) 306-1743 or rholland@nsf.gov or visit the NSF Web Site at www.nsf.gov/sbe/sber/sts/start.htm where the report can be found under "Reports of workshops . . . ."

4. 515 U.S. 687 (1995).

5. *See, e.g.*, Richard Stone, *Religious Leaders Oppose Patenting Genes and Animals*, 268 SCIENCE 1126 (1995); Ronald Cole-Turner, *Religion and Gene Patenting: Rift Between Scientists and Religious Leaders*, 270 SCIENCE 52 (1995).

6. 509 U.S. 579 (1993).

7. 46 F.3d 606 (7th Cir. 1995).

8. Notwithstanding their consistent judicial rejection (see *infra* note 49 and accompanying text), such efforts continue. *See, e.g.*, Karen Schmidt, *Creationists Evolve New Strategy*, 273 SCIENCE 420 (1996); Peter Applebome, *70 Years After Scopes Trial, Creation Debate Lives*, N.Y. TIMES, Mar. 10, 1996 at A1.

Our two workshops explored these and other questions. Section I of this report discusses the legal, political, social, and economic systems in which law and science interact. Section II considers the nature of science and its political role. Section III examines the role of law in society and the way that law deals with scientific issues. It explores the underlying differences in approaches, standards, and institutions in what counts as knowledge, standards of evidence, burdens of proof, or levels of "certainty" and confirmation. Finally, Section IV explores specific examples of special areas of study, taken from the biological sciences: environmental sciences, bioprospecting, genetics, and evolution.

Workshop participants concluded that the United States has developed a knowledge base in our understanding of democracies, law, science, and the foundational aspects of biology, but that new frontiers at the interface of science and law call for further research to improve our understanding of science and conflicting values in complex political systems. Participants stressed that innovative research at these frontiers must include coordinated interdisciplinary studies crossing traditional academic boundaries. Workshop participants agreed that this is the strategic time to undertake larger and cross-disciplinary studies concerning a range of issues about biology and law: to pursue baseline empirical studies of the way those different approaches play out in political arenas, to explore how science intersects with legal and political processes, and to build on studies already begun. These data will underpin future studies and facilitate the exploration of changes over time. With such empirical work in place, scholars can begin to pursue comparative studies across different institutions, biological specialties, cultures, nations, and times. This ideal—to bring together scholars from a variety of backgrounds—is especially important in this time of volatile legal and scientific institutional change.

## I. DEMOCRACY, SCIENCE, AND LAW

At their most basic and idealized, democratic societies share a commitment to the equal worth of individuals, to political (and even some basic minimal levels of economic) equality, and to self-rule through law—at least among those defined as "citizens." Ideally, the majority voice should prevail, but how the majority comes to exist and to be recognized differs among democracies. A representative, constitutional democracy acknowledges that all citizens cannot vote on everything, and that it is necessary to recognize and protect certain fundamental rights and interests of individuals, whether or not they are in the majority.

Another set of restrictions and responsibilities comes with the division of government into separate legislative, executive, and judicial branches. In the U.S., lawmaking is conducted in a matrix of institutions that exist at the local, state, and national levels. Ordinances, statutes, administrative rules, and judicial decisions constitute the "products" of these institutions. All are law.

Subject to varying (and somewhat overlapping) limits of jurisdiction, most domestic policy problems raise a question about where law should be made.





Lawsuits may be brought in federal or state court by private individuals; legislators at all levels may introduce bills; and agencies (relying on new or existing statutory authorization) may write rules or investigate private activities. The institutional competence and suitability of these different responses varies with the particular subject. The process is complicated and has been adapted to deal with the increasing complexities of large populations with a more highly technologically based lifestyle. This is especially true in areas where local, regional, state, national, and international interests overlap, and where there are competing values and needs.

Science, technology, and the changing social world create opportunities and challenges. Scientific expertise seems to conflict with democratic values, which seek to give all citizens an equal voice. The American lawmaking process leaves most ultimate decisions with generalist legislators and judges. Even administrative agencies, created to develop and manage programs requiring special knowledge and expertise, make final decisions through executives who may be presidential or gubernatorial appointees or are otherwise accountable to the agency's political constituencies.

In the scientific establishment, however, different experts may possess varying levels of expertise. Indeed, there are intricate hierarchies of both scientific and other expertise. Scientific experts brought into the legal and political process may acquire a special, unequal role.

Basic definitions about who qualifies for membership in the democratic polity and who qualifies for constitutional protection have depended, at least in part, on scientific knowledge. That knowledge has changed over time as blacks, women, and other disadvantaged groups have gained political status as deserving citizenship, education, and a place in the democratic process. Thus, biology raises basic issues that strike to the heart of any democracy. We need careful study to clarify the extent to which science does—and should—affect decisions about political status. When scientific claims are contested, whose expertise counts? In which arenas? How and when should we listen to experts rather than to the majority, and how do we balance diverse views? How do we adjudicate between competing claims—either competing scientific claims or competing claims about the proper political and legal uses of science?

Such questions become all the more complex when we move, as we have recently in the U.S., to increasing the number of decisions made at the level of administrative law and, in certain areas, returning more decision making to the individual state governments. What happens when an even greater variety of experts and systems of expertise operate at these levels? In many cases, we have no standardized procedures for public deliberation or decision making, especially when the goals and interests of law, legislation, and science conflict.

## II. THE ROLE OF SCIENCE

In the traditional ideal of science, the objective scientist is guided by the pure pursuit of knowledge. This scientist gathers data by observing the natural or social world, formulates hypotheses about those data and the phenomena from which they derive, generates predictions, tests those predictions and thereby the hypotheses, revises hypotheses, and continues the process, ever revising and improving. Science seeks to explain phenomena by uncovering and understanding their underlying causes. It is an analytical process that yields progress and generates useful knowledge even though the results may be tentative rather than certain, subject to considerable revision, and shaped by social input.

The legal system would like to rely on the objective results derived from such a process, but this model is too simple. A wide range of personal, political, social, and other factors complicate the process. Sociologists and historians have led the way for analysts of science to see that, to some extent, science is socially constructed. The particular problems pursued at any given time and place, the preferred approaches, and the roles or conventions for interpreting results are strongly influenced by the context in which the science is done.

In other respects, science conforms to the ideal. Disputes arise within science because theory and methods differ, but in each case there is a fact of the matter about which the participants are arguing. Careful exploration of how the dominant scientific views are developed and what level of reliability science carries should provide guidance about how best to import science into legislative and judicial proceedings. Scientific change, competing epistemologies within science, and the uncertainties of results are areas of concern in importing scientific knowledge into the legal world. First, scientific knowledge can change rapidly, which can be a problem for legal and political processes. A specific legislative act or judicial case may proceed assuming one set of "facts," while those facts are being undercut or replaced by others. This does not in itself make experts or their testimony unreliable, but it challenges any process that depends (as law does and must) on a state of evidence tied to a particular moment. Thus, the process of doing science creates a changeable set of specific evidentiary claims, even while the standards for what will count as evidence change more slowly. We need research into the nature of science and its context to develop the necessary translations between scientific and legal communities for such central concepts as the nature of evidence or what is the applicable standard of proof.

Second, there are different approaches and epistemologies within science. Part of the strength of the scientific process lies in the coexistence of different approaches and the dialogue that results about how the available data support or refute conflicting hypotheses. Obviously, disagreement over the interpretation of scientific data makes it much more difficult to carry scientific knowledge into the legal and political processes. In some cases, and at certain stages in the early development of a topic, disagreements within science prevent a unified "certainty" or "confidence" from emerging. Yet, the legal and political decisions





that must be made *now* require the best of what we know. Inconclusiveness within science should not be interpreted by decision makers as ignorance. Rather, we need to develop means of interpreting uncertainties that will allow scientific knowledge, uncertain though it may be, to inform our practices and policies. Whose science shall we accept, and by whose standards shall we judge its acceptability?

Finally, scientific knowledge is especially contested in areas where that knowledge is uncertain. Many phenomena behave stochastically and simply cannot be known in other than probabilistic terms. The law struggles with scientific uncertainty, either because it generates an unacceptable level of doubt or because it demands that immediate choices be made. The cost of error may be very high in such cases (as in the criminal law, where life or freedom may hang in the balance). This is an issue in risk assessment studies with significant political and social implications where many people will be affected, although there are cases where the law has worked out ways to deal with different levels of probabilities.

With knowledge—and especially with knowledge gained through public support of science—comes responsibility as well as privilege. Physicists realized this after the dropping of the first atomic bomb. As J. Robert Oppenheimer noted, "the physicists have known sin."[9] Biologists, concerned about unknown risk and eager to avoid a similar predicament, initially proposed a voluntary moratorium on certain kinds of recombinant DNA work. Agreement to go on with research gave rise to many different and often conflicting responsibilities.

One form of responsibility stems from the public funding of science. Accepting public funds, the scientist may have some prima facie responsibility to make the results public. If the contract does not specify how and when the knowledge must be shared, however, there will be times when it may be better to wait. Perhaps the data set is not as rich as ideally would support the conclusions others will wish to draw or to support any conclusions at all. Or perhaps the conclusions would have significant social consequences, leaving the researcher to feel that it is more responsible to seek corroborating evidence from other lines of research than to report the preliminary results. Scientists' sense of responsibility to the public as individuals who may be affected may conflict with their sense of responsibility to the public as funder of science, especially when the individual may be harmed but the larger public may gain from the dissemination of knowledge.

Tension emerges because responsibility to the scientific community requires adhering to the standards of evidence and other internal requirements of the scientific process. Social responsibility introduces other factors that may be at odds with those norms. Imagine a scientist who takes into the courtroom a

9. PETER J. GOODCHILD & J. ROBERT OPPENHEIMER: SHATTERER OF WORLDS 174 (1981), *quoted in* JUDITH AREEN ET AL., LAW, SCIENCE AND MEDICINE 113 (2d ed. 1996).

preliminary finding about the population of a federally protected endangered species. Having not counted all individual organisms in the field, this scientist nonetheless knows that there *could* be many more. There probably are not, but there could be. Admitting this in court, he hands the anticonservationists the ammunition they need to oppose any special protection of that species. Yet, not to admit that possibility would be untrue to established standards of knowledge. Scientific practice may dictate a slow and careful study of all potential causes of a phenomenon, for example, while political and legal pressure may push for immediate answers to urgent questions. When to make data available—how, where, with what explanatory framing, and through what nonprofessional channels—remains unclear.

To insist on further detailed and compelling data, the gathering of which takes time while species disappear, raises additional concerns. Has the scientist done wrong? If such a scientist felt that there likely were many individuals but spoke only of one sampling method that revealed few, and that was the only one asked about, would he or she have done wrong? Would it matter if the scientist were prodevelopment or proconservation? What, then, are the responsibilities of the scientist—*qua* scientist, *qua* economic participant with claims to the results of the research, and *qua* citizen with legal, moral, professional, and personal interests?

## III. LAW AND SCIENCE

Law and science have different underlying institutional needs and requirements, standards of evidence, burdens of proof, and other characteristics. When an issue is presented to the legal system, it often must be resolved in a concrete and timely way. Suppose the law provides that a medicine cannot be sold unless it is shown to be reasonably safe. Even if experts disagree about the safety issue, the tribunal must decide. Failure to act results in victory for those who wish to keep selling the medicine. Moreover, the question of "reasonable safety" turns in part on judgments about acceptable risk. Under the circumstances, the legal system stresses adversarial procedures through which people express opposing views. The goal is a socially acceptable set of results—a resolution of the current dispute—rather than a timeless truth.

In science, when there is insufficient information or interest, a matter simply remains unresolved. The scientific community seeks an ever-growing base of hypotheses that have withstood vigorous testing. While individual scientists may compete with each other, the goal is a broad consensus among scientists about how the world works. Accordingly, the scientific community stresses a system of professional certification and peer review through which consensus is generated (this despite the vigorous persuasive efforts by the science studies community to demonstrate the local contingencies and social conventions that influence science). The scientific community as a whole retains an ideal of science as reasonably definitive knowledge.





In addition, there are fundamental differences in the style of discussion. Judicial processes depend on an adversarial approach with a debate model of exchange. One side will win; the other will lose. The orientation in science is toward consensus, and the goal is to agree upon one answer to any given question—or at least to agree to disagree. Individual scientists debate specifics, but they all accept the goal of working through the disagreements to achieve the best available view. It may be useful at any given time to look at more than one theory, and individual scientists may have a considerable stake in having their particular theory and approach prevail. Yet, the scientific community, in principle at least, seeks the best view that will work with all the evidence. According to this concept, nature behaves in one way only. Typically, therefore, one side will not clearly win; compromise, periodic revision, and open questions will prevail.

As science is drawn increasingly into the legal process, research exploring the significance of such differences of style and approach will prove useful. Considerably more interdisciplinary study of differences and possible translations—or at least ideas about how to reconcile scientific, legal, and political differences—will improve our ability to deal with tensions between law and science.

## IV. BIOLOGICAL SCIENCES: A SPECIAL CASE

The biological sciences have expanded rapidly since World War II. Because research on the environment and genetics, and on related issues of bioprospecting— the search for economically useful products derived from microbes, plants, and animals—have provoked particularly challenging legal and political concerns, we have concentrated on those areas for the development of illustrative cases.

### A. Environmental Sciences

"Environment" is an imprecise term generally taken to include the earth and its natural resources. Usually this means the natural world of rocks, trees, and other animals, although it can also mean the social or human environment. Thus, for example, the "urban environment" includes inanimate buildings, subways, and rats. It also includes such phenomena as human violence, culture, and garbage. Environmental sciences, then, cover a vast range of subjects from architecture to zoology.

Those sciences include divergent goals. While one botanist or zoologist might focus on the presence of a particular rare plant or animal species, another might emphasize the ecological interactions of plants and animals within an ecosystem. The former stresses individual species, while the latter stresses a system, perhaps in terms of the habitat needed to support greater biodiversity. Science does not tell us which to value more. Such decisions require other values.

Which of these knowledgeable parties shall the legislature and courts count as experts? To what extent shall we rely on science to make environmental

decisions? Perhaps the natural environment is a special shared resource like the traditional town common, with diverse competing claims on it. Some argue for the existence of a special vernacular knowledge according to which those who know the local environment best are viewed as having the most valuable knowledge. In particular, indigenous populations are presented as possessing special knowledge about the land and its living populations. They sometimes claim an ethnic and historical right to use endangered species such as eagles, panthers, or whales. As the Constitution seeks to protect religious freedoms, some of these claims come in the form of religious rights; other claims concentrate on the right to make a living through continuing to hunt or fish in traditional ways.

Others argue that property rights prevail and that some knowledge supposedly accrues to those who have owned or used the land for such pursuits as hunting, grazing, agriculture, or mining development. According to this view, ranchers and farmers "know" the environment and should prove better stewards of the land and its resources than government agencies.

What is the public interest, then, and whose word should we believe? How shall we make decisions about environmental matters, and what do we need to make such decisions? How can we adjudicate the complex of competing values, including scientific views?

Our political conviction in the U.S. has been that we need collective management of at least some of our environmental commons. We began setting aside natural preserves at least as early as 1872 with Yellowstone National Park.[10] The National Park Service was created in 1916.[11] The emphasis was on preservation—on setting aside precious lands.[12] The conservation movement finds support in sports and hunting clubs and groups such as the Nature Conservancy. Conservation arguments have motivated government action to protect wetlands and to preserve individuals of certain flora and fauna through the Endangered Species Act.[13] Underlying such actions is the sense of a transcendent aesthetic or moral principle of such high value that it overrides individual economic interests.

Other environmental strategies have focused on the management of resource use—on conserving while using intelligently. The mission of the Forest Service began in 1891 when President Harrison, pursuant to enabling legislation,

10. Yellowstone was initially dedicated as a "public park or pleasuring ground for the benefit and enjoyment of the people[ ]," to be regulated by the Secretary of the Interior "for the preservation, from injury or spoliation, of all timber, mineral deposits, natural curiosities, or wonders within said park, and their retention in their natural condition. . . ." Act of March 1, 1872, ch. 24, 17 Stat. 32, 33 (1872).

11. Pub. L. No. 235, 39 Stat. 535 (1916).

12. The Park Service was charged with promoting and regulating national parks, monuments and reservations, whose purpose in turn was "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." *Id.*

13. 16 U.S.C.A. §§ 1531-1544 (1985 & Supp. 1996).





established the first federal timber reserve in Yellowstone.[14] The Forest Service itself was established in 1905 to protect and allow development of timber and water resources.[15] The Departments of Agriculture and the Interior have worked to protect and pursue practices for sustainable use of land and resources. Government efforts have set aside vast tracts of land, especially in western states. Ranchers have complained bitterly, although such private interests have gained considerably from very inexpensive access to grazing rights and other uses of public resources. Recreational land users complain about the lack of developed campsites or fishing areas, although they have access to considerable expanses of public lands.

Scholars have begun to compare U.S. land-use policies with the policies of countries such as the former Soviet Union, Cuba, and Costa Rica. Further comparative research will prove valuable in understanding the choices faced by democratic governments.

Debates about preservation versus managed use have gained wide public attention in the past decades. They have been centered on such unlikely protagonists as the snail darter, red squirrel, and spotted owl. Current disputes include the definition of protected wetlands and the limits on timber development. What is remarkable in these cases is the lip service given to scientific knowledge even when the decision-making process virtually ignores the scientific evidence. Science, while providing the appearance of value neutrality, sometimes seems to play a much more rhetorical than substantive role in environmental cases.

The legal process in land-use cases often prescribes regular sessions for public input. Independent scientists, however, are rarely consulted. A group of leading environmental scientists who met in 1994, in Wisconsin, to draft a plan for federal public land managers[16] felt that their efforts to infuse public discussions with scientific content were largely ignored. A recent news report pointed to a lack of consideration of the available science in the formulation and administration of federal wetlands policy.

The problem is not that agencies charged with conserving land use are antiscience. It is true that they do not have access to all the scientific knowledge since selected experts present only part of the larger picture. More important,

14. Proclamation No. 17, 26 Stat. 1565 (1891); Proclamation No. 6, 27 Stat. 989 (1891), *both implementing* Act approved Mar. 3, 1891, ch. 561, § 24, 26 Stat. 1095, 1103 (1891).

15. *Compare* Pub. L. No. 150, 33 Stat. 276, 286 (1904) (Congressional appropriations made to Department of Agriculture's "*Bureau of* Forestry") *with* Pub. L. No. 138, 33 Stat. 861, 872 (1905) (appropriations to Department's "Forest *Service*") (emphases added). In 1905 Congress also shifted responsibility for implementation of the 1891 forest-reserves law from the Department of Interior to the Department of Agriculture. Pub. L. No. 34, 33 Stat. 628 (1905). *See supra* note 14 and accompanying text.

16. *See* R.S. Peters et al., *Standard Scientific Procedures for Implementing Ecosystem Management on Public Lands, in* THE ECOLOGICAL BASIS OF CONSERVATION: HETEROGENEITY, ECOSYSTEMS, AND BIODIVERSITY 320-36 (S.T.A. Pickett et al. eds., 1997).

however, they are charged with carrying out policy in a manner that may lack any adequate forum for scientific input. Scientists can join other local "experts" at public hearings, but often they are not called *as* experts. This is due, in part, to not knowing what expertise to seek. The contested nature of scientific results—Just how much land is necessary for adequate habitat protection? Are there "enough" marine mammals or bald eagles?—plus competing public and private values confound the decision-making process.

Another area of federal, state, and local intervention concerns environmental quality. The Environmental Protection Agency seeks to reduce air pollution in large cities, and California is leading the way in legislating a reduction of gasoline-powered vehicles by calling for an increase in electric vehicles. Yet, a recent study in *Science* argued that the use of lead in batteries required for electric storage creates a much worse environmental hazard than gasoline emissions.[17] The concentration of pollutants moves away from the cities to areas that may benefit only from an increase in jobs in the waste-disposal industry. The result, as in many issues of toxic waste disposal, can be criticized as "environmental racism," or more properly in this case "environmental classism."

Concern with racism and economic burdens arises in global issues of land use and environmental protection. It is easy for wealthy industrialized countries to call for restrictions on the use of tropical rain forests or to urge others to avoid polluting. It is hard to argue that we know best how Brazil or Cuba, for example, should oversee or use its valuable biodiversity while calling for local self-determination and democratic ideas. Global protectionism appeals to a set of nondemocratic values, much as if there were an environmental constitution to protect environmental rights—but whose rights and to what end?

Many legislators are joining scientists in calling for more careful discussion of how to provide the best stewardship of our lands, how best to draw on available scientific knowledge, and how to maintain respect for the values and standards of environmental quality of other countries. Comparative studies of U.S. policy with other, especially neighboring, countries may be of immediate practical significance. This would be an excellent time to document each state's procedures and track the results in various arenas. How do different hunting policies in neighboring states, for example, affect wildlife populations? What effects do different states' policies concerning water use, toxic waste disposal, and differential enforcement have on the environment? Which states have long histories of fisheries development, and with what outcome? Which states, like California, have their environmental impact statements on line, and what impact has the availability of electronic data had on state practices and policies?

What results have lobbying efforts by private organizations such as the Sierra Club, the Audubon Society, or Greenpeace had? What is the impact of media

17. Lester B. Lave et al., *Environmental Implications of Electric Cars*, 268 SCIENCE 993 (1995). *But see* Daniel Sperling, *The Case for Electric Vehicles*, SCI. AM., Nov. 1996, at 54.





presentations with dramatic visual images of baby seals and tiny birds, but not of insects or diverse bacteria that inhabit salt marshes? Such species-specific efforts undercut broader arguments for the protection of the larger ecosystem and for preservation of biodiversity in particular.

One means of appreciating the complexity of these environmental and legal issues is to consider specific cases. The following case involves an effort to protect a subspecies of salamander proposed for listing under the Endangered Species Act. It raises questions related to the contingency of scientific knowledge, the qualifying of experts in a democracy, the tensions between democracy and other values, and the right of access to gather scientific information.

### *Case: Conserving Biodiversity*

In 1954 the Sonora tiger salamander, a previously unrecognized subspecies, was described from the San Rafael Valley in southern Arizona. Research revealed that this race has the genetic properties of a hybrid, and likely originated from the union of two other subspecies whose closest populations are now in northern Arizona and eastern New Mexico. Sonora salamanders presently live only in ponds (stock tanks) created and maintained for supporting livestock since as early as 1822; they are found in none of the aquatic habitats—river margins and marshes— that are most similar to Valley habitats existing before the arrival of European settlers. In 1993, conservationists from New Mexico petitioned to have the salamander listed as an "endangered subspecies" under federal law, based on its restricted range and special genetic characteristics. A researcher studying the salamander has been asked by the U.S. Fish and Wildlife Service to help develop a plan for ensuring the protection of the subspecies.

Federally and privately managed lands comprise the San Rafael Valley. Ranchers generally prefer that the subspecies not be listed under the Endangered Species Act, thus avoiding any restriction of grazing rights that might result. Often, the first question in such cases focuses on the basis for concluding that a species or subspecies is "endangered." This entails inquiry into how categories specified in legal policies constrain or structure the ways in which biologists theorize and describe phenomena. Do "rare, threatened, or endangered" legal statuses[18] have conceptual or theoretical significance within biology? What, for example, is the explanation for an increasing interest among ecologists in "rare" species? How are the boundaries characterizing a species determined, and how does the legal system influence who gets to define a species? In general, how do law and science deal with ambiguity, as in definitions of "species," "subspecies,"

18. Applicable federal law defines "endangered species" as "any species which is in danger of extinction throughout all or a critical portion of its range. . . ." 16 U.S.C.A. § 1532(6) (1985), and "threatened species" as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C.A. § 1532(20) (1985).

and "nature?" How do particular extensions of legally cognizable rights, like property rights, alter research practices and types of scientific information accessible to the researchers? How are the "rights" to information determined in these complex contexts with competing claims of authority?

Since Sonora tiger salamanders now live only in "artificial" habitats, it could be argued that this diminishes the claim that they constitute a "natural" evolutionary unit worthy of protection. This raises questions about values. How does what is "natural," and what we are trying to preserve, become defined in law? in science? How do conceptions of nature based on belief systems and values outside of science and the law affect legal policy and scientific practices? How do different groups construct boundaries between humans and nature, and in what ways do these boundaries influence or impede social activism? How and when do environmental values of policy makers (legislators, judges, administrators), and of scientists, differ from those of the general public, and how do legal and scientific processes interact in resolving value conflicts?

Local ranchers claim that they are effective stewards of natural resources, pointing in particular to the persistence of salamanders in habitats they manage. Environmentalists challenge this claim. Numerous governmental agencies have authority to adjudicate the issues and insist that it is they who properly should determine who has expert status. All of these groups asked the scientific researcher to play a mediating role. Thus numerous questions concerning expertise arise. Who qualifies as an expert? How do such qualifications vary among societies and over time? How does the concept of expertise vary among and within disciplines, such as environmental studies versus genetics, or as a function of institutional affiliation, such as membership in a professional society versus a public service organization? How does the participation of scientists within legal and policy venues affect their standing and authority in the scientific and policy communities? How do scientists playing active roles in other social institutions negotiate dual or multiple identities? How do litigation and other lawmaking processes adjudicate between the competing interests and knowledge claims of different stakeholders, allocating privilege to different views? How and why are certain viewpoints systematically included or excluded in such decision-making processes? In areas of conflict and uncertainty, how are opinions developed at various levels of organization, from local to state to international bodies? How are conflicts among these organizations resolved? How does the representation of multiple stakeholders in environmental disputes affect understandings of scientific uncertainty?

As an alternative to formally listing the Sonora tiger salamander as endangered, the U.S. Fish and Wildlife Service asked all parties concerned to participate in a "conservation agreement" that detailed tactics for all to follow to ensure the persistence of the subspecies. Enforcement of this agreement requires sampling on private land, and some landowners have refused access to their property for the collecting of data, raising questions about access to scientific





information. How is access to scientific knowledge affected by other rights, such as real property rights? How does differential distribution of these rights affect participation in environmental decision making? What special problems of scientific access arise when environmental issues cross borders of multiple sovereign entities? To what extent are new legal doctrines needed to recognize scientific access to environmental data?

A few of the issues raised by this case are specific to the Sonora tiger salamander. On the whole, however, the questions stimulated by this case are general and apply to other situations, such as the managing of salmon in the Pacific northwest of the U.S., the managing of fisheries along the Georges Banks in the North Atlantic, and the controlling of acid rain in both the southeast of Canada and the northeast and upper Midwest of the U.S.

## B. Bioprospecting

"Bioprospecting" and "gene hunting" refer to the search for agriculturally, pharmaceutically, or otherwise useful organisms and germ plasm. Often, the "prospectors" are on foreign soil or cooperate with foreign companies, which raises issues of compensation, exploitation, and property rights. Concerns intensified during the 1990s because of increasing attention to loss of biodiversity, together with growing tensions over the disparities between resource-consumptive, industrialized countries and biodiversity-rich, less-industrialized countries.

One legal strategy, thought by some both to promote economic justice and to protect biodiversity, is to extend property rights over valuable biological and genetic resources to the government of those countries—often less-industrialized—in which the resources are found.[19] In a different context, biotechnology companies may assert patent claims to *human*-derived materials obtained from less-industrialized countries.[20] Detractors of this practice have raised objections and questioned the underlying motives of the Human Genome Diversity Project; though not well-substantiated, such doubts have seriously stalled the Project.[21]

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19. *Cf.* the 1983 International Undertaking on Plant Genetic Resources, which characterizes plant genetic resources as "the common heritage of mankind" (*Report of the Conference of the FAO*, U.N. Food and Agriculture Organization, 22d Sess., U.N. Doc. C/83/Rep. (1983)), *with* the 1992 Rio Biodiversity Convention, which recognizes "the sovereign rights of States over their natural resources" and asserts that "the authority to determine access to genetic resources rests with the national governments and is subject to national legislation" (Convention on Biological Diversity, June 4, 1993, Art. 15, para. 1, S. Treaty Doc. No. 103-20, 1993 WL 796847 *22 (Treaty)).

20. *See, e.g.*, David Dickson, *Briefing: Whose Genes Are They Anyway?*, 381 NATURE 11 (1996) (discussing the highly publicized case of a U.S. patent issued on a cell line derived from a Papua New Guinean containing a human T-lymphotropic virus (HTLV)).

21. The Human Genome Diversity Project (HGDP) is an international effort to collect DNA samples from about 500 linguistically distinct populations, to enable the systematic analysis of human genetic variation and the history of modern ethnic differentiation. Dickson, *supra* note 20; Sally Lehman, *Diversity Project: Cavalli-Sforza Answers His Critics*, 381 NATURE 14 (1996).

Developments in conservation biology and genetics are influencing conceptions of property, property rights, and even trade diplomacy. In turn, changing concerns about property and property rights are influencing the direction and practice of conservation biology and genetics, and also of scientific cooperation and noncooperation across national borders.[22] One example of the foregoing is currently receiving considerable attention from biologists, economists, rural sociologists, and science-studies researchers.

*Case: Bioprospecting—Who Owns Life?*

In 1989, the Costa Rican government set up a private, nonprofit, and public interest organization, Instituto Nacional de Biodiversidad (INBio), devoted to "putting biodiversity to work for society."[23] To that end, INBio staff work to inventory and conserve biodiversity, and they enter into agreements with foreign companies that wish to use Costa Rica's biological resources. To carry out the inventory, INBio has provided training in systematics and curation for Costa Ricans who have elementary or high school education, who live in rural areas, and who serve as local biodiversity experts. In addition, INBio promotes collaborations with researchers from foreign universities and museums to help with the inventory.

In 1991, INBio entered into an agreement with the multinational pharmaceutical company Merck. For a specified period, Merck has exclusive rights to receive certain identified materials from INBio and to develop and market products based thereon. In exchange, INBio receives one million dollars plus royalties on any products developed from these materials. These funds support the national parks of Costa Rica as well as INBio's inventory and training programs.

Although this might be seen as a fairly uncomplicated, noncontroversial arrangement, it raises several questions relating to issues like biodiversity and property rights. How is biodiversity defined in scientific and legal communities, both national and international? Specifically, how do these definitions relate to

22. *See, e.g.*, K.S. Jayaraman, *Gene Hunters Home In on India*, 381 NATURE 13 (1996). Recently some Indian biologists, breaking with past practice, have become unwilling to send human blood and DNA samples from indigenous groups to U.S. researchers, at least until suitable property rights and trade agreements are worked out within India and between the two countries. Some of the tissue sample requests have come from biotechnology concerns; others, from population geneticists organizing and promoting the Human Genome Diversity Project. Meanwhile, the Indian government has initiated legislation to restrict export of all genetic material, conditional on appropriate compensation for the development of products based on the material, including transfer of the technology. *Id.*

23. Rodrigo Gamez, *Biodiversity Conservation Through Facilitation of Its Sustainable Use: Costa Rica's National Biodiversity Institute*, 6 TRENDS IN ECOLOGY AND EVOLUTION 377 (1991); *see also* Bruce Aylward, *The Role of Plant Screening and Plant Supply in Biodiversity Conservation, Drug Development and Health Care*, *in* INTELLECTUAL PROPERTY RIGHTS AND BIODIVERSITY CONSERVATION 93, 117-22 (Timothy Swanson ed., 1995).





each other and to public understandings of biodiversity? How do competing values or ethical principles shape these definitions of biodiversity? How do the concepts of biodiversity constrain or structure the types of normative understandings and agreements within differing communities? How does framing biodiversity issues in economic terms influence scientific research in biodiversity? How are the divisions between public and private knowledge affected by social, scientific, and legal structures, and by the interpretations of biological entities? How do different discourses about nature—for example, military, aesthetic, ethical, and religious—affect legal and scientific practices concerning biodiversity?

Although treating biological organisms as commodities might be seen as a way to protect the interests of countries possessing these resources, it raises the specter of "training the locals" to recognize organisms considered valuable by others. Questions arise about the value of alternate arrangements that may be used to accomplish the same ends with fewer negative impacts. How are policies and strategies created relative to biodiversity? Specifically, what are the influences of various preservation strategies like ecotourism, comanagement, economic partnerships, nature preserve planning, or debt-for-nature swaps on biodiversity? What forms and types of these strategies are most effective in defining contexts to achieve preservation aims? What are the mechanisms for assessing the benefits and burdens associated with such strategies for exploiting natural resources? What are the effects of various legal mechanisms, such as property rights, on the distribution and redistribution of these benefits and burdens? Should property rights be awarded, and, if so, by whom, and what kind? How does the discovery, extraction, and development of these resources variously affect the distribution processes? How do different legal, economic, and scientific arrangements for the management of biodiversity affect its protection and cultivation?

Examining issues related to bioprospecting is complicated by the fact that scientists themselves are divided on the relevant definitions of biodiversity as well as the value of preserving biodiversity in the first place. Added to this is the question of whether agreements such as this one are even effective in preserving biodiversity. What roles do the various participants play in shaping policy relative to biodiversity? Specifically, what role do institutions like nongovernmental organizations (NGOs), international banks, or transnational organizations play in developing and implementing legal agreements about biodiversity? How do globalizing influences, such as the media, and localizing influences, such as grassroots organizations, affect legal and scientific practices regarding biodiversity? Given the current abundance of biological diversity in less-industrialized nations, how does the dominance of scientific, economic, and legal institutions in industrialized nations constrain and structure the involvement of less-industrialized participants in its management? To what extent do the interests of the national government reflect the values of the local communities? And

whose interests should be represented? Should indigenous peoples have special rights, and if so, what rights and decided by whom? What are the mechanisms by which these local communities have a voice in the international arena? How do the competing claims get adjudicated—locally and internationally?

## C. Genetics

When genetics confronts the law and social policy, it is often in the form of human genetics. There are, however, some agricultural concerns with bio-engineered products. Society does not object to centuries of traditional breeding to create "better" crops (by which we mean crops more desirable to us—bigger, more flavorful, easier to ship, cheaper to grow, etc.). Yet public concern emerges when animal and plant life forms are genetically engineered, particularly across species lines through the insertion of foreign DNA. This method raises the specter of "playing God" and challenges the public perception of what is "natural."

Thanks to the Human Genome Initiative's mandate to explore ethical, legal, and social issues ("ELSI") as well as the science, considerable research has been done to outline and to begin exploring a wide range of issues. Two types of issues predominate: those where genetics serves as a tool for law, and those in which the genetics research itself raises legal issues. The most common example of the first type is expert testimony by geneticists in paternity cases. More recent and controversial is DNA profiling in criminal cases. Also helping to indicate identity, such DNA profiling has in the past caused confusion, in part because it is by nature probabilistic, and in part because there has been disagreement among researchers about its proper application and interpretation.[24] For all its power, the technique remains in its early stages of development—it is imperfect, dependent on the careful collection and processing of data, and subject to interpretation. We would benefit from further careful study of the science and its limits, its use in courts by trial lawyers (both for the defense and for the prosecution), and its effect on juries.[25]

In the foregoing areas, as well as in the ones that follow, judges and lawyers need to gain sufficient expertise to make wise use of evidence. It is therefore all the more important that they have access to the guidance they need. Recent

24. For examples of scientists' disagreement over the proper interpretation of forensic DNA evidence, see Letter, Daniel L. Hartl & Richard C. Lewontin, 260 SCIENCE 473 (1993), *commenting on* B. Bevlin et al., *Statistical Evaluation of DNA Fingerprinting: A Critique of the NRC's Report*, 259 SCIENCE 748 (1993); R.C. Lewontin & Daniel Hartl, *Population Genetics in Forensic DNA Typing* 254 SCIENCE 1745 (1991), and commentary thereon *in* Letters, 250 SCIENCE 1050-55 (1992).

25. *See, e.g.*, NATIONAL RESEARCH COUNCIL COMMITTEE ON DNA TECHNOLOGY IN FORENSIC SCIENCE, DNA TECHNOLOGY IN FORENSIC SCIENCE (1992); NATIONAL RESEARCH COUNCIL COMMITTEE ON DNA FORENSIC SCIENCE: AN UPDATE, THE EVALUATION OF FORENSIC SCIENCE DNA EVIDENCE (1996); *Symposium: The Evaluation of Forensic DNA Evidence*, 37 JURIMETRICS J. 395-494 (1997).





handbooks for judges, such as the *Reference Manual on Scientific Evidence*[26] distributed through the Federal Judicial Center, should reflect not only the best scientific knowledge, but also the best available assessment of how to use that knowledge. It would be valuable for social scientists to examine the impact of the dissemination of such materials, and to assess what differences they make in the courtroom or in the various stages of the case. Another valuable study would look at what science is taught in law school, how this has changed over time, and to what effect. Similar questions would hold for legislators and managers in regulatory roles. How can we assess what science they know, what they know about how best to use that science, and what difference it makes?

Then there is the second class of issues, those raised by the science itself. Genetic technology now enables us to isolate naturally occurring DNA from organisms; treat, purify or genetically modify it in the laboratory; and develop useful processes and products. More dramatically, we can alter the DNA of living organisms. By inserting foreign DNA we create recombinant "trans-species" life forms such as the Harvard mouse.[27] Similarly, through somatic cell gene therapy we can correct genetic errors in individual organisms (a technique now done experimentally on humans), and through germ-line gene therapy we "treat" *all* of an organism's descendants.[28] Finally, the onrush of human gene mapping and sequencing, along with the ability to ascertain individual variance from genetic norms or "ideals,"[29] enables us to generate predictive genetic information about individuals. For simplicity, the issues that spring from these scientific advances can be clustered under property, privacy, and public safety and health.

### 1. *Property*

Property issues might seem straightforward. Who "owns" the genome—or can DNA (and the genome) *be* property? Patent law has accommodated genomic plant and animal material under traditional legal requirements. Can a similar patentable interest be asserted in *human* DNA? The U.S. Patent and Trademark Office and lower federal courts have ruled that human DNA sequences are patentable, at least where isolated or purified,[30] but objections raised earlier to

26. REFERENCE MANUAL ON SCIENTIFIC EVIDENCE (Federal Judicial Center ed., 1994).

27. The Harvard mouse, a transgenic mouse with a cancer gene added, was designed to serve as a better animal model for the study of human cancers. *See* Rebecca Dresser, *Ethical and Legal Issues in Patenting New Animal Life*, 28 JURIMETRICS J. 399, nn.1, 60 and accompanying text (1988); Gale R. Peterson, *Introduction to the Field of Biotechnology Law*, *in* UNDERSTANDING BIOTECHNOLOGY LAW: PROTECTION, LICENSING AND INTELLECTUAL PROPERTY POLICIES 8 (Gale R. Peterson ed., 1993).

28. This technology, not yet approved for humans, is employed with some plants and animals.

29. *See* Elizabeth A. Lloyd, *Normality and Variation: The Human Genome Project and the Ideal Human Type*, *in* ARE GENES US? THE SOCIAL CONSEQUENCES OF THE NEW GENETICS 99-112 (Carl F. Cranor ed., 1994).

30. For a review of patented human DNA sequences, see S.M. Thomas et al., *Commentary: Ownership of the Human Genome* 380 NATURE 387 (1996); Robert Mullan Cook-Deegan et al.,

patenting life have been renewed and amplified.[31] These objections, along with the proliferation of patent applications on human-derived materials, are likely to continue.

The law's protection of proprietary biotechnology expanded notably in 1980, when the United States Supreme Court ruled in *Diamond v. Chakrabarty*[32] that recombinant bacteria, able to break down components of crude oil (useful for oil spills), were patentable subject matter. We now recognize the patentability of higher trans-specific life forms as well—for example, the Harvard mouse.[33] An industry has developed under the law's promise of patent recognition for a wide variety of bioengineered products and processes utilizing genetic materials.

Interest groups and some scientists have objected strongly to the patenting of life forms and their constituent, or derived, elements. Concerns include animal welfare, environmental safety, agribusiness economics, control of the underlying technology, and adequate protection of those most affected.[34] Often though, the challenges are on fundamental ethical or metaphysical grounds, including religiously based objections to the patenting of "God's creatures." How are such competing sets of values to be reconciled by law? For purposes of patent law, should genetically engineered organisms be distinguished from strains created by more traditional kinds of human intervention? Forms of plants have been patentable for decades; how is patenting genetic material of animals or "higher" organisms different? Fundamental questions are who should be allowed to "own" the genome and how competing values are to be reconciled by law.

### 2. *Privacy*

Public expectations (or, at least, public hopes) for the confidentiality of an individual's DNA sequences are high. Concerns appear most vividly in connection with genetic testing. Such testing already occurs in settings ranging

*Correspondence*, 382 NATURE 17 (1996). For other examples of patented human DNA sequences and discussion of some of the issues surrounding patenting, see Stephen Crespi, *Biotechnology Patenting: The Wicked Animal Must Defend Itself*, 9 EUROPEAN INTELL. PROP. REV. 431 (1995); George Poste, *Commentary: The Case for Genomic Patenting*, 378 NATURE 534 (1995); PATENTING HUMAN GENES AND LIVING ORGANISMS (F. Vogel & R. Grunwald eds., 1994). For a case dealing with patented human DNA sequences, see Amgen, Inc. v. Chugai Pharmaceutical Co., Ltd., 927 F.2d 1200 (F. Cir. 1991).

31. For a review of arguments against animal patenting, see Dresser, *supra* note 27, at 410-24; Peter Stevenson, *Correspondence*, 379 NATURE 672 (1996). For arguments against patenting human DNA sequences, see, for example, Stone, *supra* note 5; Cole-Turner, *supra* note 5; Bernice Wuetrich, *All Rights Reserved: How the Gene-Patenting Race Is Affecting Science*, 144 SCIENCE NEWS 154 (1993). *See also* Crespi, *supra* note 30, and Poste, *supra* note 30, contesting anti-patenting arguments.

32. 447 U.S. 303 (1980).

33. The Patent and Trademark Office issued the first animal patent, U.S. Patent 4,736,866, on the Harvard mouse in 1988. *See* Dresser, *supra* note 27, at nn.1, 60; Peterson, *supra* note 27, at 8.

34. *See, e.g.*, Dresser, *supra* note 27, at 410-24.





from newborn screening for metabolic disorders, to adult screening for reproductive planning, to prenatal fetal diagnosis, to testing for familially linked, late-onset disorders.[35]

An important first question is how we understand the *meaning* of genetic test results. Unlike the often used example of Huntington's disease, the vast majority of genetic conditions (coronary heart disease, diabetes, hypertension, various cancers, and rheumatoid arthritis, for example) are multifactorial, depending for their expression on multiple loci, environmental influences, and the interactions among them. Understanding that their occurrence is a matter of probability is as critical for law and policy as it is for science. Yet many succumb to the temptation to speak of genetics in deterministic terms.

Current law governing genomic privacy is limited and variable, and law reform efforts to date have produced uncertain results.[36] How and to what extent should the law protect the privacy and confidentiality of genetic information? Of genetic information (or inferences) gleaned from other sources? If sensitive characteristics—such as mental disorders, "criminality," or homosexuality—have genetic components, are particularly stringent protections needed? At what point might the value of privacy give way to other interests that would justify, or even require, disclosure of genetic information to blood relatives, for example, where genetic information necessarily generates information about them, or to third parties such as insurers or employers? What care needs to be taken to prevent unjust uses?

Careful research by scientists, social scientists, and legal scholars, working together, can inform the law. One starting point for further study would be a closer look at the policy proposals resulting from the ELSI project discussions, the nature and extent of genetic discrimination by various institutions, and the impact of laws enacted to date.

### 3. *Public Safety and Health*

Concerns have emerged about the safety of genetic manipulations. Courts and regulatory bodies have generally addressed the legal challenges raised,[37]

35. *See, e.g.*, ASSESSING GENETIC RISKS: IMPLICATIONS FOR HEALTH AND SOCIAL POLICY 59-115 (Lori B. Andrews et al. eds., 1994).

36. For recent summaries and analyses of law development relating to genomic privacy and "genetic discrimination," see, for example, *Symposium: The Genome Imperative*, 23 J. L., MED & ETH. 309 (1995); Richard A. Bornstein, *Genetic Discrimination, Insurability and Legislation: A Closing of the Legal Loopholes*, 4 J. L. & POL. 551 (1996); D.H. Kaye, *There Ought to Be a Law*, 37 JURIMETRICS J. v, v-vi (1996); Patricia Roche et al., *The Genetic Privacy Act: A Proposal for National Legislation*, 37 JURIMETRICS J. 1 (1996); Mark A. Hall, *Insurers' Use of Genetic Information*, 37 JURIMETRICS J. 13 (1996); Helen R. Davis & Janice Mitrius, *Recent Legislation on Genetics and Insurance*, 37 JURIMETRICS J. 69 (1996).

37. *See, e.g.*, Mack v. Califano, 447 F. Supp. 668 (D.D.C. 1978); Foundation on Economic Trends v. Heckler, 756 F.2d 143 (D.C. Cir. 1985). For a discussion of regulatory and judicial

listened to arguments, in some cases tasted the results, and allowed the research to continue. Such controversies, however, also illuminate governance issues for science and law as mediated by public perceptions.

There are two main types of safety concerns: risks to humans—from the use of genetically engineered foods and drugs as well as from research-related exposures—and risks to the "environment"—from mutation and "escape" of dangerous organisms, the evolutionary impact of incorporated genetic material, or economic damage from new pests or pathogens. How do we evaluate such risks? Nature itself, of course, is not "safe," and human intervention does not inevitably increase risk or upset a presumed natural ecological balance. What risks does a particular genetically modified organism pose to the environment or to other species? We know much more about genetic hazards and appropriate precautions in some areas than others. What risks should the law address, and what standard should define acceptable levels of hazard? By what measure of confidence or standard of proof?

When legal institutions consider such questions, it is not always clear whose views should count. Some scientists worry that human interventions may cause a degraded gene pool. How widespread is that concern? Where scientists from different disciplines (e.g., ecologists and molecular geneticists), or even from the same discipline, disagree about risks, how should lawmaking bodies choose among them? Does (should) scientific stature determine public influence? What factors (e.g., source and amount of research funding) influence that stature and the content of views? In short, how can we identify, obtain, and use science for advice and decision-making in law and policy? Further, what influence do industry and other interests have on law and regulatory policy in this area?

Public beliefs about genetic safety are important for law. What is it that makes people uneasy: modified organisms, the scientists conducting genetic research, government regulators? What does the public want the law to address? How do the answers vary among different constituencies? Closely related are issues of public participation in democratic policy-making. What kinds of public discourse about genetic safety actually occur, and what is the impact of the discourse on decisions allocating risk? What model of participation is optimal? For example, have the lay members of the federal Recombinant Advisory Committee (RAC) had a significant impact on policy in comparison with the scientist members? How important have the RAC's open meetings been? On a related point, what models do we have to address conflict of interest in government advisory bodies? What kind of oversight should exist for arguably sensitive research, such as defense-related genetic research (a category that might include biological warfare)? What oversight should exist for monitoring threats of genetic terrorism? How much secrecy is justified?

responses to the release of genetically modified organisms, see generally SHEILA JASANOFF, SCIENCE AT THE BAR: LAW, SCIENCE AND TECHNOLOGY IN AMERICA 146-59 (1995).





Safety issues have international dimensions. American policy has been rather careful and strict, at least concerning research done in the U.S., while other countries (China, for example) have held large field trials with little concern about safety in the face of at least equal risks. Yet, consequences are unlikely to respect borders. How can international cooperation be achieved?

Finally, problems arise concerning public health policy. These include population control issues and easily slide into eugenical concerns. Genetic "abnormalities" can appear diseased, and the carrier can be thought of as a public health threat.

A commitment to medical and reproductive autonomy generally favors voluntary medical care and diagnostic testing. Yet, there are public health issues that arise if we do *not* identify and correct genetic "disease" where we can. Failure to require testing allows individuals to carry disease-determining or disease-contributing genes into the gene pool. What are the limits of our concern for public health, and when does this concern outweigh individual reproductive rights? To what extent does the gene pool take precedence over individual genomes? Who decides such questions and according to what criteria?

Such pressures easily become racially or class biased as we identify genetic "diseases" within particular groups and seek—again quite rationally from some perspectives—to "cleanse" our population genetically. Careful scientists will caution against adopting too simplistic or too strongly hereditarian assumptions. Biological science shows that although genes provide information and directions to guide development, in most cases there also is tremendous developmental plasticity and ability to respond to changing environmental conditions. This is particularly true for those genes that seem in preliminary studies to direct behavior. The claims for genetic determinants of violence, for example, need much more exploration, as do the biological and behavioral studies into the causes of homosexuality.

We need to understand more clearly the processes that generate, make use of, and criticize claims about these kinds of complex behaviors—and about "traits" and characteristics (such as race or intelligence) as well. How do people's beliefs about such matters become supported by science, and how do beliefs become linked to the idea that they are "scientific"? Are assertions about the importance of genetics systematically inflated, or understated, in efforts to shape law and public policy? If so, by whom and why? A recent development appropriate for study might be the use of the book *The Bell Curve*[38] to advance arguments about race and intelligence in the debate over affirmative action and the impact that use has had. How do political groups use the work of scientists, and what effect are they having? What determines whether particular claims are accepted? What groups fund research that is used for political purposes? If

38. RICHARD J. HERRNSTEIN & CHARLES MURRAY, THE BELL CURVE: INTELLIGENCE AND CLASS STRUCTURE IN AMERICAN LIFE (1994).

research programs lacking scientific validity are being funded, by whom are they funded and why?

This area involves questions about which scientific voices enter important policy and legal debates. The accomplishments of molecular genetics in recent years may have cast an undeserved "halo" upon genetics as a whole, helping to revive discredited behavioral genetics claims. Deterministic behavioral arguments are sometimes advanced by persons (educational psychologists or political scientists, for example) who themselves lack training in genetics—while *molecular* geneticists refrain from criticism on the ground that such claims are not within *their* expertise. Whose job is it, then, to think about issues at the boundaries between scientific specialties? Who should speak, and who should be heard? Under what circumstances do scientists attack public misrepresentations of their work?

Scientific views of the complexity of the causal role of genes in the production of traits and behaviors diverge from the public's seemingly naive perceptions of genetic determinism and raise serious questions of social responsibility. That the public is presumably largely unaware of misperceptions and misinterpretations of genetic discoveries presented in popular science writing creates dilemmas. Should knowledge be made public in a context in which it will be misinterpreted and misused? On the one hand, knowledge is a social product and the public has a right to know; on the other hand, the potential for abuse has on occasion led to calls for restrictions on research or the dissemination of research results.[39] How might public education about this complex issue ameliorate the situation? How should information about genetics be framed to make it understandable to the general reader?

Moreover, what roles do legal institutions themselves play in fostering, sorting, and evaluating the merits of competing scientific claims, and what more might they do? The state should not (in the interest of scientific progress) and probably cannot (constitutionally) prohibit the positing of hypotheses or, in many cases, the ethical conduct of research. Nonetheless, there are questions that democratic lawmaking institutions appropriately can ask—and regulatory models they might apply (such as systems for the approval of drugs and medical devices)—in seeking to evaluate the validity of claims relating to behavioral genetics. Are there other roles for lawmakers to play?

39. One example is the controversy surrounding a 1995 conference, *Research on Genetics and Criminal Behavior: Scientific Issues, Social and Political Implications*, sponsored by the Institute for Philosophy & Public Policy of the School of Public Affairs, University of Maryland, with grant support from the NIH. *See, e.g.*, Natalie Angier, *At Conference on Links of Violence to Heredity, A Calm After the Storm*, N.Y. TIMES, Sept. 26, 1995, at C5; Peter Maass, *Conference on Genetics and Crime Gets Second Chance*, WASH. POST, Sept. 22, 1995, at B1; David L. Wheeler, *Genetics and Criminology Prove an Explosive Mixture*, CHRON. HIGHER EDUC., Oct. 6, 1995, at A10; David L. Wheeler, *U. of Md. Conference That Critics Charge Might Foster Racism Loses NIH Support*, CHRON. HIGHER EDUC., Sept. 2, 1992, at A6.





The balance between individual rights and community concerns about public health and population control is a delicate one. Eugenical considerations, for example, have resulted in laws to sterilize the mentally defective. The United States Supreme Court upheld one such law seven decades ago.[40] Since then, U.S. law has generally supported a citizen's right to reproduce.[41] Yet, increasingly, others challenge that right—whether because they desire to control population size or to control the quality and public health of the population. There are many precedents here,[42] but we are moving into largely uncharted territory. Thus, detailed and cooperative explorations by historians, ethicists, legal scholars, and scientists will help inform policy and regulatory decisions as scientists make new discoveries.

### *Case: Genetics and BRCA1—Who Owns the Genome?*

A case in point is the availability of a test for mutations in the gene BRCA1. Preliminary evidence suggests that 5–10% of the 185,000 annual cases of breast cancer in the United States are linked familially. The lifetime risk of developing this form of the disease is eight times higher (80–85%) than with nonfamilial breast cancer (10%), and symptoms often appear earlier (before age 50). The presence of a single mutated copy of the gene known as "BRCA1" (discovered

40. Buck v. Bell, 274 U.S. 200 (1927).

41. *See, e.g.*, Skinner v. Oklahoma, 316 U.S. 535 (1942) (striking down law imposing sterilization for certain criminal offenses); State v. Brown, 326 S.E.2d 410 (S.C. 1985) (overturning a sentence offering defendants choice of prison term or surgical castration plus probation); Ill. Ann. Stat. Ch. 730, para. 5/5-5-3(j) (Smith-Hurd Supp. 1994) (statute prohibiting sentences requiring use of birth control). *Cf.* Relf v. Weinberger, 372 F. Supp. 1196 (D.D.C. 1974) (overturning federal regulations under which minor and incompetent poor persons had been involuntarily sterilized under federally financed family planning programs); Walker v. Pierce, 560 F.2d 609 (4th Cir. 1977) (allowing physician to require that Medicaid patients undergo sterilization as a condition of his delivering their third or subsequent child). For analysis, see Rebecca Dresser, *Long-Term Contraceptives in the Criminal Justice System*, HASTINGS CENTER REP., Jan.-Feb. 1995, at S15. For discussion of the use of contraception as a condition of welfare benefits, see David S. Coale, *Norplant Bonuses and the Unconstitutional Conditions Doctrine*, 71 TEX. L. REV. 189 (1992).

The Court, of course, has also recognized the freedom *not* to procreate. *See, e.g.*, Griswold v. Connecticut, 381 U.S. 479 (1965), Eisenstadt v. Baird, 405 U.S. 438 (1972), Carey v. Population Servs. Int'l, 431 U.S. 678 (1977) (contraceptives cases); Roe v. Wade, 410 U.S. 113 (1973), Webster v. Reproductive Health Servs., 492 U.S. 490 (1989), Planned Parenthood of Southeastern Pennsylvania v. Casey, 505 U.S. 833 (1992) (abortion cases). The Supreme Court has not yet addressed claims of a right to reproduce involving technological assistance, or involving the services of non-marital partners willing to provide gametes or to gestate a child. *See, e.g.*, In the Matter of Baby M, 537 A.2d 1227 (N.J. 1988) (surrogate motherhood); Johnson v. Calvert, 19 Cal. Rptr. 2d 494, 851 P.2d 776 (Cal. 1993) (non-genetic (gestational-only) surrogate motherhood); Davis v. Davis, 842 S.W.2d 588 (Tenn. 1992) (dispute over disposition of frozen embryos between genetic parents asserting conflicting rights to reproduce and to avoid reproducing).

For further discussion of procreative freedom and the law, see generally JOHN ROBERTSON, CHILDREN OF CHOICE: FREEDOM AND THE NEW REPRODUCTIVE TECHNOLOGIES (1994).

42. *See, e.g., supra* notes 40, 41.

in 1994), or of "BRCA2" (1995), appears to be associated with the heightened risk. Certain forms of mutation in BRCA1 also create up to a 50% lifetime risk of developing ovarian cancer.[43]

Scientists have developed tests to detect defects in BRCA1, but the predictive significance of these tests for individual cases has not been established. There are over 100 known mutations of BRCA1; the effect of many is unknown. Moreover, in people with no family history of early breast disease, the incidence of the mutations identified by current tests is unknown. There is little evidence, further, that the available medical options following a positive test improve health or survival, and extreme interventions such as prophylactic mastectomy involve significant risks of their own. How should the scientific validity and clinical utility of genetic tests be established? In particular, are the uncertainties surrounding genetic tests and their interpretation adequately understood by scientists? By the public? By regulators, insurers, judges, the media? How should law exercise its regulatory power over the relevant professions and industries?[44]

Extensive media coverage of the genetics of breast cancer has tracked the rapidly unfolding shifts (and attendant uncertainties) in scientific understanding. Media coverage has also emphasized concerns about confidentiality of test results

43. The emerging and rapidly changing understanding of BRCA1 and BRCA2 is captured in Gina Kolata, *Scientists Speedily Locate a Gene that Causes Breast Cancer: Better Screening Is Seen*, N.Y. TIMES, Dec. 21, 1995, at B18; Lisa Seachrist, *Unraveling the Role of the Breast Cancer Gene*, 148 SCI. NEWS 149 (1995); Associated Press, *Breast Cancer in Young Tied to Faulty Gene*, N.Y. TIMES, Jan. 18, 1996, at A19; *Breast Cancer (Gene Discovery) Defective BRCA1 Linked to Disease in Young Jewish Women*, CANCER BIOTECHNOLOGY WEEKLY (Jan. 29, 1996); Natalie Angier, *Surprising Role Found for Breast Cancer Gene*, N.Y. TIMES, Mar. 5, 1996, at C1; Denise Grady, *Findings on Breast Cancer Have Only Complicated the Puzzle*, N.Y. TIMES, Apr. 30, 1996, at B9; Jean Marx, *A Second Breast Cancer Susceptibility Gene Found*, 271 SCIENCE 30 (1996). For a detailed account of the discovery of BRCA1, see KEVIN DAVIES & MICHAEL WHITE, BREAKTHROUGH: THE RACE TO FIND THE BREAST CANCER GENE (1996).

For more recent updates on the estimated risks accompanying mutations in BRCA1 and BRCA2, see J.P. Struewing et al., *The Risk of Cancer Associated with Specific Mutations of BRCA1 and BRCA2 Among Ashkenazi Jews*, 336 NEW ENG. J. MED. 1401 (1997); F.J. Couch et al., *BRCA 1 Mutations in Women Attending Clinics That Evaluate the Risk of Breast Cancer*, 336 NEW ENG. J. MED. 1409 (1997); M. Krainer et al., *Differential Contributions of BRCA1 and BRCA2 to Early-Onset Breast Cancer*, 336 NEW ENG. J. MED. 1416 (1997); J.F. Stratton et al., *Contribution of BRCA1 Mutations to Ovarian Cancer*, 336 NEW ENG. J. MED. 1125 (1997).

44. For recent discussion of some of the clinical and ethical issues surrounding genetic testing for breast cancer, see Judy E. Garber & Deborah Schrag, *Editorial: Testing for Inherited Cancer Susceptibility*, 275 JAMA 1928 (1996); Meredith Waldman, *Panel Softens Cancer Gene Test Warning*, 380 NATURE 573 (1996); Gina Kolata, *Breaking Ranks, Lab Offers Test To Assess Risk of Breast Cancer*, N.Y. TIMES, Apr. 1, 1996, at A1; Ruth Hubbard & R.C. Lewontin, *Sounding Board: Pitfalls of Genetic Testing*, 334 NEW ENG. J. MED. 1192 (1996); Sally Lehrman, . . . *As Concern Grows Over Screening*, 384 NATURE 297 (1996); Gina Kolata, *Advent of Testing for Breast Cancer Genes Leads to Fears of Disclosure, Discrimination*, N.Y. TIMES, Feb. 4, 1997, at B9; Delthia Ricks, *Screening Urged if Breast Cancer Is in Family; Three Flawed Genes That Link the Disease to Family History Can Be Detected in Blood Tests*, THE ORLANDO SENTINEL, Feb. 16, 1996, at D1.





and genetic discrimination. In one recent study, less than half the women in at-risk families opted to be tested for BRCA1 defects, citing concerns that insurers would discriminate against them and that false-positive test results could lead to stigmatization, as well as to unnecessary surgery.[45] What role do the media play in negotiating the supply of and demand for genetic tests? In particular, how do the media cover genetic testing, whom do they consult (and not consult) in preparing stories, and what effect does coverage have on public understanding of the science of genetic testing and its implications for health? What factors can, do, or should influence ownership of, control over, and access to the results of genetic tests? Of the human-derived materials on which they are based? Do advances in understanding of genetics itself shape the determination of what is considered "public" or "private" information? What are the relationships between particular technological developments and legislative and regulatory proposals such as DNA data banks and the proposed Genetic Privacy Act?[46]

Some states have enacted laws addressing confidentiality and discrimination based on "genetic testing," and a limited provision of federal disability law applies to employment discrimination on the basis of genetic tests. What are the different meanings and understandings of the term "genetic test," as used in law, science, and public discourse? In particular: Do genetic tests raise different legal and ethical issues than other biomedical tests, such as those based on phenotype (which can sometimes support genetic inferences), drawn from family pedigree, or gleaned from other kinds of health-related information? How do different groups, with varying interests, gain access to public debate regarding genetic testing? What sorts of arguments and evidence do they employ? Which views prevail and why? What are the ethical and social implications of the answers to those questions? How can the legitimate interests of affected groups be adequately represented? To what extent, and by what mechanisms, should differential treatment (in employment, insurance, and other areas) be allowed or prevented on the basis of genetic test results?

While these questions persist, companies are developing tests for BRCA1 mutations. Some clinicians offer them, lending momentum to work in the area and raising the stakes for policy decisions. Intimate health decisions will be made in a context shaped by business strategies, research priorities, and patenting tactics. What social and commercial interests create demand for genetic tests? What interests generate or influence the scientific research agenda that underlies the development of genetic testing?

Contributors to the project that identified BRCA1 included scientists from the private sector, government laboratories, and academic institutions, and from the U.S. and Canada. Myriad Genetics has applied for a patent on BRCA1. The

45. Caryn Lerman et al., *BRCA1 Testing in Families with Hereditary Breast-Ovarian Cancer: A Prospective Study of Patient Decision Making and Outcomes*, 275 JAMA 1885 (1996).

46. *See* Roche et al., *supra* note 36.

application was controversial because not all of the researchers involved in the collaboration that identified the gene were named as inventors. This controversy was followed by a debate concerning the BRCA2 gene, when a group of English researchers posted a sequence on the Internet—in part with the hope of provoking public debate about the patentability of BRCA2 and of genes in general.

How do the values and perceptions of different interest groups (e.g., scientists, lawyers, academics, and their institutions and professional associations) affect their positions regarding the application of patent law to emerging genetic technologies? How do shifts in scientific practices and cultures (e.g., a transition from the independent "gentleman scientist" to collaborative and interactive science) and belief systems shape legal notions of patentable property over time, and vice versa? What impact does gene patenting, which renders fundamental knowledge and the tools for applying that knowledge proprietary, have on the financing and conduct of further genetic research—including research anticipated to provide limited financial gain—and vice versa? How does this affect disclosure and the free exchange of scientific information?

Opponents of patenting BRCA1, including a coalition of women's and health advocacy groups, find gene patenting objectionable for reasons such as an aversion to commodification of the human genome. They express specific concerns that a patent may restrict scientific research on breast cancer. Others oppose patenting any components of life on religious grounds. Some, however, endorse patenting on the ground that it is necessary to promote investment and progress in scientific understanding and therapy.[47] How do the power relationships among stakeholders—companies, inventors, providers of genetic material, and the public—shape the content of patent law? In particular, what factors are influential in creating and settling disputes over what is private and what is public property? Do these factors differ in countries that do not share a contemporary western framework for considering property interests? Do they differ from Native American and other cultures that also do not share such a framework? What impacts do particular social movements or groups have on the content of, and changes in, law concerning protection of intellectual property? How do such movements or groups cause shifts in understandings of what constitutes intellectual property?

### D. Evolution

Evolutionary theory raises special challenges for our legal and political institutions. Foremost among these challenges is the need to resolve the extent to which the science of evolution can be taught in a country composed of diverse religious groups—each with different beliefs concerning the origin of the world

47. *See, e.g.*, Eliot Marshall, *Rifkin's Latest Target: Genetic Testing*, 272 SCIENCE 1094 (1996); Tamar Lewin, *Move to Patent Cancer Gene Is Called an Obstacle to Research*, N.Y. TIMES, May 21, 1996, at A10.





and the proper place of humankind within it. Influential creationist groups, for example, have repeatedly argued that evolution should not be taught in public schools. Alternatively, they maintain, creationism ought to receive equal time and emphasis.

Some opinion polls indicate that at least half of the public believes in creationism, and perhaps a majority supports its teaching in public schools.[48] Yet, the Constitution prohibits the states from teaching religious views through the public education system.[49] The tension provides a case study in which the first amendment's prohibition against the "establishment" of religion consistently has prevailed over majority opinion (without, however, defeating creationism's advocates[50]). It would be instructive to discover what voters and legislators actually understand about evolution, where they got their ideas, and what—if anything—might change their minds.

A second challenge has emerged from modern discoveries concerning the influences of evolutionary processes on human behavior. Should law, which is fundamentally about the regulation of human social behavior, be informed by insights into the evolutionary origins of some of those behaviors? How will, or can, the legal system incorporate such knowledge? Evidence that evolved, historically adaptive, biological mechanisms can strongly influence behavior seemingly contradicts widely held notions of unbounded personal responsibility and freedom—or results in overzealous, exorbitant interpretations. Moreover, lawyers typically are not trained in evolutionary theory, and often do not see its relevance. Yet evolutionarily significant human responses seem to be implicated in a variety of law-relevant behaviors, from context-specific aggression to parent-child conflicts, from mating patterns to jealous violence. What are the implications of such insights for our notions of legal responsibility (to the extent that the latter rests on assumptions of free will as the basis for conduct), and for the prevention of antisocial behaviors?

A third challenge concerns the extent to which evolutionary thinking might be relevant to our understanding of the origins of political and legal processes themselves. For example, what can we learn about the evolutionary development

48. *See, e.g.*, EDWARD J. LARSON, TRIAL AND ERROR: THE AMERICAN CONTROVERSY OVER CREATION AND EVOLUTION 130-31 (1989). Gallup polls in 1991 found that 47% of Americans believed God created man in his present form within the past 10,000 years, 40% believed that God has guided evolution over millions of years, during which man evolved from less advanced forms of life; and 9% believed purely in evolution with no role for God. *See* ST. LOUIS POST-DISPATCH, Dec. 7, 1991, at 12A.

49. The United States Supreme Court has struck down state legislation prohibiting the teaching of evolution (Epperson v. Arkansas, 393 U.S. 97 (1968)) and, more recently, legislation requiring that if evolution is taught it must be accompanied by the teaching of creationism (Edwards v. Aguillard, 482 U.S. 578 (1986)). Courts have consistently rejected creationist arguments of other types as well in the public schools. *See* STEVEN GOLDBERG, CULTURE CLASH: LAW AND SCIENCE IN AMERICA 75-79 (1994).

50. *See* Schmidt, *supra* note 8; Applebome, *supra* note 8, and accompanying text.

of law? Many biologists are using game-theoretic models to study the extent to which particular genetically influenced patterns of sociality, perceptions of fairness, and moralistic aggression may have evolved. They have observed complex protolegal patterns of reciprocities giving rise to cooperation and have witnessed uncooperative behavior that yields coordinated ostracism and hostility.[51]

Does this have implications for our understandings of the foundations, evolution, and dissolution of democratic order? What was it about the social development of humans that has led to the conviction that some form of democratic government would protect equality in a way that was considered desirable? Is democracy in any meaningful sense a "natural" form of government for humans (as biological beings)? If so, does this "naturalism" have implications for our understanding of the foundations of our sense of justice? If we should "naturalize" law and social practices, what illumination might evolutionary perspectives provide concerning our "commonsense" notions of right and wrong? Or of fair bargains and unjust results?

Contemporary educational and research institutions largely have been built around the principle of disciplinary specialization, which has reinforced the gap between natural and social sciences. Two hundred years ago, many scholars in biology or medicine were reasonably well versed in philosophy, political science, economics, law, or history. Today, these disciplines have become highly technical, and there is far less communication from one specialty to another. As a result, within each of the social sciences, attempts to bridge the gap between the life sciences and the study of human behavior confront methodological criticisms as well as political prejudices. The role of evolution in the interaction of biology and law is ripe for further study within the psychological, historical, legal, and biological disciplines; yet, for most, it is not a part of the core curriculum. It is important, especially in these early stages of interpreting the social and political implications of evolution, that we carry out careful research, including baseline studies of what we know now and what may change as we learn more. This is a necessary step in furthering efforts to adjudicate among competing scientific claims within the legal and political arenas.

51. *See, e.g.*, Christopher Boehm, *Impact of Human Egalitarian Syndrome on Darwinian Selection Mechanics*, 150 AMERICAN NATURALIST 5100 (1997); FRANS DE WAAL, GOOD NATURED: THE ORIGINS OF RIGHT AND WRONG IN HUMANS AND OTHER ANIMALS (1996); INVESTIGATING THE BIOLOGICAL FOUNDATIONS OF HUMAN MORALITY (James P. Hurd ed., 1996); OSTRACISM: A SOCIAL AND BIOLOGICAL PHENOMENON (Margaret Gruter & Roger D. Masters eds., 1986); Martin A. Nowak et al., *The Arithmetics of Mutual Help*, SCIENTIFIC AMERICAN, June 1995, at 76; JOHN MAYNARD SMITH, EVOLUTION AND THE THEORY OF GAMES (1982); RICHARD D. ALEXANDER, THE BIOLOGY OF MORAL SYSTEMS (1987); JORGEN W. WEIBULL, EVOLUTIONARY GAME THEORY (1995); LAW, BIOLOGY & CULTURE: THE EVOLUTION OF LAW (Margaret Gruter & Paul Bohannan eds., 1983); ROGER D. MASTERS, THE NATURE OF POLITICS (1989); THE SENSE OF JUSTICE: BIOLOGICAL FOUNDATIONS OF LAW (Roger D. Masters & Margaret Gruter eds., 1992).





In addition to articulating the research topics and questions described above, the workshops generated four overall recommendations. First, the group recommended that National Science Foundation (NSF) continue to encourage and support research in the areas outlined. Interdisciplinary work, fostered by special initiatives, offers rich rewards because it encourages researchers to take up areas or collaborate in ways they otherwise might not pursue. Second, NSF should encourage various baseline studies. These will provide a source of valuable data for comparison later, to document changes and impacts of policy decisions. Third, NSF should invest in the development of a research infrastructure. We need to assess what is available now as research materials—for example, ethical, legal, and social issues studies at the National Institutes of Health, records of the Recombinant Advisory Committee, and records of several pivotal environmental legal challenges. The research community and policymakers alike need to determine what data are available and to develop plans to preserve and archive that information. Finally, NSF should continue to sponsor efforts to produce a more scientifically informed citizenry. Such efforts should target legislators, judges, and other policymakers.

Nationally and internationally, we face increasing challenges to some of our most basic assumptions about science, the law, and their relations—many of these coming about because of advances within the biological sciences. Some of these challenges question our very understanding of ourselves; others question our understanding of nature or of our place in it. This is an ideal time to take up the most basic research into how our scientific and political systems deal with scientific controversy and change as they seek to address the challenges of adjudicating competing claims in a democracy.