The Nature and Necessity of Law and Science

Robert P. Merges

In the context of his discussion of the postwar curriculum in his book *Law School: Legal Education in America from the 1850s to the 1980s,* Robert Stevens writes:

> One of the most noticeable features of this period was the cyclical approach to changes in the curriculum. In the late 1940's, the innovations in substantive course offerings at Yale were "Recent Scientific Developments and the Law" [and] "Legal Aspects of Public Health." . . . In the late 1960's, similar courses mysteriously reappeared, this time emphasizing the legal control of science and technology [and] law and medicine. . . . Other developments to be seen repeatedly after World War II were *even less innovative*. . . (emphasis added).[1]

To anyone who has devoted some time to thinking about science and its complex relationship with the law, Stevens sends a double message, (1) You are not alone, others have found it profitable to address similar issues, and, therefore, the field of Law and Science *does* have a history in American law schools, but (2) it is not a new idea, and nothing much came of it last time it attracted attention.[2]

I believe there is another plausible way to interpret these curricular cycles. Law and Science as a separate field of study appears and disappears because other disciplines co-opt its subject matter. Although it is difficult to trace the curricular cycles with precision, the experience of several law schools suggests that an "assimilation scenario" is a more accurate description of the rise and fall of Law and Science courses than Stevens's "warmed-over fad" scenario. If vestiges of the earlier experience live on in many scattered corners of the traditional curriculum, then Law and Science courses are and have been much more important than Stevens thinks. In fact, upon reassessment, they may well be viewed as a critical step in the process by which law schools—and thus lawyers and even the law itself—keep in touch with technological developments. Given the importance of these developments and the critical role of law in grappling with their effects, Law and Science begins to look much more like a highly significant

Robert P. Merges is Associate Professor, Boston University School of Law. This piece was written while the author was Julius Silver Fellow in Law, Science, and Technology at Columbia University School of Law. The author thanks Jo Andrews, Glenn Reynolds, Professor Harold Edgar of Columbia Law School, and a very helpful anonymous reviewer for reading the text, and Professors Arthur Murphy and Richard Briffault, also of Columbia, who read an earlier draft prepared for their Seminar in Legal Education at Columbia Law School.

1. Robert Stevens, Law School: Legal Education in America From the 1850s to the 1980s 211 (Chapel Hill, N.C., 1983).
2. Stevens concludes his summary of attempts to include technical subjects (statistics, science, medicine) in the law school curriculum with the assertion that "little effective progress was made." Stevens, *supra* at 211.

institutional response to changing social conditions, and much less like a prime example of institutional torpor.

The experience of Yale Law School in the late 1940s is fully consistent with the assimilation scenario. Beginning about 1946, Myres McDougal taught a course entitled "New Technologies and the Law." The course touched on the legal implications of nuclear power.[3] Although the McDougal course had disappeared by 1960, its subject matter (or part of it) appeared in courses as diverse as Public Utilities and Administrative Law.[4]

The same thing happened to the material covered in the course on Law and Science given at Yale in the 1960s. It covered topics such as environmental risk assessment, biomedical technology, and computer and information systems technology. By the mid- 1970s, almost every introductory environmental law course devoted substantial attention to environmental risk assessment. Basic courses such as Torts and Constitutional Law, as well as seminars in law and medicine,[5] routinely deal with the same issues of biomedical technology touched on in the 1960s Law and Science course (wrongful birth, surrogate parenting, abortion, etc.). Even the computer and information systems segment of the course is discernible in the 1980s curriculum, in the form of segments of courses on Communications Law (FCC practice and implications of information technology), intellectual property (copyrights and patents for software), and even constitutional law (electronic surveillance and privacy).

The assimilation pattern is not unique to Yale. A seminar in Selected Problems of Atomic Energy was offered by John Palfrey at Columbia in the late 1950s; in the 1960s and 1970s, issues of atomic energy regulation began to crop up in courses on administrative law, regulated industries, and, later, environmental law.[6] A similar seminar taught at Harvard Law

3. See Report of the Dean, Yale Law School, 1946–47, Ser. 43, No. 17, at 14, describing McDougal's work.
4. See Bulletin of Yale University Law School for the Academic Year 1960–1961, Ser. 56, No. 16, at 38–39 (description of Public Utilities and Administrative Regulation of Business courses for 1960–61 academic year). Interdisciplinary work in law and other subjects—including topics appropriately classified as Law and Science—was encouraged in the Divisional Program at Yale, law school "major" or concentration proposal initiated in 1956. See Robert H. Freilich, The Divisional Program at Yale: An Experiment for Legal Education in Depth, 21 J. Legal Educ. 443 (1969). Some of the Divisional papers on file in the Yale Law School library show that the program permitted development of Law and Science themes by students. See, e.g., T. A. Farrington, The Inappropriateness of Judicialized Administrative Procedures: The ICC vs. The ABA (1963) (unpublished paper on file at Yale Law Library); J. D. Hope, The CAB as an Instrument of High Policy: A Problem of Adminstrative Coordination (1963) (unpublished paper on file at Yale Law Library); J. F. Porter, Tort and Warranty Liability in the Drug Industry (1964) (unpublished paper on file at Yale Law Library).
5. Medicine has many attributes of a branch of science, yet it has—partly for historical reasons—a slightly different orientation and problem-solving style. Similarly, law and medicine can for the most part be viewed as one facet of law and science; law and medicine is concerned with how society (through law) regulates medical practice, and also with how medical advances create new issues for the law (e.g., surrogate parenting). Both subjects are centered on the two-way relationship between law and another subject. Law and medicine, of course, has a long and distinctive history all its own, encompassing forensic medicine, law and psychiatry, and medico-legal ethics. See, e.g., 1 Transactions of the Medico-Legal Society (1902) (forensic medicine society founded in London in 1901); 1 Medicine, Science and the Law (1961) (journal covering all aspects of law and medicine).
6. See Columbia University School of Law Bulletin of Information 1957–58, Ser. 57, No.

School beginning in 1951 introduced issues that later appeared elsewhere in the Harvard curriculum.[7]

Contrary to what Stevens implies, then, Law and Science courses are more than a testimonial to the ingenuity of law professors in recycling course offerings. In part at least,[8] they seem to emerge in response to a felt necessity, expressed by various law professors at various times, to grapple with issues arising from new scientific and technological developments. They signal colleagues on the law faculty, saying, in effect, "Here are some problems hazily forming on the horizon; the legal system may have to come to grips with them."

As has happened before with courses described by Stevens, Law and Science has been inching its way into the law school consciousness in recent years. This article attempts to relate today's Law and Science courses to those of the past, and to follow the thread of continuity in Law and Science teaching and scholarship over the years. It aims to show that Law and Science is more than a recurrent fad. Law and Science has periodically served as a conduit for curricular innovation, while at the same time maintaining a small core of topics that transcend the assimilation process.

I. What It Is and Where It Came From

If one were completely unfamiliar with legal scholarship and were asked if a specific field exists, one would begin by examining relatively straightforward criteria: the existence of specialized journals, the extent to which a recognized community identifies itself as participating in the field, the availability of special research programs, and other similar activities. From this perspective, Law and Science is clearly a bona fide field. There are a number of special journals that cover Law and Science, among them *Jurimetrics*, published jointly by the American Bar Association Section on Law, Science and Technology and the Arizona State University Law School, *Journal of Law and Technology* (Georgetown), *Journal of Law and Technology* (Harvard), *High Technology Law Journal* (Boalt Hall), *Rutgers Journal of Computer and Technology Law*, and *Santa Clara High Technology Law Review*.

13, at 25 (1957) (description of atomic energy seminar); John G. Palfrey, Atomic Energy: A New Experiment in Government-Industry Relations, 56 Colum. L. Rev. 367 (1956); John Kernochan, Materials for Course on Regulated Industries (1968) (unpublished course materials on file at Columbia Law Library).

7. See 47 Official Register of Harvard University, Academic Year 1950–51, No. 8 (1950), at 46 (description of course in "Problems in the Public Control of Atomic Energy"). For evidence of the movement of this subject matter into the general law school curriculum, see, e.g., Thomas J. Schoenbaum, Environmental Policy Law (Mineola, N.Y., 1982) (includes sections discussing problems of atomic energy).
8. I do not wish to minimize the extent to which the renowned independence of law faculties plays a part in course offerings, nor to imply that some cyclical historical force accounts for the emergence of Law and Science courses every few years. Law and Science courses, in fact, have reappeared several times, and each time they have made a contribution to the curriculum that is difficult to measure—especially if the measurement criterion is whether the field "grows" or the course "survives." Nevertheless, it is interesting that these courses have reappeared at precisely those times in postwar history in which interest in science, technology, and the problems they engender has been strongest. See, e.g., Vannevar Bush, Science: The Endless Frontier (Washington, D.C., 1945); Bruce Mazlish, The Fourth Discontinuity, 8 Technology & Culture 1 (1967).

Many of the journals came into being as part of special centers for Law and Science research. *Jurimetrics*, for example, is the product of the Center for the Study of Law Science and Technology at Arizona State. The Rutgers journal has a similar history. A number of research centers have been created in the past several years that reflect similar developments in the social sciences and public policy fields.[9]

Law students have shown substantial interest in Law and Science as well. Students have established study and exchange groups at Georgetown, Yale, Harvard, Stanford, Columbia, and other schools. Indeed, students have been the driving force behind much of the recent law school interest in Law and Science. As in the case of student "focus groups" in subjects such as Entertainment Law and Sports Law, the student organizations reflect increased interest in specialized areas of legal practice. The course listings of many law schools demonstrate faculty responsiveness to such student interests, usually in the form of special seminars often cotaught by faculty members and outside practitioners.

In addition to courses, centers, and student interest, a field is of course characterized by scholarship. So it is noteworthy that scholars for a number of years have explicitly identified their work as Law and Science.[10] (This may be the most important sign that there is indeed a recognizable field.[11]) Faculty recognition extends to teaching as well; Steven Goldberg of Georgetown counts sixty-nine courses covering Law and Science in the 1985–86 Directory of American Law Teachers.[12]

Objective indications of the presence of a field, of course, fail to tell the whole story. A unifying intellectual thread is, perhaps, the essence of a new field's existence and contribution.

Several attempts have been made to identify the threads running throughout today's version of Law and Science. The most recent is Steven Goldberg's article, entitled "The Central Dogmas of Law and Science," in which he defines Law and Science as the examination of how various legal doctrines apply to the institution of science, especially research and the funding process.[13]

9. See John Walsh, Science and Policy Programs Progress, 235 Sci. 1320 (1987).
10. See, e.g., Steven Goldberg, The Reluctant Embrace: Law and Science in America, 75 Geo. L.J. 1341 (1987), and The Central Dogmas of Law and Science, 36 J. Legal Educ. 371 (1986); Judith Areen, Patricia A. King, Steven Goldberg & Alexander Morgan Capron, Law, Science and Medicine (Mineola, N.Y., 1984); Hugh Gibbons, The Relationship Between Law and Science (pts. 1–4), 22 Idea 43, 159, 227, 283 (1981); Symposium, Science and the Law, 63 Mich. L. Rev. 1325 (1965).
11. Thomas Kuhn speaks of the "constellation of group commitments" that characterizes a scientific field, emphasizing the largely social nature of the scientific endeavor. See Thomas S. Kuhn, The Structure of Scientific Revolutions 181, 2d ed. (Chicago, 1970). The same is quite obviously true in law; some would say even more so, because law lacks (for the most part) the ineluctable physical reality that constrains beliefs, and thus community formation, in science.
12. Goldberg, The Central Dogmas of Law and Science, *supra* note 10, at 371 n.1.
13. *Id.*, at 371. But see Gibbons, *supra* note 10. Gibbons would extend the reach of the field to encompass two additional areas: legal changes and problems engendered by technology, in addition to science, and the use of scientific facts and methods in the legal process. See Gibbons, *supra* note 10, at 45, 49. The first extension of the field—as

I take up the substance of Goldberg's definitional essay below. Notice for now, however, that his essay is a healthy sign for those seeking the birth (or in this case, rebirth) of a full-fledged field. It is a strong attempt to isolate a set of topics for the field, and to announce the attributes that characterize the field. His effort resembles attempts of scientists to grope for a coherent framework as a new line of inquiry emerges, a process identified by Thomas Kuhn, among others,[14] as a key step in forming the intellectual identity of a new discipline.

Just how early it is in the development of Law and Science depends to a certain extent on how one views the field. It is certainly quite distinct from the law *as* science movement of the late nineteenth and early twentieth centuries in which an attempt was made to apply the newly formalized scientific method to legal studies, e.g., the law library as laboratory and law as social engineering.[15] Law and Science as it exists today bears little resemblance to the optimistic projections of the law as science movement; the scientific revolution has overtaken law only in a much more limited and subtle way than nineteenth-century observers predicted.

Law and Science as practiced today, however, does have a number of antecedents. Of these, the earliest is patent law. Although not a "core" course of study, there is a long history of patent-law courses in American law schools.[16] In addition to the purely legal technicalities that enliven the field, patent law necessarily has been concerned with teaching an understanding of science and technology, at least on an ad hoc basis in the context of patents on individual inventions. Current developments in patent law—especially in computer technology and biotechnology—highlight its interrelationship with Law and Science.[17]

Goldberg recognizes—may be implicit in contemporary notions of science anyway, because the barrier between science and technology is more and more elusive. Gibbons' second extension is a point of real contrast with Goldberg's conception. Goldberg compares Law and Science to the teaching of Corporations, asserting that both fields apply law to a distinct subject matter area, just as (he contends) the law of corporations involves applying standard legal doctrines to a unique institution. More will be said about Goldberg's notions of the proper scope of Law and Science, but suffice it to say that a number of noteworthy observers have called for the application of modern scientific knowledge to complex legal questions, and it would be an unnecessary limitation to exclude the latter from the field. See Bruce A. Ackerman, Foreword: Law in an Activist State, 92 Yale L.J. 1083, 1111 (1983) ("[T]o allow law students to continue to graduate without the slightest understanding of statistical reasoning and formal modeling is nothing short of a scandalous dereliction of our professional responsibilities.").

14. Thomas Kuhn, *supra* note 11; Robert K. Merton, The Sociology of Science (Chicago, 1973).
15. See Christopher Columbus Langdell, A Selection of Cases on the Law of Contracts vii, 1st ed. (1871), *cited in* Robert Stevens, Law School: Legal Education in America From the 1850s to the 1980s 66 n.16 (Chapel Hill, N.C., 1983); Oliver Wendell Holmes, Law in Science and Science in Law, 12 Harv. L. Rev. 443 (1899).
16. The most influential law schools produced a number of important early patent practitioners; the first Commissioner of the Patent Office in 1836 graduated from Yale College and studied law at the Litchfield School of Law, and the author of an influential nineteenth-century patent treatise, William Robinson, taught at Yale Law School.
17. See, e.g., Ex Parte Hibberd, 227 U.S.P.Q. (BNA) 443 (Pat. Bd. of App. & Interferences 1985) (patentability of plant tissue cultures developed with genetic engineering techniques); Hybritech v. Monoclonal Antibodies, Inc., 231 U.S.P.Q. (BNA) 81 (Fed. Cir. 1986) (patentability of diagnostic tests using monoclonal antibodies produced using

Other antecedents are more recent. The journal *Jurimetrics*, founded in the early 1960s,[18] originated as an outgrowth of efforts to link law with developments in symbolic logic and computerization. It also covered early aspects of law office automation. Although currently it very seldom publishes articles in the latter area,[19] it continues to publish articles on law and science topics.

Beginning in the early 1970s, the pages of *Jurimetrics* began to reflect a change in prevailing attitudes about technology. The word "technology" began to occur more frequently next to such words as "assessment" and "control."[20] In fact, *Jurimetrics* represents one of the earliest forums for the discussion of issues that later developed into the full-fledged and formalized interdisciplinary field of technology assessment. The publication of

genetic engineering techniques). This dramatic technology represents the most recent involvement of science in the patent system, but it is by no means the first. Chemists, especially, have long been deeply involved in the patent process because of the easy reproducibility of chemical innovations. Some commentators have even called for a general system of property rights in scientific principles, although the reception for these proposals has been lukewarm in most quarters. See generally 3 Steven Ladas, Patents, Trademarks and Related Rights 1849, 2d ed. (Cambridge, Mass., 1975) (proposals in France and before the League of Nations to protect rights in scientific principles). The current resurgence in interest in patent law and intellectual property in general is attributable to other factors besides interest in science, however. In particular, it is seen by many as a policy tool useful in maintaining competitiveness in an increasingly internationalized, technology-intensive economy. See, e.g., Friedrich-Karl Beier, The Significance of the Patent System for Technical, Economic, and Social Progress, 11 Int'l Rev. of Ind. Prop. and Copyrt. L. 563 (1980); Gerald J. Mossinghoff, The Importance of Intellectual Property in International Trade, 26 BNA's Pat. Trademark & Copyrt. J. 546 (1983).

18. See Lee Loevinger, Reviews and Abstracts, 1 M.U.L.L. 15 (1959). Jurimetrics was originally called "M.U.L.L.," which stands for "Modern Uses of Logic in Law," an artifact of a brief and obscure movement in the late 1950s and early 1960s that might best be characterized as "Legal Cybernetics." For examples of this literature, see Patricia James, Applications: Mechanization of a Tax Code, 1 M.U.L.L. 1 (1959); Carl F. Stover, Technology and Law—A Look Ahead, 4 M.U.L.L. 1 (1963) (predicting wholesale automation of law offices and legal practice, leading to era of "hacker" professionals); Carl G. Paffendorf, Esq., Electronic Aids to Estate Planning, 4 M.U.L.L. 54, 54 (1963) ("Computers are unbelievably fast. They rarely make mistakes . . . [Through them, research and expertise] will not fade with the passage of time."); D. A. Kerimov, Future Applicability of Cybernetics to Jurisprudence in the U.S.S.R., 4 M.U.L.L. 153, 153 (1963) ("Cybernetics is used successfully today in the solution of many social, economic, linguistic, psychological, historical, and even literary and cultural problems."). To some extent, the legal cybernetics craze was presaged by a small movement in the 1950s concerning symbolic logic and "legal communication." See, e.g., Felix S. Cohen, Field Theory and Judicial Logic, 59 Yale L.J. 238 (1950); Layman E. Allen, Symbolic Logic: A Razor-Edged Tool for Drafting and Interpreting Legal Documents, 66 Yale L.J. 833 (1957).

19. This function has been taken over by specialty magazines. See, e.g., Law Office Economics and Management. An exception to this is in the area of legal-expert systems—packages of software demonstrating the attributes of "artificial intelligence" that simulate complex legal decisions, such as estate planning and criminal sentencing. By way of blunting the comparison between these articles and the early law and computer logic pieces, it should be mentioned that legal-expert systems are considered valid research projects by software engineers from academia as well as private industry. They are a far cry from the speculative essays first published in M.U.L.L., although it must be said, in fairness, that the early essays do contain the seeds of the later, more useful work.

20. See, e.g., Ronald A. May, Technology Assessment and the Law, 14 Jurimetrics J. 65 (1973); Michael S. Baram, Technology Assessment and Social Control, 14 Jurimetrics J. 79 (1973).

Lawrence Tribe's *Channeling Technology Through Law* in 1973[21] marks the full bloom of this branch of Law and Science.

The spirit of Tribe's book is captured in an excerpt from William Baxter's 1968 article, "The SST: From Watts to Harlem in Two Hours."[22] Baxter argues that common-law tort doctrines such as nuisance should be extended to compensate victims of sonic booms and, by extension, other effects of burgeoning technology. Whether the Baxter study had anything to do with it, the SST was denied landing rights in most of the United States, a political manifestation of the spirit that gave rise to the technology-assessment literature.

In stark contrast to the early years of *Jurimetrics*, articles on technology assessment are now concerned with evaluating the potential harms as well as explaining the benefits of new technologies. The legal system is presented as an appropriate mechanism for achieving a balance between the two. Working with scientists and engineers—those who know the technology best—lawyers are encouraged to infuse the assessment process with an appreciation for technology's impact on human values. As Laurence Tribe wrote in the preface to his book,

> [T]he growing feeling among many that technology has become a dominant and uncontrollable force in their lives requires decisive and visible steps to assert intelligent social control over the entire sequence of technological development if we are not to be plunged into darkness by a desperate and unreasoned political reaction against all scientific inquiry and all technological innovation.[23]

Although the bulk of Law and Science articles are concerned with assessing technology, at least some explore the legal implications of (and celebrate the technology behind) the exploration of outer space. In the 1970s and early 1980s, for example, *Jurimetrics* "discovered" space law.[24] During the same period, the *Journal of Space Law* was founded at the University of Mississippi.[25] McGill University's Space Law Program, founded in the initial flush that followed the publication of McDougal, Lasswell and Vlasic's *Law & Public Order in Space*, stepped up its activities enough in the early 1970s to find a significant place in the international law community.[26] Unlike the student-initiated journals at Boalt Hall, Santa Clara, and Georgetown mentioned above, the early space law publications were aimed at scholars rather than the practicing bar. Aside from the fact that there were few space law practitioners then,[27] this is attributable to the

21. Laurence Tribe, Channelling Technology Through Law (Boston, 1973).
22. William F. Baxter, The SST: From Watts to Harlem in Two Hours, 21 Stan. L. Rev. 1 (1968).
23. Tribe, *supra* note 21, at ii.
24. See, e.g., Nicholas M. Matte, Aerospace Law (Toronto, 1977); Arthur Dula, Regulation of Private Commercial Space Activities, 23 Jurimetrics J. 156 (1983); Glenn H. Reynolds & Robert P. Merges, The Role of Commercial Development in Preventing War in Outer Space, 25 Jurimetrics J. 130, 136 n.33 (1985) (summary of selected space law articles).
25. See 1 J. Space L. 1 (1971) (introductory essay by Stephen Gorove).
26. See, e.g., 1 Annals of Air and Space Law, ed. Nicholas Matte, 181 (Montreal, 1976) (first collection of papers on space law with contributors from major U.S. law schools).
27. The proliferation of space-related commerce, especially satellites, has meant that the practice of space law has now begun to approach the scope and importance its early proponents envisioned. See Glenn H. Reynolds & Robert P. Merges, Outer Space:

traditions of international law scholarship out of which space law grew—traditions that included the European style of peer-reviewed journals. Consequently, these space law publications devoted much space to theoretical issues (space jurisdiction, for instance) in their early years. With the Outer Space Treaty of 1967, the Moon Treaty of 1979, and the growing number of orbiting satellites, the journals have presented less esoteric subject matter in recent years.

II. Elements of Law and Science in Established Subjects

At roughly the same time that space law and technology assessment were receiving attention, a number of established subjects were meeting novel problems growing out of new technologies. The first substantial articles on admissibility of computer-generated evidence, for example, appeared in the 1960s. Statistical evidence, dating from the "Brandeis Brief" of 1908, became more common in the 1950s.[28] It gained wider acceptance in the 1970s, at first mostly among practitioners and then in the "Law and Sociology" or "Law and Society" movement,[29] whose intellectual roots go back to the 1920s. And, as mentioned above, the intellectual property field saw the emergence of a distinct literature dealing with the protection of new technologies.[30]

Also in the 1970s, the environmental law field emerged as a major force. With its complex risk-benefit analysis, mandated by the National Environmental Policy Act of 1970, its emphasis on assessing the impact of new projects (which in many cases include new technologies), and its reliance on contemporary ecological principles, environmental law obviously is permeated with Law and Science issues. So the growth of environmental law opened new vistas for Law and Science as well.

Problems of Law and Policy (Boulder, Co., forthcoming), especially Chapter 8, The Private Law of Outer Space Activities.

28. See Hans Zeisel & David Kaye, Social Science Research in Constitutional Litigation, *in* 4 Encyclopedia of the American Constitution, ed. Leonard W. Levy, Kenneth L. Karst & Dennis J. Mahoney, 1702 (New York, 1986).
29. For a developmental history of Law and Sociology, see Wallace D. Loh, Social Research in the Judicial Process (New York, 1984). Empirically minded jurists have long dreamed of a unified, empirical social science-based approach to law. See, e.g., Myres S. McDougal, The Law School of the Future: From Legal Realism to Policy Science in the World Community, 56 Yale L. J. 1345 (1947) (tracing the tradition back to Oliver Wendell Holmes and Roscoe Pound). The approach was criticized for its tedious and exhaustive methodology, which was typically applied to quite narrow questions. See, e.g., David F. Cavers, Science, Research, and the Law: Beutel's Experimental Jurisprudence, 10 J. Legal Educ. 162 (1957) (reviewing Frederick K. Beutel, Some Potentialities of Experimental Jurisprudence as a New Branch of Social Science (1957)).
30. See, e.g., Duncan M. Davidson, Protecting Computer Software: A Comprehensive Analysis, 23 Jurimetrics J. 337 (1983); Robert P. Merges, Apple v. Franklin: An Essay on Technology and Judicial Competence, 2 Yale L. & Pol'y Rev. 62 (1983). Largely as a consequence of student interest, there has been a concomitant growth in law school courses dealing with the transactional problems of companies in new technology-intensive (and thus intellectual property-dependent) industries—especially the "high tech" computer and biotechnology industries. Because these courses are concerned primarily with the commercial products stemming from new scientific and technical advances, they might better be classified as courses in "Law and Technology." They are, however, meant to be included in the term Law and Science.

One outgrowth of the environmental law scholarship of the 1970s was a branch of administrative law concerned with deficiencies in the "technical literacy" of institutional actors in the legal system who were called on to supervise implementation of environmental statutes. An important debate centered on nuclear power plant regulation, which had been of some concern since the late 1940s.[31] A central focus of the literature was the scientific capacity of reviewing courts.[32] How, it was asked, could judges who were scientifically naive be expected to assess administrative decision making that was infused with highly technical questions occupying squadrons of trained scientists in the agencies themselves? The appealing solution of a "science court" to resolve all technical questions has made virtually no progress.[33] In its place, academics and judges generated (and continue to generate) proposals and experiments to foster new institutional structures capable of reviewing issues with a scientific or technological dimension.[34]

In addition to new institutional structures, judges have been forced to educate themselves (with some success) to understand scientific issues and evidence. In *Ethyl Corp. v. EPA*,[35] for example, the court waded through a complex thicket of statistical data in the process of upholding regulations requiring the phaseout of lead additives in gasoline. The judges' mastery of

31. See Arthur Kantrowitz, Proposal for an Institution for Scientific Judgement, 156 Sci. 763 (1967), and Controlling Technology Democratically, 63 Am. Scientist 505 (1975); James A. Martin, The Proposed Science Court, 75 Mich. L. Rev. 1058 (1977); Joel Yellin, High Technology and the Courts: Nuclear Power and the Need for Institutional Reform, 94 Harv. L. Rev. 489 (1981). The Kantrowitz articles called for a special science court to resolve purely "technical issues" presented to federal courts. The general response to the "separatism" thesis was that scientific and technical issues were so intertwined that empaneling a science court would amount to an abdication of the essentially judicial task of dispute resolution in federal cases. Yellin, once a strong advocate, modified his position substantially in a later piece. See Joel Yellin, Science, Technology and Administrative Government: Institutional Designs for Environmental Decisionmaking, 92 Yale L.J. 1300 (1983) [hereinafter Science, Technology and Adminstrative Government]. See Stephen L. Carter, Separatism and Skepticism, 92 Yale L.J. 1334 (1983). The notion of separating technical from legal questions had been rejected as early as 1965, even before the "separatism" debate got started. See Harold L. Korn, Law, Fact, and Science in the Courts, 66 Colum. L. Rev. 1080, 1090–91 (1966). On the adminstrative law issues engendered by the passage of NEPA, see Arthur W. Murphy, The National Environmental Policy Act and the Licensing Process: Environmentalist Magna Carta or Agency Coup de Grace? 72 Colum. L. Rev. 963 (1972).
32. To be sure, this theme was often sounded in the "science court" debate. See Law and Science in Collaboration, ed. J. Daniel Nyhart & Milton M. Carrow (Lexington, Mass., 1983). It has even been applied in the context of technology-related intellectual property cases. See Merges, *supra* note 30. See generally Carter, *supra* note 31.
33. See *supra* note 31.
34. See, e.g., Scientists in the Legal System: Tolerated Meddlers or Essential Contributors? ed. William A. Thomas (Ann Arbor, Mich., 1974); Yellin, Science, Technology, and Administrative Government, *supra* note 30; Patricia Wald, Making "Informed" Decisions on the District of Columbia Circuit, 50 Geo. Wash. L. Rev. 135, 143 (1982) ("From certain facts in the record, the agency draws critical inferences that assume a general knowledge of fundamental principles of disciplines such as mathematics, physics, science and mechanics. The untutored judges have no sense of whether those inferences are correct."); Harvey Brooks, Social and Technical Inventions: Challenges to Legal and Political Institutions, 22 Idea 137 (1981); Symposium, Curbing Ignorance and Arrogance: The Science Court Proposal and Alternatives, 19 Jurimetrics J. 385 (1979).
35. Ethyl Corp. v. EPA, 541 F.2d 1 (D.C. Cir. 1976) (*en banc*), *cert. denied* 426 U.S. 941 (U.S. June 14, 1976) (No. 75–1612).

the biochemical and epidemiological expertise required for an effective resolution of the case impressed some observers.[36]

Toxic tort litigation raises similar questions of competence. The statistical sophistication with which matters of causation are presented, along with the detailed explanations required to understand specific health hazards, make scientific literacy all but a prerequisite for practitioners and judges concerned with these cases. As in the environmental law field, judges are beginning to show signs of technical competence, in some cases even questioning the scientific reliability of data presented by expert witnesses.[37] The academic law community also has shown an interest in the area.[38]

Finally, a growing number of commentators are examining the constitutional dimensions of potential restrictions on research activities by scientists.[39] Some commentators have found a clear-cut right in the First Amendment that protects scientific research from restrictions aimed at foreclosing development of theories thought undesirable by a majority of citizens.[40] At least one commentator has criticized the approach, contending that "the scientists and their allies are trying to make an end-run around public opinion, which is often cheaper than trying to change people's minds."[41] Constitutional law scholars are thus not immune from questions of Law and Science.

As the foregoing demonstrates, a wide variety of legal subjects—from patent law to constitutional law—now encompass issues that call for at least some degree of scientific knowledge. Members of the legal community, however, rarely have scientific backgrounds. The result, as an exasperated judge in a patent case once declared, is that amateurs end up deciding cases argued by experts.[42] The need to educate amateurs to understand and

36. See Yellin, Science, Technology and Administrative Government, *supra* note 31, at 1314 (praising the court for "reach[ing] its own conclusions").
37. See Eliot Marshall, Immune System Theories on Trial, 234 Sci. 1490 (1986) (describing actions taken by Judge Jack Weinstein of the Eastern District of New York in the Agent Orange litigation. The judge rejected affidavits from "clinical ecologists" purporting to demonstrate a significant relationship between exposure to toxic substances and subsequent disease symptoms).
38. See, e.g., E. Donald Elliott, Goal Analysis versus Institutional Analysis of Toxic Compensation Systems, 73 Geo. L.J. 1357 (1985); Jack B. Weinstein, The Role of the Court in Toxic Tort Litigation, 73 Geo. L.J. 1389 (1985); Bert Black & David E. Lilienfeld, Epidemiological Proof in Toxic Tort Litigation, 52 Fordham L. Rev. 732 (1984); Bruce A. Ackerman, Reconstructing American Law 105–10 (Cambridge, Mass., 1984).
39. See, e.g., Richard Delgado & James R. Millen, God, Galileo, and Government: Toward Constitutional Protection for Scientific Inquiry, 53 Wash. L. Rev. 349 (1978); James R. Ferguson, Scientific Inquiry and the First Amendment, 64 Cornell L. Rev. 639 (1979); Steven Goldberg, The Constitutional Status of American Science, 1979 U. Ill. L.F. 1; Robert M. O'Neil, Scientific Research and the First Amendment: An Academic Privilege, 16 U.C. Davis L. Rev. 837 (1983); Stephen L. Carter, The Bellman, the Snark, and the Biohazard Debate, 3 Yale L. & Pol'y Rev. 358 (1985).
40. See, e.g., Goldberg, *supra* note 39.
41. Carter, *supra* note 39, at 377 (footnote omitted).
42. Rohm & Haas Co. v. Dawson Chem. Co., 599 F.2d 685, 706 (5th Cir. 1979) (Gee, C.J.). Judge David Bazelon sounded a similar theme when he wrote: "Critics note, quite correctly, that judges have little or no training to understand and resolve problems on the frontiers of nuclear physics, toxicology, hydrology, and a myriad of other specialties." David L. Bazelon, Risk and Responsibility; Risk Regulation: A Problem for Democracy in the Technological Age, 205 Sci. 277, 278 (1979). At least one legal

manage legal disputes having a scientific dimension is at the heart of the problem that the academic field of Law and Science must address.

III. Educating the Amateurs: The Proper Goal of Law and Science?

Steven Goldberg defines Law and Science as the study of how legal doctrines apply to the institutions of modern science.[43] Although it is difficult to quibble with his conclusion that science is an enterprise worthy of being studied by lawyers, the field as currently constituted may be too narrow.[44] The "and" in Law and Science, after all, should work both ways; legal perspectives on science should be joined by a study of scientific facts and methods in the legal system. Otherwise, Law and Science would be primarily concerned with regulating the behavior of scientists and bringing scientific institutions into the ambit of our otherwise pervasive regulatory regime. This focus excludes the other half of the equation: the impact of scientific institutions on the legal system.

To be fair, Goldberg suggests that the field does include analysis of the effects of science on various fields of law. For example, he mentions a recurring theme in the literature, the conflict between review procedures in administrative law and the scientific insistence on empirical testing.[45] The conflict is often manifested in the adverse reaction of scientists to the due process constraints on regulatory decision making. Throughout his article, however, Goldberg emphasizes the tendency of the field to discuss legal issues from the perspective of the scientist, rather than the other way around. The goal seems not so much to instruct law students about scientific issues as to educate them about the divergence between how scientists and lawyers approach problems. Although that is certainly a necessary function of the emerging discipline, it is not the only function.

The current composition of the field, although a far cry from reflecting a straight "separatist" stance, still leaves technical issues primarily in the hands of scientists. Students learn how scientists think (and how scientific institutions work), but the science itself is relegated to secondary status. Although the current approach has merit as far as it goes, it seems to run the risk of further enshrining the priesthood of science, thereby reinforcing the amateur status of legal actors.

educator saw this need and offered a puissant vision of a law school structured to meet it. See Interview with Dr. Louis De Alessi: Antitrust, 'Bias,' and the Special Vision of Henry Manne—A Merger of Law and Science, 14 Ant. L. & Econ. Rev. 95, 97 (1982) (Henry Manne's ideal law school would teach economics to all and include special instruction for future patent practitioners, for whose benefit it "would have . . . a department of technical people—chemists, physicists, engineers . . . so that his graduates would know more than just what the current law was; they would know how to work with it, to apply it."). Cf. Roy H. Massengill, Training Academy For Patent Attorneys, 9 Am. Pat. L.Q.J. 365 (1982).

43. Goldberg, *supra* note 10, at 371.
44. It should be understood that Goldberg's article is purely descriptive and is meant to convey a sense of the concerns of the contemporary Law and Science literature and curricula. It in no way indicates his satisfaction with the field as presently constituted. My comments are directed solely at the Law and Science field as he describes it, rather than at his concept of what the field should look like ideally.
45. See Goldberg, *supra* note 10, at 378.

Law and science needs to expand its view of the lawyer's role by recognizing that lawyers are capable of understanding scientific issues—not all of the scientific issues, and not at the most detailed level of analysis, just scientific conclusions and the methodologies on which they are based. At the same time, it is vital that Law and Science also strive to help lawyers recognize and deal with the limits of their knowledge. Knowledge about how scientists think and how scientific institutions work should be presented in this context, and not in the context of a reification (and thus distancing) of the scientific endeavor.

The proper scope of Law and Science proposed here gives rise to several objections that must be confronted. The first is the usual response to any proposal to teach nonexperts a technical subject: the risk of being caught between the Scylla of technical triviality (not enough science) and the Charybdis of technical overkill (too much science). Perhaps the most effective answer to this criticism is the experience law schools have had with Law and Economics, a field kindred to Law and Science whose pedagogical history proves quite useful in assessing the chances for success of a new "technical" subject matter in the law school curriculum.

The critical point about Law and Economics is that although it is highly sophisticated at the most advanced level, the basic premises and principles are well within the grasp of many law professors. Witness the ever-increasing ranks of law school courses and articles on the topic. Further, no prior economics background is necessary for students to understand the area. One empirical study even concludes that prior economics training conferred no discernible advantage on students in law school economics courses.[46] Law and Economics teaches an approach to legal problems as much as a specific body of information. The same is true of Law and Science; indeed, given the rate at which people forget, this may be the most important contribution the two courses can make to legal education. Like a good Law and Economics course, Law and Science should prepare students to deal not with a fixed body of information but with the methodology of a rapidly changing field. Exposure to basic scientific sources and institutions may be the most essential ingredient in a successful Law and Science course.

Naturally, there are differences between Law and Science and Law and Economics that affect the way each is taught. The most important difference is that Law and Economics seeks to "import" into the law a unified body of thought traditionally outside the purview of law. It supplies analytical tools. Law and Science is similar only in part, e.g., in the use of statistical techniques to understand technical issues in the law of evidence (including the problems of toxic tort causation mentioned above). Law and Science, however, seeks to import knowledge about a complex subject matter on which the traditional tools of law are brought to bear (for instance, in the traditional standards for determining infringement of intellectual property rights). Another example is administrative review of

46. See John J. Siegfried, Factors Affecting Student Performance in Law School Economics Courses, 31 J. Legal Educ. 19, 26 (1981) (indicating that previous coursework in economics conferred no advantage on students in Law and Economics courses he has taught at Vanderbilt).

environmental decision making, in which scientific information is a critical component of the subject matter under review.

A good example of the process is provided by recent litigation concerning the adequacy of computer models in measuring air pollution for purposes of compliance with the Clean Air Act. In *Ohio v. EPA*,[47] the court invalidated the EPA's use of a computer model to generate air pollution counts for enforcement purposes. The court held that the EPA had failed to verify the accuracy of the model by means of empirical samples that tested the model's projections. In the course of its opinion, the court relied heavily on its own substantive review of the computer model, its operating instructions, and its minimal empirical validation, as well as the testimony of experts in environmental and computer science.

The confidence with which the court approached the scientific issues before it is heartening. (It is no coincidence that the author of the opinion, Judge Gilbert Merritt, has often tackled complex patent cases.) The case stands, in fact, as a model opinion in this regard. Just as important, however, is the potential lesson it holds for judges and lawyers confronting a wide array of complex legal-scientific issues. It is lessons such as these that Law and Science should be aiming to teach.[48]

There are several reasons the law school curriculum should include technical material sufficient to familiarize students with scientific methods. First, it is partially through recently graduated judicial clerks that judges receive a steady infusion of new knowledge; a group of clerks with minimal technical competence ought to be available to judges who want them. (Note that law students with science backgrounds, though growing in number, still make up only a small percentage of the law school population.)[49] Second, because an unknown proportion of students (perhaps a majority) will encounter at least some technical-legal problems in their careers, the law schools should prepare them accordingly. Third, law graduates are historically overrepresented in the various branches of government; but unlike, say, France, in which the École Polytechnique system trains future leaders at least minimally in technical disciplines, political leaders in the

47. Ohio v. EPA, 784 F.2d 224 (6th Cir. 1986).
48. As an example, Stephen Carter teaches a course at Yale Law School entitled "Legal Control of Science and Technology" that touches on the environmental decisionmaking review issues that surfaced in Ohio v. EPA. *Id.* Many environmental law courses also deal with the material with varying degrees of technical sophistication. One scientist of note has asserted that medical malpractice cases demonstrate that lawyers are quite capable of absorbing scientific information; he concludes that there is no inherent reason scientifically amateur lawyers cannot be responsible regulators when science is involved. Lewis Thomas, Overview: Regulating Biotechnology—Introduction, 3 Yale L. & Pol'y Rev. 309, 314 (1985). Cf. Maxine F. Singer, Genetics and the Law: A Scientist's View, 3 Yale Law & Pol'y Rev. 315 (1985) (decrying lack of scientific training among lawyers working in technical areas such as regulation of recombinant DNA experiments, but generally confident that law students can absorb scientific information when it is presented to them).
49. This information was obtained through informal consultations with admissions officers at Yale, Columbia, and Boston University law schools. In addition, my experience in assisting student law and technology interest groups has shown that normally no more than a handful of students with science degrees matriculate at law schools in any given year.

United States for the most part must learn the science they need while on the job.[50]

A final reason for minimal technical familiarity on the part of lawyers relates to that small portion of them who will one day become judges. During the past forty or so years, the rise of the administrative state has increasingly involved courts in ongoing governing processes. There is a close working relationship between the courts and the adminstrative agencies responsible for applying technical know-how to the regulatory process—the Department of Agriculture, the Food and Drug Administration, the Occupational Safety and Health Administration, and the Environmental Protection Agency, to name a few. In many ways, the federal courts share the long-term orientation of the agencies.[51] In light of the traditional short- term view of Congress and the constitutional inhibitions on congressional oversight by means of a legislative veto,[52] it is likely that courts and agencies will be increasingly responsible for the resolution of technical issues growing out of the regulatory activities. This alone ought to justify the study of Law and Science.

IV. Law and Science as Mostly Self-Effacing

Despite the need for Law and Science as a separate discipline, most of its contributions ultimately may be reabsorbed by individual subject areas. After all, most of the science-laden problems that define the field are drawn from established fields. The best measure of the success of Law and Science in the long run may well be the rate at which it disappears. When other fields routinely recognize and begin to grapple with science-related problems arising from their traditional subject matters, there will no longer be a need for those aspects of Law and Science that were drawn from the individual fields.

50. On the system of science training for future policymakers in France, see Harry W. Paul, From Knowledge to Power: The Rise of the Science Empire in France, 1860–1939 (New York, 1985).
51. See R. Shep Melnick, The Politics of Partnership, 45 Pub. Admin. Rev. 653, 655 (1985) (courts have changed the "balance of power" in regulatory affairs, by creating a court agency-Congressional subcommittee special-interest power group with shared goals and interests). It is widely accepted in the field of organizational behavior that long-term interaction between working groups creates specialization. See, e.g., Herbert A. Simon, Administrative Behavior 136–39, 3d ed. (New York, 1976). The courts themselves have noted this development. See, e.g., Greater Boston Television Corp. v. FCC, 444 F.2d 841, 852 (D.C. Cir. 1970) (courts are "in a real sense part of the total administrative process"); Environmental Defense Fund v. Ruckelshaus, 439 F.2d 584, 597 (D.C. Cir. 1971) ("We stand on the threshold of a new era in the history of the long and fruitful collaboration of adminstrative agencies and reviewing courts"); Int'l Harvester Co. v. Ruckelshaus, 478 F.2d 615, 647 (D.C. Cir. 1973) ("[A] court's role on judicial review embraces that of a constructive cooperation with the agency involved in furtherance of the public interest"). See generally Thomas O. McGarity, Substantive and Procedural Discretion in Administrative Resolution of Science Policy Questions: Regulating Carcinogens in EPA and OSHA, 67 Geo. L. Rev. 729 (1979); Harold Leventhal, Environmental Decisionmaking and the Role of the Courts, 122 U. Pa. L. Rev. 509 (1974).
52. See Immigration and Naturalization Service v. Chadha, 462 U.S. 919 (1983) (finding legislative veto in statute unconstitutional under Separation of Powers Principle). See generally Note, Chadha and the Nondelegation Doctrine: Defining a Restricted Legislative Veto, 94 Yale L.J. 1493 (1985); Harold H. Bruff & Ernest Gellhorn, Congressional Control of Administrative Regulation: A Study of Legislative Vetoes, 90 Harv. L. Rev. 1369 (1977).

There is, however, a certain "core" content of Law and Science that stands alone. In addition to the institutional perspective described by Goldberg, the core includes scientific methodology, especially statistics.[53] Although traditional courses can assume responsibility for relevant aspects of science, the general tools and techniques of science are too remote to justify much coverage in the established curriculum. The relatively new Law and Statistics or Law and Sociology courses, of course, can assume at least some of the burden.[54]

The success of Law and Science, then, might well be measured by the absorption rate of its transitory substantive content into the other disciplines over the long run. Were it not for the "science gap" in legal education and scholarship, the established subject headings, along with newer courses such as Law and Statistics, would be sufficient to grapple with most of the byproducts of new scientific knowledge and techniques, much as they did in the late 1940s and 1960s in the Yale curriculum. While the gap continues to exist, however, Law and Science must try to fill it. Once the gap disappears, and until new issues arise, a certain core should remain, one that emphasizes the uniqueness of scientific institutions and covers the scientific methodologies that are inappropriate in other courses.

I do not mean to imply that Law and Science has an insignificant role to play; it has traditionally been a significant source of innovation in the legal curriculum. It is simply a role that probably should, if the play goes well, largely melt away by the second or third act.

53. Despite the growing importance of statistics in legal practice and scholarship, relatively few law schools offer statistics training. See David H. Kaye, Thinking Like a Statistician: The Report of the American Statistical Association Committee on Training in Statistics in Selected Professions, 34 J. Legal Educ. 97 (1984). Statistical reasoning is at the heart of many scientific issues that make their way into the law; statistics is thus a legitimate subject for inclusion in a Law and Science course.

54. A recent article suggested that at least one school has had success increasing the enrollment in its Statistics and Law course by emphasizing practice-oriented applications of statistics. See John Monahan & Laurens Walker, Teaching Social Science in Law: An Alternative to "Law and Society," 35 J. Legal Educ. 478 (1985).