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The Growing Gap Between Emerging Technologies and Legal-Ethical Oversight

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The Pacing Problem

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Springer

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Foreword

On November 4, 1811 an armed gang attacked the home of a master weaver in the village of Bulwell in the Midlands of England. The gang's mission was to destroy six weaving machines. They succeeded in smashing them all. They called themselves the followers of General Ludd (or King Ludd or Captain Ludd) and for a little over a year they terrorized the Midland counties of England, busting textile machinery. The Luddites were skilled weavers, artisans of clothes-making, many stockingers, being driven out of business by the use of automated looms operated by unskilled labor that produced goods, primarily mittens and stockings, at lower prices, of inferior quality, and at six times the quantity that the fruits of their skilled labor could fashion.

In about three months the Luddites destroyed 1,100 textile machines. The British government took action on the side of the new industrialists, passed a law making the penalty for destroying a machine death by hanging, and sent in the Army to enforce it. The law was widely interpreted as proclaiming that machines have a greater value than humans. Death sentences and other penalties were carried out when machine smashing Luddites were captured. At least 24 Luddites were hanged, 44 were transported to Australia, and 18 imprisoned. The damage to machinery in the Luddite forays was estimated at £100,000.

The Luddites claimed in their pamphlets that they were not against machinery or technology per se. Their opposition was focused on "machinery hurtful to commonality." By that, they seemed to mean that they opposed the use of technologies over which the general population, presumably through their local governments, had no control and that were in their view inimical to the collective well-being and interests of that population. For the skilled weavers in the Luddite bands the machinery that they attacked fit that description not only because it produced clothes inferior to the products of their handiwork, but because its use reduced their standards of living substantially while economically benefiting only well-heeled industrialists. Their rage against the machine was triggered by the threat of job losses, penury, and to the very existence of their trades.

The Luddites, of course, were utter failures. Technology moved on and at a pace that those institutions of society that should be concerned about positive and negative effects on "the commonality" have been unable or unwilling to match ever

since. The Luddites disappeared as an organized body, but their legacy, their name, survives as a pejorative description of technophobes, and that is unfair to those skilled weavers that smashed mechanical looms in the early nineteenth century. There is something of value to be learned from the Luddites and it is not that technological progress must be stopped whatever the cost. It is that there may be a need to regularly evaluate our conception of moral permissibility and the legal apparatuses we employ to protect and defend the general interests of the community in order to insure that they are not stalled at the starting blocks when technological innovations capable of producing radical changes in communities and lifestyles are way ahead of them on the track, modifying virtually every aspect of communal and personal life. That is not to say that modifications are not welcome or that many are not significant improvements. Many are beneficial, but at the same time they create considerable shifts in the way the world must be perceived and in the conception of our individual and collective places in it. Think of the social scene before and after the automobile or the train. The wide-spread presence of the television sets in the homes of Americans radically altered neighborhood life in the 1950s, while in the 1960s the Vietnam War was not just somewhere in Southeast Asia, but, thanks to television, it was in most American living room every day.

The traditional moral theories with roots in the pre-industrial Enlightenment are typically trotted out by philosophers to confront what they perceive – generally with minimal understanding of the capacities of the technology, the science, and the engineering – to be imminent or potential assaults on the common good by the development, merchandising, or use of the products and processes of new technologies. For those theories to function usefully in real time in supporting regulatory decisions the number of unknown or unknowable variables relevant to their calculi must be minuscule. How, for example, can one decide what is the greatest good for the greatest number of people if the size of the impacted population is indeterminable, and it is not clear what the effects are until they actually happen? If we have learned anything in this area in the last half-century, it should be that predicting significant outcomes of the emerging technologies across populations is virtually impossible. Who could have predicted in the 1960s when the United States funded military research projects on distributed computer networks that a quarter of the earth's population now would be using the Internet in ways that have a profound impact on us, reshaping our lives, radically changing how we understand and interact with. . . everything?

We are living in a world that is profoundly different from the one in which the ethical theories with which we are most familiar, Enlightenment ethics, were invented, and in which many of our legal processes and policies were crafted. Our world is, in all of its aspects, including what it means to be human, contingent upon the outcomes of engineering/design projects. Of course, there has always been an element of the unknown, and the uncertain, involved in being human; in this sense the world in which we are living is not greatly different from the one depicted in the extant fragments of the ancient Greek philosopher Heraclitus. Two fragments give

something of the flavor. Heraclitus writes[1]: "Time is a child moving counters in a game; the royal power is a child's." He seems to mean that the randomizing activity of a very young child moving the pieces of a game like chess without any attention paid to the constitutive and regulative rules of that game is an apt metaphor for the world in which we have to function. To extend the metaphor, it is virtually impossible to predict where the pieces will next land on the board, or whether they will be scattered off the board, or if the board itself will be in a jumble on the floor, if there is a floor. There are a number of famous Heraclitian fragments that deal with the impossibility of stepping twice in the same river. However, the last fragment in that vein goes further than maintaining that the river is flowing, so that the water into which one steps a second time cannot be the water into which one first stepped. "Into the same rivers we step and do not step. We exist and we do not exist," he wrote. It is not just that we cannot step twice in the same river; we are not the same persons from moment to moment. Both the river and we are constantly in a state of flux.

Were Heraclitus writing today, he might comment that what it is to be human, and a particular human, is contingent upon unanticipated impacts that interactions with other fluctuating elements of a mostly engineered environment may randomly produce. We live in the brave new world of the GRINN technologies – genetic engineering, robotics, information technology, neuroscience, and nanotechnology, and all manner of other technologies that transform the material and the mental spaces in which we function. Persons (or their minds and identities) now can be distributed over information systems and design platforms of various kinds, for example as avatars in *Second Life*, and, in many cases, actively engage in multiple realities. The Enlightenment moralists and those who designed our legal systems would, by and large, be confused, if not utterly lost, in our world. But then, so, in large measure, are most of us.

Classical utilitarianism, for example, may be formulated to say that an act is right, the thing we ought to do, if and only if, in the circumstances its consequences have a higher utility than any other thing we could have performed. Utility was defined in terms of happiness or pleasure. Hence, the utilitarian principle typically is stated as "Choose the action in the circumstances that will produce the greatest happiness for the greatest number of people." The maximization of two independent variables (pleasure and population) is involved in determining what ethically we as a society ought to do. And to a large extent much of our regulatory tools are based on some sort of utilitarian basis: do what is best for the greatest number of people. But in many cases involving the emerging technologies of our era, those are unknown or unknowable variables. How then can utiliatarianism serve to guide us in

[1]The quotations attributed to Heraclitus are from *Heraclitus, The Complete Philosophical Fragments*, translated with commentary by William Harris at http://community.middlebury.edu/~harris/Philosophy/Heraclitus.html.

policymaking regarding those technologies? How can it help us decide what will be good for and what will be detrimental to society? And what if we also worry about sustainability and impacts on future generations? An ethical system for decision-making regarding public policies regulating the emerging technologies will not be much good if, at best, it were only retrospective, if it could only tell us what we should have done after an outcome of our actions has already been irretrievably set in motion or occurred. If we have virtually no way of accurately predicting what populations will be adversely or advantageously affected by the introduction of a new technological innovation, how can we use the utility calculus to tell us what we ought to do? Utilitarianism, in all of its forms, assumes a large number of constants in order to arrive at recommendations it can endorse. But none of the things it holds constant, including the humans whose happiness (or good or preferences) is to be maximized, are excludable from technological design. Humans themselves are now design spaces. Everything is in a Heraclitean flux.

That other great moral theory from the Enlightenment, Kantian deontology, fares no better. Kant's categorical imperative requires that we not decide on a course of action that we cannot universalize across the population of the moral community and that we treat all members of that community with dignity and respect, as ends and never as means only and that we not privilege ourselves over the interests of others, that we always act as both subject and sovereign in a kingdom of ends. Kant is primarily concerned not with outcomes, but with processes, not with how things turn out, but with the motives people have when they choose courses of action. An ethical person is to act always so that he or she could rationally will that the principle on which he or she is acting could become a universal law for all people. The difficulty is that in cases involving the new technologies we usually cannot say what effects they will have on populations, so we cannot be at all certain that we would not be using large numbers of people as means and not as ends were we to approve or disapprove of the introduction of this or that technological innovation or process, even with the best of intentions.

What we need, it would seem, is an ethics and a legal structure designed to respond to the contingencies and floating factors and variables that are commonplace in, indeed characteristic of, the technological potential of the Twenty-first Century. Ethicists need to be asking how much in human experience must be constant for ethical principles to be efficacious. If even the subjects of ethical principles and rules are alterable to suit conditions and whims, how do we decide what should and should not be done? Legal structures and procedures should be designed not to stymie technological innovation, but to insure that the Luddite principle regarding controlling what is "hurtful to commonality" is given sufficient attention as cases are adjudicated and policy is formulated, nationally and globally.

I do not know what form the requisite ethical systems and legal apparatuses to handle the problems and issues that are arising and that will continue to arise with respect to the emerging technologies should take. The task of designing the ethics and the legal response mechanisms that can keep pace with technology and science is a paramount challenge facing us.

Ethics and law have typically lagged far behind technological change. If we allow that lag time to increase, it will grow exponentially until both ethics and law will be realistically viewed as an irrelevant antique of a time long past and not fondly remembered. Cognizant of that likelihood, the Lincoln Center for Applied Ethics at Arizona State University, of which I am the Director, funded the first few years of what we called "The Pacing Project." Lincoln Professors Braden Allenby, Joseph Herkert, and Gary Marchant conceived of the project and have been directing it. This volume is a result of their opening the dialogue among ethicists, legal scholars, engineers, and technologists facing the challenge of trying to close the gap between the sprinting technologies and the plodding ethical and legal systems that are supposed to be concerned with regulating and recommending policy and procedures to minimize the effects of "machinery hurtful to commonality." The Lincoln Center for Applied Ethics is proud to be associated with this project.

Peter A. French

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Introduction: Why Law and Ethics Need to Keep Pace with Emerging Technologies

Andrew Askland

The evidence is unmistakable that knowledge in the sciences and various familiar and new technologies is accumulating in prodigious amounts. The accumulation is notable both for its quantity and for its variety. More noteworthy, the accelerating rate of this accumulation is staggering. Whereas the Enlightenment model had suggested a neat ordering of knowledge that might permit a good encyclopedia to circumscribe what constituted knowledge, now a more appropriate model is a swiftly moving target that continually accretes data and links that data to other data, a monumental Wikipedia continually updated with expert input. The linkages elude exact specification because the linkages connect with knowledge that is also continuously expanding. The expansions are not linear nor are they easily predicted and the potential synergies are confounding. It is like an expanding universe with more than the four familiar dimensions, a string theory account with exponential growth along each string. The technologies of recent origin, i.e., the "five horsemen" identified by Brad Allenby, viz., nanotechnology, biotechnology, robotics, information / communication technologies, and applied cognitive science, are making it increasingly obvious that, as Gary Marchant phrases it, "concurrent technological revolutions are rapidly transforming economic, social and personal domains, now and even more so in the imminent future."

The charge is that oversight and governance is not keeping pace with technological and scientific change. For example, efforts to regulate the impact of information technologies upon privacy often prove ineffectual because they are drafted to constrain technologies and practices that are continually changing and those changes escape the language of the rapidly outdated regulations. Information technologies evolve quickly and regulations often address a snapshot of a technology that is tracking quickly away from the conceptual scheme of the regulations. When technologies change so fast that consumers must accept that anything that they buy is already obsolete, how does the law stay apace? How do we evaluate the significance of the charge, i.e., what are the consequences if the legal system and ethics lag behind

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rapid changes in scientific and technological knowledge? Why does it matter if a gap opens between rapidly expanding knowledge and the law's grasp of that knowledge? These questions are important because the law serves a crucial social function that depends upon its broad applicability and its predictability and ethics can degenerate into empty platitudes when it is ignorant of the relevant facts in moral problems for which it seeks to provide guidance. Perhaps we should concede that the gap is inevitable and learn to accommodate it. Perhaps, as Scott McNeely advised *vis a vis* the loss of privacy, we need to "get over"[2] the puncturing of a popular bromide, in this case, a presumption that law should track developments in science and technology. On the other hand, it may be that the gap is a cause for alarm because it undermines the institutions and the practices of both law and science. The argument here is that the law does need to keep pace with rapid changes in knowledge and that the costs of failure are substantial. That is hardly a startling response to the gap, but it is worth drawing out, at least briefly, the impact of a substantial divide between technological/scientific knowledge and the ability of legal and ethical systems to competently grasp that knowledge.

Most democratic forms of government are divided into three familiar branches: judicial, legislative, and executive, and it is useful to describe how each performs its tasks in an ideal situation. Actual conditions fall considerably short of ideal, but the shortcomings of practice are nonetheless measured against the standard of an unrealizable model. Judges are in fact subject to biases that reflect their social and economic backgrounds. Legislators are often primarily concerned with their re-election and placating popular discontents rather than marshalling the best facts and strongest arguments to devise bills that address matters of paramount public importance. Regulators are often captured by "public choice" strategies (Buchanan and Tullock 1962) to advance their own interests rather than the purposes identified for the regulations that they promulgate and enforce.

These practical shortcomings undermine the credibility and effectiveness of governance institutions and programs, but it is a mistake to focus exclusively upon the disappointments of applied politics. There is much to value and build upon in our systems of government. Judges apply established rules to resolve the particular problems argued before them. They draw out the rationales of rules (and precedent) to identify the principles that explain the rules (and older holdings) in order to apply those principles to new variations of fact. Legislators represent the interests of the electorate and endeavor to express those interests and the principles that undergird those interests by enacting laws that connect those interests / principles to pressing social and economic challenges. Regulators fashion rules that elaborate upon principles articulated in governing legislation to efficiently guide the conduct of parties subject to the regulatory regime devised by the legislature.

These functions can be described more fully, but a cursory summary is sufficient to make the point that each branch is involved with facts and principles and,

[2]Scott McNeely is the co-founder of Sun Microsystems; he said "You have zero privacy; get over it." This famous quote was attributed to him by Stephen Manes in "Private lives? Not ours" in PC World 18 (6):312, 18 April 2000.

moreover, that facts inform the identification of suitable principles and principles cannot be well applied where the facts to which they are applied are misunderstood. The law cannot articulate suitable principles without a grasp of the facts that are relevant to those principles. Similarly, the law cannot apply principles without an understanding of the facts that constitute the problem. Thus, if an important purpose of law is to promote fair and beneficial outcomes for problems that are posed in specific factual contexts (applying known and endorsed legal norms), then law must maintain a facility with the facts of the problems that are or will be posed.

If legislation and regulation seek to provide legal guidance before the fact and adjudication seeks to sort out difficulties after the fact, then legal actions will certainly disappoint unless they are appropriately informed about the relevant facts. If we expect law to competently address the safety of new technologies, then the new technologies must be sufficiently well understood that their implications for safety can be evaluated and managed. If we expect law to sort out the value of new technologies in order to determine the cost of its accessibility, or the appropriateness of public subsidies, or the availability of immunities/safe havens, then the new technologies must be sufficiently well understood to enable a probative evaluation of those costs and benefits. There are many reasons to avoid resort to legal process, e.g., the costs of generating appropriate legislation or of taking cases to trial, the delays occasioned by these efforts, the uncertain outcomes, etc., but when disputes arise, as they inevitably do, the legal system is the ultimate means for resolving those disputes. Disputes are, in fact, often resolved without resort to legal intervention, but those resolutions are devised in the shadow of the legal interventions that will occur unless the parties can amicably resolve their differences. An informed grasp of the relevant facts and principles promotes efficient decisions about how law will likely be applied and what terms of negotiated compromise are appropriate.

A legal structure combines explicit law, implicit practice, and a broader cultural framework within which the law is situated, which in turn implicates ethical, social and economic considerations. Law is the means by which we attempt to resolve conflicts and law operates more predictably when it commands the relevant facts about the underlying conflicts. Law must be ready to competently address these conflicts and the greater the potential impact of the conflict, the greater the need to anticipate resort to legal intervention. Where there is a social impact, there is cause for competence to assess the costs/benefits of that impact. These impacts are easiest to identify when they resemble familiar legal categories, e.g., torts and contracts, but they also encompass legal issues that are less easily categorized, e.g., the definition of personhood or duties owed to non-human subjects or the international externalities of technological development.

One might argue that law should accept an intermediate resolution of the challenge of new science and emerging technologies and wait for those developments to cross an impact threshold before focusing attention upon them. It may be that law should stay abreast of scientific and technological advances to the extent that contractual disputes occur among parties, or compensation is sought for tortious conduct, or boundaries need to be identified for intellectual property claims, or other familiar legal issues arise in the context of scientific and technological research.

One might argue that, aside from these frictions, law need not worry about a divide between scientific and legal knowledge. As research nears application, the law should take note, but only as it anticipates the extension of familiar jurisdictional definitions to new subject matter. Law need not worry about its ignorance of the subject matter or the methodologies of the research in its formative stages save for focused concerns, e.g., about informed consent for human subjects or intrinsically dangerous subject matter (and these concerns do require considerable attention).

As the European Science Foundation recently reported regards stem cell research, "Most scientists are overwhelmed when they review all relevant regulations and guidance covering the storage, use and disposal of secretions, organs and tissue for regenerative research." (ESF 2010) This approach carves out a substantial area of concern for legal inquiry, but preserves a default for scientific research that lies beyond the current competence of law. Is it a suitable compromise to allow law to assure that certain important conventions are satisfied, e.g., institutional review boards to approve human and animal studies and funding agencies to control research that involves dangerous chemicals, etc., during the trail and error of research, and wait until the late stages of scientific and technological advancements before worrying about their contents, e.g., let the appropriate regulatory body address the approval of a product or service when it is offered for public consumption? Does this approach provide sufficient protection for the public interest and is it a preferred, and more easily obtainable, objective for law's ambition to keep pace with science?

An initial response to this proposed compromise is based upon prudence. It will be easier for law to accommodate applied science if it closely tracks theoretical science. The learning curve to master the intricacies of an applied technology will be better handled if law follows the early movements along that curve. Waiting until shortly before a technology is introduced to grapple with its ambitions and potential impacts may unnecessarily delay the introduction and cause uncertainties that can be considerably reduced with an earlier familiarity. Indeed, this first response blends into a second. An earlier familiarity with the blossoming technology might affect the course of its development so that it is more readily accepted and approved at its introduction. That point inspires this rebuttal: should emerging technologies be affected in the course of their development by currently governing legal conventions? As new technologies, they likely press hard on those conventions. These concerns are relevant because technologies often become "locked in" – that is, connected to other economic and technological systems in such a way that significant change is either difficult or impossible after their adoption. As Carl Mitcham phrases it, technology can "transform social structures in ways that tend factually to predetermine their uses." (Mitcham 1994, p. 273) Once "lock in" occurs, it may be difficult for the law to prescribe alternative paths even if they were obviously preferable when the technology was forming. As Andrew Feenberg points out, "Design is only controversial when it is in flux." Once the conflict is resolved, technological and legal standards become embedded in stable code that shapes our daily practices and frames our perception of the value of those practices. (Feenberg 1999, p. 96)

Applied cognitive science suggests a model of human behavior which differs significantly from the model that governs most theories of criminal and tort responsibility. Biotechnologies suggest radically different conceptions of health care and medical malpractice and mortality. Other emerging technologies entail similar reorientations of familiar practices. These emerging technologies portend dramatic changes to the legal conventions that currently prevail and it might seem that subjecting those technologies to review by soon obsolescent conventions will be counterproductive, i.e., the threatened conventions might thwart the normal course of development for new technologies. The obverse phrasing is that to the extent that emerging technologies portend such dramatic changes, they ought to be tracked with considerable care and attention lest the law be unprepared for those changes. If the changes are impending, then law will benefit from ample notice to accommodate them. If the changes are unavoidable, but their form is unspecified, then law ought to be able to negotiate about that form.

This negotiation role surely should not be limited to law, but as law reflects important ethical, social and economic values, it ought to be included among the negotiators. It is because emerging technologies will radically transform our culture and our polity that the parameters of those potential changes ought to be examined by many diverse parties. At a minimum we expect the institutions that currently resolve most social and economic disputes to actively engage with the pending changes.

Our institutions of public learning, our ethical leaders, and our journalistic enterprises, among others, should also be engaged, but it is imperative that legislatures track the new knowledge to assure that the public interest is appropriately served (and create a means for regulatory oversight where that is required) and that the judiciary similarly track this knowledge so that is prepared to adjudicate disputes. (The judicial role is emphasized in the United States by the adoption of the Daubert standard for the admissibility of expert scientific evidence at trail. This standard imposes a gatekeeper responsibility upon the trial judge to assure that proffered expert scientific evidence relies upon a valid scientific methodology. This responsibility has driven many judges to educate themselves about emerging technologies and the foundations of science.)

This broader engagement also benefits science and technology. It opens their work to perspectives free from the tunnel vision of a specific discipline or research agenda. The intense concentration of sustained and particularized research can generate a myopic focus that blinkers the researcher and dulls an appreciation for the broader implications of the work. It benefits the research and the researcher to periodically explain the work and consider its effects in larger contexts than an isolated study. In short, research can be improved by regular engagement with those whose lives will be affected by its outcomes. The results of research are better appreciated and its implications better acknowledged when the work is periodically vetted by parties and interests outside the scientific and technological communities. A backlash against the research is less likely when the work is perceived to be embedded in the polity that supports the work and whose interests and values are being advanced by the work. Science and technology are, as Daniel Sarewitz points out,

social enterprises and it is entirely reasonable to expect that their focus and progress should be justified routinely to the polity in which the research occurs.

A simple statement of the function of law is that it aims to influence behavior, either by discouraging particular behaviors with penalties, or incentivizing other behaviors with subsidies or non-interference. It is easier for law to influence behavior when it is reinforcing behavior rather than contravening it. Most criminal law is an elaboration upon basic civil norms, e.g., proscribing assaults, murder, thefts, fraudulent acts, etc. Much that has been written about the relationship between law and morality focuses upon the role of broadly shared norms of behavior in grounding the legitimacy of particular laws and legal systems. (Fuller 1960; Raz 1978; Greeenawalt 1989)

Of course, many laws are stipulative or conventional, e.g., which side of the road we drive on. Many regulations are justified by the public good promoted by consistency where many individualized behaviors would be onerously chaotic. In either case, law can more productively influence behavior when it is informed about the purposes and consequences of that behavior. Law can better decide when it should not attempt to influence behavior, e.g., where such efforts are inappropriate or inefficient, when it has a confident grasp of what is at stake. If the norms for science are opaque to law, if the benefits and costs of particular technological endeavors are secreted among a parochial corps of investigators, or are otherwise indecipherable or badly misapprehended, then it is likely that law will not phrase its legislation, its regulations or its judgments to suitably coordinate the priorities of science and technology with generally prevailing social norms. There will be persisting mismatch between, on the one hand, basic civil norms and the public good served by standardization and, on the other, the purposes and practices of science and the emerging technologies. Instead of a healthy engagement between science/technology and law which would inform each about the other's priorities and practices, there will be structural ignorance that is disruptive and costly. Cooperation is difficult, especially between contrasting cultures, (Snow 1959; Goldberg 1994), especially when those cultures are tracking rapidly away from one another, but the costs of a failure to cooperate can be disastrous.

The concern that science and technology are outpacing law recalls past concerns that a steadily increasing number of statutes was inexorably encumbering legal systems. Many statutes address conditions that change and the statutes are not timely revisited to gauge their appropriateness for the changed conditions. Guido Calabresi addressed this mismatch of statutes with changed circumstances and argued against reliance upon administrative agencies to update statutes to comport their original intentions with changed circumstances. (Calabresi 1982) He thought that administrative agencies would lack a sufficiently broad perspective on the changed circumstances and would not renovate statutes frequently enough. He was also critical of renovation by administrative agencies because they were not sufficiently majoritarian and would lack the requisite adherence to principles and consistency. They were also subject to capture by vested interests, notably the corporate parties affected by the regulations, and also were conflicted by their own preferences and a related bias against modifications to the status quo. He argued

instead for judicial authority to rephrase anachronistic statutes so that the statutes would harmonize with the prevailing legal fabric. He thought that judges possessed the skills and perspective to identify the "underlying values of a people." (p. 98) Judges, informed by the trajectory of statutory enactments, by scholarly criticisms, and by "the gravitational pull of deep constitutional principles," (p. 99) can evaluate new situations and revise old statutes to promote "conformity with a complex legal landscape." (p. 100) Calabresi was not advocating rash judicial activism, but instead sought a means to revitalize statutes that had been rendered ineffectual by changed circumstances. Whatever principles they were written to promote had been overtaken by changes that rendered them, without modification, poor fits and incompetent standards. However, a judicial authority to renovate anachronistic statutes is inconsistent with the role of judges in most civil law jurisdictions and likely strains what many people, skeptical about judicial overreaching, would accept in common law jurisdictions.

Accelerating advances in science and technology exacerbate the problem of unrevised statutes, but the crux of the problem is the same: a dissymmetry between law and newly arising facts because the law has not anticipated these new facts and attempts to govern them with an antiquated grasp of their meaning. Reprising the description of law as the matching of facts and principles, the challenge for law is to be keenly attentive to new facts in order to fashion principles that will sort out the challenges that they present. Law requires a competent grasp of those new facts to better recognize where its statutes (and precedents) require revision to best preserve what the society that it serves seeks to preserve in this hyper-technological world. In the best circumstances this will be difficult because technological evolution is unpredictable and it renders contingent many assumptions that are unreflectively regarded as fixed, and thus raises difficult challenges to the mission of pacing law with science and technology.

Given this view that law should strive to keep pace with science and technology, it is worthwhile to examine existing legal structures to identify how they might better accommodate new scientific and technological knowledge. It is also worthwhile to consider alternative legal structures and forms that might better accommodate that new knowledge than current legal structures. Finally, while law is the immediate regulator of much science and technology, ethical values often provide the foundation for both legal and broader societal responses to emerging technologies. Thus, both legal and ethical frameworks and systems must keep pace with rapidly evolving science and technologies.

There is a lengthy history of scientists serving as consultants in the legal process, whether in an official or unofficial capacity. Sheila Jasanoff has identified two common paradigms for the use of scientific input, a 'technocratic' approach, which makes "scientists the primary validators of policies with high technological content," and a 'democratic' approach, which relies upon "broad public participation as an antidote to abuses of expert authority." She instead recommends a 'negotiated' model for scientific inputs in order to "harness the collective expertise of the scientific community so as to advance the public interest." (Jasanoff, p. vii, 250) The extremes to be avoided are naïve deference to science and technology as complete

solutions to social and political problems and blind reliance upon the popular will as the final authority in matters of fact and scientific theory. The challenge is to bring accurate accounts of emerging technologies to the public and their representatives to facilitate competent debate and appropriately informed laws.

This volume is an effort to promote the availability of scientific knowledge to legal actors who serve the pubic interest by considering the challenges presented by new scientific and technological knowledge and proposing various strategies that might better enable the legal and ethical frameworks to cope with and manage that knowledge. The first part of this book describes the "pacing problem." The second part explores some of the dynamics of the oversight challenge posed by emerging technologies. The third part provides a "toolbox" of possible solutions to help address the pacing problem.

Brad Allenby opens the "pacing problem" part with a chapter that focuses on the "systems" impacts of emerging technologies. He uses the example of the railroad to demonstrate the power of a new technological system (as a Kondratiev wave of innovation) to transform a society, provoking "profound and unpredictable institutional, organization, economic, cultural and political change." "[T]echnology of any significance tends to be profoundly destabilizing ... and thus, of course, to the degree it is so, it will generate substantial and potentially powerful opposition." He then describes the NBRIC (nano, bio, robotic, info and communication) technologies and their potential to similarly disrupt currently prevailing norms and practices. However, "it is not just that each NBRIC system is powerful; it is that they are combining in unexpected ways that are both beyond any single technological domain, and very potent." Allenby elaborates upon these synergistic effects with specific examples and argues that the emergence of these technologies "dramatically affects our usual assumptions about stability and cultural frameworks along three dimensions: complexity, contingency and accelerating change." He concludes that an ability to perceive and understand these dimensions of emerging technologies can permit us to "interact with them to achieve more desirable outcomes and trajectories" and "to develop institutional mechanisms, including legal and regulatory tools that engage with the systems in ways that are both productive and predictable."

Gary Marchant provides detailed evidence of the accelerated pace of developments in science and technology over the past several decades. Moore's Law and Monsanto's Law are examples of consistent exponential growth in computing power and biological knowledge, respectively. Similar productivity impacts have been identified for DNA synthesis and sequencing and for the resolution of neuronal features of computed tomography (CT) brain scanning. Internet connectivity has grown rapidly for many years, as have nanotechnology related patents. Marchant then provides examples of the failure of the existing legal framework "based on a static rather than a dynamic view of society and technology" to cope with these rapid advances. The U.S. Congress, for example, linked attainment requirements and ozone standards without allowing for changes to the ozone standards which

would make unaltered enforcement of the attainment standards absurd. This mismatch is particularly striking because the Environmental Protection Agency (EPA) is required by the same statute to periodically upgrade the ozone standard and thus the absurdity would have been anticipated by anyone paying serious attention to the prospect of advances in scientific knowledge. Marchant also points out that the reaction times of legal institutions have slowed down in recent decades exacerbating the pacing problem, and he provides evidence for why that slowing down has occurred in legislatures, regulatory agencies and the courts.

There is a widespread awareness of the "pacing problem" and Marchant cites observations by various experts from multiple fields expressing their judgment that law is struggling to keep pace with new scientific developments. He concludes with a list of suggestions for devising more flexible and adaptive regulatory approaches to avoid or minimize the pacing problem: expedited rule-making; self-regulation (or "cooperative" regulation); issue specific statutes; courts with specialized subject matter jurisdiction; sunset clauses; periodic mandatory program reviews; free-standing independent institutions with specific issue foci; adaptive management strategies that use feedback to reorient their policies and practices; and principles-based regulation (rather than detailed prescriptive rules).

Joseph Herkert explicitly poses ethical questions that are latent in various other chapters. He explores whether emerging technologies require new ethical concepts or merely expand the scope of existing ethical concepts. He uses humanoid robotics and pervasive computing to frame his response. Human robotics are insinuating themselves into modern, technological societies in various commercial and military capacities. The increased use and reliance upon these increasingly sophisticated robots presses ethical worries beyond consumer safety and products liability to more fundamental ethical categories such as moral agency, free will and human identity. Pervasive computing is the convergence of advances in fields such as microelectronics, materials science, solid state physics, nanotechnology, radio frequency identification (RFID), wireless communications, and global positioning systems (GPS) and can affect "every facet of our lives, including our homes, workplaces, schools, businesses, and entertainment venues." These two technologies share with other emerging technologies a few characteristics which make them especial challenges to ethics: embeddedness; unlimited reach; an engineering of the mind and the body; and specificity.

Herkert points to engineering ethics as a useful source of perspective for these challenges and describes in particular a grid scheme that cross references various domains for engineering ethics as either macro-ethics or micro-ethics and either engineering practice or scientific research. He is attracted to such new formulations because there is a growing sentiment, at the very least within engineering ethics, that traditional ethical concepts have proven inadequate in general and in particular when confronted with emerging technologies. Herkert notes that promoters of the emerging technologies seem willing to abandon traditional ethical concepts, such as the primary role of human agency, which might impede the progress of technology, while critics of the emerging technologies tend to focus on the process of ethical deliberation, both in terms of timeliness and participation. He identifies a middle

ground where moral imagination and preventive ethics are important themes that can be developed to devise new ethical concepts and frameworks that can meet the task of pending and future ethical challenges.

The second part of the book, focusing on oversight dynamics, opens with David Rejeski's chapter addressing public policy on the technological frontier. He notes that there are a number of reasons why public policy makers encounter difficulties on this frontier: its novelty; cognition biases of the policy makers; framing that distorts issues and debates; intractable problems with inadequate resources assigned to them; and many known unknowns. To confront these issues, Rejeski suggests that we rephrase the governing metaphors to deemphasize an "assessment and regulation" paradigm, with its "interminably long process of issue identification, analysis, recommendations, and implementation" to an emphasis on co-evolution. He also recommends an embedded early warning system approach to promote reflexive and anticipatory governance. Another useful (open-source) tool would be an evolving list of known unknowns to help reduce the likelihood of surprises where possible scenarios can be considered before they occur. Rather than keying on best practices, Rejeski instead focuses on bad practices in order to collect and manage information about them and channel that information into solutions. He also recommends that research scientists and engineers be appropriately trained so that they provide oversight for the research enterprises in which they are engaged rather then relying exclusively upon social scientists and ethicists from outside that enterprise. Finally, Rejeski recommends that we develop and implement learning strategies that focus upon learning from mistakes instead of obsessing about the impossible task of avoiding all mistakes. Advances in computation and rapid prototyping systems permit learning and innovation through experimentation that promotes better solutions informed by many tested hypotheses. Rejeski sums up these recommendations as efforts to rephrase learning about emerging technologies as co-evolution rather than an effort to run faster on the technology treadmill.

Deborah Johnson uses software agent technology to explore an anticipatory ethics approach to rapidly developing technologies. This approach engages with the ethical implications of a technology in its early stages of development in order to influence that development. The early engagement applies the insight of various Science and Technology Studies (STS) scholars that technological development is fluid and contingent because it is social negotiated and constituted. The software agent technology example, which involves complex systems designed to operate independently of their human designers, is instructive because these agents have been described by some commentators as autonomous and this characterization collides with traditional moral notions and practices of accountability. Johnson examines the strengths and weaknesses of an argument for a moral ontology for software agents that keeps them tethered to those who design and deploy them. Her analysis of software agents supports the conclusion that moral notions and practices do influence technology and that they can more intentionally and effectively address the pacing problem by affecting the future development of emerging technologies.

Lyria Bennett Moses considers the extent to which *sui generis* rules are an effective approach for dealing with the "pacing problem." The *sui generis* approach is

often recommended where there is pressure to enact new laws for a new technology, or where uncertainty arises about the application of law in new contexts, or where the law may not apply as intended in the new context. She provides several examples where *sui generis* rules were adopted in response to technological change and describes the rationales for the *sui generis* approach in each case. She identifies and evaluates several potential disadvantages of the *sui generis* approach: the failure to cover sufficient ground (the completeness problem); the administrative costs of maintaining multiple legal regimes (the administrative cost problem); the tendency of *sui generis* rules to assume a temporary technological framework (the problem of technological change); and the potential for narrowly defined rules to unfairly benefit narrowly defined groups (the political problem). Moses then describes the pros and cons of *sui generis* rules, concluding that the decision on whether or not to adopt such an approach may be technology and context-specific and needs to be carefully and openly considered on a case-by-case basis.

Daniel Sarewitz identifies the context for governing technological change as the dilemma created by a commitment to pluralism, participation and openness in our governance structures, on the one hand, and the enormous transformational power of technology and technological systems, "a power that often seems at once inscrutable, unconscious, overwhelming, and autonomous," on the other. He describes how the challenge of this dilemma has been largely deflected: "the pursuit of technological transformation is largely exempted from formal democratic processes of eliciting value preferences and adjudicating value disputes about desired future states." He offers an alternative resolution for the dilemma, namely a technological assessment (TA) where the pace and direction of knowledge and its applications are directed by human choice, where those choosers encompass a range of socio-economic, cultural and political components, and where social settings interact with techno-scientific advances to create evolving outcomes that reflect the values of the widely encompassed decision-makers. Sarewitz offers the example of the real time technology assessment (RTTA) project pursued by the Center for Nanotechnology and Society at Arizona State University that attempts to exemplify the alternative approach by building reflexivity into the research process.

The third part of this volume describes an assortment of possible solutions to the "pacing problem." Brian Rappert describes his experience with codes of conduct as a possible means of addressing the challenge of keeping pace with science and technology. Codes of conduct encompass a variety of aims, drafters and target audiences, but are generally an attempted form of self-regulation. Rappert adjudges that, if our standard for assessing whether codes are working is their effects on guiding the behavior of practitioners, then this aim has largely been unrealized. Codes have tended to codify existing practices rather than establishing new standards that require changed behavior. Rappert counters that the process of deliberating about codes has helped track developments in science and technology by helping to build shared agendas and enabling coordinated initiatives and in that sense codes are working if we recalibrate our standard of review. Raising awareness about important topics, fostering ethical reflection about emerging issues, clarifying responsibilities and increasing public confidence are also valuable effects of the code drafting

process. Rappert rehearses the history of efforts in the United Kingdom to draft codes for biological weapons to prevent the destructive use of life science research to support his evaluation.

Kenneth Abbott focuses on international action to coordinate national law and policy in response to scientific and technological innovation. International action can steer national law and policy toward greater uniformity, and also towards greater efficiency, legitimacy and a public interest orientation in form and content, and, moreover, facilitate speedier responses, especially in states with limited regulatory capacity. He provides a general institutional framework for international coordination, steering, and facilitation, with two key elements: a "framework convention" and a set of international institutions and procedures that would operate under the authority of that convention. He proposes arrangements that would operate at the international, the trans-governmental, and the transnational levels. The first value of this international approach is that it helps states and other actors to produce and share information more effectively, which increases the comparability of information and assessments from varied sources. The second value is its usefulness in coping with the problem of inconsistent or inappropriate national responses. Abbott provides a detailed elaboration of the framework approach to the "wicked" problem of innovation by drawing upon the structure and history of various international framework approaches as applied in other contexts.

Ruth Carter and Gary Marchant consider the strengths and weaknesses of principles based regulation, rather than rules-based regulation, as a means to address the complexity and rapid pace of innovation. Principles-based regulation tries to focus on desired outcomes rather than rigid rules by promulgating guiding principles that are broad, general and abstract. Regulated companies are intended to have considerable discretion about how to apply the principles to new situations. Carter and Marchant compare the principles-based and rules-based approaches, using the finance industry, which uses principles-based regulations, to draw distinctions. Principles-based regulations place the spirit of the law before the letter of the law; provide flexibility and freedom to regulated companies; better respond to the changing practices of evolving industries at lower cost; and can foster better relationships between regulated companies and the regulators. There are limitations to the principles-based approach: flexible principles can beget uncertainty; principles can ossify over time to resemble and function like rules; the transformation from rules-based regulations to principles-based regulations can be costly and time consuming; there can be substantial compliance problems because the regulator requires more information and cooperation from regulated companies to provide effective regulatory oversight; and a rules-based approach requires a change in the culture of the regulated companies and its industry to adopt a cooperative perspective on the role of the regulator in monitoring regulatory compliance. A special problem for a principles-based approach is technologies that are subject to regulatory oversight by more than one agency; it is unlikely that a principles-based approach can be implemented unless all involved agencies are pursuing principles-based regulation.

Lyn Gaudet and Gary Marchant explore four administrative law strategies that might be applied in a modified form to address issues raised by emerging technologies. The four tools are negotiated rulemaking, direct final rulemaking,

online forums, and temporary legislation/sunset provisions. The chapter provides a brief introduction to administrative law and then addresses the four tools individually, elaborating upon their particular features and offering examples. Negotiated rulemaking attempts to join affected parties together in order to forge a consensus version of the proposed rule. This effort aims to avoid the delays and inefficiencies of an agency drafted rule that is contested in a lengthy notice and comment process followed by judicial review, perhaps in several iterations. Negotiated rulemaking is limited to situations where a limited number of interests are affected by the rule, a balanced representation of persons affected by the rule can be convened, there is a reasonable likelihood that consensus is achievable and the process will not cause, but rather avoid delay in the proposed rulemaking and the issuance of the rule.

Direct final rulemaking bypasses the elaborate notice and comment phase of most rulemaking. Instead, an agency drafts its proposed rule, provides public notice of the rule, and adopts it shortly thereafter without public input or comment. The motivation for this direct final approach is streamlined rulemaking, i.e., getting rules into effect promptly. Rules adopted in this manner must be uncontroversial because receipt by the proposing agency of any adverse comment or a notice on an intent to file an adverse comment leads directly to the withdrawal of the rule. Direct final rulemaking is well suited to minor changes to rules, e.g., cleaning up language ambiguities in a rule, but it problematic for proposed rules with encompassing or significant impacts.

Online rulemaking is the use of digital technologies to develop and implement regulations. It promotes access to a large quantity of information from a large number and variety of sources and increases public access and participation in the rulemaking process. Temporary legislation/sunset provisions involve the expiration of laws/rules after a specified period of time. This can be especially applicable to emerging technologies because regulations promulgated with limited information/significant uncertainties about such technologies must be revisited when they expire and more information/less uncertainty will lead to better phrased regulations at the subsequent revision. The regulations are likely more malleable and responsive when they must be redrafted periodically. Unfortunately, regulations that sunset are often reenacted without a careful reconsideration of their strengths and weaknesses.

Kathleen Waugh and Gary Marchant consider the possible use of collaborative voluntary programs to remedy part of the "pacing problem." They use environmental law as a lens to evaluate such programs because environmental law has a 20 year history of addressing the outputs of technology. Environmental law has pioneered regulatory experiments that attempt to avoid the shortcomings of command and control approaches, e.g., Best Available Technology (BAT), that lock in the status quo and provide no incentive for investment in new processes or technologies. Collaborative voluntary programs take various forms, but they strive to include regulated entities in regulatory target setting and emphasize flexibility about how those targets will be met. These collaborative programs often create institutional frameworks for on-going negotiations and innovation. Some regulatory models allow participating entities to essentially self-regulate. In general, leadership arises from multiple sources; solutions are framed to fit specific circumstances (instead of a one size fits all approach); potential for continuous improvements (rather than