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Anti-Prognostication

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BOOK NOTE

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INTRODUCTION

Cassandra is generally regarded as the Greek goddess of prophecy.[1] As the legend would hold, the god Apollo, in expression of his divine love for the beautiful Cassandra, promised to grant her the gift of prophecy in exchange for her hand in marriage.[2] After conferring his gift upon her, she declined his advances and refused to marry him.[3] Outraged, Apollo spat in Cassandra's mouth, revoking from her the ability to persuade others while preserving in her the ability to foretell.[4] As a result, Cassandra's ability to prognosticate was rendered worthless, for no one would believe her prophecies.[5]

Cassandra's tale is enriched given her inability to persuade others during the Trojan War. Upon Paris' return to Troy with the lovely Helen, Cassandra predicted that the abduction of Helen would lead to the destruction of the seemingly invincible city of Troy; but alas, Apollo's curse caused no one to believe her prediction.[6] Then, after what appeared to be the culmination of the Trojan War, Cassandra urged the Trojans to refrain from bringing the infamous Trojan horse inside the city walls and warned of the armed warriors hiding inside.[7] Her prophecy was once again ignored and, as the tale would hold, Troy was conquered and Cassandra was awarded to Agamemnon.[8] Incidentally, after

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1. CHARLES RUSSELL COULTER & PATRICIA TURNER, ENCYCLOPEDIA OF ANCIENT DEITIES 116 (2000).

2. *Id.* Note that there is an alternative story as to how Cassandra obtained the gift of prophecy. To celebrate the births of their daughters Cassandra and Helenus, Priam and Hecuba held a feast in the temple of Apollo Thymbrius. That evening, when Priam and Hecuba left the temple, they mistakenly left the infants behind. The following morning, the parents returned to find two serpents licking the sensory organs of the infants. The infants thereafter displayed the gift of prophecy. PIERRE GRIMAL, THE DICTIONARY OF CLASSICAL MYTHOLOGY 90 (A.R. Maxwell-Hyslop trans., Basil Blackwell Publisher 1986) (1951).

3. COULTER & TURNER, *supra* note 1, at 116.

4. GRIMAL, *supra* note 2, at 90.

5. COULTER & TURNER, *supra* note 1, at 116.

6. GRIMAL, *supra* note 2, at 91.

7. *Id.*

8. COULTER & TURNER, *supra* note 1, at 116.

Agamemnon fell in love with the prophetess, the two were killed by Agamemnon's incensed wife, Clytemnestra.[9]

In our modern American jurisprudence, Richard A. Posner, Seventh Circuit Court of Appeals judge and senior lecturer at the University of Chicago, has, on at least one occasion, been compared to the Greek goddess Cassandra.[10] However, given Posner's latest work, *Catastrophe: Risk and Response* (hereinafter *Catastrophe*), this comparison is poor. Indeed, as this review will demonstrate, there are a series of striking dissimilarities between Posner and Cassandra. First, while Cassandra was cursed with the inability to persuade others of her prophecies, Posner's lucid writing style in *Catastrophe* invites persuasion, albeit along with a great deal of criticism. *Catastrophe* is the quintessential example of Posner's uncanny ability to deduce the seemingly difficult study of law and economics into words, phrases, analogies, and examples that the lay reader can easily understand without a background in economics. This communication of an economic analysis of catastrophic risks in a comprehensible manner is adeptly accomplished with the use of straightforward terminology to illustrate the complexities of formulating social policy in response to low-probability, high-consequence events. Posner's clear writing style, as evinced in *Catastrophe*, invites persuasion.

Interestingly enough, Posner has admitted that he purposefully does not write to persuade others of his point of view; rather, he writes to be accused.[11] Herein lies another striking dissimilarly between Posner and Cassandra. Although it is highly probable that Cassandra derived little utility from being perceived as untrustworthy, Posner seemingly enjoys criticism. He effectuates his arguments by inviting his adversaries to critique his points of view; although sometimes, Posner's arguments border on the outrageous. As Larissa MacFarquhar has pointed out:

> [Posner's] accounts of the world are sometimes so eccentric as to be almost Martian. He has argued, for instance, that a higher proportion of black women than white women are fat because the supply of eligible black men is limited; thus, black women find the likelihood of profit from an elegant figure too small to compensate for the costs of

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9. *Id.*

10. Robert F. Blomquist has argued that Posner's dissent in *Vail v. Board of Education*, 706 F.2d 1435, 1449-56 (7th Cir. 1983) (Posner, J., dissenting), "rings with an Old Testament ominatio," or a prophecy of evil. Robert F. Blomquist, *Dissent, Posner-Style: Judge Richard A. Posner's First Decade of Dissenting Opinions, 1981-1991 – Toward an Aesthetics of Judicial Dissenting Style*, 69 Mo. L. Rev. 73, 98 (2004). Allegedly motivated by "a cathartic need to express his dissatisfaction with sloppy, inefficient or shopworn legal reasoning," the dissent supposedly illustrates Posner-the-Cassandra. *Id.* at 155.

11. Larissa MacFarquhar, *The Bench Burner; How Did a Judge with Such Subversive Ideas Become a Leading Influence on American Legal Opinion?*, THE NEW YORKER, Dec. 10, 2001, at 78.

dieting.[12]

Given the eccentricity of *Catastrophe*, it appears that Posner is once again writing to be accused. The very subject matter of the work – an exploration of a variety of contemporary cataclysmic risks – surely is capable of inviting a great deal of criticism. And thus, to this extent, Posner is not Cassandra. *Catastrophe* is an invitation to explore public policy formulation in response to catastrophic risks as opposed to a plea to be heard.

As the title of this work indicates, while Cassandra was given the uncanny ability to foretell, Posner does not attempt to sidetrack the reader with prophecies or visions of doomsday. Nevertheless, the reader may feel at first glance that *Catastrophe* emits an aura of prognostication[13] as the radical subject matter of the work may initially cause the reader to get sidetracked with imaginations of the apocalypse. Notably, Posner does not attempt to portray the end of the world as inevitable or near, but rather utilizes a rational, economic evaluation of catastrophic risks to guide appropriate hypothetical social policy in response to the *potentially* imminent. Additionally, Posner's application of cost-benefit analysis is the antithesis of the prognosticator's general use of conjecture and hyperbole. Moreover, prophetic works such as Nostradamus' *Centuries* were founded upon a pseudoscience akin, in terms of logical soundness, to that of alchemy or astrology, but Posner's *Catastrophe* is not inherently prophetic in nature.[14] His use of the economic analysis, as opposed to reliance upon supposed prognostic indicators (such as the relative position of the stars in the heavens), exemplifies anti-prognostication. As a result, Posner should be commended for his creative application of legal-economic theory to catastrophic risks, but should not be worshipped by constructing a statue in his honor with a golden tongue.[15]

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12. *Id.*

13. 'Prognostication' is used in the sense that that it involves "[a]n act or instance of prognosticating; a foreknowledge or foretelling of something; a forecast, prediction, prophecy" characterized by "[a] conjecture of some future event formed upon some supposed sign; a presentiment, foreboding." 12 THE OXFORD ENGLISH DICTIONARY 588 (J.A. Simpson ed., 2d ed. 1989). And thus, as a result of radical subject matter of *Catastrophe*, the reader may initially believe that Posner is practicing the "art" of fortune telling.

14. For a background on Nostradamus' prophecies, see, e.g., EDGAR LEONI, NOSTRADAMUS AND HIS PROPHECIES (2000); IAN WILSON, NOSTRADAMUS: THE MAN BEHIND THE PROPHECIES (2002); ERIKA CHEETHAM, THE FURTHER PROPHECIES OF NOSTRADAMUS: 1985 AND BEYOND (1985).

15. In honor of his prophetic skills, the Athenians erected a statue with a gilt tongue for the Chaldean priest Berosus. Amelie Kuhrt, *Berossus' Babyloniaka and Seleucid Rule in Babylonia*, *in* HELLENISM IN THE EAST: THE INTERACTION OF GREEK AND NON-GREEK CIVILIZATIONS FROM SYRIA TO CENTRAL ASIA AFTER ALEXANDER 37 (Amélie Kuhrt & Susan Sherwin-White eds., 1987). Of Berosus' many misconceptions was his belief that the moon was of a half-fiery sphere, which explained both the moon's light and its phases. *Id.* at 39.

In Part I, I focus on the threshold question in Posner's assessment of catastrophic risks: his use of cost-benefit analysis. Part I identifies some of the difficulties in applying cost-benefit analysis to catastrophic risks. Some of these difficulties, such as assigning a value to human life, are discussed by Posner in *Catastrophe*. However, Posner fails to address other problems that accompany cost-benefit analysis, such as evidence suggesting that regulators actually do not apply cost-benefit analysis to governmental regulations. Moreover, I suggest that the application of cost-benefit analysis in *Catastrophe* evinces a departure, by Posner, from his support of the traditional legal-economic paradigm partially in favor of behavioral economics. In Part II, I turn to Posner's identification of potential catastrophic risks and the appropriate public policy measures that ought to be taken in response. Although Posner does propose certain resolutions to hedge the expected value of disasters in *Catastrophe*, it is important to note that, according to Posner, his suggested social policy responses are hypothetical and merely intended for discussion rather than immediate action.

I. Cost-Benefit Analysis of Catastrophic Risks

Posner contends that cost-benefit analysis is an important tool in the formulation of social policy in response to catastrophic risks. It is generally accepted that under the economic analysis of law, governmental regulation should act to promote economic efficiency. To promote economic efficiency, cost-benefit analysis of public policy is inherently useful as a method for preventing inefficient resource allocation.[16] Consequently, theorists and practitioners of the economic analysis of law subject legal rules and social policies to cost-benefit analysis to assess the efficiency of social policy measures.[17]

In *Catastrophe*, Posner adopts cost-benefit analysis, as well as some derivatives thereof, to justify hypothetical social policy measures in response to catastrophic risks. Note that while not directly discussed in the book, Posner has argued, in a previous work, that "cost-benefit analysis has positive as well as normative utility" in that it could be used to explain and predict governmental decisions as well as suggest desirable courses of action.[18] But in *Catastrophe*, Posner does not address the fact that cost-benefit analysis may actually lack a positive dimension. Indeed, regulators may not be in the business of integrating cost-benefit

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16. *See, e.g.,* Matthew D. Adler & Eric A. Posner, *Rethinking Cost-Benefit Analysis,* 109 Yale L.J. 165 (1999).

17. Robert P. George, *One Hundred Years of Legal Philosophy,* 74 Notre Dame L. Rev. 1533, 1537-38 (1999).

18. Richard A. Posner, Frontiers of Legal Theory 121 (2001) [hereinafter Frontiers].

analysis into social policy measures. Although it is clear that cost-benefit analysis has normative utility, in that it serves the goal of economic efficiency, it is not clear that cost-benefit analysis can be used to accurately predict governmental decisions.[19] For instance, in an article analyzing the formulation of water policy, Jack Hirshleifer and J. W. Milliman concluded that policy makers had completely ignored the advice of economists and had rather embarked on grossly inefficient schemes for pricing and allocating water when better alternatives were readily available.[20] Governmental authorities did not view themselves "as mere purveyors of a commodity but instead as crusaders for the cause of ample and pure water."[21] As a result, Hirshleifer and Milliman suggested that:

> the agenda for economists, at this point, should place lower priority upon the further refinement of advice for those efficient and selfless administrators who may exist in never-never land. Rather, it should center upon the devising of institutions whereby fallible and imperfect administrators may be forced to learn from error.[22]

In the aggregate, Posner's application of cost-benefit analysis to catastrophic risks ensures efficient resource allocation. However, given the fact that cost-benefit analysis may lack a positive dimension, it is truly unclear whether regulators would even attempt to formulate social policy in accordance with Posner's suggestions in *Catastrophe*.

Incidentally, while Posner has expressed concern over the validity of what is known as behavioral economics,[23] or the application of social science disciplines such as psychology to the study of economics, the application of cost-benefit analysis to catastrophic risks may also serve to minimize psychological confusions by regulators. More specifically, cost-benefit analysis may curb biases in perception and motivation, which are usually thought as areas of focus under the behavioral economics paradigm.[24] To elaborate, the behavioral economics paradigm is distinguishable from the legal-economic paradigm in that behavioral economics seeks to aid the economic analysis of law by exposing flaws in human rationality, which is the postulate of traditional legal-economic

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19. *But see* Adler & Posner, *supra* note 16, at 167 (claiming that "[g]overnment agencies now routinely use [cost-benefit analysis]").

20. Jack Hirshleifer & J. W. Milliman, *Urban Water Supply: A Second Look*, 57 AM. ECON. REV. 169 (1967).

21. *Id.* at 169.

22. *Id.* at 178.

23. *See* FRONTIERS, *supra* note 18, at 252-87.

24. Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471, 1544 (1998) (citing RISK V. RISK (John D. Graham & Jonathan Baert Wiener eds., 1995)). For a series of interesting articles critiquing traditional economic assumptions, see RICHARD H. THALER, THE WINNER'S CURSE: PARADOXES AND ANOMALIES OF ECONOMIC LIFE (1992).

theory. For example, Cass R. Sunstein, in applying the insights of behavioral economics has argued that the best justifications for cost-benefit analysis lie in cognitive psychology and behavioral economics.[25] As a result, cost-benefit analysis may be justified precisely as a corrective measure to predictable problems in individual and social cognition.[26] "Poor judgments, by individuals and societies, can result from certain heuristics, from informational and reputational cascades, from thinking processes in which benefits are 'on screen' but costs are not, from ignoring systemic effects of one-shot interventions, from seeing cases in isolation, and from intense emotional reactions."[27] Thus, in the behavioral economics paradigm, cost benefit-analysis may not only promote efficient resource allocation, but also encourage sensible decision-making by curtailing psychological misconceptions.

Posner has expressed concern over the strength of behavioral economics in the past and, generally speaking, he apparently considers himself to be a traditional legal-economist. For instance, he has argued that the traditional economic analysis of law is not handicapped by its commitment to rationality, for all humans are capable of choosing the best available means to the chooser's end.[28] And thus, Posner has maintained that "[r]ats are at least as rational as human beings when rationality is defined as achieving one's ends (survival and reproduction, in the case of rats) at least cost."[29] But in *Catastrophe*, Posner appears to be departing from his rigid support of the traditional economic analysis of law. Posner asserts that cost-benefit analysis is capable of curbing the psychological misconceptions that accompany the formulation of social policy in response to catastrophic risks. He contends that there are a variety of social and psychological factors that may distort our views on catastrophic risks. For instance, he argues that people have a difficulty understanding that science and technology create both enormous risks and enormous benefits.[30] More specifically, it is clear that science and technology have contributed positively to human welfare, and therefore,

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25. Cass R. Sunstein, *Cognition and Cost-Benefit Analysis*, 29 J. LEGAL STUD. 1059 (2000).

26. *Id.* at 1059.

27. *Id.*

28. FRONTIERS, *supra* note 18, at 252 (accepting the usefulness of behavioral economics but nevertheless critiquing the behavioral economists' critique that the traditional economic analysis of law is "handicapped by its commitment to the assumption that people are rational").

29. FRONTIERS, *supra* note 18, at 253.

30. Posner argues that people generally have a tendency to overestimate the benefits and underestimate the costs associated with science and technology (p. 116). Indeed, social attitudes toward the potential harmful effects of technology appear to be mitigated as a result of coherence-based reasoning.

> Ultimately, people make decisions through what appears to be a rational-like choice
> in which a strong alternative is straightforwardly preferred over its rival. However,
> this dominance is the product of an unconscious cognitive process that reconstructs

people are eager to dismiss the intrinsic dangers of science (p. 98).[31] By recognizing the fact that people are reluctant to give due regard to the intrinsic dangers posed by science, Posner is implicitly accepting the central tenet of the behavioral economics paradigm: a thorough understanding of human psychology can aid the traditional economic analysis of law.

Posner further elaborates on other catalysts for our ignorance of catastrophic risks, many of which are deeply rooted in psychological misconceptions. For example, scientific doomsters mitigate the perceived risk of catastrophe. "After enough false prophecies of doom, people stop paying attention" (p. 111).[32] Similarly, our ignorance of catastrophic risks may be the result of scientific lexicon that baffles the layperson's mind (p. 96).[33] On the contrary, however, Posner also notes that while many are quick to dismiss the likelihood of catastrophe as negligible, others may be inadvertently inflating, to our detriment, the likelihood of catastrophe. For instance, the interrelation between science and catastrophe is sometimes irrationally inflated as a result of sci-

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> and transforms difficult and complex decisions into easy ones by amplifying one
> alternative and deflating the other.

Dan Simon, *A Third View of the Black Box: Cognitive Coherence in Legal Decision Making*, 71 U. CHI. L. REV. 511, 583-84 (2004).

31. Scientific ignorance has been a popular topic of study. As Posner notes, in 1999, a study found that a large proportion of the United States population was scientifically literate. Jon D. Miller, *Civic Scientific Literacy: A Necessity in the 21st Century*, 55 J. FED'N AM. SCIENTISTS 3, 4, 6 (2002) (concluding that "[w]e should take no pride in a finding that four out of five Americans cannot read and understand the science section of the New York Times"). Moreover:

> [o]nly a third of American adults know what a molecule is, 39 percent believe that
> astrology is scientific, and 46 percent deny that human beings evolved from earlier
> animal species. Only 52 percent do *not* believe in astrology, 50 to 60 percent
> believe in ESP, only a little more than half know that it takes the earth a year to
> revolve around the sun (some don't know it takes a year; some don't know the earth
> revolves around the sun), about a third believe in UFOs, and similar percentages
> believe in ghosts and in communication with the dead. It is possible that science is
> valued by most Americans merely as another form of magic.

(pp. 93-94) (emphasis original) (internal citations omitted).

32. Take, for instance, Carl Sagan's stance on the potential catastrophic harm that would result if Saddam Hussein had set fire to Iraq's oil fields during the 1991 Gulf War. Sagan stated:

> the net effects will be very similar to the explosion of the Indonesian volcano
> Tambora in 1815, which resulted in the year 1816 being known as the year without
> a summer. There were massive agricultural failures in North America and in
> western Europe, and very serious human suffering and, in some cases, starvation.
> Especially for south Asia that seems to be in the cards, and perhaps for a significant
> fraction of the northern hemisphere as well.

(p. 111) (quoting *Nightline: First Israeli Scud Fatalities; Oil Fires in Kuwait* (ABC television broadcast, Jan. 22, 1991).

33. Maybe understanding science is akin to understanding how to pilot a steamboat. *See* Paul D. Carrington, *Of Law and the River*, 34 J. LEGAL EDUC. 222 (1984) (utilizing Mark Twain's *Life on the Mississippi* to compare steamboat pilots to lawyers). In such an instance, increased allocations in education may be an adequate social response to scientific illiteracy.

ence fiction novels and movies. Instead of drawing serious attention to risks, as the authors so desire, science fictions novels and movies sometimes unrealistically exacerbate catastrophic risks (pp. 100-10).[34] In the aggregate, Posner's reliance upon psychological factors to explain our ignorance of catastrophic risks suggests that Posner is implicitly supporting the use of psychology in formulating social policy in response to catastrophic risks. As a result, Posner appears to be subscribing, at least partially, to the behavioral economics paradigm.

All things considered, cost-benefit analysis is an inquiry that reduces decision-making to a simple weighing of expected costs against expected benefits. Concerning catastrophe however, Posner notes that the assignment of monetary variables to cost-benefit analysis may be a difficult endeavor. More specifically, cost-benefit analysis may force us to contemplate the unthinkable: for instance, to assign a monetary variable to the value of human life. But Posner offers a practical way to contemplate the unthinkable in his discussion of the value of life.[35]

Posner has argued, in a previous work, that "[m]ost people would not exchange their lives for anything less than an infinite sum of money if the exchange were to take place immediately, since they would have so little time in which to enjoy the proceeds of the sale."[36] The corollary, therefore, is not that the value of life is infinite. If the value of life were infinite, "[t]his would imply that the optimum rate of fatal accidents was zero, or very close to it . . . and it is plain that people are unwilling, individually or collectively, to incur the costs necessary to reduce the rate of fatal accidents so drastically."[37] Cost-benefit analysis rarely yields the conclusion that an optimal expenditure requires that the likelihood of a fatal risk should be reduced to zero. Due to our reluctance to reduce fatal risks to a negligible probability, Posner contends

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34. Posner argues that melodramatic films such as *Armageddon* (1998 Touchstone Pictures), *Outbreak* (Warner Studios 1995), *The Day After Tomorrow* (20th Century Fox 2004), and *The Matrix* (Warner Studios 1999) shape our attitudes of potential catastrophic risks (pp. 104-10).

35. Note that Posner's value-of-life analysis is restricted to humans. Consequently, no value of life is assigned to animals at risk from the loss of biodiversity (other than the animal's intrinsic market value). *See infra* Part II.C.2. Perhaps the value of life analysis should not be restricted merely to humans. Indeed, a utilitarian analysis has been applied to animal rights. *See* PETER SINGER, ANIMAL LIBERATION 1-23 (2d ed. 2002) (arguing, on utilitarian grounds, that the interests of all animals ought to be weighted equally). The recent advocacy of some scientists to move humans, chimpanzees and bonobos within a single genus has sparked a moral debate as to whether all should be treated equally under the law. *See* Rowan Taylor, *A Step at a Time: New Zealand's Progress Toward Hominid Rights*, 7 ANIMAL L. 35 (2001); *see also* The Jane Goodall Institute, *at* http://www.janegoodall.org/default.asp (last visited Apr. 20, 2005). All in all, "[a]nimals feel pain . . . so that utilitarianism collides with powerful intuitions that our social obligations are . . . greater to human beings than to (other) animals." FRONTIERS, *supra* note 18, at 98.

36. RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 196 (6th ed. 2003) [hereinafter ECONOMIC ANALYSIS].

37. *Id.*

that human life cannot be valued at infinity.[38]

Posner suggests a calculation to determine the value of life. He maintains that the "[d]ivision of the 'price' charged to bear a given risk by the risk [itself] yields the value-of-life estimate" (p. 165).[39] In other words, the value of life is computed by dividing the price demanded to eliminate a death-causing event by the probability that the death-causing event will occur.

Posner observes that governmental regulations of different risks produce inconsistent results with respect to value-of-life estimates. For example, government awards have ranged from "$100,000 for death in accidents involving unvented space heaters to $92 billion for death from the herbicides atrazine or alachlor in drinking water" (p. 188).[40] His observation is meritorious. Governmental regulations have lead to inconsistencies in monetizing human life. A study of seatbelt use found the value of life to be roughly $370,000,[41] while another study examining the wage differentials received by workers on various hazardous jobs estimated the value of life at roughly $3.2 million.[42] Posner notes these inconsistencies, and argues that estimates on the value of human life are currently in the range of four to nine million dollars, with a mean estimate of seven million dollars (p. 166).[43]

In opposition to previous value-of-life estimates, Posner argues that

38. Gary Becker has taken this analysis one step further and argued that due to the inherent unwillingness of some persons to reduce risks, such as smoking or driving, all deaths to some extent can be considered suicide. *See* GARY S. BECKER, THE ECONOMIC APPROACH TO HUMAN BEHAVIOR 10 (1976) (stating that "deaths are to some extent 'suicides' in the sense that they could have been postponed if more resources had been invested in prolonging life").

39. *See also* ECONOMIC ANALYSIS, *supra* note 36, at 196-200; FRONTIERS, *supra* note 18, at 125-27.

40. Posner states that "[t]he differences among the value-of-life estimates probably can be explained by information costs; by psychological factors such as probability neglect, the availability heuristic, and the 'dread' factor . . .; by political factors; and by the asymptotic relation between risk and the value of life" (p. 188).

41. Glenn Blomquist, *Value of Life Saving: Implications of Consumption Activity*, 87 J. POL. ECON. 540, 556 (1979). Note that this sum is in 1978 dollars.

42. Craig A. Olson, *An Analysis of Wage Differentials Received by Workers on Dangerous Jobs*, 16 J. HUM. RESOURCES 167 (1981). Note that the study was published in 1981. For other works discussing value-of-life estimates, see ECONOMIC ANALYSIS, *supra* note 36, at 197 n.5.

43. Posner cites the work of W. Kip Viscusi & Joseph E. Aldy, *The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World*, 27 J. RISK UNCERTAINTY 5 (2003), which estimates the median value of a prime-aged worker's life in the United States at seven million dollars. *But see* G. C. Blomquist, *Economics of Value of Life, in* 24 INTERNATIONAL ENCYCLOPEDIA OF THE SOCIAL & BEHAVIORAL SCIENCES 16133-39 (Neil J. Smelser & Paul B. Baltes eds., 2001) (estimating the mean value of life to be five million dollars). It is important to note, however, that the value-of-life estimates computed by dividing the price charged to bear a certain risk by the risk itself may not accurately monetize the value of life, for as Lisa Heinzerling has argued, these "studies do not measure the ultimate value a person places on her own life; they measure only the value she places on an increased risk of death." Lisa Heinzerling, *Discounting Life*, 108 YALE L.J. 1911, 1913 (1999) (correspondence).

the statistical evidence leaning toward a mean value-of-life estimate of seven million dollars in the case of catastrophe is misleading. Previous studies concerning value-of-life estimates were based upon incomes in wealthy countries, where value-of-life estimates tend to be proportionate to incomes (p. 167). Furthermore, the risk of extinction from catastrophe is generally less likely than the smallest risks evaluated in value-of-life studies (p. 167). Indeed, the low probability of catastrophe minimizes value-of-life estimates because the relationship between the risk of death from catastrophe and the perceived cost to mitigate that risk is not linear.[44] For instance, suppose the risk of death is 1/1,000 and the price demanded to bear such a risk is $7000, then the value of life is seven million dollars.[45] However, what if the risk posed was much higher? For example, how much would you demand to play the "game" of Russian roulette, where the risk of death is 1/6?[46] Most persons would insist on an enormous amount of money to assume such a risk, almost certainly greater than seven million dollars (p. 170). More precisely, although the risk of death in the game of Russian Roulette is approximately 167 times greater than that of a 1/1,000 risk of death, the price demanded to play Russian Roulette will probably not be 167 times greater than that demanded to bear a 1/1,000 risk; indeed, it will probably be much greater than $1,169,000.[47]

In sum, Posner argues that "most people are content to incur very small risks for negligible benefits because the likelihood that the risk will materialize and the benefit thus be snatched away is very slight" (p. 166).[48] Due to the low probability of most catastrophic events, as opposed to the probability associated with risks akin to the "game" of

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44. Posner proposes the following equation to illustrate the non-linear relationship between risk and the value of life:

$$v = r/(1-r)^{10}$$

where

    r is the risk

and

    v is the value to the average individual of avoiding risk r.

(pp. 166-67).

45. Recall that Posner argues a more accurate valuation of life can be achieved by dividing the price charged to bear a certain risk by the risk itself, thus 7000 dollars divided by 1/1000 yields a value of life of seven million dollars. *See supra* note 44 and accompanying text.

46. Russian roulette is a "game" in which one bullet is randomly placed in one of six chambers in the cylinder of a standard revolver. The participating member proceeds to spin the cylinder of the revolver. The member then holds the gun to his head and pulls the trigger. Consequently, the probability that the gun is successfully discharged (or perhaps unsuccessfully discharged if you are the participating member) is 1/6.

47. The product of 167 and $7000 (the price demanded to bear a 1/1,000 risk) is $1,169,000.

48. Posner cites Milton C. Weinstein et al., *The Economic Value of Changing Mortality Probabilities: A Decision-Theoretic Approach*, 94 Q. J. ECON. 373, 384 (1980) to support this proposition.

Russian roulette, Posner conservatively estimates that the value of life in the case of catastrophe is approximately $50,000 (p. 169).[49] He therefore conservatively estimates the loss from extinction of the entire human race to be $600 trillion; although, if every human were to die at once and without any warning, there would arguably be no loss.[50] It is counterintuitive to assign a monetary value to the entire human race, for no one would be around to absorb the cost in the case of extinction.

There is, however, another twist that Posner discusses in valuing human lives. Notice the impact of present value discounting on the value of life: a discount rate that is based on market interest rates tends to trivialize the welfare of future generations (p. 152). For instance, "[a]t a discount rate of five per cent [sic], one death next year counts for more than a billion deaths in 500 years" (p. 152).[51] Similarly, if we wish to save one life this year, we ought to "be willing to sacrifice almost 150 lives a century hence" (p. 152). Thus, the effect of present-value discounting on the value of life, and moreover cost-benefit analysis in general, is dramatic because "the benefits of the responses are likely to be spread out over a very long time while many of the costs may have to be incurred in the present and near future" (p. 151). Indeed, if we were to treat every potential human life, from now until the sun expands to incinerate the Earth, as inherently equal, then the effect would be to reduce the utility of the present generation to a minimal level (p. 153).[52]

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49. *Id.* at 169. Note, however, that Posner's estimation applies to only the smallest catastrophic risks. In the case of a catastrophic asteroid collision, as we will see below, the value of life may be much greater than the conservative estimate of 50,000 dollars.

50. The cost of extinction is the product of the value of life and the adjusted number of humans (to take into account the utility of future generations). If we give no consideration to future generations, the cost of extinction is approximately $300 trillion, which is the product of the current global population of roughly six billion persons and $50,000. However, Posner proposes that "as a crude adjustment we simply double the figure for the current population and, despite the [dubious procedure of weighing all future generations equally as the current one], multiply it by only $50,000" (pp. 169-70). Accordingly, the cost of extinction is the product of twelve billion persons and $50,000, which yields an extinction cost of $600 trillion (pp. 169-70).

51. Quoting DEREK PARFIT, REASONS AND PERSONS 357 (1984).

52. Adrian Kent complicates the analysis by concluding that the number of people inhabiting the earth between now and when the sun expands to incinerate the earth is 100 quadrillion (p. 191) (citing Adrian Kent, *A Critical Look at Risk Assessments for Global Catastrophes*, 24 RISK ANALYSIS 157, 164 (2004)). Notice that Kent's computation does not presume that the population will continue to grow indefinitely and uncontrollably until our Earth's demise. Current analyses suggest that the Earth will reach a steady-state population between eleven and thirteen billion in the next few decades. STEPHEN WEBB, IF THE UNIVERSE IS TEEMING WITH ALIENS . . . WHERE IS EVERYBODY?: FIFTY SOLUTIONS TO THE FERMI PARADOX AND THE PROBLEM OF EXTRATERRESTRIAL LIFE 125 (2002). *But see World Population in 2300*, U.N. Department of Economic and Social Affairs, Population Division, U.N. Doc. ESA/WP.187/Rev.1 (2004) (stating that a steady-state population of nine billion persons will not be reached until 2300), *available at* http://www.un.org/esa/population/publications/longrange2/2004worldpop2300reportfinalc.pdf.

As a result, Posner concedes that it is relatively unclear how much we should really care about our remote descendants (p. 118-19).

It is clear that concerns regarding economic efficiency may be hampered if we give too much weight to distant, future generations. Posner's discussion of present-value discounting is invigorating because he illustrates that there is no discernable amount of consideration that we should give to our descendants. I am convinced, from Posner's discussion of present-value discounting, that while altruism may be a virtue, too much altruism may indeed be a bad thing. Should social policy reflect the well-being of our children? Probably. What about our grandchildren? Perhaps. At what point should we cease to give regard to our ancestors? There may truly be no correct answer. But, it is important to note that the problems associated with discounting future lives does not render cost-benefit analysis useless. Although cost-benefit analysis may concededly lack a positive dimension and it may be difficult to assign a monetizable value to all future generations, cost-benefit analysis, as demonstrated above, is still an important tool to formulate efficient responses to catastrophic risks. With this background in mind, we move to the breadth of *Catastrophe*: Posner's discussion and evaluation of catastrophic risks.

II. POSNER ON CATASTROPHE

Catastrophe: Risk and Response utilizes cost-benefit analysis, and some derivatives thereof, as described in Part I to evaluate the cataclysmic potential of a variety of catastrophic risks that have more than a negligible probability of occurrence (p. 21). Posner classifies these catastrophic risks as: natural catastrophes or man-made catastrophes, with the latter broken down into three subgroups: scientific accidents, unintentional catastrophes, and intentional catastrophes (p. 21). Posner's taxonomy is useful in distinguishing between catastrophic risks for educational purposes, but as he concedes in *Catastrophe*, these catastrophic risks may sometimes act synergistically. For instance, an asteroid collision (as a natural risk) could interact with global warming (as a man-made risk) to precipitate catastrophe. As a result, his categorization, while aiding the reader in classifying and understanding catastrophic risks, should not be understood as an attempt to isolate all catastrophic risks and respective social policy responses from one another.

A. *Natural Catastrophe*

1. PANDEMICS AND *FORCE MAJEURE* EVENTS

Of the natural catastrophes – pandemics, *force majeure* events,[53] and asteroid collisions – Posner contends that the only catastrophic risk with truly disastrous cataclysmic potential is that of an asteroid collision. According to Posner, natural pandemics do not present a major catastrophic risk due primarily to modern improvements in medical science (pp. 23-24). Although recent technological innovations in transportation have resulted in the rapid spread of once-territorial diseases and the "promiscuous use of antibiotics" has spurred the evolution of bacteria, the likelihood of extinction resulting from a natural pandemic is negligible (p. 23). Posner argues that in an evolutionary sense, pathogens are generally not suicidal; indeed, Darwinian "[n]atural selection favors germs of limited lethality" as such germs are more likely to spread to other hosts if they do not kill their initial host too hastily (p. 23). There is generally a correlation between the spread of a disease and the length of the infectious incubation period (p. 22). Despite the fact that natural pandemics have historically caused a great number of casualties, such as the Black Plague of the Middle Ages and the Spanish Influenza of the early twentieth century, humans have managed to survive each pandemic (p. 23).

Posner's willingness to dismiss the devastating effects of pandemics as sub-catastrophic may seem quite extreme. The dichotomy that Posner creates in *Catastrophe* by dividing the purely catastrophic from the sub-catastrophic is apparently one of mere rhetoric. While it is clearly apparent that Posner is not interested in entirely dismissing the potential harmful effects of sub-catastrophic events, it is unclear why Posner initially creates such a rigid dichotomy. Although the dichotomy created serves the function of limiting discussion to low probability risks with the potential for cataclysmic harm, it is not clear as to why Posner would dismiss low probability events that only had the propensity to kill, for instance, one-quarter of the population, as merely sub-catastrophic. Posner's desire to distinguish the catastrophic from the sub-catastrophic leads to the same concern posed above regarding the social cost created by extinction of the human race. Were a Posner-defined catastrophe to occur, eliminating the entire human population, would there be any social loss? If the answer is no, then perhaps Posner should have limited his discussion to only sub-catastrophic events, in which there is a discernable social loss.

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53. For the purpose of this review, the term *force majeure* refers to naturally occurring events such as earthquakes and volcanic eruptions.

Posner argues that with respect to *force majeure* events, technological breakthroughs have decreased the likelihood that a volcanic eruption or earthquake could lead to global catastrophe. *Force majeure* events, which pose a potentially higher expected cost than most other catastrophic risks, are currently less destructive than before due to our ability to detect and protect against these disasters.[54] Although Posner would probably not classify the December 26, 2004 tsunami, which caused widespread havoc to the shores of the south-Asian continent, as a catastrophic event, it is clear that *force majeure* events may nevertheless impose a great deal of harm upon civilizations. All things considered, due to technological breakthroughs, the likelihood of the mass extinction of the human race from a naturally occurring pandemic or *force majeure* event is probably less today than in the past.

2. ASTEROID COLLISIONS

Among the natural catastrophes, Posner claims that the catastrophic risk with the greatest potential for harm is that of an asteroid collision.[55] It is believed that roughly 250 million years ago, an asteroid collision resulted in the extinction of ninety percent of the earth's species (p. 25). Likewise, some sixty-five million years ago, it is believed that an asteroid collision may have resulted in the extinction of the dinosaurs, although paleontologists disagree over the actual cause of extinction (p. 25). The dominant view is that the dust emitted from the asteroid strike

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54. Note that the expected cost for both earthquakes and volcanic eruptions is greater than that of other catastrophes due to the comparatively larger likelihood that such an event will occur (p. 29).

55. Although noting that contrary authority exists regarding the potential catastrophic risk posed by a comet collision, Posner disregards the likelihood of such a collision as negligible. Posner states that "only about 1 percent as many comets as asteroids approach close enough to the earth to pose a danger of collision" (p. 24). Accordingly, Posner argues that social policy aimed at protecting the Earth from a comet collision would be inefficient, since:

> the function of threat assessment, in regard to catastrophic risks as well as to more familiar threats, is not only to rank threats by their expected cost but also to fix a cutoff point below which threats will be disregarded because they would require attention disproportionate to the social benefits that attention to them would confer.

(pp. 182-83).

In other words, the time diverted to assessing the threat of extremely low-probability events may impede social reaction to higher probability events (p. 183). Consequently, Posner dismisses the probability as being too low to warrant consideration. However, according to W. M. Napier et al., comet strikes represent a major, if not dominant, global impact hazard at the present time. Dark comets – those comets too dark to be seen with modern astronomical tools (the counterexample being Halley's Comet) – may pose an enormous catastrophic risk. Current detection and deflection strategies may not be able to detect or deflect an incoming comet. Alas, "there exists a large population of extremely dark comets in Earth-crossing orbits, which are undetectable with current near-Earth object (NEO) search [programs] but are nevertheless impact hazards." W. M. Napier et al., *Extreme Albedo Comets and the Impact Hazard*, 355 MONTHLY NOTICES ROYAL ASTRONOMICAL SOC'Y 191, 194 (2004).

impeded photosynthesis and consequently caused the dinosaurs to starve to death (p. 25). An alternative view supposes that the synergy of dust, forest fires, and sulfuric acid emitted from the vaporizing of sulfate rock caused the extinction of the dinosaurs (p. 25). Regardless of which story is correct, the "real world" effect of asteroid impact is clear. Were a large enough asteroid to strike the earth, the extinction or near extinction of the human race could result from a "combination of fire, concussion, enormous tidal waves, and the blocking for several years of the sunlight required for crops and other plant life" (p. 25).

Posner supposes that modern technology is ill-equipped to deal with an incoming, potentially-catastrophic, asteroid. NASA currently spends roughly $3.9 million annually "compiling its catalog of near-earth objects," which is a preliminary defense measure against an asteroid collision (p. 179). Unfortunately, our lackadaisical current defense measures grant us only a few seconds to detect an incoming asteroid (p. 26). As a result, Posner strongly suggests that we improve our knowledge of the composition, density, and other properties of asteroids to help us better understand how to alter their orbits.[56]

On a global scale, Posner illustrates that cost-benefit analysis indicates that international governments ought to be spending more on asteroid detection. The United States is the primary investor in asteroid defense. Accordingly, global expenditures in asteroid defense amount to only slightly greater than $3.9 million (p. 180). Applying a value of life analysis to an asteroid collision, the risk, as estimated by a United Kingdom task force, of an asteroid collision killing 1.5 billion people is one in 250,000 (p. 180). Part I illustrated that studies regarding risks as small as one in 100,000 yield a mean value-of-life estimate of approximately seven million dollars. Noting that the risk of an asteroid collision is not small enough to justify the conservative value of life estimate of $50,000, Posner extrapolates that the value of life is nevertheless substantially less than seven million dollars (p. 180). For the sake of argument, Posner supposes that the value of life in the case of an asteroid collision is two million dollars (p. 180). By giving no consideration to future generations, the annual expected cost of a globally catastrophic asteroid collision is therefore approximately twelve billion dollars (p. 180).[57] Thus, Posner claims that cost-benefit analysis calls for increased expenditures to protect against asteroid collisions on a global scale, for

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56. Posner proposes that if we were able to gain notice of an incoming asteroid, we may be able to use missiles tipped with nuclear warheads to destroy it, or alternatively, alter the asteroid's trajectory with rockets (p. 28). Yet, such solutions are not so simple as an attempt to destroy an incoming asteroid with a nuclear weapon would result in the creation of a multitude of smaller asteroids, which increases the probability that a fragment would strike a population area (p. 28).

57. The expected annual cost is the product of the annual probability of an asteroid collision

an annual expected cost of twelve billion dollars exceeds the current annual expenditure of $3.9 million by a factor of roughly 3000!

While Posner's calculation regarding the expected cost of an asteroid collision is contingent upon probabilities and magnitudes of harm that the reader is asked to take for granted, Posner's application of cost-benefit analysis to an asteroid collision illustrates the ability of cost-benefit analysis to identify social problems that most would be eager to dismiss as so highly improbable as to not warrant a social policy response. More precisely, absent cost-benefit analysis, it is difficult to see that investing in asteroid defense confers a substantial social benefit that far outweighs expected social loss.

Posner points out that although cost-benefit analysis yields the conclusion that greater investments ought to be made in asteroid detection and prevention (p. 197), the implementation of a global response to the threat of asteroid collisions may be a difficult endeavor. The United States, currently the only nation with the technological capacity to build an asteroid defense system, may be required to step to the fore (p. 127). Initially, this proposition would lead one to believe that the likelihood of the United States constructing an asteroid defense system is low due to the disincentive generally associated with international free riding. This disincentive, mainly that other nations will derive a benefit from an asteroid defense system while the United States will be forced to incur the entire cost, would initially lead one to suppose that the United States would be hesitant to construct such a system. However, Posner argues that other nations might be willing to contribute financially to an asteroid defense fund, since a common enemy, such as an asteroid, generally induces nations to cooperate.[58] Additionally, the cost of an asteroid defense system may only be a few billion dollars, incurred over a number of years. At such a small cost, Posner contends that international free riding will probably not stop the United States from creating an asteroid defense system (pp. 127-29).

B.   *Scientific, Man-Made Catastrophe*

1.   THE STRANGELET SCENARIO

The strangelet scenario involves the possibility that a particle accelerator could produce a strange quark capable of initiating a chain reaction that would inevitably convert all matter into strange matter and

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(one in 250,000) and the magnitude of harm (the product of two million dollars per person and 1.5 billion persons).

   58. Posner points out that the expected cost of an asteroid collision among nations is generally uniform. Although larger countries are more likely to be struck by an asteroid, the smaller countries would likely suffer greater devastation (p. 128).

consequently mutate the earth into a hyperdense sphere. Physicists are currently in a "'search for the Holy Grail' of a unified theory of physical forces" (pp. 133-34).[59] Unfortunately, the physics of subatomic particles is presently not well understood (p. 30). Physicists at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory in Long Island, New York collide and shatter gold nuclei to further their search for a unified theory of physical forces (p. 31). These collisions produce an alarming volume of quarks – the basic form of matter constituting protons and neutrons (p. 31). Of special worry is the possibility, albeit extremely low, that such a collision might "produce a shower of quarks that would 'reassemble themselves into a very compressed object called a strangelet . . . . [which could], by contagion, convert anything else it encountered into a strange new form of matter . . . . [transforming] the entire planet Earth into an inert hyperdense sphere about one hundred meters across'" (p. 30).[60] More specifically:

> [i]f such particle were also negatively charged, it would be captured by an ordinary nucleus as if it were a heavy electron. Being heavier, it would move closer to the nucleus than an electron and eventually fuse with the nucleus, converting some of the 'up' and 'down' quarks in its protons and neutrons, releasing energy, and ending up as a larger strangelet. If the new strangelet were negatively charged, the process could go on forever (p. 31).[61]

Thus, the strangelet could theoretically grow "until all matter was converted to strange matter" (p. 31).

Posner believes that the safety regarding the physics behind particle accelerators is relatively unknown. Initial risk assessors of the Brookhaven National Laboratory's particle accelerator speculated that the cataclysmic risks associated with particle accelerators were not limited to the strangelet scenario. Additionally, a catastrophic risk included the possibility that the energies created at the particle accelerator could lead to the formation of a black hole that would tunnel down from Long Island to the Earth's center and proceed to devour the planet (p. 31).[62] While the destructive power of the strangelet and black hole scenarios is lim-

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59. Posner quotes Paula E. Stephan, *The Economics of Science*, 34 J. ECON. LITERATURE 1199, 1217 (1996).

60. Posner quotes Sir Martin Rees from MARTIN J. REES, OUR FINAL HOUR: A SCIENTIST'S WARNING: HOW TERROR, ERROR AND ENVIRONMENTAL DISASTER THREATEN HUMANKIND'S FUTURE IN THIS CENTURY ON EARTH AND BEYOND 120-21 (2003) to explain how a strangelet may occur.

61. Posner quotes John Marburger, the Director of the Brookhaven National Laboratory in John Marburger, Committee Report on Speculative "Disaster Scenarios" at RHIC (Oct. 6, 1999) (Synopsis of Committee Report), *available at* http://www.phys.utk.edu/rhip/Articles/RHICNews/BNL_rhicreport.html.

62. *See* WEBB, *supra* note 52, at 129.

ited to Earth, a universe-threatening scenario involves the possibility that the Tevatron particle accelerator at Fermilab in Batavia, Illinois, could trigger the collapse of the quantum vacuum state and destroy all the atoms in the entire universe (p. 31).[63]

Posner dismisses the possibility of the collapse of the quantum vacuum state as highly unlikely for "if there is intelligent life elsewhere in the universe, as seems highly likely from the sheer number of planets . . . some civilization more advanced than our own would already have built a particle accelerator as powerful as RHIC, precipitating a phase transition that would have destroyed the universe" (p. 31). Posner posits, as did the great physicist Enrico Fermi, that the sheer number of planets with suitable environments for the development of life, when coupled with the vast age of our universe, leads to the conclusion that intelligent extraterrestrial life must exist.[64] The fundamental premise behind Posner's dismissal of universe-threatening catastrophic risks may be based on Fermi's Paradox – the fact that we see no signs of intelligence life when we might expect to.[65]

Posner offers the following question: with so little known regarding the inherent safety of particle accelerators, how was Brookhaven given the proverbial "green light" to construct RHIC? The initial safety assessment at RHIC was done by a four-member team selected by the laboratory itself (p. 189). Led by Robert Jaffe, this team consisted of a theoretician and three particle physicists, all arguably with career stakes in the success of RHIC (p. 189). The potential benefits to the team were enormous; if RHIC were to become a success, the team could potentially share immense benefits "in the form of prestige, career placement, and personal satisfaction" (p. 189). Thus, self-interested assessors may have

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63. *See id.* at 129-30.

64. *Id.* at 3-4.

65. *Id.* at 22. The story behind Fermi's Paradox is quite intriguing. Enrico Fermi, the Nobel Prize winner in Physics in 1938, was mingling with co-workers during lunch at Los Alamos in the summer of 1950. *Id.* at 8, 17. The topic of conversation was the recent flurry of flying saucer observations. *Id.* at 17. When the conversation later changed to more mundane topics, Fermi interrupted the discussion and seemingly out of nowhere asked, "Where is everybody?" *Id.* at 18. His co-workers were well aware of the implications of Fermi's statement; indeed, the massive size and great age of the universe were conducive to the belief that intelligent life must exist elsewhere in the universe. *Id.* Fermi went on to make a series of rapid calculations and concluded that the Earth should have been visited long ago. *Id.*

Tangentially, Posner dismisses the possibility that extraterrestrials pose a catastrophic risk to mankind. The risk is negligible for two reasons: first, the distance between habitable planets is extremely large; consequently, travel among inhabited planets may be impossible (pp. 40-41). Second (and more relevant to Fermi's Paradox), the possibility exists that extraterrestrial intelligent beings have already destroyed their civilizations by abusing technological advance (p. 41). Alas, this is a "level we may be approaching" (p. 41).

tainted the initial safety assessment of RHIC.[66]

Of concern to Posner is that the Center for European Nuclear Research (CERN) is planning to begin operating a particle accelerator "that will outdo RHIC in luminosity" – the likeliness for a collision to occur in an accelerator (p. 32). Also, Brookhaven is seeking to upgrade RHIC (RHIC-II) by 2010, which would "enable particle collisions with up to 40 times the luminosity of the existing RHIC" (p. 32). Regardless of CERN's plan and Brookhaven's proposed upgrade, Posner argues that cost-benefit analysis of the existing RHIC yields the conclusion that RHIC ought to be closed, at least temporarily. RHIC's expected life span is ten years (p. 141). The fixed construction cost of RHIC is $600 million and its annual operating costs are expected to be roughly $130 million (p. 140). With a discount rate of three percent, RHIC's net present cost is $1.7 billion, which is the sum of the present-value of the annual operating costs ($1.1 billion) and the fixed construction costs ($600 million) (pp. 140-41).

The benefits of RHIC have been estimated by Posner to be approximately $250 million per year (pp. 140). Unlike an asteroid collision, which incidentally would yield a benefit only to a Malthusian or a masochist, RHIC may confer some utility upon the scientific community according to Posner. "Particle accelerators have played an important role in the growth of physical knowledge, knowledge that has in turn given rise to important products and services, including PET (positron emission tomography) scans, the ion-implementation method of manufacturing integrated circuits, and the development of superconductors" (p. 143). Although experiments in the near future are unlikely to yield any monetary benefits, even unsuccessful current experiments confer utility upon other people inside and outside the scientific community (p. 145). Therefore, with a discount rate of three percent, Posner argues that the net present stream of benefits of RHIC is $2.1 billion (pp. 140-41).

Posner states that the lynch-pin of cost-benefit analysis of RHIC is whether RHIC does indeed pose a catastrophic risk. For instance, posit that the probability of strangelet scenario is zero.[67] In such an instance,

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66. Paradoxically, although the assessment team dismissed the strangelet scenario as fiction, the team hoped that RHIC would actually yield a strangelet as an experimental result (p. 192).

67. The director-general of CERN commissioned a study into the safety of the Large Hadron Collider and found the probability of the strangelet scenario to be negligible (p. 193). This commission dismissed the possibility of the strangelet scenario "[f]or as the strangelet expanded, the strange quarks, because of their density, would sink beneath the surface, which would thus come to be dominated by the positively charged nuclei" (p. 194). Thus, the strangelet scenario did not pose a danger because a hypothetical strangelet would conceivably stop growing far before it mutated the earth (p. 194).

cost-benefit analysis yields a positive difference of $400 million, for the net present cost of $1.7 billion is outweighed by the net present benefit of $2.1 billion (pp. 140-41). However, Posner supposes that the probability of the strangelet scenario is slightly greater than zero. Posner presumes, for the sake of argument, that the annual risk of extinction resulting from the strangelet scenario is one in ten million.[68] As mentioned in Part I, for extremely low-probability risks (such as the strangelet scenario), Posner conservatively estimates the extinction of the human race at $600 trillion. The expected annual cost of extinction from the strangelet scenario is therefore $60 million – the product of a one in ten million probability of extinction and the $600 trillion cost of extinction (p. 141). Taken over ten years the total expected cost of extinction, discounted to present value, is $500 million (p. 142). Accordingly, the total expected cost of RHIC, including the expected cost of extinction, is $2.2 billion (p. 142). Thus, Posner claims that cost-benefit analysis tips in favor of closing RHIC, for the expected cost of $2.2 billion exceeds the expected benefit of $2.1 billion by $100 million.[69] The obvious critique, however, is whether the appropriate

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68. Because RHIC has been operating for four years without precipitating a strangelet disaster, Posner concludes that there has been no change in the probability of extinction stemming from the strangelet scenario. As a counterexample, Posner states:

> one might predict that the probability that an innocuous-seeming object was a land mine that would explode when one stepped on it was 1 in 1,000. But if one then stepped on it once and it did not explode, one would no longer think that the risk of explosion if it were stepped on again would be 1 in 1,000; the risk would be reestimated downward, perhaps radically, because stepping on the object was in the nature of an experiment and yielded highly relevant information.

(pp. 194-95). Posner argues that the risk associated with particle accelerators is different because "[t]he fact that the first particle collision in RHIC, or the first four years of collisions, did not result in a strangelet disaster did not falsify the very low probabilities that the concerned scientists had assigned to such an event" (p. 195). Indeed, the fact that RHIC has been running safely for four years does not falsify the low probability of the strangelet scenario. However, given Bayes' Theorem – simply stated, prior probabilities must be updated based on relevant evidence – it can be argued that the fact that RHIC has not precipitated catastrophe in the past four years has lowered (even further) the initial probability assigned by assessors. *See* THOMAS BAYES, AN ESSAY TOWARDS SOLVING A PROBLEM IN THE DOCTRINE OF CHANCES (1763).

69. The costs, including the risk of extinction, are the construction costs ($600 million) summed with the operating costs ($1.1 billion) and the expected cost of extinction ($600 trillion multiplied by 10^{-7}), which is $2.2 billion. The benefits remain as the present value of RHIC's stream of annual benefits ($2.1 billion).

In the case of RHIC-II, Posner concedes that cost-benefit analysis may be an inadequate threshold inquiry because the relevant probabilities, costs, and benefits are difficult to ascertain. Posner therefore advocates the use of the tolerable-windows approach – a method recognizing that we may know enough about the benefits and costs, even when uncertainty exists, to be able to create a 'window' of acceptable expenditures (p. 184). The utility of the tolerable-windows approach lies in the fact that it ensures that "neither grossly inadequate nor grossly excessive" measures are taken when ambiguity exists (p. 184). Posner concludes that if the tolerable-windows approach is applied to RHIC-II, then RHIC-II should be postponed for a period of time

probability has been inserted into cost-benefit analysis. If the probability is indeed correct, Brookhaven ought to be shut-down. Conversely, if the probability has been marginally inflated, then cost-benefit analysis leads us to the conclusion that Brookhaven should continue operating, given the potential for catastrophe. All things considered, Posner states:

> [w]e shall almost certainly survive another six years of RHIC, and the Large Hadron Collider as well, but what is next? Many scientists are unsure about the future direction of such research. And remember RHIC-II, which Brookhaven hopes to begin operating in 2010 and which will have 40 times the luminosity of RHIC. One hopes that before a decision is made on the funding request, the proposed upgrade will be subjected to a careful cost-benefit analysis by neutral experts (p. 196).

2. THE GRAY-GOO PROBLEM, GENETICALLY MODIFIED PLANTS AND ANIMALS, AND ARTIFICIAL INTELLIGENCE

Nanotechnology is the technology of the future. Nanotechnology may one day enable the economical manufacturing of computer chips the size of molecules. Nanotechnology envisions nanomachines – machines measured in billionths of a meter – capable of self-assembly that "will allow us to place components and assemblies inside cells and to make new materials using the self-assembly methods of nature" (p. 36).[70] Self-assembly is the essential characteristic of nanotechnology; nanosized machines are too small to be economically created by building them one-by-one (pp. 35-36). All in all, "[f]uture nanotechnologists will have the ability to assemble custom-made molecules into large, complex systems; their capacity to create materials will be almost magical."[71]

Note the juxtaposition of self-assembly and self-replication. The former is the process "in which small, relatively simple parts combine to form somewhat more complex structures," while the latter is the process "in which a complex system reproduces itself" (p. 36). Self-assembly may not pose a cognizable catastrophic risk, while the catastrophic risk

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(p. 185). The postponement of RHIC-II would allow physicists to do more research, adding a margin of safety (p. 186).

70. Posner quotes from the Introduction to Nanotechnology for Non-Specialists, which is found in THE INTERAGENCY WORKING GROUP ON NANOSCIENCE, ENG'G & TECH., NANTECHNOLOGY RESEARCH DIRECTIONS: IWGN WORKSHOP REPORT xxv (M.C. Roco et al. eds. 1999). For a discussion of nanomachines, see, e.g., Robert A. Freitas, Jr., Nanomedicine, Vol. IIA: Biocompatibility (2003); Robert A. Freitas, Jr., Nanomedicine, Vol. I: Basic Capabilities (1999); K. Eric Drexler, Engines of Creation: The Coming Era of Nanotechnology (paperback reprint 1987) (1986).

71. WEBB, *supra* note 52, at 126.

associated with self-replication is readily apparent. Hypothetically, if a nanobot with the power of self-replication were to escape into the environment, the nanobot could reproduce exponentially until it had consumed all living material (p. 36). The nanobot could be more omnivorous than any bacterium, and under ideal conditions, convert the "environment we see today into a sea of ravenous nanobots plus waste sludge."[72] This potential catastrophic risk is known as the gray-goo problem (p. 36).[73]

Posner dismisses the risk associated with the gray-goo problem because nanotechnology lies in the distant future and therefore we have a great deal of time to learn more about nanotechnology. Once we have gained the appropriate level of information, we can respond to the risk posed. Furthermore, preemptive measures have already been taken in response to the gray-goo problem; nanotechnologists have issued "guidelines limiting the power supply for nanomachines to power sources that, unlike sunlight, are not found in the natural environment" (p. 36).

Posner states that genetically modified plants and animals pose a similar catastrophic risk to that of nanotechnology. With respect to genetically modified plants, the hybridization of weeds with crops through genetic splicing may lead to catastrophic results (p. 38). Weeds, in general, have an uncanny ability to replicate, a property that threatens the well-being of other plant life (p. 38). One catastrophic risk is the potential for weed genes to escape "into the natural flora of the same species, causing the natural flora to become destructively aggressive and herbicide resistant" (p. 38). Likewise, genetically modified animals, such as salmon, have the ability to escape into the wild. The danger of genetically modified animals is that they may be able to "outcompete and destroy native species" (p. 38). However, cost-benefit analysis argues for a continuation of genetically modified crops, since they provide immense benefits and their inherent dangers are unlikely to materialize (p. 135).

Posner argues that genetically modified salmon are to native salmon as robots enabled by artificial intelligence are to humans. In other words, just as genetically modified salmon may be Darwinian superior to native salmon, robots enabled with artificial intelligence may, one day, be Darwinian superior to humans. Posner has indeed identified an area of concern, for artificial intelligence has greatly expanded over the years and no end appears to be in sight. The potential power of artificial intelligence is illustrated by the publicized chess

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72. *Id.* at 127.
73. *Id.*

matches between chess-champion Garry Kasparov and IBM's Deep Blue. In 1996, Deep Blue, currently the greatest chess-playing computer ever constructed, defeated Kasparov in the initial chess match of their six game series, but eventually lost the series to the mortal chess champion.[74] However, in 1997, Deep Blue exacted revenge and defeated Kasparov in a six-game series by a score of 3.5 - 2.5.[75] IBM's Deep Blue had achieved a milestone victory over the world's human chess champion.

As Posner states, "[t]he game of chess is modeled on war" (p. 41) and therefore it is not a stretch to assume that "[r]obots several generations from now may be able to beat any nation in a war" (p. 41).[76] Just as Deep Blue's algorithm was effectively programmed to defeat a mortal in the game of chess, a robot may one day be programmed with an algorithm capable of enslaving or destroying the human race (p. 42). Posner mitigates this risk by arguing that "[t]he problem of creating a computer with the capability of the human brain is not the hardware but software" (p. 42). I am not completely certain that Posner is correct with this assertion. With the onset of DNA computing in the horizon, Posner may be correct in assuming that the problem of mimicking the human brain may not be the hardware (or, at the very least, *will* not be the hardware in the very near future). However, innovations in artificial intelligence indicate that we may be closer than we think in our quest to recreate the human mind algorithmically via computer software.

While Posner may disagree, the cataclysmic power of artificial intelligence may not depend on preconceived notions of consciousness, which many humans believe is a unique human trait. Although robots capable of self-sufficiency are yet to be created, the works of Alan Turing and Hans Moravec illustrate that artificial intelligence and human intelligence may not be as divergent as once thought. According to the

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74. Jonathan Schaeffer & Aske Plaat, *Kasparov versus Deep Blue: The Re-match*, 20 INT'L COMPUTER CHESS ASS'N J. 95 (1997), *available at* http://www.cs.vu.nl/~aske/db.html. For a review of Deep Blue's stunning defeat of Kasparov in game one of their 1996 chess series, see Bruce Weber, *In Upset, Computer Beats Chess Champion*, N.Y. TIMES, Feb. 11, 1996, at A32.

75. Schaeffer & Plaat, *supra* note 74.

76. Posner notes that the analogy between chess and war is imperfect because resource constraint does not exist and there are only a limited number of possible moves in the game of chess. However, Posner does not note a further difference between chess and war: unlike war, chess is a game in which both sides have perfect and complete information (p. 41). Due to the characteristically asymmetric state of information in war, the game of poker may be more analogous to war than chess. In the game of poker, where information is not readily available to all parties, poker-simulating machines – such as Darse Billing's and Jonathan Schaeffer's Loki (named "after the Norse god of mischief and chaos") – "still [have] a long way to go before [they] can realistically challenge a living, breathing no-limit [poker] expert." JAMES MCMANUS, POSITIVELY FIFTH STREET 111 (2003). Similarly, machines "may have a long way to go" before they can realistically challenge humans in the "game" of war.

mathematician Alan Turing, the human brain is a discrete state machine
– a machine that falls within the scope of the mathematically computa-
ble and thus able to be written as an algorithm.[77] "[E]very feature of the
brain relevant to thought can be captured by a table of behaviour, and so
emulated by a computer."[78] For example, in 1950, Turing devised a test
in which participants were asked to discriminate between samples pro-
duced by a human and samples produced by a computer.[79] The test was
employed:

> to determine with what frequency people are unable to discriminate
> between sample output from human beings and sample output from
> computing machines. If the test results show that the frequency with
> which the test's subjects can discriminate between the human output
> and the machine output is statistically insignificant, then the fact that
> they cannot discriminate between these outputs would (it is asserted)
> mean that it is right to say that there is no (essential) difference
> between a 'thinking' human being and such a sophisticated piece of
> robotics, and also, therefore, that it is right to say that the latter is as
> much capable of 'thinking' as the former (insofar as the outputs are
> of the sort which, when produced by human beings would be said to
> involve 'thinking').[80]

Turing concluded, under this infamous test, that "[i]f a machine cannot
be distinguished from a human being under these conditions then we
must credit it with human intelligence."[81]

Presumably building upon Turing's intuitions, Hans Moravec has
concluded that robots will match human intelligence in less than fifty
years.[82] Moravec has argued that barring a cataclysm, "the development
of intelligent machines [is] a near-term inevitability."[83] More specifi-
cally, we should expect the artificial intelligence industry to produce
computers capable of reasoning by 2030 or 2040 "that in some ways
resemble us [as humans], but in others are like nothing the world has

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77. ANDREW HODGES, TURING: A NATURAL PHILOSOPHER 34-35 (Ray Monk & Frederic
Raphael eds., 1997).

78. *Id.* at 36.

79. Dennis Patterson, *Fashionable Nonsense*, 81 TEX. L. REV. 841, 883-84 (2003) (reviewing
VINCENT DESCOMBES, THE MIND'S PROVISIONS: A CRITIQUE OF COGNITIVISM (Stephen A.
Schwartz trans., 2001)).

80. *Id.* at 883 n.258 (quoting GRAHAM BUTTON ET AL., COMPUTERS, MINDS AND CONDUCT 13
(1995)) (alteration in original).

81. HODGES, *supra* note 77, at 37-38.

82. HANS MORAVEC, ROBOT: MERE MACHINE TO TRANSCENDENT MIND 23 (1999). For a
review of Moravec's publications, see Hans Moravec's home page, *at* http://www.frc.ri.cmu.edu/
~hpm/ (last visited Apr. 28, 2005).

83. Hans   Moravec,   Robots,   Re-Evolving   Mind   (2000),   *available   at*   http://
www.frc.ri.cmu.edu/~hpm/project.archive/robot.papers/2000/Cerebrum.html (archived project,
Robotics Institute, Carnegie Mellon University).

seen before."[84] All in all, the works of Turing and Moravec illustrate that the human mind may not be that difficult to recreate via computer software. Thus, Posner may be overestimating the difficultly of programming software that mirrors the human mind.

Posner proposes, *inter alia*, institutional and educational reforms to ameliorate the catastrophic risk posed by artificial intelligence.[85] Our current American legal system is poorly equipped to deal with scientific risks (p. 199). Alas, the legal profession itself is not contributing positively to the management of catastrophic risks (p. 200-09). As an institutional reform, Posner proposes that additional requirements be imposed upon law students to surmount the cultural barrier between law and the physical sciences (p. 203).[86] For instance, Posner claims that law students could be required to show proficiency in one of the natural sciences. To support this claim, Posner states, "[l]aw is more like a language than a science. It is important to know the rules of a language as codified in a grammar, lexicon, and textbook, but that knowledge is only the first step in learning how to use the language" (p. 202).[87] This position is odd given Posner's desire to condense legal education into a two-year curriculum.[88] Previously, Posner argued that legal education should be modeled on the two-year MBA awarded by business schools because "the practice of law is becoming more like a business at the same time that law school is becoming less like a business school and more like a graduate department."[89] Posner does not offer cost-benefit analysis with respect to lengthening legal education, which initially should make this radical proposition suspect in the eyes of the legal-economist. Regardless, by requiring proficiency in one of the natural

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84. Hans Moravec, The Universal Robot (1991) (archived project, Robotics Institute, Carnegie Mellon University), *available at* http://www.frc.ri.cmu.edu/~hpm/ project.archive/ robot.papers/1991/Universal.Robot.910618.html.

85. *Contra* WEBB, *supra* note 52, at 127 (relaying Isaac Asimov's favored observation that "when man invented the sword he also invented the hand guard so that one's fingers did not slither down the blade when one thrust at an opponent"). Following Asimov's intuitions, institutional and educational reforms may not be necessary, for it is implied that humans have the technological prowess to respond intellectually to risks – such as formulating a response to the risk of lacerating one's hand when one thrusts a sword at an enemy.

86. Posner's proposed educational reforms are reminiscent of the radical reforms in legal education by Christopher Columbus Langdell at Harvard Law School. *See* WILLIAM P. LAPIANA, LOGIC AND EXPERIENCE: THE ORIGIN OF MODERN LEGAL EDUCATION 55-78 (1994). For a brief glimpse of Langdell's important role in shaping American legal history, see GRANT GILMORE, THE AGES OF AMERICAN LAW 42, 41-48 (1977) (stating, as a tribute to Langdell's greatness, "if Langdell had not existed, we would have had to invent him").

87. Emphasis omitted. For an analogous argument pertaining to the lexicon of the American legal system, see Carrington, *supra* note 33 (discussing the lexicon of the steamboat profession as akin to the lexicon of the legal profession).

88. RICHARD A. POSNER, THE PROBLEMATICS OF MORAL AND LEGAL THEORY 281-95 (1999).

89. *Id.* at 285.

sciences, it is clear that legal education would then take the shape of a graduate department as opposed to a business school. By implication, instead of shorting legal education to a two-year curricula as previously argued, Posner is advocating for an extension in the duration of legal education.

As an interrelated institutional reform, Posner advocates for the creation of a science tribunal of original jurisdiction – a court composed of judges each educated in one of the physical sciences (p. 209). A science tribunal of original jurisdiction would be composed of judges who volunteered to take on cases (p. 211). Further, the lawyers themselves could request to be on the science docket (p. 211). Sadly, our current courts are composed of random jurors and generalist judges – whose discretion is generally limited to the issues at trial (p. 212-13). The lawyer's sole commitment is not to scientific truth; rather, the lawyer's main concern is her client (p. 202). Moreover, lawyers coach experts and witnesses "to maximize their contribution to 'the team'" instead of search for the truth (p. 212). Posner thus proposes that a science tribunal would:

> dispense with juries and with the standard method of witness interrogation. It would instead have the judge – who would be the sole trier of fact and would be expected to have some minimum competence in the relevant science – sitting at a round table with scientists selected by some neutral procedure . . . and discussing the scientific in the case with them (p. 213).

This method of eliciting facts would mirror the continental European adversarial approach (p. 213).

Posner's discussion of the necessity of a science tribunal illustrates an overarching problem in the legal system – mainly, that the courts are not in the business of finding "the truth." Personally, I believe that lawyers act (or ought to be acting) in the best interests of their clients, as opposed to searching for "the truth." Expert witnesses are bought and sold. After enough searching, an expert can declare "the truth" upon the courtroom (for the right price of course). To this extent, Posner is correct in arguing that law and science need to merge to develop uniformity. Indeed, there is a sharp distinction between law and the natural sciences; law is concerned with action while the natural sciences are oriented toward knowledge (p. 202).[90] Thus, the creation of a science tribunal of original jurisdiction would aid in our epistemological search

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90. *Cf.* LaPIANA, *supra* note 86, at 29-54 (stating that antebellum legal theory traditionally characterized law as a natural science, which, if consistently pursued, would lead to a rational understanding of the legal universe and reveal the nature of the mind of the world's creator).

and would help to curb systemic imperfections to aid in the formulation of adequate responses to catastrophic risks posed by scientific accidents.

C. *Unintended, Man-Made Catastrophe*

1. GLOBAL WARMING

Global warming is probably the most salient catastrophic risk. "[C]arbon dioxide and other 'greenhouse gases' such as methane . . . make the earth habitable" (p. 44). Greenhouse gases allow sunlight to reach earth through the atmosphere; however, they also trap "heat radiated skyward from the earth's surface" (p. 44). Indeed, without greenhouse gases, our planet would be extremely cold (p. 44). Posner claims that since the onset of the Industrial Revolution, the volume of greenhouse gases emitted by the burning of fossil fuels has increased dramatically (pp. 44-45). Moreover, deforestation – generally accomplished by burning sections of a forest – not only emits carbon dioxide as a byproduct of the burning of trees, but also hampers the ability of vegetation to absorb carbon dioxide via photosynthesis (p. 45).

Posner states that the effects of extreme global warming may be cataclysmic.[91] As the atmosphere holds greater levels of greenhouse gases, the earth's climate warms. As a secondary effect, water vapor has a greenhouse effect. If water vapor remains dissolved in the atmosphere instead of returning as precipitation to the earth's surface, the atmosphere warms, increasing its water-retention capacity and strengthening the effects of other greenhouse gases (p. 44). William Nordhaus, the leading economic expert on global warming, has argued that global warming may lead to:

> a sea-level rise of 20 feet or more; unexpected shifts in ocean currents, such as displacement of the warm current [the Gulf Stream] that warms the North Atlantic coastal communities; a runaway greenhouse effect in which warming melts tundras and releases large amounts of additional GHGs [greenhouse gases] like methane; large-scale desertification of the current grain belts of the world; very rapid shifts in temperature and sea levels; or the evolution and migration of lethal pests in new climatic conditions (p. 46).[92]

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91. Posner borrows a helpful and illustrative analogy to the potential harmful effects of global warming: global warming as leaning in a canoe. "'[L]eaning slightly over the side of a canoe will cause only a small tilt, but leaning slightly more may roll you and the craft into the lake'" (p. 46) (quoting R. B. Alley et al., *Abrupt Climate Change*, 299 SCIENCE 2005, 2006 (2003)). Alas, a small change in any environmental variables, such as rainfall, could trigger potentially cataclysmic results (p. 48).

92. Posner quotes WILLIAM D. NORDHAUS, MANAGING THE GLOBAL COMMONS: THE ECONOMICS OF CLIMATE CHANGE 114 (1994) (omissions in original) to describe some possible consequences to global warming.

Known as the runaway greenhouse effect, warmer temperatures could cause the melting of permafrost and glaciers, which would release greater amounts of the greenhouse gas methane (p. 47). Such an effect could potentially lead to the phenomenon known as snowball earth, the increased cloud cover as a result of a strong concentration of greenhouse gases in our atmosphere would cause entering sunlight to be reflected, leading to a dramatic fall in temperatures (pp. 47-48). Although the notion of a snowball earth is controversial, it is reasonable to expect that the melting of the polar ice sheets would leave most coastal regions flooded and uninhabitable (pp. 46, 48). Even more problematic, however, is the effect of global warming on the Gulf Stream. The dense, salty water of the Artic deflects warm water east toward Europe (p. 47). If the dense, salty water of the Artic was diluted as a result of the melting of the north polar ice cap, the warm water of the Gulf Stream would not be deflected toward Europe. Instead, it would continue into the Arctic, transforming Europe's climate into that of Siberia (p. 47).

There are, however, many uncertainties as to the catastrophic effects of global warming. The very causes of global warming may confer net benefits to our planet. For instance, deforestation increases the amount of carbon dioxide in the atmosphere which then stimulates the growth of vegetation in the remaining forests (p. 50). As a result, it is entirely feasible that global warming may actually cause a net increase in vegetation (p. 50). Additionally, according to Laurence Pringle, air pollution may have a cooling effect and consequently reduce atmospheric temperatures (p. 50).[93] Furthermore, a thawing of the Arctic sea-ice may improve ship accessibility, which may have major positive implications on the global economy.[94] Perhaps most radically, conservative extremists such as S. Fred Singer have argued that no credible evidence of catastrophic global warming exists as carbon dioxide levels "have been many times higher in the past than today's value without causing irreversible climate catastrophes" (p. 55).[95] Singer concludes

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93. Posner cites LAURENCE PRINGLE, GLOBAL WARMING: THE THREAT OF EARTH'S CHANGING CLIMATE 21-22 (2001), who asserts that previously aerosol particles in particular cooled the atmosphere offsetting the heating effects of other air particulates.

94. SUSAN JOY HASSOL, IMPACTS OF A WARMING ARCTIC: ARCTIC CLIMATE IMPACT ASSESSMENT 82-85 (2004). It should be noted that the opening of new shipping routes around the Arctic Basin would also confer a substantial risk upon international relations for it is foreseeable that nations would battle over the usage of the Arctic passageway. Furthermore, natural marine mammal migration would be altered by the dynamic Arctic sea-ice. Melting could also alter the contour of existing Arctic shipping lanes, which may pose additional problems to the shipping industry.

95. *See, e.g.,* S. FRED SINGER, CLIMATE POLICY – FROM RIO TO KYOTO: A POLITICAL ISSUE FOR 2000 – AND BEYOND, (Hoover Institute on War, Revolution and Peace, Essays in Public Policy No. 102, 2000), *available at* http://www-hoover.stanford.edu/publications/epp/102/102c.html.

that global warming may be a very gradual phenomenon that could con-
fer, over time, net benefits to society; although according to Posner,
Singer's reasons proffered are difficult to evaluate (p. 54). All in all, the
potential costs of global warming may be overstated.

Posner treats the catastrophic risk posed by global warming with
delicacy, for there are many difficulties surrounding the application of
cost-benefit analysis. Currently, Posner argues that there are too many
doubts regarding the catastrophic risk posed by atmospheric pollution
and deforestation. He contends that we remain uncertain as to the poten-
tial devastating effects, including the time frame in which such a transi-
tion would take place, with respect to global warming. If global
warming were an abrupt phenomenon, taking place over the course of a
decade or so, it would be impossible to relocate agriculture and cities (p.
46). Further, polar and tropical species of plants and animals tend to
only be adapted to a small range of temperatures (p. 63). Hence,
because "[t]he human impact on the climatic equilibrium is inherently
unpredictable," scientific study of global warming does not offer precise
and accurate conclusions (p. 53).

With all of the uncertainties regarding the potential catastrophic
effects of global warming, Posner claims that cost-benefit analysis is
incomplete because no discernable probability can be attached to the risk
posed by global warming (pp. 49-50). As a result, Posner assumes that
there cannot be an expected cost attached to global warming.[96] Posner
also notes that there is a problem with respect to present-value discount-
ing, for the benefits of curtailing the catastrophic effects of global warm-
ing lie in the distant future, while the costs are immediate. As a result,
price-value discounting leads us to undesirable results (pp. 150-55).
Although Posner contends that cost-benefit analysis is an inadequate
threshold inquiry in the case of global warming, he believes that it does
not necessarily follow that we should do nothing about the potential cat-
astrophic consequences of global warming. Even if we are unable to
attach a probability to global warming, there is a risk, albeit indis-
cernible, that once global warming hits "the point of no return," we will
be unable to abridge its harmful effects and catastrophe will be eminent.
It is against this incomputable risk – the risk of abrupt global warming –
with which Posner is concerned (p. 163-64)

Posner argues for systemic checks, such as an emissions tax and
technology forcing, to curb the potential catastrophic effects of global
warming (p. 155-65). Notice "that because greenhouse-gas emissions
are not taxed (or classified as pollutants), the private incentives to reduce

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96. This point is rather controversial, given the subjective Bayesian proposal that objective
probabilities may be altered based on relevant evidence. *See supra* note 68.

them are meager" (p. 159). A technology-forcing emissions tax would create "powerful market pressures to speed the development of economical alternatives to fossil fuels as energy sources" (p. 157). Moreover, an emissions tax would establish an incentive for technologies that sequester carbon dioxide (p. 157). "An emissions tax may be efficient to the extent that the demand for fossil fuels both is inelastic in the short run . . . *and* reduces the long-run costs of curbing greenhouse gases by accelerating the development of clean fuels and efficient methods of carbon sequestration." (p. 159). As a result, if carbon sequestration technologies were to become economically feasible, and the major emitting countries imposed substantial emissions taxes, it is foreseeable that greenhouse emissions could be reduced to zero.

Posner further suggests that the formation of an international environmental protection agency under the auspices of the United Nations would act to curtail the harmful effects of global warming (p. 216). Posner's suggestion, albeit a rational response to correct the prisoner's dilemma of international capitulation in formulating a global response to the catastrophic risk posed by global warming, does not give due regard to current developments in environmental legislation.[97] Indeed, recent developments in California have led me to question Posner's suggestion that the creation of an international body is truly necessary, or in the event that such body is created, will even be effective. To begin, notice the relationship between automobile emissions and global warming. Automobile emissions currently constitute twenty-seven percent of all global greenhouse emissions.[98] In response to the harmful effect of automobile emissions on global warming, ex-California Governor Gray Davis, on July 22, 2002, signed Assembly Bill 1493 which contained legislation aimed at curbing the potential catastrophic effects of global warming via strict greenhouse gas emissions standards for cars and light-trucks.[99] Assembly Bill 1493, an act to amend California Health and Safety Code Section 43018.5, delegated to the California Air

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97. *See infra* note 118 (discussing the prisoner's dilemma).

98. In 2001, emissions from electricity accounted for thirty-three percent of greenhouse emissions; transportation accounted for twenty-seven percent; and industry accounted for nineteen percent. The remaining twenty-one percent was contributed by residential, agriculture, and commercial sectors. U. S. ENVTL. PROT. AGENCY, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001 ES-7 (2003), *available at* http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html. Although automobile emissions account for roughly twenty-seven percent of all greenhouse emissions globally, "[p]assenger vehicles and light-duty trucks are responsible for approximately 40 percent of the total greenhouse gas pollution in the state [of California]." 2002 Cal. Legis. Serv. Ch. 200 § 1(6)(e) (A.B. 1493) (West) (codified at CAL. HEALTH & SAFETY CODE § 43018.5 (West 2002)).

99. *See* 2002 Cal. Legis. Serv. Ch. 200 A.B. 1493) (West) (codified at CAL. HEALTH & SAFETY CODE § 43018.5 (West 2002)).

Resources Board the authority to issue regulations controlling green-house emissions by cars and light-trucks.[100] These regulations for con-trolling emissions would apply to automobiles issued in the 2009 model year.[101]

Domestically, section 43018.5 may have a substantial effect on automobile manufacturing. California is the single most important domestic automobile market, accounting for ten percent of all new auto-mobile sales in the United States.[102] "Given . . . the more immediately pressing need to produce vehicles that can comply with the exacting emissions standards of California[ ], several of the world's car makers – notably Ford, DaimlerChrysler and Honda – are studying fuel cells."[103] Due to California's immense automotive market, its "stringent emissions control policies [are] particularly acknowledged [somewhat mockingly] as imposing a 'fuel penalty relative to automobiles subject to the 49-State standards.'"[104] "If other states copy California's law . . . that could set off a domino reaction from Seattle to New England, forcing the entire U.S. car fleet to achieve greater gas mileage in the next dec-ade."[105] California's environmental-friendly laws "could fundamentally alter vehicle design and stimulate nationwide reductions in greenhouse gas (GHG) emissions."[106]

If California's emissions standards were to survive domestic judi-cial scrutiny, a global chain reaction could potentially occur.[107] Califor-nia alone is the fifth-biggest economy in the world![108] International automobile manufacturers, pressed not to lose California's market or the United States' domestic market (regulated *de facto* by California's emis-

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100. Section 43018.5(a) of the California Health and Safety Code provides: "No later than January 1, 2005, the state board shall develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles." CAL. HEALTH & SAFETY CODE § 43018.5(a) (West 2002).

101. "The regulations . . . shall apply only to a motor vehicle manufactured in the 2009 model year, or any model year thereafter." CAL. HEALTH & SAFETY CODE § 43018.5(b)(1) (West 2002).

102. *Id.*

103. *Replacing Gas with a Gas*, ECONOMIST, July 21, 2001.

104. Rachel L. Chanin, Note, *California's Authority to Regulate Mobile Source Greenhouse Gas Emissions*, 58 N.Y.U. ANN. SURV. AM. L. 699, 736 (2003) (citing H.R. REP. No. 94-340, at 87 (2002)).

105. Paul Rogers, *California Could Set Trend with Tougher Gas Mileage Standards*, SAN JOSE MERCURY NEWS, July 15, 2002, at 1.

106. Christopher T. Giovinazzo, Comment, *California's Global Warming Bill: Will Fuel Economy Preemption Curb California's Air Pollution Leadership?*, 30 ECOLOGY L.Q. 893, 896 (2003).

107. Automobile manufacturers have expressed their intent to challenge the substance of California's auto emissions laws. Mark Hertsgaard, *California Green Light*, THE NATION, Aug. 19, 2002, at 7.

108. 2002 Cal. Legis. Serv. Ch. 200 § 1(b) (A.B. 1493) (West); Hertsgaard, *supra* note 107, at 7.

sions standards), may choose to construct their automobiles in compliance with California's standards. California's emissions standards may therefore set forth a global *de facto* market emissions standard for all cars and light-trucks, altering the standards for vehicles worldwide. In this scenario, the effect of California's emissions laws may not be limited to the United States. Hence, unilateral domestic legislation aimed at altering emissions standards, and *not* the imposition of collective international action as Posner suggests, may be enough to curb the catastrophic effects of global warming.

It is foreseeable, however, that global automobile manufacturers may find it profitable to produce two separate automobile models: one built in accordance with California's strict emissions standards and one built to please the remaining global market. If this does become the case, then it is still doubtful whether international, collective action will be effective. Even if an international environmental protection agency were to be created, it is unclear whether the United States would capitulate with the standards imposed by the international agency (think ratification of the Kyoto Protocol). The United States would undoubtedly continue to act in its own domestic interest, for an international environmental protection agency would not have the power to impose enforceable sanctions upon defiant nations. In other words, given Austin's positivist view of law – that law is a series of commands by the sovereign – the standards imposed by an international environmental protection agency would have not have the force of law because there would be no sovereign body capable of enforcement. Thus, there would be no true grave threat to the United States to induce reduction of greenhouse emissions; the United States would continue to emit greenhouse gases as it pleased. This brings me to my point: the only way in which the United States will reduce its output of carbon dioxide emissions is to enact strict social policy from within. If automobile manufactures find it profitable to continue to only produce only one model of each car and light-truck, then California's strict emissions standards may be enough to create a *de facto* domestic standard and begin to abridge the harmful effects of global warming. On the other hand, if car manufactures produce two models for each car and light-truck, then it may require federal legislation, as opposed to Posner's proposed international collective action, to mitigate the catastrophic risk posed by global warming.

2. THE EXHAUSTION OF NATURAL RESOURCES AND THE LOSS OF BIODIVERSITY

Posner argues that the exhaustion of natural resources, such as oil, coal, and water, does not pose a catastrophic risk. Posner contends that

the price system limits our consumption of natural resources. Notice that the price system posits that as a good becomes scarcer, the initial price of the good will rise and people will search for more attractive substitutes (p. 59). As a result, "the price system will prevent oil, gas, or coal from running out before there are feasible substitutes" (p. 59).

However, Posner notes that the safeguards of the price system do not apply to plants or animals without commercial value (p. 60). Similarly, no self-regulating economic process can ensure the survival of commercial plants and animals (p. 60). Indeed, the exploitation of commercial plants and animals may result in extinction.[109] Take, for example, the conservationist fisherman:

> [A] fisherman who limits his catch will not be benefiting himself in
> the least. He will just be leaving more fish for his competitors to take
> unless he is able to make a legally enforceable agreement with them
> to limit the amount of fishing that all do (p. 60).

Alas, the rapid increase in industrialization and urbanization since the Industrial Revolution has caused widespread destruction of habitats (p. 63). "[T]here is little doubt that species are going extinct extremely rapidly and that we are in the midst of a major extinction interval" (p. 64).[110] Although we are not certain as to the potential catastrophic effect of mass extinction, we may run the risk of suffering an ecological domino-effect. Genetic diversity is an insurance policy against catastrophe resulting from a drastic loss of biodiversity (p. 67). For instance, if the Dutch elm tree was our only source of wood, there would be a drastic influence on human welfare if Dutch elm disease struck our remaining trees (p. 67).

The catastrophic implications of the loss of biodiversity are currently unknown. As an alternative to cost-benefit analysis, Posner proposes the use of the tolerable-windows approach.[111] With respect to the

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109. It has been argued, however, that extinction may not necessarily be a bad thing. "Extinction 'creates space for evolutionary innovations'" (p. 64) (quoting DAVID M. RAUP, EXTINCTION: BAD GENES OR BAD LUCK? 19-20 (1991). Indeed, "extinction is at the heart of the gale of creative destruction . . . that we call evolution" (p. 61). "Without periodic extinctions biodiversity would increase exponentially . . . . Rather soon, the system would saturate: speciation would have to stop because there would be no room for new species" (p. 64) (quoting RAUP, *supra*, at 19-20) (internal quotation marks omitted).

Ronald A. Dworkin has argued that law itself is evolutionary in nature. *See* Ronald A. Dworkin, *"Natural" Law Revisited*, 34 FLA. L. REV. 165 (1982). Does it logically follow that if law progresses evolutionary, then nihilism – destruction of the social system for its own sake – may not necessarily be a bad thing? It is doubtful that this question can be answered in the affirmative, and as a result, intuitively either: law is not characteristically evolutionary, or alternatively, extinction of the legal system may not necessarily be a good thing.

110. Quoting Helen M. Regan et al., *The Currency and Tempo of Extinction*, 157 AM. NATURALIST 1, 8 (2001).

111. *See supra* note 69 (discussing the tolerable-windows approach).

loss of biodiversity, "[since] samples can be preserved at low cost in the form of frozen seeds that can be resuscitated and made to germinate, large-scale efforts to preserve biodiversity by tightly limiting human land uses may not be cost justified" (p. 184). In such an instance, the marginal benefit derived from limiting human land use may be similar to preserving frozen samples of specimens. However, the latter can be adequately accomplished at a much lower marginal cost. An optimal level of precaution exists at the intersection of marginal cost and marginal benefit; therefore, Posner argues that social policy should be directed at preserving frozen samples of specimens as opposed to stringent land use controls (pp. 184-85).

D. *Intentional, Man-Made Catastrophe*

The September 11, 2001 terrorist attacks provide an example of intentional catastrophe; although arguably, Posner believes that the attacks themselves lead to sub-catastrophic results. While Posner did not make this explicit point, if there is a case to be made for the application of cost-benefit analysis to catastrophic risks, then the application ought to be made in cases involving intentionally-inflicted, man-made catastrophic risks (assuming, *arguendo*, that a relevant probability of occurrence is discernable). Intentionally-inflicted catastrophic risks are often given a different treatment than the other catastrophic risks discussed above. Returning to Posner's discussion of natural catastrophes, statistically, the average number of deaths from asteroid collisions greatly exceeds the average number of deaths from airline crashes (p. 121).[112] If we isolate social policy as a response to potentially fatal risks, one would presume that social policy would respond by allocating more resources to defend against asteroid collisions as opposed to airline security.[113] However, it is readily-apparent that the reverse is true. Since the September 11 terrorist attacks, social policy has taken a tough

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112. *But see* WEBB, *supra* note 52, at 173 (stating that "averaged over a human lifetime, the chance of being killed by meteorite impact is about the same as dying in an aircraft crash").

113. Tangentially, Posner argues that the:

> difference between airline crashes and asteroid collisions, which may not seem related to probabilities but is, is that one can *do* something about the risk of being killed in an airline crash – not fly, or fly less frequently, or fly only on major airlines – and one cannot do anything about asteroid collisions except write one's Congressman (p. 122) (emphasis original).

The September 11, 2001 terrorist attacks caused thousands of casualties on the ground. This may have altered one's perception (perhaps irrationally) of the risk associated with intentional and unintentional airline mortality to persons on the ground. *See* Kimberly M. Thompson et al., *The Risk of Groundling Fatalities from Unintentional Airplane Crashes*, 21 RISK ANALYSIS 1025 (2001). If we focus solely on ground mortalities resulting from airplane crashes, the only possible alternative for persons who fear "death from above" is to move one's abode a reasonable distance from all flight paths; and even then, that does not meliorate the risk of dying from an intentional,

stance against man-made catastrophic risks; much tougher than that against asteroid collisions. Posner accurately points to the cause of this anomaly. "[P]eople sometimes overreact, from a statistical standpoint, to a slight risk because it is associated with a particularly vivid, attention-seizing event" (p. 171). The human mind may be evolutionarily programmed to react, perhaps irrationally, to salient events – such as the macabre scene that often results from airline crashes.[114]

1. BIOTERRORISM

Posner argues that now more than ever, dangerous biotechnologies are within the grasp of terrorists, small rogue nations, and sociopaths. There is a direct correlation between the risk of apocalyptic terrorism and technological advancement (p. 92). Unfortunately, science and technology have brought us to the point where a person or group of persons may have the capability to cause global catastrophe. Hypothetically, a terrorist group could launch a biological attack if they were:

> to obtain a suitable pathogen, engineer it to maximize its lethality and defeat any existing vaccine, handle it without infecting themselves before they could complete their work (since they would have no vaccine protection), aerosolize it – the most difficult stage – and disseminate it (pp. 82-83).[115]

Once an airborne pathogen is biologically fabricated, a terrorist could place it in "aerosolizers that he would unobtrusively deposit in airport departure lounges, shopping malls, movie theaters, indoor stadiums, and other enclosed spaces in which people congregate" (p. 79). This invisible mist would contaminate hundreds of thousands of people, and in turn, make these people carriers of the airborne pathogen (p. 79). Within weeks, a pandemic with catastrophic implications could be trig-

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terrorist-related airline crash. Indeed, it is not a stretch to presume that the risk associated with airline mortality on the ground is perceived irrationally greater than that of an asteroid collision.

114. Two forms of terrorism, not extensively discussed in this piece but mentioned in *Catastrophe*, are nuclear terrorism and cyberterrorism. The design of nuclear weapons is well-known, and currently much of the material required to build a nuclear weapon is not adequately protected against theft or diversion (p. 74). Hypothetically, a terrorist could easily create a crude nuclear explosive by coating a conventional bomb with radioactive materials to cause extensive radioactive contamination (p. 74). Similarly, a terrorist could commandeer an airplane and crash it into a nuclear reactor (p. 74).

Notice that cyberterrorism also poses a catastrophic risk. "The Internet is to the computer virus as the atmosphere is to an airborne biological virus" (p. 84). The cost of cyberterrorism is substantial to the United States economy; billions of dollars are spent to prevent cyberterrorism annually (p. 84). Lone individuals, working with inexpensive equipment, are currently in an arms race to devise more dangerous viruses to counter current sophisticated defenses (p. 85). Cyberterrorism could be used to dismantle military computers or to dismantle the World Wide Web in an effort to trigger a major economic depression (pp. 85-86).

115. Internal citation omitted.

gered by the release of a fatal, easily-spread bacterium or virus with an optimal infectious incubation period (p. 75).

Posner maintains that it is readily-apparent that terrorist groups have a substantial interest in bioterrorism (p. 77).[116] Although technology has undoubtedly played a role in the growing risk of bioterrorism, there are other influential factors. Posner claims that effective security measures taken against other terrorist means, such as hijacking airplanes, have forced terrorists to search for more feasible substitutes, such as bioterrorism (p. 76). Moreover, bioterrorists may have fluid objectives and perceive fewer political, ethical, and moral constraints; consequently, such groups are less easily deterred (p. 76). Furthermore, bioterrorism may be accomplished by one deranged individual with the appropriate educational background because information regarding biological experiments is widely available (p. 76).

Of utmost concern to Posner is the proliferation of potentially dangerous biochemical information. "Several years ago a team of Australian biologists developed a lethal virus by accident while trying to invent a contraceptive vaccine for mice as a means of pest control" (p. 78). Some years later, microbiologists at St. Louis University, while mimicking the Australian team's experiment, created an even more lethal virus than that created by the Australian team (p. 80). What is most alarming about these experiments is the fact that both teams eventually had their findings published publicly (pp. 78-80). In effect, these publications provided "a blueprint for any bioterrorist able to obtain a virus that causes disease in human beings and might be enhanced by the method employed by those scientists" (p. 78). Alas, bioresearch that is readily available to the public may destroy the value of combating terrorism (p. 80).

Thus, combating bioterrorism is a double-edged sword. In order to combat bioterrorism, we must train biochemists to experiment "on vaccines, cures, and other methods of detection" (p. 81). Unfortunately,

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116. According to Jessica Stern:

> Several incidents before the 2001 anthrax attacks made clear that terrorists have been interested in acquiring and using [weapons of mass destruction]. Perhaps the most significant of these was the sarin gas attack by Aum Shinrikyo, a Japanese cult, on the Tokyo subway in 1995. During the 1990s the cult also attempted to use biological weapons, apparently unsuccessfully. The U.S. government has repeatedly stated that Osama bin Laden is interested in acquiring biological agents . . . . During the last decade, several American antigovernment individuals and groups were found to have acquired biological agents, revealing gaps in existing regulations regarding the sale or possession of lethal or incapacitating biological agents.

Jessica Stern, *Dreaded Risks and the Control of Biological Weapons*, 27 INT'L SECURITY 96-97 (2003) (citations omitted).

there is a direct correlation between the number of people trained in biochemistry and "the number of people who know how to alter, create, and distribute such agents" (pp. 81-82). While public disclosure of research equips potential terrorists with a template for destruction, we are lucky that bioterrorism has yet to cause mass casualties (p. 99).[117]

Posner contends that cost-benefit analysis is incomplete with respect to bioterrorism for the probability of a bioterrorist attack cannot be ascertained (p. 174). However, we are well aware of the catastrophic risk posed by bioterrorism, and consequently a social response ought to be formulated. Posner initially proposes that an international bioweaponry agency could enforce security measures against the development of bioweapons (pp. 218-21). In terms of the efficacy of global domestic security measures, international cooperation is required to investigate and apprehend bioterrorists and scientists who fail to observe proper security precautions (p. 219). Indeed, Posner is correct to assume that international cooperation is at the crux of the war against bioterrorism, for the unilateral regulation of biotechnology results in a prisoner's dilemma.[118] However, we return again to the problem of international enforcement, articulated in the Part II.C.1 discussion regarding global warming. Regardless, Posner states that there are no uniform safety standards in biotechnical research, development, and production; nor is there an international regime for monitoring or enforcing such standards. Therefore:

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117. It is unclear as to why bioterrorism has not already been employed. Perhaps bioterrorists have not attained the prerequisite biotechnology to carry out such an attack (p. 83). Perhaps bioterrorists are worried that a pandemic would wipe out the entire human population, including their loved ones (p. 83).

118. The prisoner's dilemma is:

> [a] paradigmatic, two-person, two-strategy normal form game of complete but imperfect information. In this game, the strategy combination that is in the joint interests of the players (to remain silent in response to a prosecutor's questions) is not played, because each player finds that the strategy of remaining silent is strictly dominated by the other strategy (confessing).

DOUGLAS G. BAIRD ET AL., GAME THEORY AND THE LAW 312 (1994) (emphasis omitted). The prisoner's dilemma exists when "collective action problems in the law in which individual self-interest leads to actions that are not in the interest of the group as a whole." *Id.* at 312-13. The prisoner's dilemma evident in attempts to minimize the expected cost of catastrophic risks posed by bioterrorism is inherently systemic; indeed, self-interested nations will not take into account the potential greater payoff of international cooperation. Accordingly, self-interested nations will not take unilateral, domestic safety-measures against dangerous biotechnical research because it will induce, rather than discourage, other countries to take part in the same research (p. 186). Arguably, however, if all nations were to contract with one another collectively, each nation would receive a greater payoff and the world would be a much safer place to be. The prisoner's dilemma therefore results because self-interested nations will continue to act rationally by permitting biotechnical research and will probably be worse off than if they had acted irrationally. For an in-depth analysis of the prisoner's dilemma, see Robert Birmingham, *Remarks*, 29 CONN. L. REV. 827 (1997).

[a]n agency is needed that will reduce the risk of bioterrorism . . . by
establishing, and verifying compliance with, standards for (1) secur-
ing such [biotechnology] facilities, (2) denying access by dangerous
people to lethal pathogens and to the training, facilities, and knowl-
edge required to create bioweaponry, and (3) regulating the publica-
tion of research involving such substances (pp. 219-20).

Posner thus postulates that unless bioterrorism is internationally regu-
lated, any efforts by the United States to regulate bioterrorism may be
fruitless.

     Posner also argues that social policy should be aimed at limiting the
study of potentially dangerous sciences by foreigners. Posner does not
claim that citizens of foreign nations should be completely banned from
studying dangerous sciences in the United States. A purely domestic,
unilateral move would be ineffective. Foreigners would attend universi-
ties in nations that do not regulate the study of dangerous sciences (p.
222). Such an abrasive restriction could also potentially damage foreign
relations and weaken universities (p. 222). Consequently, Posner does
not advocate a complete ban on the study of dangerous sciences by for-
eigners; rather, the existing domestic policy limiting access to the most
lethal pathogens and toxins is sufficient (p. 222). As a result, Posner
believes that present domestic policy grants foreigners an adequate
opportunity to study biology and other natural sciences. (p. 223).

2. TERRORISM, IN GENERAL

     The September 11, 2001 terrorist attacks illustrate the destructive
power of terrorism. According to Posner, harsh criminal sanctions
should be imposed for perpetrators of terrorism. Criminal sanctions,
under an economic analysis, are generally deterrent strategies, aimed at
internalizing the cost of crime in the *ex ante* decision-making process.[119]
Posner believes that under our current regime, criminal sanctions may
not be adequately deterring terrorism. In response, Posner contends that
criminal law ought to shift from an exclusively deterrent strategy to a
mixed deterrent-prophylactic strategy (p. 226). To accomplish this goal
Posner supports the application of harsh criminal sanctions, including
extended prison sentences and the possibility of reprisals against family
members of terrorists as a form of collective punishment (p. 235). With
respect to the latter, it is a possibility that terrorists may derive utility
from the well-being of family members; indeed, the utility of family
members may be embedded in a terrorist's utility function. Also, collec-
tive punishment imparts an incentive on family members to try to pre-

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119. *See* Becker, *supra* note 38, at 39-85 (arguing that the internalization of criminal sanctions
requires that "crime does not pay" to the criminal).

vent potential terrorists from carrying out attacks (pp. 234-35). This incentive-based reasoning, while increasing the expected cost of terrorist activity, has struck scholars such as Daryl J. Levinson as unattractive. More specifically, Levinson has objected to communal sanctions because "[l]iberal conceptions of morality insist that agency and responsibility be attributed only to individuals, not groups."[120] Levinson's article relies on liberalism, as opposed to the economic analysis, and demonstrates that the two schools of thought can sometimes support contradictory social policy measures.

Posner further argues that extreme police measures could be implemented to curtail possible terrorist threats. "[I]n the wake of 9/11, there is growing interest in extreme police measures as a response to extreme risks" (p. 234). Take, for instance, the Patriot Act, which has included measures such as a "relaxed standard for eavesdropping on conversations between a criminal defendant and his lawyer, the detention of noncitizens on secret charges, increased power to monitor email traffic, easier access to certain private records, and liberalized use of secret warrants" (p. 234). The Patriot Act, as an extreme police measure, improves our ability to minimize the risk of terrorism. Civil libertarians argue that the imposition of extreme police measure may lead to political catastrophe. Posner dismisses this possibility by stating that "[t]here must be *some* room for curtailing the current, historically unprecedented extent of those liberties without precipitating a political catastrophe" (p. 238). Indeed, the Patriot Act's restrictions on civil liberties are mild in comparison to those imposed as a response to the Red Scare of the 1950s (p. 234). By implication, Posner argues that civil libertarians should be worrying less about our civil liberties, and more about what would happen if another September 11th occurred (p. 242). "Before 9/11, the American Civil Liberties Union opposed the screening of airline passengers who traveled to countries that sponsored terrorism. It is conceivable that such screening would have prevented the 9/11 attacks - and the restrictions on civil liberties that ensued in reaction to those attacks" (p. 242).[121]

CONCLUSION

Richard A. Posner, in *Catastrophe: Risk and Response*, bridges the gap between law and science in his discussion of a number of catastrophic risks. Utilizing cost-benefit analysis and some derivatives thereof, Posner proffers a series of hypothetical regulatory responses to catastrophic risks. Cost-benefit analysis, while sometimes imperfect in

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120. Daryl J. Levinson, *Collective Sanctions*, 56 STAN. L. REV. 345, 348 (2003).
121. Citations omitted.

evaluating domestic policy, is extremely helpful in curtailing the political, psychological, economic, and cultural misconceptions that accompany catastrophe. Noting that natural catastrophes pose a cognizable risk, Posner argues that science and technology, both increasing at an enormous rate, are also capable of producing colossal harm. Sadly, our current domestic policy with respect to "asteroid collisions, global warming, biodiversity loss, and the other accidental doomsday dangers is, with exception of natural pandemics and the partial exception of global warming, essentially one of ignoring them" (p. 221). Indeed, it currently appears that the American public only cares about "social issues of far less intrinsic significance, such as race relations, whether homosexual marriage should be permitted, the size of the federal deficit, drug addiction, and child pornography" (pp. 92-93). Posner's *Catastrophe*, as a truly insightful and lucid work, pushes the reader to understand the terrifying dangers posed by catastrophe without emitting an aura of prophecy or inevitability. The work is a significant step toward efficient and effective domestic policy responses to catastrophic risks. All things considered, Posner, as the anti-prognosticator, should be commended for his rational economic evaluation of catastrophic risks.

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