LAW AND BEHAVIORAL BIOLOGY

Owen D. Jones & Timothy H. Goldsmith***

Society uses law to encourage people to behave differently than they would behave in the absence of law. This fundamental purpose makes law highly dependent on sound understandings of the multiple causes of human behavior. The better those understandings, the better law can achieve social goals with legal tools. In this Article, Professors Jones and Goldsmith argue that many long-held understandings about where behavior comes from are rapidly obsolescing as a consequence of developments in the various fields constituting behavioral biology. By helping to refine law's understandings of behavior's causes, they argue, behavioral biology can help to improve law's effectiveness and efficiency.

Part I examines how and why law and behavioral biology are connected. Part II provides an introduction to key concepts in behavioral biology. Part III identifies, explores, and illustrates a wide variety of contexts in which behavioral biology can be useful to law. Part IV addresses concerns that sometimes arise when considering biological influences on human behavior.

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* Professor of Law & Professor of Biological Sciences, Vanderbilt University. B.A. Amherst College; J.D. Yale Law School. The authors received many useful comments on various aspects of this work from participants in Harvard Law School's Law and Economics Seminar, the University of Michigan Law School's Law and Economics Workshop, a Vanderbilt University Law School faculty seminar, a UCLA School of Law Colloquium, a presentation for Stanford Law School's Center for Law and the Biosciences, a symposium of the Yale University Department of Molecular, Cellular, and Developmental Biology, a conference of the Gruter Institute for Law and Behavioral Research, and the Annual Scholarship Conference of The Society for Evolutionary Analysis in Law (SEAL). We are particularly grateful for detailed comments on earlier versions from Louis Kaplow, Jeffrey Stake, Erin O'Hara, John Alcock, Ron Rutowski, Kingsley Browne, Paul Andrews, and Lydia Jones. Michael Saks, David Faigman, Steven Goldberg, J.B. Ruhl, Tom Ulen, John Monahan, and Andrew Daughety offered key insights and information on important pieces of the work. Charles Trumbull, Mariya Tytell, Michael Burgoyne, Michelle Notrica, and Rajeev Ruparell provided able research assistance. Vanderbilt University and Arizona State University provided research support. Direct correspondence to owen.jones@vanderbilt.edu.

** Professor Emeritus of Molecular, Cellular, and Developmental Biology, Yale University. B.A. Cornell University; Ph.D. Harvard University.

INTRODUCTION

In all but a few universities, human behavior is studied by social scientists in one set of buildings, while the behavior of every species except humans is studied by life scientists in other buildings. There are reasons for this—but few good ones.

The division reflects a long history of scholarly traditions moving on separate tracks. To be sure, there are gains from specialization. But there are also losses from impeded exchange of knowledge, insufficient synergy, and a scholarly isolation that allows crossdisciplinary inconsistencies to lurk unnoticed. These in turn enable longstanding but disciplinarily constricted conceptions of human behavior to harden into the received truths of the next academic generation.

This poses increasingly significant problems for legal thinkers, for human behavior is the very currency in which law deals. Helping to govern how humans behave and interact with one another, in their myriad individual and collective ventures and misadventures, is a—perhaps the—principal reason law exists. Law consequently has an unending need for improved understandings of how and why humans behave as they do.

Yet there is no widespread consensus in law that a deeper understanding of the causes of human behavior is really necessary for the day-to-day work. And among those who consider a deeper understanding desirable, there is no standard method for seeking, extracting, and developing that information from among the ranging disciplines. Viewed as a whole, the process by which law informs itself about the *causes* of human behavior (as distinct from the effects and patterns of human behavior) is haphazard, idiosyncratic, and unsystematic. When legal thinkers do look to other disciplines for updated theories and findings about causes, most tend to focus principally on social sciences such as economics, psychology, or political science, sometimes supplemented by a sprinkling of philosophy, sociology, or passing references to "human nature."[1] This focus

1. A recent search of all state and federal cases in the Westlaw database reveals that the phrase "human nature" has appeared in 6,485 cases to date. The Supreme Court alone has made reference to "human nature" in eighty-two different cases. See, e.g., Hamdi v.

has, of course, often been productive. But not everyone holds the same truths to be self-evident.

We see four problems. First, law still struggles to induce people to behave more constructively. This, coupled with explicit calls from some legal quarters for a more comprehensive behavioral science,[2] strongly suggests that existing perspectives on behavior are incomplete and insufficiently satisfying. Second, when it does look to other disciplines for insights concerning a given behavior, law commonly incorporates the perspective of one discipline at a time, rather than pursuing a synthesis of perspectives that may be more accurate and more useful. Third, the favored perspective on the causes of human behavior often reflects ephemeral enthusiasms wafted on the politics of the moment. Fourth, by focusing almost exclusively on the social sciences (sometimes supplemented by the humanities), legal thinkers have generally ignored an array of interdisciplinary approaches that are rapidly changing the way we understand how the mind works and what it means to be human.

Failure to attend to this new knowledge can lead to importantly incorrect assumptions about the causes of human behaviors, as well as to missed opportunities for improvements in law's ability to regulate behavior. For example, it is common to assume that virtually all behavior relevant to law arises exclusively through environmental, cultural pathways. This assumption overlooks essential components of causation that underlie the behaviors law seeks to address and also obscures important patterns of behavior that offer both knowledge and utility. That, in turn, risks law's anachronism, and it is limited, limiting, and costly—as well as avoidable.

It is avoidable, in part, because there is gathering momentum within universities for interdisciplinary work, including that which explores the human mind. And it is avoidable, in particular, because the important melding of perspectives and techniques now occurring in the behavioral sciences is increasingly accessible to legal scholars. Just as exploring the moon or Mars requires the integrated efforts of physicists, astronomers,

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Rumsfeld, 124 S. Ct. 2633, 2655 (2004) (Souter, J., concurring in part, dissenting in part, and concurring in the judgment); Payne v. Tennessee, 501 U.S. 808, 826 (1991); Coy v. Iowa, 487 U.S. 1012, 1017 (1988); Arizona v. Roberson, 486 U.S. 675, 692 (1988) (Kennedy, J., dissenting); Baldwin v. Alabama, 472 U.S. 372, 397 (1985) (Stevens, J., dissenting); Pillsbury Co. v. Conboy, 459 U.S. 248, 290 (1983) (Stevens, J., dissenting); Manson v. Brathwaite, 432 U.S. 98, 134 (1977) (Marshall, J., dissenting); Procunier v. Martinez, 416 U.S. 396, 404 (1974). Federal and state judges, as well as authors of law review articles, have used human nature to explain hundreds of different behavioral predispositions, including tendencies to exaggerate, deceive, hold grudges, conform, be deterrable, be empathetic, be morally frail, have a sense of fairness, be sexual, be greedy, discriminate, be emotional, and need privacy, security, and freedom. Informal study by authors (2004) (on file with the *Columbia Law Review*).

2. See generally, e.g., Russell B. Korobkin & Thomas S. Ulen, Law and Behavioral Science: Removing the Rationality Assumption from Law and Economics, 88 Cal. L. Rev. 1051 (2000) [hereinafter Korobkin & Ulen, Law and Behavioral Science].

geologists, engineers, chemists, and physiologists, it is increasingly clear that exploring and understanding the human mind requires the integrated, interdisciplinary efforts of cognitive scientists, neuroscientists, and evolutionary biologists as well as social scientists in psychology, anthropology, economics, and related disciplines. Empirical findings from different disciplines increasingly point toward similar conclusions that reflect a converging understanding of behavior. In principle, this synergy is valuable because it enables us to synthesize a coherent whole greater than the sum of its parts. It can help us to understand realities underlying behavior in a more subtle, comprehensive, and sophisticated way.

Some legal scholars have begun to deploy insights from behavioral biology to address existing problems in law.[3] To date, most of these efforts have focused on a wide variety of discrete individual legal features, such as environmental issues, the sense of justice, sex differences, privacy, apology, cooperation, memetics, child abuse, morality and norms, emotions, sexual aggression, and the irrational behaviors of interest to scholars of law and behavioral economics.[4] In this Article, we attempt to com-

3. This work goes by a variety of names, such as evolutionary analysis in law, law and biology, law and behavioral research, and the like. One of us (Jones) maintains a bibliography of works in this area that can be accessed through the webpage of the Society for Evolutionary Analysis in Law (SEAL) at http://www.sealsite.org (last updated Jan. 27, 2005) (bibliography on file with the *Columbia Law Review*) [hereinafter SEAL] or Professor Jones's website at http://law.vanderbilt.edu/faculty/jones.html.

4. Early work, for example, includes Margaret Gruter, Law in Sociobiological Perspective, 5 Fla. St. U. L. Rev. 181 (1977) [hereinafter Gruter, Law in Sociobiological Perspective]; Margaret Gruter, The Origins of Legal Behavior, 2 J. Soc. & Biological Structures 43 (1979) [hereinafter Gruter, Origins of Legal Behavior]; John H. Beckstrom, Sociobiology and the Law: The Biology of Altruism in the Courtroom of the Future (1985). Works reflecting the diversity of perspectives and approaches include Margaret M. Blair & Lynn A. Stout, Trust, Trustworthiness, and the Behavioral Foundations of Corporate Law, 149 U. Pa. L. Rev. 1735 (2001); Kingsley R. Browne, Sex and Temperament in Modern Society: A Darwinian View of the Glass Ceiling and the Gender Gap, 37 Ariz. L. Rev. 971 (1995) [hereinafter Browne, Sex and Temperament]; E. Donald Elliott, Law and Biology: The New Synthesis?, 41 St. Louis U. L.J. 595 (1997); Richard Epstein, A Taste for Privacy?: Evolution and the Emergence of a Naturalistic Ethic, 9 J. Legal Stud. 665 (1980); Lawrence A. Frolik, The Biological Roots of the Undue Influence Doctrine: What's Love Got To Do With It?, 57 U. Pitt. L. Rev. 841 (1996); Oliver R. Goodenough, Mapping Cortical Areas Associated with Legal Reasoning and Moral Intuition, 41 Jurimetrics J. 429 (2001); Mark F. Grady & Michael T. McGuire, A Theory of the Origin of Natural Law, 8 J. Contemp. Legal Issues 87 (1997); Morris B. Hoffman & Timothy H. Goldsmith, The Biological Roots of Punishment, 1 Ohio St. J. Crim. L. 627 (2004); Owen D. Jones, Evolutionary Analysis in Law: An Introduction and Application to Child Abuse, 75 N.C. L. Rev. 1117 (1997) [hereinafter Jones, Evolutionary Analysis in Law]; Bailey Kuklin, Evolution, Politics and Law, 38 Val. U. L. Rev. 1129 (2004); Erin Ann O'Hara & Douglas Yarn, On Apology and Consilience, 77 Wash. L. Rev. 1121 (2002); Michael Edmund O'Neill, Irrationality and the Criminal Sanction, 12 Sup. Ct. Econ. Rev. 139 (2004); William H. Rodgers, Jr., Bringing People Back: Toward a Comprehensive Theory of Taking in Natural Resources Law, 10 Ecology L.Q. 205 (1982) [hereinafter Rodgers, Bringing People Back]; J.B. Ruhl, The Fitness of Law: Using Complexity Theory to Describe the Evolution of Law and Society and Its Practical Meaning for Democracy, 49 Vand. L. Rev. 1407 (1996) [hereinafter Ruhl, Fitness of Law]; Jeffrey Evans Stake, Are We

plement that work by considering how behavioral biology might fit more broadly into the legal landscape. Specifically, we provide in this Article a framework of contexts, each briefly illustrated, in which tools and concepts from behavioral biology can provide unique and useful insights to legal thinkers.

In Part I we explore how and why law and behavioral biology are connected. We explain how the nature of the relationship between law and behavior makes law's effectiveness highly sensitive to the robustness of the behavioral models on which it relies. We discuss some weaknesses in existing behavioral models, and foreshadow some ways in which behavioral biology, partnered with contemporary perspectives on behavior, can improve behavioral models.

In Part II we provide a brief overview of some foundational concepts of behavioral biology. We first discuss the variety of subdisciplines that constitute behavioral biology, as well as the relationship between behavioral biology and other disciplines. We then describe the relationships between environments, genes, brains, and behaviors, as well as the effects of evolutionary processes on behavioral predispositions.

In Part III we identify, explore, and briefly illustrate a wide variety of contexts in which behavioral biology can be useful to law. Part III.A shows how behavioral biology can help us discover useful patterns in regulable behavior, uncover conflicts among contemporaneous legal policies, sharpen the cost-benefit analyses that often influence legal policymaking, and clarify links between various causal influences and their effects on human behavior. Part III.B considers how evolutionary insights into human decisionmaking processes can increase our understanding about people in ways useful to law and can also provide theoretical foundation for, and potential predictive power about, a variety of human behaviors—including, for example, economically irrational behavior. Part III.C then builds on the foregoing by demonstrating how behavioral biology can help us to disentangle the multiple causes (so often confusingly lumped together) of various law-relevant behaviors and also to expose a variety of unwarranted assumptions underlying legal approaches for inspiring behavioral changes. Part III.D combines several of the preceding insights, showing how they can help us to assess the comparative effectiveness of legal strategies we employ to change specific behaviors. Part III.E then addresses a variety of questions about the relationship of behavioral biology to law that move beyond matters of causation and behavior. It first considers how the perspectives from behavioral biology about the effects of evolutionary processes on the human brain may help to reveal deep patterns in legal architecture. It next turns from considering the effects of evolutionary processes on humans to considering the often un-

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Buyers or Hosts?: A Memetic Approach to the First Amendment, 52 Ala. L. Rev. 1213 (2001) [hereinafter Stake, Buyers or Hosts?]; see also supra note 3 (referencing bibliographic material).

noticed effects of humans on evolutionary processes, through the changes to selection pressures that legal policies can create. Finally, it addresses some ways in which metaphorical uses of evolutionary concepts have been used to highlight changes in legal systems.

Part IV offers thoughts on a variety of concerns that sometimes arise during discussions that bring biology and human behavior together. One feature common to these concerns is that the public, policymakers, or both will assume that what is "biological" is "good." So this Part first examines why it is impermissible to reason directly from a description to a prescription—from an "is" to a normative "ought." It then discusses mistaken assumptions about biology, as well as several concerns about potential misuses of biology in political and discriminatory contexts.

1. Law, Behavior, and Behavioral Models

Until about forty years ago, legal thinkers were firm in the conviction that law was an autonomous discipline.[5] Law was a subject "properly entrusted to persons trained in law and in nothing else,"[6] who could draw to sufficient effect upon general intelligence, general education, legal texts, and the experiential wisdom developed early in law practice.[7] The decline of that parochial view has coincided with the rise of the many "law and" subjects familiar today.[8] Law is increasingly seen, at least in large measure, as a consumer and applier of knowledge that other disciplines offer.

For example, authors have used law and economics to demonstrate how greater attention to economic efficiency can yield gains in productivity and align incentives in socially desirable ways.[9] Law-and-literature scholars have argued that a greater understanding of human emotions, contexts, and experiences can enrich our understanding about the impact of law on real people and have used techniques of literary theory to help us better analyze and understand legal texts.[10] Critical legal studies scholars borrowed from political philosophy, literary theory, and elsewhere to question whether there is rational determinacy in legal reasoning and to suggest that the seeming logic and structure of law is but a

5. See generally Richard A. Posner, The Decline of Law as an Autonomous Discipline: 1962–1987, 100 Harv. L. Rev. 761 (1987).

6. Id. at 762. As Posner put it, "Just as society had left the design of bridges to civil engineers, so it could leave the design of its legal institutions to lawyers." Id. at 765.

7. Id. at 763.

8. See generally Robert C. Ellickson, The Market for "Law-And" Scholarship, 21 Harv. J.L. & Pub. Pol'y 157, 158–59 (1997); Edward L. Rubin, Law And and The Methodology of Law, 1997 Wis. L. Rev. 521 [hereinafter Rubin, Law And].

9. For a bibliography of the many legal areas to which economic analysis has been applied, see Howard Gensler, Law and Economics: A Topical Bibliography, 26 Int'l J. Legal Info. 184 (1998).

10. See generally Jane B. Baron, Law, Literature, and the Problems of Interdisciplinarity, 108 Yale L.J. 1059 (1999) (collecting sources).

manifestation of power.[11] Law's still underdeveloped relationship with psychology,[12] which one might expect to have been stronger for longer, has been rejuvenated by interest in cognitive psychology's exposure of seemingly irrational patterns of behavior.[13] And many in the law and society movement have emphasized how we might usefully deploy a broad array of social sciences to examine the interrelationships of legal structures, their effects, and social interactions.[14]

Some efforts have proved more enduring than others. But the very proliferation of "law and" subjects must give pause to those who, like the two of us, argue the case for expansion of a relatively new one. To be clear, our claim is not that law and behavioral biology should compete with other disciplines for dominant influence.[15] The study of biology is, after all, the study of how multiple causal influences interact in organisms and their behavior. Our claim is therefore necessarily more modest: Behavioral biology provides one important component of many necessary to any firm foundation for understanding human behavior.

This Part explains, at the broadest level, why we believe this to be so. Part I.A considers the relationship between law and behavior generally, and Part I.B explores more specifically the relationship between law and behavioral models. Part I.C offers views on the existing state of behavioral models in law and identifies some weaknesses in current approaches. To lay the foundation for particularized applications discussed later in the work, Part I.D provides a brief overview of why behavioral biology is important and how it might be used to enhance behavioral models in ways that increase law's efficiency, effectiveness, and accuracy.

A. *The Relationship Between Law and Behavior*

One view—perhaps the most common one—is that law attempts many things, only one subset of which concerns behavior. Law allocates property, it reduces injuries, it provides justice, and it also both prohibits some behaviors and mandates others. From a broader perspective, however, one can make a strong case that all law exists to effect changes in human behavior.[16]

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11. See generally Duncan Kennedy & Karl E. Klare, A Bibliography of Critical Legal Studies, 94 Yale L.J. 461 (1984).

12. See generally Craig Haney, Psychology and Legal Change: The Impact of a Decade, 17 Law & Hum. Behav. 371 (1993); James R.P. Ogloff & David Finkelman, Psychology and Law: An Overview *in* Psychology and Law: The State of the Discipline 1 (Ronald Roesch ed., 1999).

13. See infra note 113 and accompanying text.

14. See generally Law and Society: Readings on the Social Study of Law (Stewart Macaulay et al. eds., 1995).

15. For a view, only half facetious, that nonlaw disciplines engage in zero-sum contests for dominance in law, see J.M. Balkin, Interdisciplinarity as Colonization, 53 Wash. & Lee L. Rev. 949, 952 (1996).

16. Some might argue that law fulfills an important function, even if—in its expressive role, for example—it restates values that are already widely or uniformly held, thereby

Allocating property rights, for example, is meaningless except to the extent it defines how people may and may not behave with respect to owned things. Reducing injuries involves inducing those who have unjustifiably caused harm to behave differently in the future—for example, by taking more care or designing safer products. Procedural rules govern how people will coordinate their behavior during formal contests over conflicts. Constitutional law prescribes how people in branches of government may and may not behave toward each other, and may and may not behave toward the governed. Contract law ensures that people who behaved a certain way in the past (creating obligation) will behave a particular way in the future (performing or paying compensation)—all so that still other people will have requisite confidence to engage in future transactional behavior with yet other people. Providing justice almost inevitably results in important changes in behavior, as the essence of injustice is unfair or improper treatment of one party at the hands of another. And criminal and civil fines are among the ways we induce people to behave as society wants.[17] Examples could of course be multiplied.

B. *The Relationship Between Law and Behavioral Models*

We can consider law effective when it gets its job done, and efficient when it does so with minimum waste. If the enterprise of law is, in the main, to change human behavior according to socially percolated preferences, then its ability to deploy legal tools to effect these changes at the least cost to society often (though importantly not always) depends on the accuracy of the behavioral models on which law relies. By "behavioral models" we refer to the combination of knowledge, intuition, and experience that enables us collectively to expect that, when law takes a given action, people will likely respond in patterns consistent with law's intent.

In the context of a given behavior of interest, a sound behavioral model should include, at a minimum, two features. It should include the impressions we have, arising from empirical observations, about how people actually behave in response to various changes in the legal environment, and it should also include, whenever possible, prevailing theoretical and empirical understandings of *why* people will behave the way the behavioral model anticipates.

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reinforcing existing behavior rather than changing it in a material sense. On expressive law, see generally Elizabeth S. Anderson & Richard H. Pildes, Expressive Theories of Law: A General Restatement, 148 U. Pa. L. Rev. 1503 (2000); Richard H. McAdams, A Focal Point Theory of Expressive Law, 86 Va. L. Rev. 1649 (2000); Alex Geisinger, A Belief Change Theory of Expressive Law, 88 Iowa L. Rev. 35 (2002). This and other functions that may theoretically yield a change of mind that does not manifest in changed behavior are beyond the scope of this Article. However, we suspect the set of such functions is small, particularly because reinforcing present behavior or prompting shifts in perspective can generally be expected to change future behavior from what it otherwise might have been.

17. Sometimes the behavioral change law seeks is a prerequisite to some goal not essentially behavioral in nature, as when law attempts to reduce illegal dumping so as to preserve the ecological health of wetlands people value.

This "why" component is both critical and understudied. Saying so inevitably invites semantic discussions attempting to divide "how" questions from "why" questions, because in common usage these two frequently blend into each other at the edges. For example, economic analysis generally takes tastes and preferences as given.[18] So one could argue that economists are interested not in "why" a person chooses to purchase one thing instead of another, but instead in discovering regularities in "how" people behave.[19] Under this view, people simply make their choices according to their inscrutable, idiosyncratic tastes. On the other hand, one could argue that economists do provide a reason sufficient to answer the "why" question: A person chooses as she does because she maximizes utility by deciding according to the respective values she places on various alternatives.

We will have more to say below about how the "how" and "why" questions regarding behavior can be usefully distinguished.[20] The key point at the outset is that a good behavioral model makes predictions about the ways environmental inputs will affect behavioral outputs not only on the basis of raw observational data, but also by connecting the data with explanatory, causal theories that enable not only a greater understanding of phenomena already observed, but also useful extrapolations into new contexts. Although it is possible to learn a fair amount about how people behave solely through multiple iterations of trial and error, that approach is not very practical. Not only is it inefficient, but it also has no theoretical foundation from which to generate promising hypotheses to be tested. Even if it worked reasonably well, this approach would not be particularly satisfying, for it affords no sense of the distance between what has been achieved and what is achievable. In short, it neither provides nor leads to any deep and generative understanding of human behavior, either generally or specifically.

In current legal education, it is not only possible but also common to study torts, criminal law, contracts, and all the rest without ever pausing to specifically consider the behavioral models on which different legal approaches within these subjects rely. Moreover, we suspect it is only the exceedingly rare judge, legislator, professor, or member of law enforce-

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18. J. Hirshleifer, Economics from a Biological Viewpoint, 20 J.L. & Econ. 1, 17 (1977) [hereinafter Hirshleifer, Economics] ("Modern neoclassical economics has forsworn any attempt to study the source and content of preferences, that is, the goals that motivate men's actions.").

19. Although we would not want to hang a full argument on the hook of a single word, it is nonetheless useful to note that leading economists often phrase their work in this "how" rather than "why" context. See, e.g., Thomas S. Ulen, Firmly Grounded: Economics in the Future of the Law, 1997 Wis. L. Rev. 433, 436 ("The single most important contribution that law and economics has made to the law is the use of a coherent theory of human decision-making ('rational choice theory') to examine how people are likely to respond to legal rules.").

20. See infra Part III.C.1.

ment who considers this question explicitly. One might therefore wonder whether law really uses any behavioral models at all.

The answer, we believe, must clearly be yes. We all live in contexts thick with human behavior. The better we understand people—what they are like, how they behave, when they will respond to circumstances with one set of reactions instead of others, and within what general ranges of behavior they will act—the better we can navigate the insistent challenges of social living. Our understanding may grow as a product of cultural experience, but even that experience is processed by and reflected in brains that evolved in highly social environments. We therefore carry with us—partly for evolutionary reasons, and whether we are aware of them or not—assumptions about human nature that serve to make sense of social actions.[21]

What is true in life is no less true in law. The legal system is immersed in behavioral models, some open, most hidden. Every time a judge pronounces sentence, every time Congress passes a law, every time an agency establishes penalties for transgressions, every time parties maneuver through threats of litigation, people are acting with a theory about what will happen in the minds of other people. As surely as all legal activities reflect assumptions about how people's behavior will respond to particular environmental circumstances, these aggregated assumptions constitute behavioral models, however hidden from conscious view.

To put the relationship metaphorically, law is a lever for moving behavior that has a model of human behavior as its fulcrum.[22] That fulcrum consists of what we think we know about how and why people behave as they do, and it therefore incorporates the aggregated insights that

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21. See Steven Pinker, The Blank Slate: The Modern Denial of Human Nature 1 (2002) [hereinafter Pinker, Blank Slate]. Pinker explains:

> Everyone has a theory of human nature. Everyone has to anticipate the behavior of others, and that means we all need theories about what makes people tick. A tacit theory of human nature—that behavior is caused by thoughts and feelings—is embedded in the very way we think about people. We fill out this theory by introspecting on our own minds and assuming that our fellows are like ourselves, and by watching people's behavior and filing away generalizations. We absorb still other ideas from our intellectual climate: from the expertise of authorities and the conventional wisdom of the day.

Id. For a similar view, see Patricia Adair Gowaty, Introduction: Darwinian Feminists and Feminist Evolutionists, *in* Feminism and Evolutionary Biology: Boundaries, Intersections, and Frontiers 1, 2 (Patricia Adair Gowaty ed., 1997).

22. One of us has developed this idea from slightly different angles in Owen D. Jones, Law and Biology: Toward an Integrated Model of Human Behavior, 8 J. Contemp. Legal Issues 167 (1997); Owen D. Jones, On the Nature of Norms: Biology, Morality, and the Disruption of Order, 98 Mich. L. Rev. 2072 (2000) [hereinafter Jones, Nature of Norms]; Owen D. Jones, Proprioception, Non-Law, and Biolegal History, 53 Fla. L. Rev. 831 (2001) [hereinafter Jones, Proprioception]; Owen D. Jones, Time-Shifted Rationality and the Law of Law's Leverage: Behavioral Economics Meets Behavioral Biology, 95 Nw. U. L. Rev. 1141 (2001) [hereinafter Jones, Law's Leverage].

underlie our prediction that if law moves this way behavior will move that way, and not some other way. Consequently, law can generally obtain no more leverage on human behaviors it seeks to change than the accuracy of its behavioral model allows. Since a soft fulcrum provides poor support, the success of every legal system necessarily depends, in part, on the solidity—the accuracy, robustness, and predictive power—of the behavioral model on which it relies.

C. *Contemporary Behavioral Models*

It remains to be considered, then, how well law's behavioral models serve as fulcra for the levers of law. Although it is possible to make some generalizations, it is not a simple matter to assess the quality and relative solidity of existing behavioral models. There are at least four reasons.

First, as alluded to earlier, the behavioral models on which law relies are rarely explicit. There is nearly an inverse relationship between the importance to law of behavioral models and the frequency with which they are described, even in general contours. Behavioral models—and particularly their "why" components—simply have not received as much attention as their critical role in law's function might suggest they should. We suspect this is because legal thinkers have generally not been encouraged to reflect deeply on where human behavior comes from and why it is that we think the human organism grows, becomes organized, and is socialized in such a fashion that we can find its behavior ordinarily unsurprising in the aggregate, yet frequently surprising in the individual.

Second, behavioral models almost certainly vary somewhat by jurisdiction. The collective legal systems of the United States obviously do not reflect a coordinated effort to deploy a common and consistent national model of behavior. Nor does it appear likely that any single constituent jurisdiction, state or local, actually deploys a consistent approach to behavioral models across all or even many areas of law.

Third, behavioral models vary considerably across behaviors. Looking across the many facets of law's endeavors, it is unavoidably obvious that law rarely attempts to connect—let alone crosscheck for consistency—assumptions that underlie its approaches to different behaviors. Law's pattern—though often reasonably effective—is generally ad hoc and narrowly reactive. It addresses accidental pool drownings of infants here, driving while intoxicated there, underreporting income somewhere else, and sexual aggression, overfishing, jaywalking, market coordination, and discovery rules still elsewhere, with isolated focus.

Fourth, there has been to date no concerted effort to systematically develop a science for fairly, reliably, and correctly inferring, deducing, and otherwise extracting from legislative, judicial, and executive actions the specific set of assumptions on which each legal action lies. Nor, since that would be an obvious prerequisite, has there been a subsequent metastudy of how the behavioral models aggregating these assumptions compare with one another on various relevant dimensions, such as con-

tent of assumptions, accuracy of assumptions, and effectiveness of programs based on the assumptions.

It would have been convenient for our argument to say that the legal system reflects a clear and consistent set of behavioral models, with components defined by individually identifiable predicates that are demonstrably incorrect. But the reality is clearly both more subtle and less systematic. Because behavioral models are rarely explicit, not coordinated at national or local levels, seemingly disconnected among the various behaviors in law's purview, and as yet not subjected to rigorous scrutiny, it would be impossible for us to conclude that law has *a* behavioral model that is evident, single, and specific. In fact, we think the opposite is true: Existing behavioral models are multiple in number, diffuse in kind, indistinct in form, and inconsistent in content. The general impression one gets from reading and observing legal activity is that there is no consistent set of assumptions about human behavior that has been drawn from relevant scholarly disciplines. There is little to suggest that behavioral models do anything more regularized than shift according to varying emphases on such things as emotions, perceptions, rational choice, heuristics and biases, and political movements.[23]

Even in the absence of a conclusive study, most legal thinkers likely agree that to the extent law relies on behavioral models, these reflect varying amalgamations of trial and error, intuition, observation, experience, self-reflection, path dependence, imitation, the influence of various disciplines that appeal at any given moment, and hope. Although there are clearly many pockets of legal thinkers focusing efforts on various aspects of human behavior,[24] an explicit focus on the causes of behavior is relatively new to legal scholarship and to legal education.[25] And it is also

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23. There is no inherent problem in the multiplicity of models. Law is pragmatic: Whatever works works. But having so few formal links between behavioral models is like having separate physics for cars, planes, and human bodies.

24. See, e.g., Behavioral Law and Economics (Cass R. Sunstein ed., 2000); Michael S. Moore, Law and Psychiatry: Rethinking the Relationship (1984); Eric A. Posner, Law and Social Norms (2002); Ralph Reisner et al., Law and the Mental Health System: Civil and Criminal Aspects (2004); Chris Guthrie, Prospect Theory, Risk Preference, and the Law, 97 Nw. U. L. Rev. 1115 (2003); Russell B. Korobkin, Behavioral Analysis and Legal Form: Rules vs. Standards Revisited, 79 Or. L. Rev. 23 (2000); Korobkin & Ulen, Law and Behavioral Science, supra note 2; Donald C. Langevoort, The Human Nature of Corporate Boards: Law, Norms, and the Unintended Consequences of Independence and Accountability, 89 Geo. L.J. 797 (2001); John Monahan, Violence Risk Assessment: Scientific Validity and Evidentiary Admissibility, 57 Wash. & Lee L. Rev. 901 (2000); Jeffrey J. Rachlinski, Heuristics and Biases in the Courts: Ignorance or Adaptation?, 79 Or. L. Rev. 61 (2000); Christopher Slobogin, A Jurisprudence of Dangerousness, 98 Nw. U. L. Rev. 1 (2003); Cass R. Sunstein, Human Behavior and the Law of Work, 87 Va. L. Rev. 205 (2001); Thomas S. Ulen, Evolution, Human Behavior, and Law: A Response to Owen Jones's Dunwody Lecture, 53 Fla. L. Rev. 931 (2001) [hereinafter Ulen, Evolution]; sources cited in Jones, Law's Leverage, supra note 22, at 1152 n.40.

25. An interesting exception to this timing is the comparatively limited movement linking Freudian theories of psychoanalysis and law. See Jay Katz et al., Psychoanalysis, Psychiatry, and Law (1967). Important vestiges of that movement are notably evident in

clearly the case in both legal scholarship and the legal system generally that there is no broad consensus that it is important to learn more about the very foundations of human behavior.

Despite these several challenges, it is still possible to generalize that law's behavioral models are imperfect and to offer at least some partial diagnosis for why this may be true. First, and least surprisingly, we know law is imperfect because there are so many ways in which efforts to channel human behavior fail daily. Without minimizing law's many successes, which are in part responsible (alongside nonlegal norms, technological advances, cultural practices, religions, and other cultural practices) for the internal stability of many human societies, no one could seriously entertain the argument that legal systems are not in need of improvement.

Second, and more to the point, at least some large measure of law's failings can be attributed to weaknesses in the behavioral models law deploys to regulate behavior. True, one could instead argue that the behavioral models are perfect but the implementation of laws based upon them is compromised by insufficient funding, political infighting, insufficient monitoring, errors in the choice of legal tools, and other flaws. But we are aware of no one who has laid law's imperfections at that doorstep alone, and it seems implausible on its face to do so. Instead, if law is about changing behavior, and if behaviors are insufficiently changed by law, it follows logically that some failures of law may be attributable to an incomplete understanding of human behavior.

There are doubtless many areas in which these and other perspectives on behavioral models could be improved. But in this Article we focus on one, which happens to be an elephant in the room. However else they may be aligned, law's behavioral models are aligned in this: their nearly wholesale omission of life science perspectives on where behavior comes from, how it emerges, what processes give rise to its patterns, and how multiple causal influences will intersect to affect it.[26]

We do not, of course, mean to suggest that biology has played no role in law. In the broad sense, biology has become central to myriad legal questions, such as those addressing reproductive technology, environmental resources, forensic identification, genetically modified foods, and property rights in biotechnology industries. Nor do we suggest that lawyers have not attempted to use—and sometimes, intentionally or not, misuse—discrete aspects of behavioral biology in litigation. Nor are we

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child custody law. See, e.g., Joseph Goldstein et al., Beyond the Best Interests of the Child (1973). Another exception concerns legal realism, the main proponents of which focused on the influence of extralegal values on judicial decisionmaking. See, e.g., Jerome Frank, Courts on Trial: Myth and Reality in American Justice (1949).

26. It is, of course, far harder to prove that a perspective is absent tban it is to prove that it is present, or is present but misused. However, periodic searches of the legal literature reveal comparatively little attention to behavioral biology in recent decades, despite the explosion of knowledge emanating from the collected fields of which it is composed. It remains the case that social sciences are "by far the most commonly invoked" methodology for legal scholarship. Rubin, Law And, supra note 8, at 536.

suggesting that we are the first or only authors to explore possible intersections of law and behavioral biology.[27]

We are referring, instead, to the near-total absence of recognition in legal thinking that all behavior, and all the brain activity that perceives and directs it, are fundamentally biological phenomenona, rendering the study of behavioral biology manifestly relevant to any deep and current understanding of how and why humans behave in ways important to law. Phrased this way, some might object that everyone knows that the brain is involved in behavior and that actions occur as a function of muscle contractions, themselves biological in origin. But that is a very superficial nod to the biology of human behavior, as we will describe briefly in Part II. Furthermore, broad consideration of the possible uses of behavioral biology in law remains at a very early stage.

There is already a large body of nearly untapped literature in behavioral biology that is rich in theory and increasingly robust in empirical work. Over the last few years, it has been growing at an extraordinary rate. Given law's focus on behavior, it is regrettable that law's behavioral models have for so long omitted life science perspectives. Neglect may be attributable to path dependence, the overspecialization of scholars, and the attendant balkanization of subjects within most universities. It may be a product of demonstrably false dichotomies—such as "nature versus nurture"—taking misleading hold in the public's mind, suggesting that the set of biological influences excludes the set of cultural influences. It probably is a function of the fact that so few trained in law have also been trained in science generally, or biology specifically.[28] It is almost certainly also a product of a variety of misunderstandings, as well as both reasonable and unreasonable fears about what biological knowledge does and can legitimately say about human behavior, and about what the political implications—for racism, sexism, genetic determinism, and other evils—might be, whether based on use or misuse of biological information.[29]

At the broadest level, however, law's relationship to science and technology is complex and often problematic.[30] Science is routinely ignored, misunderstood, or improperly invoked by judges, legislators, agency per-

27. See, e.g., sources cited supra note 4. The Society for Evolutionary Analysis in Law and the Gruter Institute for Law and Behavioral Research hold regular conferences on these subjects. For scholarship in this area, see SEAL, supra note 3.

28. "Fewer than 10 percent of all students attending law school have undergraduate training in fields that require substantial math and science training, such as the natural sciences, math and statistics, computer science, and engineering." David L. Faigman, Legal Alchemy: The Use and Misuse of Science in the Law 53–54 (1999) [hereinafter Faigman, Legal Alchemy].

29. We address these latter concerns, among others, in Part IV.

30. See generally David L. Faigman, Laboratory of Justice: The Supreme Court's 200-Year Struggle to Integrate Science and the Law (2004); Faigman, Legal Alchemy, supra note 28; Steven Goldberg, Culture Clash: Law and Science in America (1994).

sonnel, and other policymakers.[31] Well-known examples include litigation contexts in which the underlying scientific claims are largely undemonstrated or in which error rates are far higher than courts acknowledge, such as those involving lie detectors, handwriting, bitemarks, toolmarks, arson, visual identification of individuals, and even fingerprints.[32] Courts frequently misunderstand or misapply statistical research[33] and are confronted with the efforts of parties to introduce as science what some refer to as "junk science."[34] Experts have called law reform efforts reflecting a large gap between legislative assumptions and empirical data "breathtakingly negligent."[35] And Congress has been known to empanel commissions charged with recommending legal approaches to a technology without bothering to include any experts on the technology itself.[36]

In the context of law and biology generally, science often is similarly ignored, misunderstood, or improperly invoked. The breast implant litigation famously ignored medical findings, including negative results.[37] The notorious Delaney Amendment established a scientifically ridiculous policy of zero tolerance for carcinogens.[38] Tort reform, particularly medical malpractice reform, regularly proceeds on the basis of assumptions contrary to data.[39] And in the environmental context, legislators routinely legislate as if difficult matters of science were simple.[40]

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31. See generally Faigman, Legal Alchemy, supra note 28. In Faigman's view, science is misunderstood in law most of the time. Id. at xi.

32. See generally Science in the Law: Forensic Science Issues (David L. Faigman et al. eds., 2002).

33. See, e.g., Colgrove v. Battin, 413 U.S. 149 (1973); Williams v. Florida, 399 U.S. 78 (1970). For analysis of errors in these cases, see generally David Kaye, And Then There Were Twelve: Statistical Reasoning, the Supreme Court, and the Size of the Jury, 68 Cal. L. Rev. 1004 (1980).

34. Peter Huber, Galileo's Revenge: Junk Science in the Courtroom (1991).

35. See, e.g., Teresa A. Sullivan et al., As We Forgive Our Debtors: Bankruptcy and Consumer Credit in America 336 (1989).

36. See Pamela Samuelson, CONTU Revisited: The Case Against Copyright Protection for Computer Programs in Machine-Readable Form, 1984 Duke L.J. 663, 699 (describing such an instance).

37. Marcia Angell, Science on Trial: The Clash of Medical Evidence and the Law in the Breast Implant Case 97–108 (1996).

38. Food Additives Amendment of 1958, Pub. L. No. 85-929, 72 Stat. 1784, 1786 (codified as amended in scattered sections of 21 U.S.C.).

39. See, e.g., Michael J. Saks, Do We Really Know Anything About the Behavior of the Tort Litigation System—And Why Not?, 140 U. Pa. L. Rev. 1147 (1992); Michael J. Saks, Medical Malpractice: Facing Real Problems and Finding Real Solutions, 35 Wm. & Mary L. Rev. 693, 699–707 (1994) (book review).

40. The Endangered Species Act, for example, defines "species" to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." 16 U.S.C. § 1532(16) (2000). As Ruhl notes, "Scientists have enough trouble defining a species; now they must also define subspecies and distinct populations segments . . . ." J.B. Ruhl, The Battle over Endangered Species Act Methodology, 34 Envtl. L. 555, 576 & n.67 (2004).

In the context of law and behavioral biology, more specifically, the situation is often equally grim. The discordant clash of law and science has been especially obvious in cases involving mental illness.[41] Clinical predictions of future dangerousness are often untrustworthy, despite their often unskeptical use in law. Courts typically assume that individualized evaluations and predictions by clinical psychologists and psychiatrists, parole officials, and others are more accurate than statistical profiles, even though those assumptions are predominantly wrong.[42]

More disturbingly, the operation of the legal system often reflects outdated and incorrect assumptions about behavior that—even when they do not yield clear errors—often forgo opportunities for improvement. To mention just a few examples to be explored in Part III, outdated assumptions about the processes that shape human behavior generally can obscure patterns relevant to law, such as those evident in instances of child abuse. Outdated assumptions about the causal influences on human behavior can lead to false dichotomies, such as those evident in the law's treatment of sexual aggression. Outdated assumptions can cause us to overlook factors relevant to cost-benefit calculations. And outdated assumptions about how the brain operates can yield analytic missteps, such as are present in the law and behavioral economics approach to irrational behavior.

D. *The Relationship Between Behavioral Models and Behavioral Biology*

So if law is about changing behavior, changing behavior requires sound behavioral models, and our behavioral models are evidently incomplete, then by what process might they be improved so as to serve as a more solid fulcrum for the lever of law? We do not have a full answer. But we have a partial one, explored in the balance of this Article: Building more robust behavioral models to serve as solid fulcra for the lever of law requires, among other things, integrating existing social science and humanities models of human behavior with life science models.

Such an integrative approach should offer some gains in both the effectiveness and efficiency of law for the simple reason that biology addresses some unrecognized or underrecognized influences on behavior that in fact exist. It is important to distinguish biology, in this respect, from disciplines such as those constituting the humanities that—however useful they may be—are generally more interpretive or normative than

41. Faigman, Legal Alchemy, supra note 28, at 27.

42. William M. Grove & Paul E. Meehl, Comparative Efficiency of Informal (Subjective, Impressionistic) and Formal (Mechanical, Algorithmic) Prediction Procedures: The Clinical-Statistical Controversy, 2 Psychol. Pub. Pol'y & L. 293 (1996); see id. at 318–19 (finding support for superiority of clinical over statistical prediction in only 8 of 136 studies); see also Robyn M. Dawes, House of Cards: Psychology and Psychotherapy Built on Myth (1994); John Monahan, Forecasting Harm: The Law and Science of Risk Assessment Among Prisoners, Predators, and Patients (2004) (unpublished manuscript, on file with the *Columbia Law Review*).

scientific. Biology is not a discipline that simply offers one way of looking at human behavior—though it does offer that, too. Biology provides a process for uncovering scientific facts about what influences human behavior, why, and how.

Except for those radical relativists who believe that all knowledge is socially constructed, there is an objective reality underlying the influences on human behavior. While existing social science and humanities approaches focus exclusively on the influences of environmental features (such as cultural norms) on human behavior, modern science makes unequivocally clear that the complexity of the causal influences underlying that behavior cannot be captured by simplistic models that focus on environmental features alone. Gaining an improved understanding of that complexity requires attention to biology because (1) all theories of human behavior are ultimately theories about the brain; (2) the brain is a computational organ that works on physical principles; and (3) modern biology makes forcefully clear that the brain's design, function, and behavioral outputs are all products of gene-environment interactions that have been shaped through time by various evolutionary[43] and developmental[44] processes.

To this point, we have been focusing principally on the goal of increasing the effectiveness and efficiency of law's behavioral models, but we should say a few words about the distinct notion of accuracy. We stated earlier that improving the effectiveness of behavioral models often, *but not always*, requires improving their accuracy.[45] It should be evident, therefore, that our approach does not give accuracy automatic premier place. The reasons for this warrant brief mention.

In science, improving accuracy is often an end unto itself, as there is a deep satisfaction in gaining a greater understanding of nature. In law, accuracy is but one servant of utility.[46] Our concern in this Article is not to pursue accuracy solely for the purpose of being accurate, but rather to pursue accuracy when and because it improves law's ability to get a job done. To put this back in the behavioral context, our initial, overriding concern is that inaccuracy often impedes improvements in law's ability to regulate human behavior effectively and efficiently.

For example, a policy that either rejects or remains agnostic on the question of whether there are evolutionary influences on patterns of human aggression, while emphasizing only sociocultural contributors, is

43. The evolutionary processes—defined infra Part II.B—are natural selection, sexual selection, mutation, random genetic drift, and gene flow. See Timothy H. Goldsmith & William F. Zimmerman, Biology, Evolution, and Human Nature 67–68, 95–100, 143–48 (2001).

44. See infra note 55 and accompanying text.

45. See supra Part I.B.

46. One need only think about the balancing of interests that underlies, for example, statutes of limitations, limitations on the number of depositions in federal discovery, and limitations on criminal appeals.

inaccurate because it is incomplete. There is overwhelming evidence that evolution has equipped the brain to detect threats and to assess the need for countermeasures.[47] Responses of the brain include psychological states tending to increase or decrease aggressive behaviors. But evolutionary theory (among other tools of behavioral biology) can be useful in predicting, at least statistically, both the environmental causes of these states and the nature of the responses that are likely to follow.

In this and many similar contexts relevant to law, more biology means more accuracy, which in turn may increase law's effectiveness and efficiency. Any behavioral model law deploys that is inconsistent with fundamental principles of behavioral biology is probably inaccurate and should ordinarily be avoided.

Nevertheless, not every gain in accuracy translates into a gain in effectiveness or efficiency.[48] There are three important caveats. First, gains from increased accuracy can be offset, either because of high inherent costs in improving the behavioral model, or because the model is misunderstood or misapplied. Second, the law may already deploy tools that are highly effective and efficient, even if they are based on inaccurate understandings of human behavior. Third, the process of improving scientific knowledge is inherently never-ending. Neither accuracy nor consensus is easily obtained. This counsels caution, but it as important to avoid being overdettered as it is to avoid overzealousness. Frequently, delay while waiting for every conceivable doubt to dissipate may bear its own significant costs in forgone improvements. For this reason, our legal system appropriately affords somewhat greater latitude in necessary scientific certainty when operating in policymaking contexts, in contrast to adjudicative ones. The purpose of incorporating behavioral biology into legal analysis is to improve law's functioning, and we should explore possible incorporation when it appears advantageous to do so.

II. BEHAVIORAL BIOLOGY

In this Part we provide a very brief overview of some important features of behavioral biology. Part II.A describes how behavioral biology exists at the intersection of a variety of related disciplines. Part II.B then offers brief background on various concepts that are necessary to the particular applications appearing in Part III of the Article.

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47. See, e.g., Martin Daly & Margo Wilson, Homicide (1988) [hereinafter Daly & Wilson, Homicide]; Goldsmith & Zimmerman, supra note 43, at 333–42; Richard Wrangham & Dale Peterson, Demonic Males: Apes and the Origins of Human Violence (1996); J. Maynard Smith & G.R. Price, The Logic of Animal Conflict, 246 Nature 15 (1973).

48. For instance, once we are already working to reduce emissions of a certain airborne toxin, it may not matter whether we know that between x and y percent of lung cancers are attributable to that toxin, or whether precisely x+2 percent are.

A. *Behavioral Biology's Relationship to Other Disciplines*

Behavior is studied in a broad array of disciplines. Legal thinkers are most familiar with psychology, sociology, and economics. The fields that have their principal roots in the natural sciences include evolutionary biology, evolutionary ecology, developmental biology, cognitive neuroscience, behavioral genetics, and behavioral ecology.[49] Yet even here the disciplinary boundaries are indistinct, and many other disciplines and techniques contribute to an understanding of biological influences on behavior. These include neuroanatomy, brain chemistry, neuroeconomics, evolutionary anthropology, evolutionary psychology, Darwinian medicine, Darwinian psychiatry, psychopharmacology, and brain imaging. In this Article, we use the term "behavioral biology" to refer to information and perspectives from these many disciplines that overlap to provide the rich and textured foundation—both in theory and in empirical work—for understanding how biological processes winnow, shape, and influence patterns of behavior in all animal life, including humans.

The extraordinary growth of behavioral biology is the product of intersecting developments. The school of psychology known as behaviorism—the notion that all behavior of importance results entirely from cultural learning—passed into history some time ago. We now recognize that animals of each species come evolutionarily equipped not only with behavioral predispositions, but also with proclivities to learn some behaviors far more easily than others.[50] Evolutionary theory, in tandem with animal studies in both natural and experimental contexts, has clarified the general conditions under which social systems can evolve and has illuminated many of the behaviors that social animals, including humans, are likely to display.[51] Technological advances have enabled neurobiologists to ask meaningful questions of single nerve cells in neural circuits in awake and active animals, to clarify how neurons operate on known principles of physics and chemistry, and to localize cognitive activities in human brains by using noninvasive techniques such as magnetic resonance imaging.[52] Of course, the storied discovery of the structure of

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49. For the important distinction between the last two, see infra Appendix A.

50. See generally, e.g., Martin E.P. Seligman, On the Generality of the Laws of Learning, 77 Psychol. Rev. 406 (1970). An early, elegant, and influential demonstration of this is reported in J. Garcia et al., Cues: Their Relative Effectiveness as a Function of the Reinforcer, 160 Science 794 (1968). For an overview of Garcia's experiment, see Timothy H. Goldsmith, The Biological Roots of Human Nature 97–98 (1991) [hereinafter Goldsmith, Biological Roots of Human Nature]. For general treatments of evolved behavior, see John Alcock, Animal Behavior (7th ed. 2001) [hereinafter Alcock, Animal Behavior]; Goldsmith & Zimmerman, supra note 43.

51. For overviews, see generally Alcock, Animal Behavior, supra note 50; Goldsmith & Zimmerman, supra note 43; Mark Ridley, Evolution (3d ed. 2004); Monroe W. Strickberger, Evolution (3d ed. 2000); Jones, Evolutionary Analysis in Law, supra note 4, at 1126–57; references described in Appendix B.

52. See, e.g., Michael I. Posner & Marcus E. Raichle, Images of Mind (1994). See generally Principles of Neural Science (Eric R. Kandel et al. eds., 4th ed. 2000).

DNA in 1953 opened the way to the avalanche of fresh discoveries about genes and developmental biology that has increased knowledge at an extraordinary rate.[53]

Cognitive neuroscience, itself an interdisciplinary approach, now explores both patterns of cognition and underlying neural activity.[54] Developmental biology examines the processes by which genes and environments interact during the process of development in ways that guide a brain's form and function, with consequences, ultimately, for developmental psychology, learning, and the evolution of behavior.[55] Evolutionary anthropology and evolutionary psychology are helping us to understand features of human behavior shared widely across cultures.[56] Molecular genetics has brought new understanding to human evolution and the physical features of people from different parts of the world.[57] Behavioral genetics has helped us to understand some of the ways that genes influence behavior.[58] Evolutionary game theory is increasingly used by economists and others to examine patterns of human decision-making.[59] And primatologists are investigating the limits of cognitive capacity in our closest living relatives, the great apes, to understand better the possible evolutionary origins of human behaviors, such as the need for reconciliation after conflict, alliance formation, and intergroup aggression.[60]

A few examples of some of the many important advances in these fields will give the flavor of their importance. We now know that even in the tiniest brains—such as those of ants—there is extraordinary complexity that enables not only flexible and successful interaction with environ-

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53. See generally Bruce Alberts et al., Molecular Biology of the Cell (4th ed. 2002); Scott F. Gilbert, Developmental Biology (7th ed. 2003). A very useful introduction to this material is Matt Ridley, Nature Via Nurture: Genes, Experience and What Makes Us Human (2003) [hereinafter Ridley, Nature Via Nurture].

54. See generally The Cognitive Neurosciences III (Michael Gazzaniga ed., 3d ed. 2004).

55. See generally Jonathan Slack, Essential Developmental Biology (2001); Lewis Wolpert et al., Principles of Development (2d ed. 2002).

56. See generally Adaptation and Human Behavior: An Anthropological Perspective (Lee Cronk et al. eds., 2000); David Buss, Evolutionary Psychology: The New Science of the Mind (2d ed. 2004); The Adapted Mind: Evolutionary Psychology and the Generation of Culture (Jerome Barkow et al. eds., 1992) [hereinafter Adapted Mind].

57. See generally L. Luca Cavalli-Sforza et al., History and Geography of Human Genes (1996); Steve Olson, Mapping Human History: Genes, Race, and Our Common Origins (2002).

58. See generally Robert Plomin, Nature and Nurture: An Introduction to Behavioral Genetics (1990); Robert Plomin et al., Behavioral Genetics (4th ed. 2001).

59. See generally Herbert Gintis, Game Theory Evolving: A Problem-Centered Introduction to Modeling Strategic Behavior (2000); Jorgen W. Weibull, Evolutionary Game Theory (1996).

60. See generally Tree of Origin: What Primate Behavior Can Tell Us About Human Social Evolution (Frans B.M. de Waal ed., 2001) [hereinafter Tree of Origin]; Frans de Waal, Good Natured: The Origins of Right and Wrong in Humans and Other Animals (1996) [hereinafter de Waal, Good Natured].

mental challenges, but also highly sophisticated social behavior with other members of the species. We have come increasingly to understand how species-wide commonalities in genes and brain architecture yield species-typical repertoires of context-specific and algorithmic (that is, "if-then") processing patterns that provide behavioral predispositions consistent with and often predicted by a modern understanding of evolutionary theory.[61] Even in humans, behavioral predispositions reflect evolved, species-typical perceptual processes and motivational systems, including emotions and elements of moral decisionmaking. Synaptic connections in the brain ebb and flow—not only over the course of a lifetime, but during a single day. And we can not only see how different parts of the brain fulfill different functions, but we can also observe in real time how different parts of a brain operate when it is thinking, analyzing, deciding, or experiencing emotion.

Behavioral biologists study the mechanisms and the evolutionary pathways that yield the capacities for behavioral variation we observe in the world. And human behavior, it turns out, is even more complex and more interesting than commonly supposed. As will be discussed more fully in a moment, genes do not alone determine behavior, for experience and culture exert important and strong influences.[62] Yet brains are not blank slates on which culture can inscribe anything with equal ease, for genes affect learning and contribute to cultural patterns common to the species.[63] All human behavior reflects the intersection of genes, environments, developmental history, and the evolutionary processes that built the brain to function in the ways it does. This means that the human organism is neither genetically determined nor environmentally determined, but rather possesses multiple potentials that arise through successive interactions of genes and environments.[64]

B. *Some Foundational Concepts*

There are many excellent sources, ranging from the general[65] to the technical,[66] that provide introductions to various aspects of the biology of behavior. These sources are typically at least as accessible to motivated legal thinkers as are, for example, introductions to the economic principles relevant to law. We could not duplicate these introductions here,

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61. See infra Appendix A.

62. See generally Ridley, Nature Via Nurture, supra note 53.

63. For useful overviews of this research, see generally Pinker, Blank Slate, supra note 21; Ridley, Nature Via Nurture, supra note 53.

64. For further discussion on why genes do not determine behavior, see infra Part IV.B.1.

65. See, e.g., Pinker, Blank Slate, supra note 21. John Cartwright, Evolution and Human Behavior (2000) and Matt Ridley, The Red Queen: Sex and the Evolution of Human Nature (1993) provide highly readable and useful background. A primer written expressly for a legal audience appears in Jones, Evolutionary Analysis in Law, supra note 4, at 1126–57.

66. Alcock, Animal Behavior, supra note 50; Goldsmith & Zimmerman, supra note 43.

nor would we wish or need to do so. What we provide here, instead, is a short tour of some of the key concepts that underlie the discussions that follow and that provide the broad conceptual bases for better understanding, anticipating, and dealing with human behaviors relevant to law. We examine how genes and environments interact to lay a foundation for behavior. We discuss the ways in which the features of that foundation also reflect the effects of important evolutionary processes. We then turn to principles of behavioral biology that underlie two phenomena particularly important to law: cooperation and conflict.

1. *From Genes to Behaviors Through Environments and Brains.* — At the most basic level, organisms exist and become capable of behaving because information flows across time. As is today widely known, that information—essentially a broadly general recipe for constructing organisms—is coded in genes. A gene is a molecule that codes for a sequence in which twenty different kinds of amino acids are strung together in long chains to make a protein. Proteins, in turn, are molecules responsible for the complex chemistry that occurs in living cells.

Of course, that bare genetic information must interact with environmental conditions to build an organism. That process of building is known as development, and during development different genes are active—i.e., actively contributing to the manufacture of proteins—at different times in different tissues.[67] This is why brain tissue differs from liver tissue, and why different physical changes, such as the eruption of third molars or anatomical changes brought on by puberty, can occur at specific times. The sequential activation of genes means that there are critical periods during development in which genes must encounter specific signals in order for development to occur normally.[68]

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67. A bit more detail: Proteins perform myriad functions. Reference to the function of a gene thus refers to the role of the protein for which it codes. Some genes control the activation of other genes, a process that is key to understanding the complexities of development. Still other genes are activated by molecules—e.g., hormones—that are produced by newly formed tissue in other regions of the developing embryo. Development is thus a complex but natural process of assembly in which the results at each stage are dependent not only on genes but also on signals produced by preceding steps in the process. Early in development, genes are primarily influenced by the environment within the fetus itself (although in mammals some influences may cross the placenta), but after birth the environment includes the outside world, and important influences on the developing brain come through the sense organs. We are accustomed to think of this latter influence as learning, but in fact it is a continuation of development and involves the expression of genes and physical changes in the brain. In summary, single genes do not specify organs as complex as brains or the activities of brains that cause behaviors. Suites of genes act in a concerted fashion during development, together with environmental feedback, to make brains that tend to process information in ways that are characteristic of each species.

68. For example, if one eye of a baby monkey or cat is covered for a week or so in a critical period after birth, the animal becomes blind in that eye for life; coordinated input from both eyes is required for proper connections of nerves in the brain. David H. Hubel, Eye, Brain, and Vision 192–95 (1988). Similarly, young monkeys deprived of opportunities for social interactions with peers become neurotic misfits, unable to relate to the group

The importance of this gene-environment interaction is profound. The interaction is as crucial for the construction and proper function of brains as it is for the construction and function of other organs. It is consequently as true for behaviors as it is for simpler anatomical structures. Behavior flows from brains that (a) encounter specific environmental stimuli and (b) possess a neural architecture that is as importantly shaped by environments as it is by genes. The essential point is that biological processes, properly understood, provide no support for genetically deterministic views of human behavior, whether they arise from political motivations or from misconceptions.

Yet at the same time, the variation in brains among members of a species is not infinite, for members of a species share the vast majority of their genes. Even with both genetic variation and differences in environmental inputs, members of a species tend to have species-typical brains—which tend in turn to incline the organisms bearing them toward patterns of behavior that, in the aggregate, can be described as the general "nature" of that species.

2. *The Effects of Evolutionary Processes.* — We turn now to the origins of species-typical brains and behaviors. The processes that lead to evolutionary change include mutation, genetic drift, gene flow, and natural selection (including sexual selection and kin selection). It is important to have a sense of how each of these operates, though our attention later in the Article will—for reasons to be explained shortly—focus principally on natural selection.

Mutation—simply a change in the code within a gene—is the initial source of all genetic variation. Mutations typically arise when genes are miscopied.[69] Genetic drift occurs in small populations where the number of individuals is so small that chance rather than natural selection tends to govern which variants of a gene are passed to the next generation.[70] Gene flow describes the movement of genes between populations

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later in life. H.F. Harlow et al., Maternal Behavior of Rhesus Monkeys Deprived of Mothering and Peer Associations in Infancy, 110 Proc. Am. Phil. Soc'y 58 (1966). These are examples of postnatal environmental inputs that are essential for normal development. Much of what we characterize as learning, however, is obviously more open-ended, with the value of the outcome dependent on the cultural environment (e.g., learning to read), or simply personal taste (e.g., fly casting). See supra note 67.

69. In their simplest form, mutations arise from an error in the insertion of a single nucleotide base—"copy error"—made during the replication of DNA, the substance from which genes are constructed. More complex mutations occur during cell division, including deletions and insertions of longer pieces of DNA. Humans have two copies of most genes. Copies of the same gene that differ from each other in small detail because of a mutation are called alleles and usually specify variants of a protein with somewhat different structures.

70. We note in passing that mutation and genetic drift are not the only instances of chance influencing evolutionary outcomes. For example, regardless of how evolutionarily fit a bird may be, a snake may eat its eggs or lightning may strike its tree. On a larger scale, during evolutionary history asteroid impacts and climate changes have led to mass extinctions.

of organisms as a consequence of the movement of the individual organisms carrying the genes, which can slow the formation of new species or, alternatively, maintain genetic continuity in large populations.

In most instances, however, natural selection is the evolutionary process with the strongest influence over the distribution of different kinds of genes in successive generations.[71] Natural selection is the one process that can lead to increases in complexity and can produce the fit between the features of an organism and its environment.[72] It is a sorting process resulting from the combination of (1) replication of genes (in which new copies are made in the formation of eggs and sperm); (2) variation of genes (as a function of mutation, as well as unique combinations of genes arising from sexual reproduction); and (3) differential reproduction of individual organisms (as a consequence of their genetic variation). Put another way, some individual organisms have complements of genes that enable their bearers, on average, to be more successful reproducers—in given environmental conditions—than are other members of the population. Genes of successful reproducers tend to appear with increasing frequency (that is, in larger percentages) in successive generations.[73] Note, however, that which individuals have a reproductive advantage is a function of the prevailing environment. Finally, natural selection appears to occur chiefly among individual organisms, not groups.[74]

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71. The essential outlines of natural selection were contemporaneously and independently discovered by Alfred Russell Wallace and Charles Darwin, though it was given its most forceful explanation by Charles Darwin. See Charles Darwin, On the Origin of Species by Means of Natural Selection (John W. Burrow ed., Penguin Books 1985) (1859). For an overview of evolutionary processes, see generally Stephen C. Stearns & Rolf F. Hoekstra, Evolution: An Introduction (2000).

72. This point has been elaborated in George Williams, Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought (1966), and more recently by the philosopher Daniel C. Dennett in Darwin's Dangerous Idea: Evolution and the Meanings of Life (1995). For a summary discussion of the concept of adaptation, how it can be recognized, alternative meanings of the word, and its relation to other evolutionary change, see also Goldsmith & Zimmerman, supra note 43, at 116–23.

73. The compounding effect of natural selection can be dramatic; a heritable trait providing its possessors with a mere one percent reproductive advantage over competitors will increase (all else being equal) from one percent representation in a population to ninety-nine percent in 265 generations. Robert Trivers, Social Evolution 28–29 (1985).

74. George Williams provided a clear argument why natural selection should be expected to act at the level of individuals rather than groups of individuals. See Williams, supra note 72; see also Goldsmith & Zimmerman, supra note 43, at 110–16. Although group selection is theoretically possible, the necessary conditions seldom if ever occur. This is an issue on which there is much discussion and confusion, partly because in the domain of cultural conflict, one society frequently has displaced another. Although this may lead to alterations in gene frequency (e.g., skin color), the reasons for differential group success can be accounted for by selection at the level of individuals. Success of groups can be attributed to cultural differences such as relative group size, technological advantage, leadership, or simply good luck. For an alternative, if minority, view on group selection, see David Sloan Wilson, Introduction: Multilevel Selection Theory Comes of Age, 150 Am. Naturalist S1 (1997); David Sloan Wilson & Elliott Sober, Reintroducing

Sexual selection is a form of natural selection that operates differently on males and females, resulting in both physical and behavioral differences between the two sexes.[75] It results from differences between females and males in (a) the minimum parental investment each sex must make in an offspring and (b) the maximum number of offspring a member of either sex could have. Females (usually) make a greater physiological minimum parental investment in offspring than do males, because producing eggs is generally more costly in energy and nutritional resources than is producing sperm. In mammals, this difference in minimum necessary investment is increased enormously by internal gestation and lactation. Further, the greater minimum parental investment of females means that the maximum lifetime number of offspring that females can produce is smaller than that of males. Put another way, a male can dramatically increase the number of offspring he sires by increasing his number of female mates, whereas for females, increasing mate number has little effect on the maximum number of offspring she can bear. These asymmetries between the sexes tend to produce two outcomes: (1) greater male-male than female-female competition for mates and (2) greater female than male "choice" among willing mates.[76]

The honing of a heritable physical or behavioral feature through natural selection that produces increasing complexity and "fit" between the organism and its environment is called adaptation. An adaptation (the result of the process) results from specific environmental conditions that create "selection pressures." Sometimes it is useful to refer to a previous "environment of evolutionary adaptation" for a feature that exists now but arose in a remote and different past.

3. *Cooperation and Conflict.* — Few subjects have been more closely studied in behavioral biology than cooperation and conflict. Among the many concepts relevant to this topic, four will be particularly useful for discussions that follow: kin selection, reciprocal altruism, parental investment, and parent-offspring conflict.

Kin selection explains the evolution of heritable predispositions to cooperate with those who appear to be relatives. The basic idea is that offspring are not the only relatives who carry copies of genes by reason of

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Group Selection to the Human Behavioral Sciences, 17 Behav. & Brain Sci. 585 (1994) (followed by extensive peer commentary).

75. Sexual selection was first described in detail by Darwin in 1871. Charles Darwin, The Descent of Man and Selection in Relation to Sex (photo. reprint, Princeton Univ. Press 1981) (1871) [hereinafter Darwin, The Descent of Man]. A more recent, classic work on these topics is Robert Trivers, Parental Investment and Sexual Selection, *in* Sexual Selection and the Descent of Man 1871–1971, at 136 (Bernard Campbell ed., 1972). See also Malte Andersson, Sexual Selection (1994).

76. The greater competition among males can play out in a variety of ways. For example, in many species males are larger than females and more "armed," with big antlers or large canine teeth, for example, enabling them to dominate other males. In other species, for example many birds, males have bright coloration—a good proxy for good health, specifically for resistance to parasites—and compete for female choice.

common descent; so do parents, siblings, nieces, nephews, cousins, and others. That means that one's reproductive success can be enhanced indirectly by behaviors that help to increase the reproductive success of near relatives.

Reciprocal altruism is a behavior by which cooperation can evolve even in the absence of close genetic relatedness. The basic idea is akin to the tit-for-tat strategy in game theory, in which parties start out with cooperative exchanges and then do unto others as others have done unto them. A predisposition toward selectively cooperative behavior that is directed toward others who cooperate usually yields higher reproductive success than persistent selfishness. When reciprocal altruism becomes a social condition, it gives rise to an evolutionary arms race between deception and detection of deception.

Parental investment is a technical term that refers to anything a parent does to enhance the success of an offspring at potential cost to the parent's investment in other offspring, present or future. A moment's reflection reveals that even though parents and offspring have overlapping interests—namely, the offspring's survival and eventual reproduction—those interests are not fully identical.

Parent-offspring conflict therefore arises because a parent's genetic interest in each offspring is half that of each offspring's genetic interest in itself. Conflict over the timing of weaning is the classic example. The distribution of resources among existing and future siblings presents another opportunity for conflict with the parents, because each offspring is only fifty percent related to its sibling (assuming the siblings have both parents in common) but one hundred percent related to itself.

III. Behavioral Biology in Law: Functions and Contributions

In this Part, we build on the conceptual and scientific foundations developed in Parts I and II. Specifically, our purpose in this Part is to provide readers with a sense of the great breadth of legal contexts in which behavioral biology can be useful. To this end, we have identified, named, described, and illustrated discrete contexts, grouping them into a number of supercategories (represented by Parts III.A to III.E). This is not the only possible structure; the contexts can stand independently or in other combinations reflecting still different relationships. The overarching goal of this Part, however, is to suggest both that basic biological processes and principles that underlie all behaviors recur in different contexts throughout the law, and that our understandings of a great many behaviors relevant to law can be improved by viewing them through the lens of behavioral biology.

A. *Patterns, Policy Conflicts, and Causal Links*

As important as it is to improve law's behavioral models, the process of doing so has its deepest roots in theory. Consequently, it can feel

overly abstract. What are some of the more concrete contexts in which behavioral biology can be useful to law? In this subpart we explore how incorporating insights from behavioral biology into law can help discover useful patterns in some behaviors that law seeks to regulate, uncover possible conflicts among contemporaneous legal policies, sharpen the cost-benefit analyses that underlie the implementation of some legal policies, and clarify links between behaviors and their possible causes. To demonstrate how these four separate contexts can overlap and interact, we will illustrate them using a single legal topic: the crime of infanticide.

1. *Discovering Useful Patterns in Regulable Behavior.* — Discovering patterns in human behavior relevant to law requires collecting and assembling data. But data do not self-organize. Choices concerning what data to collect and consider, and how to slice and cross-correlate, can either aid or hinder the discovery of patterns. Those choices, in turn, typically reflect assumptions based on beliefs about causation. It therefore often takes new insights to find new patterns. Behavioral biology is one source of comparatively untapped insights that can reveal patterns of behavior useful to law.

For example, our society aspires to eliminate infanticide—or, more technically, to at least reduce the sum of the costs of infanticide and the costs of efforts to prevent it. Scientists observing infanticide within animal species once thought the phenomenon confined to contexts of predation or random pathology. But those applying knowledge of how evolutionary processes operate discovered that a great deal of infanticidal behavior is patterned in specific ways remarkably—often stunningly—consonant with predictions of evolutionary theory.[77]

For example, one well-known, well-documented, and consistent pattern of infanticide in many animals—including species as diverse as rodents, great cats, and primates—is the increased risk to unweaned infants of being killed by an adult male that is not the father of the infant.[78] There is a clear evolutionary reason for this behavior. In mammals, lactational amenorrhea—the contraceptive effect of steady nursing, which functions to regulate the interbirth interval—ends when a nursing infant

77. See, for example, studies collected in Infanticide and Parental Care (Stefano Parmigiani & Frederick S. vom Saal eds., 1994); Infanticide: Comparative and Evolutionary Perspectives (Glenn Hausfater & Sarah Blaffer Hrdy eds., 1984). For a detailed overview, see Jones, Evolutionary Analysis in Law, supra note 4, at 1170–1214. As but one example, the pattern of infanticidal behavior of male house mice precisely matches the female gestation period. That is, the infanticidal predisposition virtually vanishes precisely one gestation period after the male's ejaculation and reemerges after a period precisely equivalent to that of the female's birth-to-weaning interval, during which period the male's own offspring might be present. Glenn Perrigo & Frederick S. vom Saal, Behavioral Cycles and the Neural Timing of Infanticide and Parental Behavior in Male House Mice, *in* Infanticide and Parental Care, supra, at 365, 366–68.

78. For an overview of this research, see Jones, Evolutionary Analysis in Law, supra note 4, at 1170–1214.

dies.[79] This, in turn, speeds the female's return to reproductive readiness and thus affords an advantage to the new male.

The heritable propensity toward this very selective form of male aggression has been favored by natural selection[80] over alternative predispositions, such as laissez faire behavior, because it can and often does lead to the new male's fathering more offspring than he otherwise would.[81] Significantly, the risk of infanticide typically plunges when nursing ends, although the risk remains consistently greater in the presence of unrelated adult males.[82]

What does this have to do with human behavior? Evolutionary theory generates predictions about the circumstances in which male infanticide might occur among humans.[83] In humans, it turns out, the probability that a stepfather or boyfriend of the mother will kill an unweaned infant is nearly *one hundred times* greater than is the probability of death at the hands of an infant's genetic father.[84] Moreover, the probability of infanticide declines sharply with the age of the child, as the following figure illustrates.

79. Goldsmith & Zimmerman, supra note 43, at 113; see also sources cited in Jones, Evolutionary Analysis in Law, supra note 4, at 1179 n.162.

80. On natural selection, see supra Part II.B.2.

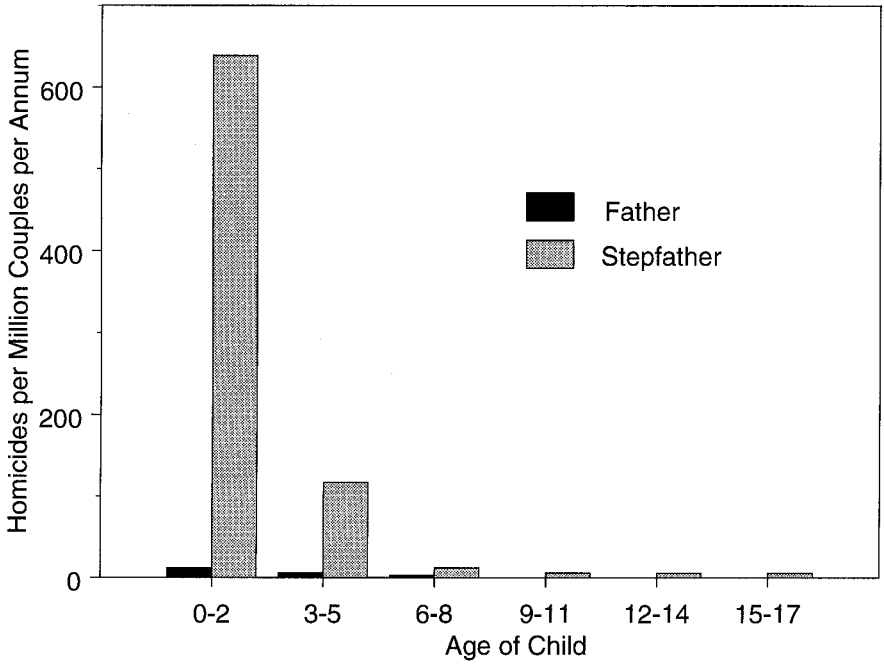
81. Note how in the example of infanticide given above, the reproductive interests of the males and females are different; only the new male benefits by killing the female's young. See supra Part II.B.2.

82. Extensive details on the theories, predictions, and data concerning a great many nonhuman species can be found in Infanticide and Parental Care, supra note 77; Infanticide: Comparative and Evolutionary Perspectives, supra note 77; Jones, Evolutionary Analysis in Law, supra note 4, at 1170–1214.

83. For extensive discussion of the predictions, data, and sources concerning infanticide in humans, see Jones, Evolutionary Analysis in Law, supra note 4, at 1193–1211. For information concerning lactational amenorrhea in human females, see id. at 1179 n.162.

84. See Daly & Wilson, Homicide, supra note 47, at 88–89; sources discussed in Jones, Evolutionary Analysis in Law, supra note 4, at 1207–08; see also citations collected in id. at 1207 n.298 (discussing origin of frequently cited one-hundred-fold figure).

FIGURE 1: THE RISKS OF BEING KILLED BY A STEPFATHER COMPARED WITH THE NATURAL FATHER IN RELATION TO THE CHILD'S AGE[85]



On first reflection, one might have thought it obvious, given stereotypes, that unrelated human males would be a greater danger to infants than related males. But, with some exceptions—most notably in the medical community—the stereotype was often dismissed in modern culture, academic literature, and law enforcement as an artifact of ignorant prejudice and as having no grounding in reality. Consequently, those investigating infanticides and other child abuse typically failed even to *collect* data on whether an infanticidal male had been related to the victim—an obvious prerequisite for the discovery of any causal relationship between risk and relatedness.

Four important issues emerge from this example. First, before those informed about behavioral biology used evolutionary analysis to connect human and nonhuman behaviors and to predict specific patterns of risk, the contours of the differential risk described above were largely undocumented, scientifically uninvestigated, and therefore often ignored by officials.

Second, even if we were to assume that people maintained private, unofficial suspicions about the differential risk, as seems probable, it is extremely unlikely that in the absence of behavioral biology anyone

85. Modified from Daly & Wilson, Homicide, supra note 47, at 90 (data from Canada, 1974–1983).

would have predicted either the magnitude of differential risk to infants or its dramatic decline after weaning. The risk would likely have been thought—quite incorrectly—to diminish *gradually*, commensurate with the potential victim's increasing age, size, and ability to defend.

Third, differential risk can be important, even if, as is the case, the vast majority of stepparents never kill their infant stepchildren. So long as infanticide is an ongoing concern and investigative resources are limited, it is beneficial to know when there are enormous differences in the statistical risks.

Fourth, it is very important not to confuse the effects of evolutionary processes on behavior with what are commonly called *motives* for behavior. The existence of multiple, simultaneous causes of behavior will be discussed at greater length below.[86] But the general points are these: (1) evolutionary processes tend to predispose organisms to behave in ways that increased reproductive success, on average, in ancestral environments, and (2) the effects of that predisposition can be, and often are, wholly independent of consciously perceived "motives" for behaviors.[87] For example, just as the effects of sexual behavior on reproductive success in past environments can underlie modern sexual desire, even in the absence of a conscious motive to create children, evolutionary processes can contribute to patterns of infanticide, even in the absence of any conscious motive to replace someone else's offspring with one's own.[88]

2. *Uncovering Policy Conflicts.* — Using law to pursue many different goals at the same time creates opportunities for conflict. Unresolved conflicts undercut the overall effectiveness of a legal regime. Uncovering policy conflicts is the first step toward their resolution, and behavioral biology can help to uncover hidden policy conflicts between two contemporary goals thought to be independent.

To continue the prior example, consider the commonly advocated and seemingly independent goals of (1) preventing as many child deaths as reasonably possible and (2) continuing to destigmatize stepparents.[89] Knowledge about the details of patterns of infanticide that were de-

86. See infra Part III.A.3.a.

87. See Martin Daly & Margo Wilson, Evolutionary Psychology and Marital Conflict: The Relevance of Stepchildren, *in* Sex, Power, Conflict: Evolutionary and Feminist Perspectives 9, 23–24 (David M. Buss & Neil M. Malamuth eds., 1996) [hereinafter Sex, Power, and Conflict].

88. Lest there be any confusion on this score, behavioral biology does not supply an *excuse* for infanticidal (or any other) behavior. Nor could it infallibly predict precisely who, in the population of stepparents, will actually abuse.

89. On efforts to bring stepparents into parity with biological parents, see, e.g., Gilbert A. Holmes, The Tie That Binds: The Constitutional Right of Children to Maintain Relationships with Parent-Like Individuals, 53 Md. L. Rev. 358, 410 (1994) (arguing law should "grant[ ] parent-like individuals greater consideration than the current jurisprudence affords"); Carol Lynn Tebben, An Expansion of Stepparent Rights? The Equitable Parent Doctrine After *Atkinson*, 6 Am. J. Fam. L. 43, 53 (1992); see also Margaret M. Mahoney, Stepfamilies and the Law 194–99 (1994); sources cited in Jones, Evolutionary Analysis in Law, supra note 4, at 1238 n.367.

scribed in the prior subsection may help us to recognize a potential conflict between these two goals. For example, some infant deaths could surely be prevented by legislatively biasing the notoriously limited investigative resources of child protective services toward reports of child abuse occurring in homes with an unrelated male sex partner of the child's mother. At the same time, such a policy would inevitably stigmatize a large group of men who are loving stepfathers, devoted to the well-being of both a mother and her children.

Evolutionary analysis says precisely nothing about how to weigh these competing social goals against each other. The key point is that familiarity with behavioral biology does make clear that these two goals are virtually certain to conflict. In this case, as in others, evolutionary analysis can starkly reveal significant subsurface tensions between policies that previously seemed to coexist peacefully. By doing so, it can help to lessen internal inconsistencies and inefficiencies in law and allow more informed choices by policymakers.

3. *Sharpening Cost-Benefit Analyses.* — When policy conflicts generate observable inconsistencies and inefficiencies, one's mind is led inexorably to consider the tradeoffs between the policies. People may continue to debate when cost-benefit analysis is and is not appropriate.[90] But clearly, whenever it is appropriate, inaccurate tallies will improperly skew results, undercutting the very efficiency the analysis is supposed to yield. To the extent that behavioral biology can help uncover hidden policy conflicts, it can also help to clarify and to quantify the actual tradeoffs involved in simultaneously pursuing two different legal goals that are in conflict.

For example, stigmatizing a group of unmarried males and stepfathers could be one cost of reducing infanticide by men. Conversely, some number of preventable infant deaths is a likely cost of ignoring situations where the probabilities of male infanticide are highest. Having a clear sense of these tradeoffs is a prerequisite for competent cost-benefit analysis. Behavioral biology does not weigh these options for us, but it can materially increase the comprehensiveness of the cost-benefit evaluations that help society select and prioritize legal goals.[91]

4. *Clarifying Causal Links.* — In an ideal world, sound theories would precede meaningful action. Legal policymakers would gain a sound understanding of the causes of perceived problems before acting to rectify

90. On cost-benefit analysis, see generally Cost-Benefit Analysis (Richard Layard & Stephen Glaister eds., 2d ed. 1994). For some recent thoughts, see generally Darryl K. Brown, Cost-Benefit Analysis in Criminal Law, 92 Cal. L. Rev. 323 (2004); Cass R. Sunstein, Lives, Life-Years, and Willingness to Pay, 104 Colum. L. Rev. 205 (2004); Michael Abramowicz, Toward a Jurisprudence of Cost-Benefit Analysis, 100 Mich. L. Rev. 1708 (2002) (book review).

91. See Jones, Evolutionary Analysis in Law, supra note 4, at 1236–40; Jeffrey Evans Stake, Pushing Evolutionary Analysis of Law, 53 Fla. L. Rev. 875, 889 (2001) [hereinafter Stake, Pushing].

them. But when policymakers function in their protective roles, they often cannot wait for knowledge that approaches deep understanding of cause and effect.

Nor would we often want them to. For example, it was perfectly appropriate for the Environmental Protection Agency (EPA) to restrict lead in gasoline simply on the informed impression that lead in exhaust gases increases exposure of humans to lead poisoning.[92] We simply—and properly—employ different criteria in our laws than we do in our science, being sometimes willing to see precautionary acts in law when it seems sufficiently likely that action will be better than inaction.

At the same time, we regularly and sensibly demand, as a foundation to legal policy and a prerequisite to action, at least some reasonably plausible explanation—meaning at least a very sensible working hypothesis—for alleged connections between law-relevant phenomena (harms, for example) and things we might affect with the tools of law (factors that arguably increase the incidence or magnitude of those harms). That is, we prefer not only to have data suggesting correlations between some law-relevant phenomenon and some variable, but we also prefer to have a plausible explanation for how these two things may be causally linked. For we are, and often should be, hesitant to construct a legal policy on the foundation of mere intuitions or observations that lack explanations. Correlation is not causation, and causality cannot be convincingly inferred from correlation unless the process that binds the relationship is understood.[93]

As a consequence, there will be times when one great value of integrating knowledge of behavioral biology into legal analysis will be the buttressing of uncertain belief, suspicions, or intuitions with theory drawn from another discipline. It can help to boost confidence in otherwise uncorroborated judgments about the causal relationships that may underlie observed patterns. This will be useful whenever that extra support leads to implementation of a legal approach that ultimately proves valuable.

For example, suppose we would be willing in the abstract to risk stigmatizing stepparents in order to prevent some infant deaths, but we are as yet uncertain that stepparentage is causally linked to rates of infanticides. Even in the presence of an antecedent belief that infants are at a substantially increased risk of abuse in a home with an unrelated adult

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92. See, e.g., Ethyl Corp. v. EPA, 541 F.2d 1 (D.C. Cir. 1976). The *Ethyl* Court held,

> Where a statute is precautionary in nature, the evidence difficult to come by, uncertain, or conflicting because it is on the frontiers of scientific knowledge, the regulations designed to protect the public health, and the decision that of an expert administrator, we will not demand rigorous step-by-step proof of cause and effect. Such proof may be impossible to obtain if the precautionary purpose of the statute is to be served.

Id. at 28.

93. See Daniel L. Rubinfeld, Reference Guide on Multiple Regression, *in* Federal Judicial Center, Reference Manual on Scientific Evidence 179, 184–85 (2d ed. 2000).

male, we might hesitate to act. And even in the presence of data indicating that belief was largely accurate, we may still hesitate, thinking that such a correlation may be coincidental, and that the risk is attributable to as yet unidentified and more palatable phenomena having nothing to do with the degree of genetic relatedness between infant and adult male.

In such a case, evolutionary analysis can make a critical difference by supplying a useful theoretical foundation that helps to clarify probable causal links. That is, evolutionary analysis can detail the *pathway* by which natural selection can favor condition-dependent male behavioral predispositions that can yield fatal abuse of the unweaned offspring of potential mates—even in the absence of any conscious reproductive motive. It can also connect, through theory, empirical data on infanticide in humans and nonhumans. This can make legal strategies attentive to the status of the adult male nonarbitrary and therefore potentially palatable as quite plausibly useful. The principal point is that the absence of a sound and accessible theory of causation can prevent useful legal change, and there are times when behavioral biology can supply that theory.

B. *Evolutionary Insights About Decisions*

Yet another way to improve our understanding of human behavior is to improve our understanding of human decisionmaking. The next two subsections concern aspects of human decisionmaking that pose perennial problems for law. Part III.B.1 considers how behavioral biology can help illuminate the interplay of emotions and deliberations, using examples concerning fairness and spite. Part III.B.2 addresses ways in which behavioral biology can provide a theoretical foundation for behavioral data that otherwise seem to lack coherence. Together, these two approaches to understanding human decisionmaking may aid our ability to make new predictions about human behavioral phenomena relevant to law.

1. *Increasing Understanding About People.* — Everyone knows the human experience is inherently imbued with emotions. Furthermore, the role of emotions in law is drawing increasing attention.[94] But emotions are more easily discussed than defined. Historically, emotions were thought to be states of the mind that caused one to deviate from purely rational calculation, sometimes with consequences for the legal system. Emotions were thus to be controlled, when possible, by reason.

We now know that although they supply us with such feelings as fear, rage, sexual desire, jealousy, and sadness, the emotions are by no means divorced from rational deliberation. A broader and more accurate view is that emotions and reasoning each affect the other. Emotions are states of

94. See, e.g., Eric A. Posner, Law and the Emotions, 89 Geo. L.J. 1977 (2001); Cass Sunstein, Probability Neglect: Emotions, Worst Cases, and Law, 112 Yale L.J. 61 (2002); Symposium on Law, Psychology, and the Emotions, 74 Chi.-Kent L. Rev. 1423; see also Owen D. Jones, Law, Emotions, and Behavioral Biology, 39 Jurimetrics J. 283 (1999).

the nervous system—arising from evolutionarily old parts of the mammalian brain—that exist to propel behavior in ways that were historically adaptive.[95] Emotions supply us generally with wants and desires, and these lead us to pursue those desires in ways that sometimes involve conscious planning. At the same time, thoughts can create mental scenarios that reciprocally generate emotional responses. In short, the emotions are so woven into our rational cognitive reasoning that it is safe to say we do nothing, at least in the domain of social relations, that is not influenced by feelings.

a. *Fairness.* — A sense of fairness plays an important role in many aspects of law, from welfare policies to settlement of disputes.[96] But where does the sense of fairness come from? Does it bubble up out of emotional substrates? Does it flow from coolly deliberative deduction? Neither or both? Consider the following well-known example drawn from game theory. In the one-shot ultimatum game, two players—the identity of each unknown to the other—are in separate rooms. Each is told that one player, the "proposer," will be given a sum of money with instructions to choose an amount to offer to the other player, the "responder."[97] Both know the total amount available for division. The responder can either accept the anonymous proposer's offer, in which case each player pockets his winnings, or he can reject the offer, in which case neither player gets anything. The game ends after this single play.

The modal offer is fifty percent, the mean somewhat lower, and offers less than thirty percent are often rejected.[98] The result is independent of the size of the stake, at least up to several months' wages,[99] and these general findings are robust—replicated in the United States, Europe, Israel, and Japan. These findings have puzzled some investigators because from a strictly economic consideration, it should benefit the re-

95. See Antonio R. Damasio, Descartes' Error: Emotion, Reason, and the Human Brain (1995); Joseph LeDoux, The Emotional Brain (1996); Pinker, Blank Slate, supra note 21; Steven Pinker, How the Mind Works (1997) [hereinafter Pinker, How the Mind Works]; see also Cartwright, supra note 65.

96. In the last four years alone, the word "fairness" has appeared in the titles of over 130 law review articles. For recent discussion, compare Louis Kaplow & Steven Shavell, Fairness Versus Welfare (2002) (arguing that fairness should play a somewhat lesser role), with Michael B. Dorff, Why Welfare Depends on Fairness: A Reply to Kaplow and Shavell, 75 S. Cal. L. Rev. 847 (2002).

97. See Robert H. Frank, Microeconomics and Behavior 237–39 (3d ed. 1997) (discussing ultimatum game); Sheryl Ball & Catherine C. Eckel, The Economic Value of Status, 27 J. Socio-Econ. 495, 497 (1998) (discussing ultimatum game and citing much of the recent literature). See generally Colin Camerer & Richard H. Thaler, Anomalies: Ultimatums, Dictators and Manners, J. Econ. Persp., Spring 1995, at 209; Werner Güth & Reinhard Tietz, Ultimatum Bargaining Behavior: A Survey and Comparison of Experimental Results, 11 J. Econ. Psychol. 417 (1990).

98. See Robert Frank, Passions Within Reason, 170–73 (1988) [hereinafter Frank, Passions]; Gintis, supra note 59, at 252–54.

99. See Joseph Henrich et al., In Search of Homo Economicus: Behavioral Experiments in Fifteen Small-Scale Societies, 91 Am. Econ. Rev. 73, 74–75 (2001).

sponder to accept *any* offer. Clarity emerges, however, when the players are questioned about their behavior. When proposers are asked why they offered so much, they answer that they did not want their offer rejected. When responders are asked why they rejected a low offer, they say the offer was not fair or that they wished to punish the proposer for an inadequate offer.

In this game, decisions by the responder present a conflict between maximizing immediate financial self-interest and maintaining longer-term self-interests both in not being considered and exploited as a sucker and in punishing those who behave unfairly. To cast the issue in even broader, evolutionary terms, each human is genetically unique, with self-interests that do not map exactly onto those of any other individual. At the same time, however, we are all members of an intensely social species. Unrestrained self-interest is an impossible strategy for living among others. Our future welfare is dependent on effective social intercourse involving many individuals. Therefore, status and reputation are important to foster and protect.[100]

When a choice that would seem to maximize financial gain is overridden by other considerations, the outcome is sometimes characterized as irrational. The cerebral cortex, however, does not operate independently of the emotions. The emotional centers of the brain exist to nudge behavior in one direction or another, and decisions are inevitably influenced by our "feelings." The prospect of winning some money may make one feel good, whereas leaving the room with only one dollar while knowing that the proposer has pocketed nine dollars is likely to stir feelings ranging from annoyance to wounded pride. In short, and depending upon the breadth of the context considered, either accepting or rejecting a low offer can advance self-interest, and both alternatives are likely to have affective overtones.

Why do the motivations for *both* alternatives influence the responder's final decision? People engage in numerous bargains and exchanges during their lives, but in small groups (and within strata of more complex societies) agreements—even in one-shot encounters—usually provide onlookers with information about the exchange, enabling judgments about who got the better deal. The ultimatum game presents a distillate of conditions in which evolution has prepared the brain to function. Because anonymity was not an ordinary feature of exchanges, it has a minor role in stirring the responder's feelings about a low offer. In other words, that the other player is anonymous neither neutralizes the responder's diminution of self-esteem that comes from accepting an unfair offer nor mutes the proposer's recognition that a low offer is likely to be rejected.

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100. This idea is explored, in part, in Robert H. Frank, Choosing the Right Pond: Human Behavior and the Quest for Status (1985). The idea that punishment to deal with free riders is an evolved propensity of the human brain has been developed at greater length in Hoffman & Goldsmith, supra note 4.

The ultimatum game has been played in a variety of low-technology cultures.[101] There is more variation in the mean offer than was found in industrialized societies, but the lowest offers still tend to be rejected. The variation in the data correlates with the degree to which barter and exchange with individuals outside of the family are important parts of the tradition of the culture: the more experience with markets, the higher the offers and the higher the threshold of rejection.[102] When observation reveals a feature of humans widely if not universally distributed among very different cultures, it suggests that the character may be an evolved feature of our species. This cross-cultural study indeed suggests that an intrinsic sense of fairness, albeit quantitatively tuned by cultural norms, is part of our evolutionary heritage. Viewed from this perspective, the ultimatum game provides an example of how behavioral biology (particularly evolutionary theory) can help us to understand our own behavior, as a function of interplaying emotional and deliberative activities, set against a backdrop of evolutionary history.

b. *Spite.* — Considering the interaction of fairness and spite can deepen this understanding of human behavior. Spiteful litigation is well known to lawyers. Traditional economic theory predicts that plaintiffs will pursue litigation so long as the potential recovery, multiplied by the probability of success, exceeds foreseeable costs of litigation.[103] This sounds reasonable; we expect people not to spend a dollar to buy a ten percent chance of winning two dollars. But some people don't follow that calculus and pursue litigation at significant cost to themselves with the desire to impose a great cost on others.

Precisely why this happens seems puzzling. Economists can get around the evident problem for rational choice theory by positing a "taste" for spite.[104] But behavioral biology can put this phenomenon in a different context. As discussed immediately above, people will often forgo a benefit to impose a cost on someone they consider to be unfair, or will incur some costs to impose even larger costs on someone else. Research suggests there are biological underpinnings to a sense of fairness.[105] For example, we know from game theory that condition-depen-

101. For data on ultimatum games in preindustrial cultures, see Henrich et al., supra note 99, at 74–75.

102. Interestingly, an offer of more than fifty percent was sometimes rejected in societies in which receipt of a gift imposed an obligation to reciprocate in the future on terms set by the giver. Id.

103. See, e.g., David W. Barnes & Lynn A. Stout, Cases and Materials on Law and Economics 288 (1992).

104. The economic theory of rational choice posits that humans have well-ordered tastes and preferences and arrange their behavior in efforts to satisfy them. Thomas S. Ulen, The Prudence of Law and Economics: Why More Economics is Better, 26 Cumb. L. Rev. 773, 780 (1996) (The Ray Rushton Distinguished Lecture).

105. See Richard D. Alexander, The Biology of Moral Systems (1987); Matt Ridley, The Origins of Virtue: Human Instincts and the Evolution of Cooperation (1997); de Waal, Good Natured, supra note 60; see also Biology and the Foundation of Ethics (Jane Maienschein & Michael Ruse eds., 1999); Investigating the Biological Foundations of

dent (in this case, retaliatory) spitefulness can be a feature of an evolutionarily stable strategy for reaping gains from cooperators, punishing defectors, and encouraging cooperative outcomes.[106] This has the social function of maintaining or establishing a reputation as one who will not be cheated. It is adaptive both to identify cheaters and not be seen as a sucker—someone easily exploited. Individuals may miscalculate the cost-benefit ratio in particular instances. But the point is that evolutionary processes can generate condition-dependent predispositions toward spiteful behavior, rendering it not only unsurprising but also predictable.

What this excursion into fairness and spite illustrates is that behavioral biology can provide windows on law-relevant aspects of decisionmaking that simultaneously invoke emotional and deliberative functions of the human brain. At a broad level, this provides increased understanding about people generally, which has myriad advantages for legal thinkers.[107]

2. *Providing Theoretical Foundation and Potential Predictive Power.* — In the last subsection we discussed how evolutionary underpinnings of emotions inevitably influence decisions and, moreover, how urges for conflicting goals can lead to behavior that forgoes immediate gain for a broader advantage, albeit deferred. Here we consider how, counterintuitively, evolutionary processes may in some circumstances contribute to behaviors that are *not* advantageous. Specifically, we briefly illustrate how a per-

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Human Morality (James P. Hurd ed., 1996); The Sense of Justice: Biological Foundations of Law (Roger D. Masters & Margaret Gruter eds., 1992); Dennis L. Krebs, The Evolution of Moral Behaviors, *in* Handbook of Evolutionary Psychology: Ideas, Issues, and Applications 337 (Charles Crawford & Dennis L. Krebs eds., 1998). There is also the possibility that spitefulness is correlated with failures to satisfy an evolved taste for apology. O'Hara & Yarn, supra note 4, at 1156–58.

106. An early model appears in W.D. Hamilton, Selfish and Spiteful Behaviour in an Evolutionary Model, 228 Nature 1218 (1970). For background information on relevant game theory, see generally Robert Axelrod, The Evolution of Cooperation (1984); Game Theory and Animal Behaviour (Lee Allen Dugatkin & Hudson Kern Reeve eds., 1998); John Maynard Smith, Evolution and the Theory of Games (1982).

107. This Article focuses principally on the utility of behavioral biology for legal policymakers. Nonetheless, behavioral biology can be useful to practicing lawyers as well. Good lawyers understand people—both those regulated and regulating. They have a good sense of how various aspects of life affect people's behaviors. They have a useful understanding of what motivates people and how those motivations translate into behavior, from obeying or disobeying the law, initiating and settling lawsuits, turning other people in for transgressions, using powers granted by office, rendering jury verdicts, and so forth. See generally, e.g., William H. Rodgers, Jr., Deception, Self-Deception, and Mythology: The Law of Salmon in the Pacific Northwest, 26 Pac. L.J. 821 (1995) (placing lying and self-deception within evolutionary framework); William H. Rodgers, Jr., Where Environmental Law and Biology Meet: Of Pandas' Thumbs, Statutory Sleepers, and Effective Law, 65 U. Colo. L. Rev. 25 (1993) [hereinafter Rodgers, Environmental Law] (discussing how evolutionary analysis illuminates how people both make and respond to law). Many lawyers, particularly trial lawyers, thus have practical understandings of what makes people tick. But just as the legal system cannot be maximally effective unless it has a robust model of human behavior against which to gain leverage with the tools of law, lawyers cannot be maximally effective without solid understandings of human behavior.

spective from behavioral biology can help provide useful theoretical foundation by examining some of the behaviors that economists deem irrational and that currently lack satisfying theoretical understanding.[108]

a. *The Puzzle of Irrational Behaviors.* — When economists refer to a choice or behavior as "rational," they generally are referring not to the *process* that leads to the behavior, but rather to the substantive nature of the *outcome* of the behavior. To clarify the distinction, behavior is *procedurally rational* when it is the product of deliberative, conscious analysis. But behavior is *substantively rational* when it is appropriate for achieving particular goals, given conditions and constraints, regardless of how the behavior was actually chosen.[109] Substantive rationality is the meaning that economists generally employ, and it is the one we will use here.[110]

It is obvious that people do not always behave rationally in this second sense of the word. Irrationality poses a problem for economists because the standard economic model assumes that humans will respond rationally to changes in incentives.[111] Irrationality also poses problems for legal policymakers because they frequently rely on economic analyses when recommending ways that incentives should be changed to achieve the goals of law with the tools of law. When the economic theory is wrong, the law is likely to follow down the same erroneous path. If people routinely fail to maximize their utility in a manner that the rational choice model of economics assumes, then law's assumptions about the efficiency of legal rules will be flawed.[112]

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108. One of us has explored several aspects of this topic in Jones, Law's Leverage, supra note 22, and Owen D. Jones, The Evolution of Irrationality, 41 Jurimetrics J. 289 (2001). We are not, of course, the first to argue that biology is relevant for understanding matters of interest to economists. Gary Becker, Jack Hirshleifer, Paul Rubin, Richard Posner, and Robert Frank, among others, have explored this biology-economics connection in various contexts. See, e.g., Gary S. Becker, Altruism, Egoism, and Genetic Fitness: Economics and Sociobiology, 14 J. Econ. Literature 817 (1976); J. Hirshleifer, Economics, supra note 18, at 39; Paul H. Rubin, Evolved Ethics and Efficient Ethics, 3 J. Econ. Behav. & Org. 161 (1982); Richard A. Posner, Sex and Reason (1992); Frank, Passions, supra note 98.

109. See generally Herbert A. Simon, Rationality in Psychology and Economics, 59 J. Bus. S209, S210 (1986).

110. To elaborate, economists consider a person to act "rationally" (regardless of what deliberation is or is not present) when he pursues consistent ends using efficient means as a function of preferences that are "complete, reflexive, transitive, and continuous." Nicholas Mercuro & Steven G. Medema, Economics and the Law: From Posner to Post-Modernism 57 (1997); see also Nicholas Mercuro & Steven G. Medema, Schools of Thought in Law and Economics: A *Kuhnian* Competition, *in* Law and Economics: New and Critical Perspectives 65, 67 (Robin Paul Malloy & Christopher K. Braun eds., 1995).

111. See generally Robert Cooter & Thomas Ulen, Law and Economics (4th ed. 2003); Richard A. Posner, Economic Analysis of Law (6th ed. 2003).

112. See Thomas S. Ulen, Cognitive Imperfections and the Economic Analysis of Law, 12 Hamline L. Rev. 385, 388 (1989).

Consider the following phenomena, discussed in a wide variety of economic and legal materials.[113] At first, they seem to pose a challenge not only to economic analysis, but also to evolutionary analysis, because with no obvious countervailing motivation—as there is in the ultimatum game—some behavioral choices do, in fact, appear to be irrational.

Irrationally Steep Discounting. — Rational choice theorists generally assume that people evaluate the future sensibly, deploying appropriate discount rates. But people routinely employ absurdly high discount rates.[114] For example, they often prefer a slightly less expensive but energy-guzzling appliance to a slightly more expensive appliance that is far less costly to run. This has important consequences for things as disparate as environmental law and retirement savings policies.

Mistaken Probability Assessments. — Rational choice theorists generally assume that people will base their choices on realistic assessments of probabilities. But people quite often make gross errors in assessing probability. For example, they will fail to recognize that a 0.7 risk of death is the same thing as saying that 7 out of 10 people will die.[115] This has important consequences for risk regulation.

Endowment Effects. — Rational choice theorists generally assume that people will value property sensibly and consistently. For example, the difference between the maximum price an individual would be willing to pay for a good and the minimum price that an individual would demand to sell the same good should be negligible, provided no new information about the good's value has been acquired. But often it is not—and for reasons unrelated to sentimental attachment. Experiments suggest, for example, that people frequently value something they have just received at a higher amount than they would have been willing to pay for it.[116] This may have important consequences for the le-

113. See, e.g., Behavioral Law and Economics, supra note 24; Christine Jolls et al., A Behavioral Approach to Law and Economics, 50 Stan. L. Rev. 1471 (1998); Korobkin & Ulen, Law and Behavioral Science, supra note 2; sources cited in Jones, Law's Leverage, supra note 22, at 1152 n.40.

114. See generally George Ainslie, Derivation of "Rational" Economic Behavior from Hyperbolic Discount Curves, 81 Am. Econ. Rev. (Papers & Proc.) 334 (1991); Kris N. Kirby & R.J. Herrnstein, Preference Reversals Due to Myopic Discounting of Delayed Reward, 6 Psychol. Sci. 83 (1995); George Loewenstein & Drazen Prelec, Anomalies in Intertemporal Choice: Evidence and an Interpretation, 107 Q.J. Econ. 573, 574–75 (1992).

115. There is a large literature on mistaken probability assessments. See, e.g., Gerd Gigerenzer, Ecological Intelligence: An Adaptation for Frequencies, *in* The Evolution of Mind 9 (Denise Dellarosa Cummins & Colin Allen eds., 1998) [hereinafter Gigerenzer, Ecological Intelligence]; Paul Slovic et al., Facts Versus Fears: Understanding Perceived Risk, *in* Judgment Under Uncertainty: Heuristics and Biases 463 (Daniel Kahneman et al. eds., 1982).

116. Elizabeth Hoffman & Matthew L. Spitzer, Willingness to Pay vs. Willingness to Accept: Legal and Economic Implications, 71 Wash. U. L.Q. 59, 89–90 (1993), provides a useful overview. On the legal relevance, see generally Russell Korobkin, The Endowment

gal distribution of entitlements (since the Coase Theorem predicts that, so long as transaction costs are low, the final allocation of resources will be Pareto-efficient, regardless of the initial distribution of entitlements).[117]

Over the years, economists and scholars of "behavioral law and economics" (BLE)[118] have come to attribute many such irrationalities to a combination of "bounded rationality"[119] and cognitive fallibilities. Bounded rationality postulates that deviations from rational choice are the result of (a) constraints on time and energy for gathering perfect information and (b) constraints on the brain's information capacities, wiring, and computing speed. Cognitive fallibilities are presumed frailties, flaws, defects, and quirks that do not seem to be explained by bounded rationality.[120]

The notion of bounded rationality invites us to conclude that what we observe as substantive irrationality—the failure to choose the optimal outcome under the circumstances—may often be the product of procedural rationality (i.e., deliberation) operating within realistic constraints. Positing bounded rationality thus temporarily alleviates the problem of irrationality, because the high costs of acquiring complete information and the fixed limits on human computation, viewed together, make it clear that in some cases it would be irrational to become fully informed.

A common criticism of this BLE approach is that it is essentially atheoretical, reasoning from observations to implications without adequate explanations.[121] There is as yet no satisfying theoretical framework that

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Effect and Legal Analysis, 97 Nw. U. L. Rev. 1227 (2003). For recent critiques, see generally Gregory Mitchell, Taking Behavioralism Too Seriously? The Unwarranted Pessimism of the New Behavioral Analysis of Law, 43 Wm. & Mary L. Rev. 1907 (2002); Charles R. Plott & Kathryn Zeiler, The Willingness to Pay/Willingness to Accept Gap, the "Endowment Effect," Subject Misconceptions and Experimental Procedures for Eliciting Valuations, Am. Econ. Rev. (forthcoming), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=615861.

117. See Jeffrey Evans Stake, Loss Aversion and Involuntary Transfers of Title, *in* Law and Economics: New and Critical Perspectives, supra note 110, at 331 [hereinafter Stake, Loss Aversion].

118. For partial bibliographies on the growing BLE literature, see Jones, Law's Leverage, supra note 22, at 1152 n.40; Donald C. Langevoort, Behavioral Theories of Judgment and Decision Making in Legal Scholarship: A Literature Review, 51 Vand. L. Rev. 1499 (1998).

119. See generally John Conlisk, Why Bounded Rationality?, 34 J. Econ. Literature 669 (1996); Jon Elster, When Rationality Fails, *in* The Limits of Rationality 19 (Karen Schweers Cook & Margaret Levi eds., 1990); Barton L. Lipman, Information Processing and Bounded Rationality: A Survey, 28 Can. J. Econ. 42 (1995) (collecting sources).

120. See generally sources cited in Jones, Law's Leverage, supra note 22, at 1169 n.93.

121. See Mark Kelman, Behavioral Economics as Part of a Rhetorical Duet: A Response to Jolls, Sunstein, and Thaler, 50 Stan. L. Rev. 1577 (1998); Richard A. Posner, Rational Choice, Behavioral Economics, and the Law, 50 Stan. L. Rev. 1551 (1998) [hereinafter Posner, Rational Choice]. But cf. Christine Jolls et al., Theories and Tropes: A Reply to Posner and Kelman, 50 Stan. L. Rev. 1593, 1597 (1998) (offering rebuttal on this point); Jones, Law's Leverage, supra note 22.

makes sense of the particular patterns of irrationalities, connects them together, and predicts as yet undiscovered patterns. This is not fatal to BLE, of course, because much good can come from novel observations. Unexpected empirical facts can, in sufficient number, warrant changes in legal strategies for pursuing existing goals, even absent convincing explanations for their patterned occurrence. In fact, a number of BLE scholars have succeeded in making convincing cases for legal reform based on empirical data about irrationalities alone, irrespective of causes.[122]

Surely, however, the effort would be even more successful if it had an adequate theoretical foundation. There are two reasons. First, many economists, as well as scholars of law and economics, remain skeptical of behavioral economic findings and are evidently loath to relax the traditional assumption of rationality. For them, existing data on alleged irrationalities are simply scattered anomalies, insufficient to warrant complicating existing models that so often work well. An embracing explanation that could make coherent sense of unusual, unfamiliar, or inconveniently aberrational data without resorting to the ad hoc assumptions of bounded rationality would ease acceptance that the data are accurate, meaningful, and neither the artifactual result of flawed study designs nor computational limitations of the human brain.

Second, a sound theory that is broadly grounded and able to bring coherence to existing data provides predictive power that can help us discover useful new facts. After all, many of the facts we discover, and the patterns we ultimately see in facts, are functions either of luck or of presuppositions that, if wrong, may obscure facts and interpretations that are relevant to law. At present, both behavioral law and economics and the underlying literature in cognitive psychology are far better at explaining *that* people often behave in ways inconsistent with traditional economic theory than they are at explaining *why* they do so.[123]

Why, for example, do people tend to discount at rates that are too high rather than too low? And why do they tend to *over*endow rather than *under*endow? Without an adequate theory—a basis for understanding why these features exist and how they may be connected—it is difficult to anticipate in whom they will appear, in what contexts, and with what vigor.[124] Conspicuously absent is a "meta-explanation" to weave the various anomalies together into some larger pattern and to provide coherence to the whole. The following subsection provides such an explanation.

b. *Expanded Perspectives on the Human Brain.* — As we showed above in discussing the ultimatum game, viewing economic decisions in an evolutionary framework can reveal the presence of conflicting but neverthe-

122. See sources cited supra note 118.

123. Jennifer Arlen, Comment, The Future of Behavioral Economic Analysis of Law, 51 Vand. L. Rev. 1765, 1768 (1998).

124. See Thomas S. Ulen, The Growing Pains of Behavioral Law and Economics, 51 Vand. L. Rev. 1747, 1757 (1998); see also Arlen, supra note 123, at 1768–69, 1778.

less rational motivations. We will now provide an evolutionary analysis of the examples of irrational behavior cited above. This exercise suggests that the seeming irrationalities of oversteep discounting, mistaken probabilities, and endowment effects are not necessarily the products of conventional bounded rationality or of cognitive defects, as those concepts are generally understood, but instead may arise for very different reasons. Our argument is based on the premise that our cognitive machinery has a long evolutionary history, most of which transpired in a very different physical and social environment than we experience today. Below, we invoke a principle previously termed by one of us "Time-Shifted Rationality" (TSR).[125]

The evolutionary logic is as follows. First, the brain was not designed to maximize individual utility. Nothing is. Individuals do not replicate, nor do brains; only genes replicate. Evolutionary processes therefore favor replication of genetically heritable traits, some of which appear in relatives. To the extent that people and other animals often behave as if they were rational maximizers of individual utility, it is partly because their information processing pathways have been honed by natural selection, the most relentlessly economizing force in the history of life, and partly because maximizing individual utility is often epiphenomenal to maximizing genetic utility. As a result, evolutionary processes inevitably and importantly contribute to the common origins and ordering of some preferences that constitute every individual's utility curve.

Second, the brain is not a general, all-purpose, unspecialized information processor.[126] There is no reason to believe that evolution has designed the human brain to yield either substantively or procedurally rational outcomes in each and every circumstance in which the body may happen to find itself. This renders misleading many commonly encountered analogies of the brain to a computer. True, both computers and brains are information-processing devices in which outputs are sensitive to inputs. Yet computers are essentially general purpose machines into which infinitely differing software can be installed. Brains, to a far greater extent, come prepackaged with a wide variety of information-processing predispositions that, though flexible, are not infinitely variable.[127]

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125. Jones, Law's Leverage, supra note 22.

126. Evidence for this is overwhelming and growing daily. See generally The Cognitive Neuroscience of Face Processing (Nancy Kanwisher & Morris Moscovitch eds., 2000); The Cognitive Neurosciences III, supra note 54; Handbook of Functional Neuroimaging of Cognition (Roberto Cabeza & Alan Kingstone eds., 2001); Michael S. Gazzaniga, Organization of the Human Brain, 245 Science 947 (1989).

127. See generally Pinker, Blank Slate, supra note 21; Pinker, How the Mind Works, supra note 95; Leda Cosmides et al., Introduction: Evolutionary Psychology and Conceptual Integration, *in* Adapted Mind, supra note 56, at 3; John Tooby & Leda Cosmides, The Psychological Foundations of Culture, *in* Adapted Mind, supra note 56, at 19.

Third, the brain is a functionally specialized, context-specific information processor, better at some tasks than at others. Like other aspects of basic anatomy, the basic internal psychological mechanisms leading to many behavioral predispositions evolved under the challenges and selection pressures posed by particular environmental conditions. Because natural selection results in increasing frequencies of heritable traits that solve environmental challenges in ways offering comparative gains in reproductive success, both anatomical and behavioral traits tend to reflect historically contingent, specialized solutions rather than optimal or universal ones. Consequently, the brain is not a general purpose cost-benefit maximizer.[128]

Finally, evolutionary processes have left the brain designed, de facto, to predispose its bearers toward behaviors that were adaptive (that is, they contributed to reproductive success), on average, in the environment of evolutionary adaptation.[129] Because natural selection cannot anticipate environmental changes or generate new mutations[130] in response to changes, there is often a significant time lag between environmental change and adaptation of complex features. The fact that modern humans can rapidly change their environments in significant ways increases the chances of mismatch between evolved psychologies and current circumstances.[131]

This all suggests that some behaviors currently ascribed to either cognitive limitations or to flaws in the brain may actually result from finely tuned features of the brain. In other words, some substantive irrationalities are likely to arise from specific, narrowly tailored, efficiently operating features of the brain's evolved architecture. In such cases the existing notions of bounded rationality and cognitive fallibilities will be both descriptively wrong and materially misleading. They will be descriptively wrong in the same way that it would be incorrect to characterize a Porsche Boxster as "defective" when it fails to climb logs and ford streams, or a moth's brain as "defective" when the moth flies into an artificial light source. They will be materially misleading because they consider irrationalities to be necessarily unsystematized and random rather than potentially predictable, interrelated, and content-specific. Put another way, turning old cognitive tools to entirely new uses introduces changed circumstances. If the old tools seem inappropriate for the new uses, it does not mean those tools lack specialized design and function.

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128. See Cosmides et al., supra note 127, at 7–9.

129. For discussion, see Leda Cosmides, The Logic of Social Exchange: Has Natural Selection Shaped How Humans Reason?, 31 Cognition 187, 187–97 (1989).

130. See supra text accompanying notes 69–70.

131. Two caveats: First, natural selection can act quite quickly in some contexts, such as when selection against particular heritable traits is both consistent and severe. Second, the more complex the feature, the less likely it is that natural selection will quickly generate significant new adaptations. The human brain is a case in point. So while natural selection continues to affect humans, one should not necessarily expect that, given time, the human brain will necessarily reflect adaptations to modern, technological societies.

Understanding what the tools evolved to do provides significant foundation for explaining and predicting how they will function when applied in novel contexts.

This perspective calls into question an important premise of bounded rationality: the assumption that rationality can be understood solely in the present tense, evaluating current behavior in current environments for current outcomes. The temporal, historical dimension to information processing that evolutionary analysis affords suggests something quite different: that a great deal of what bounded rationality presumes to explain occurs in discrete contexts in which there is a temporal mismatch between features of cognition appropriate for ancestral environments and the demands of the current environment.

The concept of Time-Shifted Rationality (TSR) is derived from the observation that there are sometimes temporal mismatches between historically adaptive characteristics of organisms and later environments in which those characteristics persist. Specifically, TSR refers to evolved cognitive traits that were adaptive in an ancestral environment but that lead to irrational or maladaptive behavior in the present environment.[132]

Consider stress and its consequences.[133] In most species, stress automatically reduces an organism's immediate ability to perform basic functions such as digesting, growing, and having sex. This can be beneficial, and thus adaptive, if stress is immediate and short lived. Sex and digestion are transiently unimportant if the danger arrives in the form of a predator and escape is paramount. In a different environment, however, where stress is caused through relatively long-lasting social interactions with members of the same species, relief becomes difficult. Ongoing stress imposed by lengthy divorce and child-custody proceedings, hostile corporate takeovers, or fear about meeting year-end production quotas, for example, can contribute to serious, life-threatening medical conditions. Clearly, evolution has not equipped us to deal effectively with serious and prolonged conditions of stress.

By similar reasoning, substantively irrational or maladaptive behavior that is observed in the present environment may reflect the brain's deployment of old, once-successful techniques in confronting new problems. The next subsection applies this reasoning to the examples of irrationally steep discounting, mistaken probability assessments, and endowment effects.

c. *Examples of Apparent Irrationality.*

i. *Irrationally Steep Discounting.* — How might modern environments differ from the environment of evolutionary adaptation in ways relevant

132. See Jones, Law's Leverage, supra note 22, at 1171–73.

133. See generally, e.g., Randolph M. Nesse & George C. Williams, Why We Get Sick: The New Science of Darwinian Medicine (1994); Robert M. Sapolsky, Why Zebras Don't Get Ulcers: An Updated Guide to Stress, Stress-Related Diseases, and Coping (1998).

to discounting?[134] First, average life expectancy has increased several-fold,[135] and high discount rates make sense when life expectancy is short. Second, for nearly all of the roughly seventy million years of primate evolution, there was no such thing as a reliable future, let alone a reliable future payoff from investment or delayed gratification. Even under the most generous definition of investment, time horizons were short. Third, a "right" to receive something in the future is a trivially recent invention of modern humanity.

Because long lives, reliable futures, and reliable rights to future payoffs were not part of the environment in which the modern brain was slowly built, it is not particularly surprising that the modern brain tends to steeply discount the value of a future benefit compared to an immediate one and is not particularly well equipped to reach the outcome currently deemed most rational. Rather than assume that people will be rational discounters, we should logically expect and assume the opposite: Most often, people will be oversteep discounters. In the environment of evolutionary adaptation, the kind of oversteep discounting humans now so regularly exhibit often would have led to more substantively rational results than the alternative.

Put another way, at almost no time in human evolutionary history could there have been a selection pressure that regularly favored the kind of coolly calculated and lengthily deferred gratification now deemed so reasonable. Selection pressures can result only from the differential reproduction of contemporaneously existing, heritable alternatives in light of regularly encountered environmental features. Absent a regular environmental feature that offered a "guarantee" of future payoff, future payoffs would be quite speculative. Consequently, forgoing immediate payoffs would often be irrational and thus subject to selection pressure against such delayed satisfaction.[136]

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134. Only two other authors, to our knowledge, have specifically explored the possibility that human time preferences may have evolved. Alan R. Rogers, Evolution of Time Preference by Natural Selection, 84 Am. Econ. Rev. 460 (1994), provides an elegant argument for why human time preferences may be in evolutionary equilibrium. Adam Gifford, while agreeing that time preferences are likely to reflect the operation of evolutionary processes, argues that "the rate of time preference that resulted from cultural coevolution of large brains, language and consciousness diverged from . . . the rate of time preference in biological fitness." Adam Gifford, Jr., Being and Time: On tbe Nature and the Evolution of Institutions, 1 J. Bioeconomics 127, 139 (1999).

135. For example, life expectancy in the United States rose nearly 30 years last century (from 47.3 to 76.5). See Robert N. Anderson, United States Life Tables, 1997, CDC Nat'l Vital Stats. Reps., Dec. 13, 1999, at 1, 32–33, available at http://www.cdc.gov/nchs/data/nvsr/nvsr47/nvs47_28.pdf. For a treatment by the National Academy of Sciences of modern, international, and ancestral life expectancy, see Between Zeus and the Salmon: The Biodemography of Longevity (Kenneth W. Wachter & Caleb E. Finch eds., 1997), available at http://www.nap.edu/books/0309057876/btml/index.html.

136. Much evidence suggests that preferences for earlier over later gratification sometimes reverse as the earliest possible reward becomes more distant. See generally, e.g., Kirby & Herrnstein, supra note 114; Loewenstein & Prelec, supra note 114. This may

ii. *Mistaken Assessments of Probability.* — In view of what we know about how evolutionary processes shape perception and behavior through effects on information-processing organs, we should expect that people's preferences for different outcomes will often vary as a function of the ways and the formats in which questions are posed. This will be particularly likely whenever one option is presented in a form that is more consonant with the ways in which options were regularly encountered in the environment of evolutionary adaptation. This is because the brain is functionally specialized in a context- and content-specific way. Thus, the more closely a problem resembles a challenge faced by our ancestors, the more likely it is to invoke evolved, context-specific cognitive mechanisms. These may or may not yield the same behavioral inclination that dispassionate cost-benefit analysis would. For example, people are more afraid of snakes than cars, although the latter are currently far more dangerous. The brain may therefore reflect TSR, because it is better adapted to bias behavior appropriately in the face of a historically significant problem than it is in the face of a novel one.

Gerd Gigerenzer and colleagues have recently argued that supposedly robust errors in statistical, probabilistic reasoning disappear entirely when probabilistic information is reframed in terms of frequency distributions.[137] The argument, in essence, is that it was never likely that humans would be equally good at bandling decimals and percentages (the vocabulary of probability), on one hand, and at handling integers (the vocabulary of frequency distributions), on the other. Because the overwhelming abundance of data observable in the environment of evolutionary adaptation appeared in the natural sampling form of event frequencies, the brain is likely to be better adapted to making substantively rational choices on the basis of frequency distributions expressed as integers than on the basis of more abstract, and only recently invented, statistical techniques of representing probabilities. Gigerenzer's evolutionarily informed analysis explains why, and predicts that, for example, people will typically have a far more realistic assessment of risk when told that

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also be worth exploring from an evolutionary perspective, because natural selection excels at generating predispositions that are context-dependent. For example, temporal distance may allow the more deliberative parts of the brain greater latitude than it allows the more emotional parts, when confronted with more immediate temptation toward earlier gratification. [As this Article went to press, researchers using functional magnetic resonance imaging found evidence consistent with this prediction. Specifically, the limbic cortex is engaged in the preference for initial gratification, and it gives way to less emotive and more analytical processing in the prefrontal cortex, and to deferred gratification, as the time of reward recedes farther into the future. Samuel M. McClure et al., Separate Neural Systems Value Immediate and Delayed Monetary Rewards, 306 Science 503 (2004).]

137. See generally G. Gigerenzer, The Bounded Rationality of Probabilistic Mental Models, *in* Rationality: Psychological and Philosophical Perspectives 284 (K.I. Manktelow & D.E. Over eds., 1993); Gigerenzer, Ecological Intelligence, supra note 115, at 11–15; Gerd Gigerenzer, How to Make Cognitive Illusions Disappear: Beyond Heuristics and Biases, 2 Eur. Rev. Soc. Psychol. 83 (Wolfgang Strobe & Miles Hewstone eds., 1991).

seven people out of ten died after eating a plant than they will when told that if they eat the plant they incur a "0.7" risk of death.

Gigerenzer's approach makes use of the image of an "adaptive toolbox" into which the brain reaches for "fast and frugal heuristics."[138] When problems come in unfamiliar forms, the tool—which was "ecologically rational" in ancestral times—may be confounded. This model emphasizes the extent to which, by changing the current format of information to be compatible with what the brain evolved to expect, irrationalities and other failures will "disappear" and a rational result can follow. This finding provides another illustration of how a feature of human cognition reflects the era of evolutionary adaptation. It differs from overly steep discounting (and endowment effects, see following subsection) in that the cognitive "error" can often be corrected by altering the mode in which the information is presented. Time-Shifted Rationality, by contrast, refers to situations in which the brain's predisposition toward a seemingly irrational result does not necessarily result from presenting the information in an unfamiliar form. Even when the information is presented in the same manner to which the brain is adapted, the behavioral outcome can be substantively different from one that would be adaptively optimal in today's environment. In other words, the brain will tend to respond to the information in a manner that would have been appropriate during most of the period of the brain's evolution.

iii. *Endowment Effects.* — As mentioned earlier, the rational actor model, as reflected in the Coase Theorem, predicts that the value one ascribes to a good or to a right will be stable, unaffected by whether one already happens to own it. Much empirical evidence suggests the contrary.[139] The strength of the preference to own appears to be irrationally contingent on whether or not one already *does* own the item. People's indifference curves appear to shift in a systematic manner as soon as they acquire a good, increasing the ascribed value of the endowed good relative to all other goods.

More specifically, people tend to value an object more highly, often twice as highly, as soon as they possess it compared to how they value the same object if they had to purchase it.[140] The legal implications for the

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138. See, e.g., Gerd Gigerenzer & Peter M. Todd, Fast and Frugal Heuristics: The Adaptive Toolbox, *in* Simple Heuristics That Make Us Smart (Gerd Gigerenzer et al. eds, 1999).

139. See generally Hoffman & Spitzer, supra note 116, at 89–90; Daniel Kahneman et al., Experimental Tests of the Endowment Effect and the Coase Theorem, *in* Quasi-Rational Economics 167 (Richard H. Thaler ed., 1991); Jack L. Knetsch, The Endowment Effect and Evidence of Nonreversible Indifference Curves, 79 Am. Econ. Rev. 1277 (1989); George Loewenstein & Daniel Adler, A Bias in the Prediction of Tastes, 105 Econ. J. 929 (1995).

140. Thomas S. Ulen, Rational Choice and the Economic Analysis of Law, 19 Law & Soc. Inquiry 487, 517 (1994) [hereinafter Ulen, Rational Choice]; see also Loewenstein & Adler, supra note 139, at 929–30.

initial distribution of rights and resources are potentially profound.[141] For example, the existence of a robust endowment effect would suggest that it might be impossible to discuss the initial assignment of rights meaningfully in terms of efficiency.[142]

BLE scholarship currently lacks satisfactory explanations for this phenomenon. While it appears that, psychologically, losses loom larger than gains,[143] BLE lacks any meta-explanation for why this is so.[144] Evolutionary theory, on the other hand, does offer some suggestions.

If we view the endowment effect through the lens of TSR, we can see that some of the environmental features that contribute to the endowment predisposition being currently irrational are evolutionarily novel. For example, the abstract notion of tradable "rights" to things, which we now take for granted, is a wholly modern invention. Never before, in the history of natural selection, could a selection pressure have favored the ability to process information about a thing itself in precisely the same way as information about a tradable *right* to a thing—even if such a trait were to have arisen.

In addition, the view through the TSR lens suggests that the reason losses loom larger in the human mind than gains may share a common origin with the reason losses loom larger than gains in so many other species. That is, there is a literature in behavioral biology documenting numerous examples of territorial systems in which residents of a territory almost invariably defeat challengers.[145] Although the literature does not refer to it in terms of "endowment effects," observational and experimental evidence can be read in the language of economics to reflect that in such systems, the defenders routinely ascribe a higher value to what they have than they ascribe to the same territory if they have to procure it

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141. See generally, e.g., Herbert Hovenkamp, Legal Policy and the Endowment Effect, 20 J. Legal Stud. 225 (1991); Jeffrey J. Rachlinski & Forest Jourden, Remedies and the Psychology of Ownership, 51 Vand. L. Rev. 1541 (1998); Jeffrey Evans Stake, The Uneasy Case for Adverse Possession, 89 Geo. L.J. 2419 (2001).

142. Ulen, Rational Choice, supra note 140, at 517; see also Stake, Loss Aversion, supra note 117, at 348 (discussing ambiguity in the terms "value" and "utility").

143. Daniel Kahneman et al., Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias, 5 J. Econ. Persp. 193, 197–98 (1991); Amos Tversky & Daniel Kahneman, Rational Choice and the Framing of Decisions, 59 J. Bus. S251, S258 (1986); see also Amos Tversky & Daniel Kahneman, Loss Aversion in Riskless Choice: A Reference-Dependent Model, 106 Q.J. Econ. 1039, 1040–45 (1991) (reviewing prior work on loss aversion).

144. As one commentator put it, explaining endowment effects with reference to loss aversion is like trying to explain the phenomenon of rain by pointing out that it is caused by a storm. Edward J. McCaffery, Cognitive Theory and Tax, 41 UCLA L. Rev. 1861, 1865–66 (1994).

145. See generally, e.g., James L. Gould & Carol Grant Gould, Sexual Selection: Mate Choice and Courtship in Nature 132–35 (1989); L.D. Beletsky & G.H. Orians, Territoriality Among Male Red-Winged Blackbirds, 24 Behav. Ecology & Sociobiology 333 (1989); John R. Krebs, Territorial Defence in the Great Tit (*Parus major*): Do Residents Always Win?, 11 Behav. Ecology & Sociobiology 185 (1982); Joe Tobias, Asymmetric Territorial Contests in the European Robin: The Role of Settlement Costs, 54 Animal Behav. 9 (1997).

from another.[146] That is, they fight harder to defend a territory than they do to reacquire it once it has been transferred to another. The marked nonrandomness of the distribution of territorial systems in which the defender wins and those in which the challenger wins suggests there may be an adaptive value to a predisposition to hang on to what you have once you have managed to get it. If so, this phenomenon may provide both an empirical and a theoretical foundation for understanding and predicting the endowment effect in humans.[147]

C. *Causes and Assumptions*

The first two subparts of Part III explored how behavioral biology can help to reveal useful information about law-relevant patterns of human behavior, policy conflicts, cost-benefit analyses, and cause-effect links, and also provide useful insights about how people make decisions. These various categories provide essential conceptual building blocks for the remaining three subparts. In this subpart, we examine the role of behavioral biology in disentangling multiple kinds of causes and exposing unwarranted assumptions. In the subsequent two subparts, we consider how behavioral biology can help us to assess the comparative effectiveness of various legal approaches to regulating human behavior and illuminate undernoticed or undiscovered structures and effects of law.

1. *Disentangling Multiple Causes.* — Arguments about causes are often caustic. In particular, arguments that devolve into dichotomous choices are rarely fruitful because behavior has multiple causes. When the analysis also fails to recognize basic principles relevant to studying and understanding behavior, the problem is even deeper and more insidious.

In biology there are always two entirely different realms of cause operating simultaneously. Importantly, however, they do not butt heads competitively in the same plane of analysis. When they are incorrectly assumed to be alternatives, however, one might as well be arguing whether it is the length or the width of a rectangle that determines its area.

Biologists recognize that all behavior is the result of both "proximate" and "ultimate" causes.[148] Proximate causes are the "how" causes,

146. See sources cited supra note 145.

147. Judge Posner apparently anticipated this argument, hypothesizing that "[t]he only 'rights' in prehistoric society would have been possessory rights, and so people who didn't cling to what they had would have been at a disadvantage." Posner, Rational Choice, supra note 121, at 1565. Yet Posner instead favors an explanation rooted in traditional rationality, which he subsequently offers. Id. at 1565–67. Paul Rubin raises a similar possibility, suggesting that individuals living at subsistence who did not overweigh losses would have left fewer offspring than those who did. Paul H. Rubin, Darwinian Politics 173 (2002).

148. For discussion of these central concepts, see Alcock, Animal Behavior, supra note 50, at 2–6; Goldsmith, Biological Roots of Human Nature, supra note 50, at 6–11; John Alcock & Paul Sherman, The Utility of the Proximate-Ultimate Dichotomy in Ethology, 96 Ethology 58 (1994); Ernst Mayr, Cause and Effect in Biology, 134 Science 1501 (1961).

involving the immediate mechanistic logistics of physiology and biochemistry as well as an organism's unique developmental history that lead to particular behavioral outcomes.[149] Ultimate causes are the "why" causes, involving the aggregate reproductive consequences of behavior over evolutionary time. Explanations of ultimate cause are thus historical, involving adaptation by natural selection over many previous generations. Understanding ultimate causes helps to explain why specific environmental stimuli tend to yield predictable behaviors.

A classic example will clarify the proximate/ultimate distinction. Why do male robins sing in the spring? Proximate causes include the hormonal changes triggered by the lengthening of successive days, the activation of particular motor neurons to the vocal apparatus, and each bird's individual experience of songs heard and songs practiced. But this answer, correct so far as it goes, leaves many important questions unanswered, indeed not even addressed. The participation of hormones does not explain, for instance, why lengthening days instead of shortening ones spark these hormonal changes, or why these hormonal changes lead to singing, instead of to some different behavior. Answers to those sorts of questions require attention to the separate but complementary realm of ultimate causation.

Ultimate causes of the singing address the effects and functions (or "purposes") of singing, such as claiming territory, advertising health, and attracting mates. These contribute to reproductive success and have thus been favored by natural and sexual selection. The ultimate cause of singing behavior is therefore the long history of natural selection in which the role of singing contributed to the reproductive success of those individuals that were able to use these vocal signals to attract mates and hold territory.

Explanations of ultimate cause are thus hypotheses about selective advantage of one heritable feature—including aspects of behavior—relative to other alternatives. The lens of ultimate causation helps explain why it was more probable that the *lengthening* days of the food-rich and temperate spring, rather than the shortening days of fall, would lead to singing, as well as why lengthening days lead to *singing*, rather than to some alternative behavior unconnected to mating success. And yet this explanation too would be incomplete without some complementary understanding of the general physical mechanisms and pathways that both trigger and enable singing.

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149. Proximate causes are themselves further divisible, of course. For example,

> [a]n endocrinologist, a geneticist, a neurobiologist, a clinical psychologist, a social psychologist, a sociologist, and a developmental biologist might each ask questions about the cause of a given behavior. They might each come up with different answers, each of which indeed might cause simultaneously the given behavior. . . . [T]hey can all be simultaneously right.

Gowaty, supra note 21, at 4. Note that the biological term "proximate cause" should not be confused with the term "proximate cause" in the law of torts.

It is essential to recognize that proximate and ultimate causes operate together, with *all* behavior depending on ultimately shaped proximate mechanisms. For a law-relevant example, consider the crime of rape. There are few things that warrant greater efforts from the legal system than reducing the incidence of sexual aggression toward women. In its various forms, such aggression contributes to a political, emotional, and social environment in which women's bodies, lives, and realities are abused or improperly restrained.[150]

On one hand, it seems clear that the better we can understand what factors combine to cause rape, the better we may be able to reduce its incidence. On the other hand, existing studies of rape focus nearly exclusively on the proximate, environmental causes.[151] These include, for example, misogyny, patriarchy, disinhibiting effects of alcohol, and the effects of sexual objectification in advertising and pornography. Many of these factors undoubtedly play important roles in rape behavior. Unfortunately, however, much of the rape literature argues that these and similar factors afford a *complete* causal explanation for why some men rape.[152] Male sexual desire is deemed not only unimportant or simply irrelevant but necessarily excluded by evidence in support of these other factors.

With the lens of behavioral biology, this dichotomous thinking appears inherently oversimplified. It creates competition where none need exist. The situation is complicated, of course,[153] and one of us has elsewhere explored the rape context several times and at length.[154] Our point here is that it is as counterproductive to propose that human sexual aggression is influenced *either* by cultural variables *or* by evolutionary processes as it would be to argue about whether it is the lengthening of the day or the historical reproductive consequences of vocalizing that

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150. See generally, e.g., Susan Estrich, Real Rape (1987); Stephen J. Schulhofer, Unwanted Sex: The Culture of Intimidation and the Failure of Law (1998); Owen D. Jones, Sex, Culture, and the Biology of Rape: Toward Explanation and Prevention, 87 Cal. L. Rev. 827, 829–32, 838 n.30 [hereinafter Jones, Sex, Culture, and the Biology of Rape].

151. For an overview, see Barry Burkhart & Mary Ellen Fromuth, Individual Psychological and Social Psychological Understandings of Sexual Coercion, *in* Sexual Coercion: A Sourcebook on Its Nature, Causes, and Prevention 75 (Elizabeth Grauerholz & Mary A. Koralewski eds., 1991); see also, e.g., Mary E. Odem & Jody Clay-Warner, Introduction, *in* Confronting Rape and Sexual Assault xi, xi (Mary E. Odem & Jody Clay-Warner eds., 1998) (reflecting this focus).

152. See Jones, Sex, Culture, and the Biology of Rape, supra note 150, at 838–41 (providing brief history of rape theories).

153. Not surprisingly, biological theories of sexual aggression have attracted criticism. See, e.g., Evolution, Gender, and Rape (Cheryl Brown Travis ed., 2003). Some such criticism is constructive. Some is misleading—mischaracterizing or misunderstanding the biological literature. For some common errors in criticism, see Jones, Sex, Culture, and the Biology of Rape, supra note 150, at 872–907.

154. See generally Owen D. Jones, Law and the Biology of Rape: Reflections on Transitions, 11 Hastings Women's L.J. 151 (2000) [hereinafter Jones, Law and the Biology of Rape]; Jones, Sex, Culture, and the Biology of Rape, supra note 150; Owen D. Jones, Realities of Rape: Of Science and Politics, Causes and Meanings, 86 Cornell L. Rev. 1386 (2001) (book review).

causes a bird to sing. *Both* kinds of causes operate, each in its own distinct analytic realm, and each over its characteristic scale of time.

The point is not to trivialize rape by comparing it to bird song, but rather to illustrate the general principle that behavioral phenomena have two fundamentally, categorically different kinds of causes, and that pitting them against each other obscures understanding. The proximate causes identified in mainstream rape literature are important causes of rape, but so are the evolutionary processes that underlie male/female differences in sexual behavior.

Ultimate (evolutionary) causes have shaped the human brain to associate particular sources of proximate cause with behaviors that in the past have been, on average, adaptive. Consequently, viewing behavior as the product of both proximate and ultimate causes can provide a less contentious as well as a deeper understanding of how behaviors come to be as they are.[155] A principal advantage of conceptualizing behavior as the product of both proximate and ultimate causes is that it draws attention to the origins of pancultural features of the species and can help to focus attention on the environmental circumstances in which particular behaviors are more likely to occur. But just as it is apparent that neither genes nor environment alone can yield behavior, neither proximate nor ultimate causes provide explanations sufficient unto themselves. This point is essential for understanding the argument of the next subsection.

2. *Exposing Unwarranted Assumptions.* — Legal policymakers are typically not experts in the causes of behaviors they seek to regulate. In some contexts, greater knowledge of behavioral biology—including the knowledge of proximate and ultimate causation—can sharpen their ability to identify scientifically unwarranted assumptions about the nature of human cognition and behavior, and thereby narrow the range of plausible hypotheses.[156]

Let us return to the example of rape raised in the prior subsection. It is clear that the legal goal of reducing the incidence of rape has remained roughly constant in recent years. Yet the legal strategies for pursuing that goal have changed markedly as different theories—psychiatric, sociological, and feminist—have been advanced to explain where sexual aggression *comes from.*[157]

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155. Gowaty, supra note 21, at 4–5 (indicating that recognition of multiple levels of causation can facilitate discussion among feminists of their differences in political philosophies).

156. Daniel Dennett has argued that evolutionary perspectives often serve as a kind of "universal acid." Dennett, supra note 72, at 63. Our suggestion here is similar, in that evolutionary perspectives can sometimes help to dissolve the scientifically untenable.

157. On early psychiatric theories, see Ron Langevin, Sexual Strands: Understanding and Treating Sexual Anomalies in Men 413–22 (1983); Richard T. Rada, Sexual Psychopathology: Historical Survey and Basic Concepts, *in* Clinical Aspects of the Rapist 1, 3–10 (Richard T. Rada ed., 1978). Reflecting these perspectives, by 1965 thirty states had enacted sexual psychopath laws defining rapists as persons unable to control sexual impulse or otherwise having to commit sex crimes. Karl M. Bowman & Bernice Engle,

One relatively recent strategy has been to consider sexual aggression as simply another form of hate crime. Features of hate crime legislation from other contexts have consequently migrated into the domain of sexual aggression.[158] The assumption seems to be that the underlying motivation for a male to rape a female is based on misogyny, in a way that is meaningfully analogous to racial lynching.[159] This idea, in turn, seems built on the assumption that this form of sexual aggression is not only nonsexual experientially to a female victim, but it is also wholly unrelated to sexual desires of male perpetrators. It also leads to a blurring of the various proximate causes mentioned in the previous section, which has implications for policy decisions that can reduce the incidence of rape. For example, the proximate causes of rape reported during the civil war in Bosnia seem to have little in common with the "date rape" that occurs at college parties.

Again, the situation is complicated. But it is clear beyond doubt that the oft-repeated assertion that sexual desire is wholly irrelevant to rape has ossified into an assumed fact without serious scientific efforts to establish, examine, or evaluate that hypothesis.[160] The hypothesis is treated as

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Sexual Psychopath Laws, *in* Sexual Behavior and the Law 757, 758 (Ralph Slovenko ed., 1965). For sociological explanations, see Menachem Amir, Patterns in Forcible Rape (1971); Mary Beard Deming & Ali Eppy, The Sociology of Rape, 65 Soc. & Soc. Res. 357 (1981). On the development of various feminist perspectives, see Nancy A. Matthews, Confronting Rape: The Feminist Anti-Rape Movement and the State (1994); Colleen A. Ward, Attitudes Toward Rape: Feminist and Social Psychological Perspectives 18–37 (1995).

158. The principal federal effort in this regard, the Violence Against Women Act of 1994 (VAWA), Pub. L. No. 103-322, 108 Stat. 1902 (codified as amended in scattered sections of 8, 16, 20, 18, 28, and 42 U.S.C.), afforded civil rights remedies to victims of crimes of violence motivated by gender, meaning "committed because of gender or on the basis of gender, and due, at least in part, to an animus based on the victim's gender." 42 U.S.C. § 13981(d) (2000). The Supreme Court struck down the civil rights remedy on federalism grounds. United States v. Morrison, 529 U.S. 598 (2000). A number of state statutes, however, including some enacted recently, reflect roughly similar approaches. See, e.g., Cal. Civ. Code § 52.4 (West Supp. 2004); Gender Violence Act, 740 Ill. Comp. Stat. Ann. 82/1–20 (West Supp. 2004) (effective Jan. 1, 2004). In addition, several recently introduced or pending state bills have language closely tracking VAWA's language, ensuring that interpretive and factual issues concerning the causes of rape will remain important. See, e.g., A.B. 6380, 2003 Leg., 226th Sess. (N.Y. 2003); S.B. 5451, 57th Gen. Assem., Reg. Sess. (Wash. 2001).

Interestingly, the U.S. Senator who sponsored VAWA (Joseph Biden) thought it likely that all rapes would qualify as driven by gender animus. See Ruth Shalit, Caught in the Act, New Republic, July 12, 1993, at 12, 14 (quoting Biden). For discussion of problems in interpreting and applying the "animus" language, see generally J. Rebekka S. Bonner, Note, Reconceptualizing VAWA's "Animus" for Rape in States' Emerging Post-VAWA Civil Rights Legislation, 111 Yale L.J. 1417 (2002).

159. See sources cited supra note 158.

160. See Del Thiessen & Robert K. Young, Investigating Sexual Coercion, Society, Mar./Apr. 1994, at 60. The authors reviewed over 1,610 studies of sexual coercion published between 1982 and 1992 in over 400 different journals or books, from the fields of psychology, educational psychology, anthropology, and sociology. They conclude that

fact without sound basis in the scientific study of causation. Extensive review of hypotheses and evidence concerning sexual aggression and forced copulations in many other species, and in the many distinct patterns in which it appears, indicates that evolutionary history has very likely influenced patterns of human rape and other forms of sexual aggression.[161] The patterns in other species are simply too numerous and too consonant, and the parallels with human data on sexual aggression are striking.[162]

So while the immediate causes of any individual act of sexual aggression can vary, and while it is undoubtedly the case that some acts flow from raw misogyny or are entangled with ethnic conflict, it is simply scientifically incorrect to assume that the effects of evolutionary processes on the biology of sexual desire are irrelevant to human patterns of rape and other forms of sexual aggression.[163] As this example demonstrates, even a minimum facility in behavioral biology can help to uncover similarly unwarranted assumptions in other legal contexts that may send well-intentioned policies in inefficient directions.[164]

D. *The Law of Law's Leverage*

We now turn to the *interaction* of behavior and law. Consider, by way of background, some of the principal insights of law and economics.[165] We know from basic economics that a population's demand for a good will tend to decrease as the cost of the good increases, along a curve that simply traces the quantity of goods people are willing and able to buy at different prices. Further, we know that this relationship between quantity and price tends to hold for behaviors, as well as for goods, such that we

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"scientific methods are not being applied to the understanding of sexual coercion" because, in part, "[h]ardly ever is a specific hypothesis tested." Id. at 60, 62.

161. See generally Jones, Sex, Culture, and the Biology of Rape, supra note 150; see also sources cited in id. at 936–39.

162. See id. at 857–72.

163. Of course, there is still room to disagree over such things as whether the results reflect adaptation, drift, the byproducts of adaptation, some combination of these, and the like. See supra note 70 and accompanying text.

164. There are many examples of scholars using various aspects of behavioral biology in efforts to expose unwarranted assumptions. Ruhl, for instance, has argued that biological perspectives expose as naive our assumptions about how environments operate and species interact. J.B. Ruhl, Thinking of Environmental Law as a Complex Adaptive System: How to Clean Up the Environment hy Making a Mess of Environmental Law, 34 Hous. L. Rev. 933, 936–38 (1997). Kingsley Browne has argued that evolutionary theory affords reason to question the assumption that, in the absence of discrimination by employers or indoctrination by a sexist society, men and women would have identical workplace preferences and would equally value all workplace opportunities. See, e.g., Kingsley R. Browne, Biology at Work: Rethinking Sexual Equality (2002); Browne, Sex and Temperament, supra note 4. Jeffrey Stake has argued that evolutionary theory affords reason to question the assumption that donors will not make gifts that reduce the value of assets. Jeffrey E. Stake, Darwin, Donations, and the Illusion of Dead Hand Control, 64 Tul. L. Rev. 705, 725–32 (1990).

165. See supra note 111 and accompanying text.

can consider legal sanctions as prices imposed on behaviors that will tend to decrease the incidence of those behaviors.

The subset of behavior that law sanctions with criminal penalties has been an especially rich area of research. Many scholars have documented a variety of patterns that detail relationships between the severity of penalties and specific crimes.[166] Such research is enormously useful, and there should be even more. But it is important to note that we really know precious little at the theoretical level—that is, from ways other than intuition, after-the-fact data analysis, and trial and error—about what *governs* the precise relationship between increased penalties and the rates of incidence for different kinds of crimes.[167] First, by how much would we need to increase penalties (for robbery, for example) in order to achieve a specified percentage reduction in the incidence of that crime? Second, how will the relationship between increasing penalties and the decreased incidence of one crime compare with the corresponding relationships across the landscape of different crimes? For example, how will the relationship between increasing prison time and decreasing incidence of robbery compare to the relationships between prison time and the incidences of drug trafficking, homicide, or rape? Likewise, how will these relationships in the criminal contexts compare to the analogous relationships in civil contexts, such as fines and jaywalking? Third, how do the demand curves for different crimes depend on other social parameters, such as population demographics and socioeconomic status of the perpetrators?

Even to begin answering these kinds of questions requires us to have some sense of the slopes of the demand curves for these different behaviors.[168] But while we have no reason to believe the slopes for different

166. See, e.g., Franklin E. Zimring & Gordon Hawkins, Incapacitation: Penal Confinement and the Restraint of Crime 100–27 (1995) (discussing patterns of incarceration and crime rates in California); Franklin E. Zimring, Firearms, Violence, and the Potential Impact of Firearms Control, 32 J.L. Med. & Ethics 34 (2004). Various statistical methods are used. For example, to assess the effectiveness of capital punishment in deterring homicides, researchers have used immediate impact studies, comparative research, and time-series studies. See Rudolph J. Gerber, Economic and Historical Implications for Capital Punishment Deterrence, 18 Notre Dame J.L. Ethics & Pub. Pol'y 437, 438–39 (2004).

167. Economists tell us Slutsky equations can help us to predict the tradeoffs people will make among various alternative behaviors given people's preferences with respect to those activities. See, e.g., Hal R. Varian, Intermediate Microeconomics 136–59 (6th ed. 2003). Yet taking people's preferences as given is precisely what we don't want to do. We want to know enough about where those preferences come from, and what forms they are likely to take, to know how to design maximally efficient incentives and disincentives using the tools of law.

168. We adopt here the common but imprecise convention of using variations in slope to capture the idea of variations in elasticity by, for example, describing inelastic demand with a steeply sloped demand curve. The slope of a demand curve is the rate of change of price with demand. Elasticity is the percentage change in price divided by the percentage change in demand and can be computed from knowledge of the slope at a given point on the curve. A curve is said to be inelastic when elasticity is less than one. In

behaviors are identical, we also at present have no reasoned way of explaining or predicting why and how steepness varies among behaviors or even along the curves. Although we have a great deal of empirical evidence indicating that some behaviors are less easily influenced by legal interventions than others, we nonetheless lack theoretical models to predict systematically whether a given increase in price will be associated with a large or small change in the incidence of a behavior. Because sanctions are costly, it would be useful to develop more accurate predictions of the probable return to society on its investment in sanctions.

1. *Assessing the Comparative Effectiveness of Legal Strategies.* — Although we do not propose that behavioral biology affords clear and precise answers to the questions raised above, we do believe that it can help shed important light on the subjects. By combining principles of behavioral biology with the concept of Time-Shifted Rationality discussed in Part III.B.2.b, we can derive a general and useful principle about the relationship between law and behavior. That principle, previously termed by one of us "The Law of Law's Leverage,"[169] can help us to anticipate, at least in general terms, the comparative sensitivities of a population's various behaviors—criminal or otherwise—to changes in incentives that we make with legal tools. This principle can help us predict and explain the general features of the aggregated demand curves for different behaviors, and thus why some behaviors are less easily manipulated by law than are others.

The Law of Law's Leverage predicts that:

> The magnitude of legal intervention necessary to reduce or to increase the incidence of any human behavior will correlate positively or negatively, respectively, with the extent to which a predisposition contributing to that behavior was adaptive for its bearers, on average, in past environments.[170]

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this Article, a reference to slope is not intended to imply that the demand curves we are postulating are necessarily linear; in comparing demand curves for different crimes (or other behaviors), comparisons of slope must therefore refer to comparable regions of nonlinear curves. Demand curves relating price (e.g., prison time) with a reduced rate of crime may suggest a causal connection in which crime rate is influenced by legal sanctions. To the extent this is the direction of the causal arrow, scientifically trained readers who are accustomed to seeing the independent variable on the x-axis should recognize that price is conventionally put on the y-axis of demand curves. Consequently, a behavior that is insensitive to price will be characterized by a steep demand curve.

169. Jones, Nature of Norms, supra note 22, at 2100–01; Jones, Law's Leverage, supra note 22, at 1190.

170. Jones, Law's Leverage, supra note 22, at 1190. "Magnitude of legal intervention" typically refers to costliness. Greater resistance to change will increase the cost of effecting change. However, assessing the magnitude of legal intervention may in some cases require separate attention to the severity of an intervention (e.g., the harshness of a penalty). Although in the typical case increased severity will simply yield increased costs, there may be unusual cases in which severe interventions are less administratively cumbersome and therefore less costly, than are less severe interventions. By emphasizing "the extent to which a predisposition contributing to that behavior was adaptive to its bearers," we refer to the fact that some adaptations are more important than others. By "a predisposition" we

There are caveats, of course. First, because the proportional relationship between sanction and behavior may not be constant, comparisons across behaviors require comparisons of similar portions of the demand curves. Second, the slopes and shapes of two curves can appear identical at the same time that the magnitudes differ substantially, or one curve is shifted horizontally or vertically with respect to the other. Third, properly defining the behavior at issue is critical. For example, "theft" would be too broad; the term encompasses behaviors that are materially diverse, such as theft of services by refusing to pay a proper bill, theft of candy, theft by burglary, identity theft, and more. Conversely, "theft of nineteenth century hand-forged double calipers," or the like, is obviously too narrow. Fourth, many factors combine to affect the demand curves for defined behaviors. In addition to evolutionary heritage, a variety of contextual, situational, and temporal variables—including not only educational, economic, and socioeconomic ones, but also those reflecting shifts in social and legal attitudes about behaviors in question—can lead to considerable variation in the demand curves of individuals, and can complicate assessments of the aggregated, population-wide demand curves.[171]

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refer to a psychological trait that is a heritable and behavior-biasing algorithm manifested in the brain's neural architecture. For a behavioral predisposition to be "adaptive," it must have conferred greater reproductive success on individuals that bore it than did any other contemporaneously existing alternatives exhibited by other individuals within the population—and thus have been maintained by natural selection. The language "on average" refers to whether the cumulated effects of the adaptation, across all the organisms that bore it, yielded increases in inclusive fitness that outweighed any decreases. That is, "on average," the trait increased the reproductive success of organisms that bore it. Thus, the occurrence of maladaptive outcomes for some individuals, even in the environment of evolutionary adaptation, is not dispositive of the adaptation analysis, since it is only the average effect that matters. "On average" does not refer to the average fitness consequences within a single individual throughout its lifetime. Nor does it refer to any net of fitness effects of all behavioral traits an organism simultaneously manifests. "Past environments" refers to the environment of evolutionary adaptation (EEA). The relevant environment of evolutionary adaptation varies from feature to feature. See Martin Daly & Margo I. Wilson, Human Evolutionary Psychology and Animal Behaviour, 57 Animal Behav. 509, 512–13 (1999); Robert Foley, The Adaptive Legacy of Human Evolution: A Search for the Environment of Evolutionary Adaptedness, 4 Evolutionary Anthropology 194 (1995).

A more precise, though also more cumbersome, definition of the Law of Law's Leverage is this: The Law of Law's Leverage states that the magnitude of legal intervention necessary to reduce or to increase the incidence of any human behavior will correlate positively or negatively, respectively, with the extent to which a behavior-biasing, information-processing predisposition underlying that behavior (a) increased the inclusive fitness of those bearing the predisposition, on average, more than it decreased it, across all those bearing the predisposition, in the environment in which it evolved and (b) increased the inclusive fitness of those bearing the predisposiuon more, on average, than did any other alternative predisposition that happened to appear in the environment during the same period.

171. Another factor that can potentially complicate analysis, as Ulen notes, is a person's over-optimism (about the likelihood of getting caught in criminal behavior, for example). Ulen, Evolution, supra note 24, at 934–35.

Keeping these caveats in mind, the Law of Law's Leverage can be useful because it predicts that behaviors that have the deepest roots in evolutionary history are likely to be the most resistant to change. For example, it predicts that shifting behavior in ways that tended to increase reproductive success in ancestral environments will generally be less costly than shifting behavior in ways that tended to decrease such success.[172] The malleability of a behavior in reaction to changes in law—and therefore, to a great extent, the commensurate cost of trying to change the behavior—will tend to vary as a function of the extent to which the behavior—or, more specifically, the psychological mechanism underlying it—was historically adaptive.

Put another way, the slope of the demand curve for historically adaptive behavior that is now deemed socially undesirable will be far steeper—reflecting less sensitivity to price—than the corresponding slope for behavior that was comparatively less adaptive in ancestral environments. Importantly, this rule will tend to hold even when the costs that an individual actually and foreseeably incurs in behaving in a historically adaptive way exceed the currently foreseeable benefits of such behavior.

Because of the way natural selection builds brains, legal contexts in which we may observe the operation of the Law of Law's Leverage likely include those—from criminal law, family law, torts, property, and the like—that involve such things as mating, fairness, homicide, childrearing, status-seeking, property and territory, resource accumulation, sexuality (including infidelity and jealousy), speech, privacy, empathy, crimes of passion, moralistic aggression, risk-valuation and risk-taking, cooperative/altruistic behavior, and male mate-guarding and related violence.

Here are several quick examples. Evolutionary analysis predicts and explains why the slope of the demand curve for adulterous behavior is likely to be comparatively steep,[173] as is the slope for most sexual behavior, and thus comparatively insensitive to the imposition of legal prohibitions, or other costs, such as effect on career. It also predicts and may help explain why marriage, separation, divorce, and remarriage behavior

172. In his famous concurring opinion in *Youngstown Sheet & Tube Co. v. Sawyer*, Justice Jackson argued that presidential authority waxes when exercised pursuant to authorization of Congress, wanes when incompatible with Congressional will, and otherwise occupies a "zone of twilight." 343 U.S. 579, 635–38 (1952) (Jackson, J., concurring). We are suggesting a similar idea: Legal interventions will encounter least resistance when encouraging behaviors that contributed toward reproductive success in deep ancestral environments, and most resistance when encouraging behaviors that diminished reproductive success in deep ancestral environments. Applying this principle coherently will require developing suitable conventions on how law-relevant behaviors are defined and how the effects of behaviors on reproductive success in past environments are estimated.

173. See generally David M. Buss, The Evolution of Desire: Strategies of Human Mating (1994); Helen E. Fisher, Anatomy of Love: The Natural History of Monogamy, Adultery, and Divorce (1998).

will be less sensitive to legal changes—at least in moderately democratic cultures—than will be many other forms of behavior.

Because natural selection disfavors inbreeding among close relatives,[174] evolutionary analysis also predicts that it will be far less costly to discourage incest among parents and their natural children, and between siblings reared together, than among stepparents and stepchildren.[175] Because natural selection favors predispositions to direct parental resources principally toward offspring and other close relatives,[176] we can explain and anticipate that the cost of reducing child abuse will be greater, per capita, for stepparent households than for nonstepparent households.[177] Similarly, we can predict that men under court order to provide child support payments for a child they know or suspect they did not father will be less likely to comply, on average, than will biological fathers.[178]

Because in internally fertilizing species only males can be uncertain of their genetic relationship to their putative offspring, in many species sexual selection has favored sexual proprietariness in males.[179] Consequently, we can predict that the slope of the demand curve for jealous violence against rivals and sexually straying partners will tend to be

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174. See Michael C. Whitlock, Inbreeding, *in* 2 Encyclopedia of Evolution 567–69 (Mark Pagel ed., 2002).

175. Although data seem mixed, some studies suggest that a girl is much more likely to be incestuously abused by a stepfather than by a biological father. See, e.g., Diana E.H. Russell, The Prevalence and Seriousness of Incestuous Abuse: Stepfathers vs. Biological Fathers, 8 Child Abuse & Neglect 15, 17 (1984) (noting that it is eight times more likely). Moreover, the severity of incestuous abuse appears to be greater with stepfathers. Id. On the human tendency to avoid brother-sister incest where siblings are reared together, see Goldsmith, Biological Roots of Human Nature, supra note 50, at 9–10.

176. This predisposition is often referred to as "discriminative parental solicitude." See, e.g., Martin Daly & Margo Wilson, The Darwinian Psychology of Discriminative Parental Solicitude, 35 Neb. Symp. on Motivation 91 (1987); Martin Daly & Margo Wilson, Discriminative Parental Solicitude and the Relevance of Evolutionary Models to the Analysis of Motivational Systems, Evolutionary Perspectives, *in* The Cognitive Neurosciences 1269 (Michael S. Gazzaniga ed., 1995).

177. See generally supra Part III.A.

178. See Margo Wilson, Impact of the Uncertainty of Paternity on Family Law, 45 U. Toronto Fac. L. Rev. 216, 223 (1987) [hereinafter Wilson, Impact] (citing S. H. Fritschner, The Nature of Paternity Actions, 19 J. Fam. L. 475, 492 (1981)). Recent discussion of this point appears in Todd K. Shackelford & Viviana A. Weekes-Shackelford, Why Don't Men Pay Child Support? Insights from Evolutionary Psychology, *in* Evolutionary Psychology, Public Policy and Personal Decisions 231 (Charles Crawford & Catherine Salmon eds., 2004).

179. For useful texts on sex differences, see generally Andersson, supra note 75; David C. Geary, Male, Female: The Evolution of Human Sex Differences (1998) (containing particularly extensive bibliography); Linda Mealey, Sex Differences: Development and Evolutionary Strategies (2000). On sex differences in sexual proprietariness, also known as mate-guarding, see id. at 112, 297–98, and sources cited therein.

steeper for males than for females.[180] Because threats to status within a social group have often imposed significant reproductive costs, we can predict that the slope of the demand curve for retaliation consequent to status threats will be steeper than that for most other proscribed behavior, and will be particularly steep in public fora.[181]

Obviously, the Law of Law's Leverage cannot predict demand curves for law-relevant behaviors with precision. Nor can it individualize a curve to a single person, as demand curves vary among individuals, and the range of variation itself varies among behaviors. Nonetheless, the Law of Law's Leverage can offer broad and useful insights into the differing ways law and behavior interact, *depending on the behavior at issue.* Because we are alert to the fact that the brain tends to process information in ways that tended to yield adaptive solutions to problems encountered in the environment of evolutionary adaptation, we may expect that behavioral inclinations will generally vary in their susceptibility to the influence of different legal tools. It can afford us more intellectual traction than we now have on predicting the *comparative* slopes of the demand curves, thereby supplying information useful to estimating the relative costs to society of attempting to shift behaviors in constructive directions. The principle also provides a new and powerful tool for explaining and predicting many of the existing and future architectures of legal systems, which we address next.

E. *Structures and Effects of Law*

To this point, we have discussed a variety of advantages of using behavioral biology in law, explored how the evolutionary history of the brain influences human behaviors, and considered how this knowledge usefully broadens our understanding of causation. In this subpart we consider a variety of issues closely related to these central themes.

Part III.E.1 explores how the effects of evolutionary processes on characteristically human patterns in hopes, concerns, and conflicts have likely influenced the structure of legal systems. We argue that the issues with which law grapples, and the general contours of how law grapples with them, both bear the stamp of evolutionary history. Part III.E.2 turns from addressing how evolutionary processes affect law to considering how the legal system can reciprocally affect evolutionary processes. Specifically, we consider how the power of law to alter environments can change the force or direction of natural selection. Part III.E.3 briefly considers

180. See generally David M. Buss, The Dangerous Passion: Why Jealousy Is as Necessary as Love and Sex (2000); David M. Buss et al., Sex Differences in Jealousy: Evolution, Physiology, and Psychology, 3 Psychol. Sci. 251 (1992).

181. See generally Daly & Wilson, Homicide, supra note 47; David M. Buss & Todd K. Shackelford, Human Aggression in Evolutionary Psychological Perspective, 17 Clinical Psychol. Rev. 605 (1997). Biologists expect, of course, that reactions to status threats will vary according to such things as sex, age, and the like.

several efforts to ask whether law itself "evolves" in a way meaningfully analogous to genetic evolution.

1. *Revealing Deep Patterns in Legal Architecture.* — Much as the lens of economic analysis has helped legal thinkers to see how some features of legal systems reflect selection pressures that reward economic efficiency, the lens of evolutionary analysis can help us to see how architectural features of legal systems reflect the effects of evolutionary processes on the human brain. Although human cultures vary greatly in detail, human brains are basically the same in all cultures.[182] The human brain inevitably reflects its evolutionary history in the ways that it processes information and in the behavioral predispositions it exhibits. Consequently, all legal systems, like the cultures of which they are a part, have heen shaped to some degree by fundamental attributes of human brains that in turn are expressions of basic human goals and desires. By this reasoning, it should be possible to see the telltale results of evolutionary processes in the framework of legal systems across both cultures and time.

A previous exploration of this idea by one of us considered the role of four factors in framing the superstructure of legal systems: Topics, Content, Tools, and Effort.[183] Following a brief description of how behavioral biology affects these parameters, we will consider how they come together in a design space for legal systems, observing that the probable architectures of legal systems constitute a narrow subset of all conceivable architectures.

a. *Topics and Content.* — All legal systems necessarily reflect, at a minimum, two basic features. First, from all of the things people might conceivably care about, all legal systems deal with a subset of key elements, such as sex, inheritance, family, status of children, reputation, property, and resources. We call these key elements "Topics." Second, all legal systems reflect social attitudes toward Topics. Specifically, each legal system manifests a harsh winnowing from the full variety of normative preferences people might conceivably have toward Topics down to the particular ways people do actually tend to care about them. Put another way, there are aspirations and goals associated with each Topic. We refer to these as constituting legal "Content." Both Topics and Content tend to

182. This does not mean, of course, either that people are identical or that their brains are identical. The form that each individual brain takes is the result of the sequential expression of genetic information in a complex developmental process involving multiple feedback loops and numerous environmental influences. The developmental process is not over at birth, and environmental influences range from the physical and chemical to the social. These influences contribute to the unique identity of each individual. Nevertheless, there are important evolved neuroanatomical commonalities that enable reference to a shared human nature. For a more detailed description of the evolutionary processes that underlie species-typical brain structures, see Goldsmith & Zimmerman, supra note 43, at 95–100.

183. Jones, Proprioception, supra note 22, at 847–57. Earlier, preliminary exploration of this topic appears in Jones, Nature of Norms, supra note 22, at 2099–2100.

reflect the norms, including the morality, of a population.[184] Consequently, better understanding of causal processes that lead to norms should afford a better understanding of law.

In recent work on higher primates, primatologists, behavioral scientists, and anthropologists have found instances of cooperation, reciprocity, reconciliation after conflict, deception of other members of the social group, division of labor, sharing of production, averse reaction to distributional inequities, tool use, and lethal intergroup conflict.[185] This research reveals that a number of behaviors traditionally believed to be uniquely human have counterparts in our closest living relatives. Although we have only a dim understanding of the cognitive processes used by nonhuman species, evolutionary analysis can nevertheless clarify why these behaviors occur and suggest that the same reasoning can be extended to *Homo sapiens*. By this argument we can see why particular patterns of norms and morals appear in legal systems: They recur because they harmonize with evolved goals and aspirations of the human mind.

For example, earlier we discussed how people have an intrinsic expectation of fairness in their dealings with others. People who are cheated may respond with immediate physical aggression, but the complexity of the human brain allows alternatives. Private revenge by stealthy means may avoid placing the aggrieved party in danger of further retaliation. Perhaps more commonly, moral outrage can damage the social status of the cheater and bring about group punishment. What this perspective means in the end is that some of the Topics legal systems tend to address, as well as some of the general Content of law regarding those Topics, manifesting common normative preferences, will often reflect the effects of evolutionary processes on human minds.

We inevitably tend (on average, of course) to care most about things that were relevant to survival and reproduction throughout evolutionary time. For instance, we care about acquiring, holding, and using resources, and these evolved, shared sentiments likely helped to shape the law of property. We care about increasing our resources through beneficial exchange, and this concern likely affected the development of the law of contracts. We seek to be secure in both our property and in our

184. To clarify, Topics is clearly the most diverse element, encompassing all potential subject matter within the human experience. Content, which reflects our attitude about behaviors relevant to each Topic, may vary along a spectrum from positive to neutral to negative, indicating our normative preference to encourage, to discourage, or at least to standardize the behavior. Preferences may arise from, among other things, our moral judgments, religious prescriptions, emotional realities, and sense of economic efficiencies. For example, we might conclude that theft is bad, not good; false imprisonment is bad, not good; and slander and libel are bad, not good.

185. See generally, e.g., Chimpanzee Cultures (Richard W. Wrangham et al. eds., 1994); Tree of Origin, supra note 60; Frans de Waal, Chimpanzee Politics: Power and Sex Among Apes (rev. ed. 2000); de Waal, Good Natured, supra note 60; Frans de Waal, Peacemaking Among Primates (1989); Wrangham & Peterson, supra note 47; Sarah F. Brosnan & Frans B.M. de Waal, Monkeys Reject Unequal Pay, 425 Nature 297 (2003).

bodies, and this desire likely helped give general form to criminal law and tort law. We seek mating and reproductive autonomy, and those evolved goals likely helped to shape family law.

It is vanishingly unlikely that cultures across time and throughout the globe settled upon these same basic features of law because they happened to encounter one another. These features are almost undoubtedly an outgrowth of the effects of evolutionary processes on human brains functioning in social environments. One might initially suppose that features common to many legal systems arose solely from the conscious mind of humankind—as if some ancestral human invented the idea of property, or the idea of exchange—or as if we care about sex, mating, and status only because of our socio-cultural milieu. But that is unlikely in the extreme.[186]

In terms of Content, no single database exists that enables us to compare the legal features of cultures—across geopolitical space and time—on common metrics relevant to legal analysts.[187] Nonetheless, the general aspirations and goals associated with each Topic appear remarkably nonrandom across human populations. In our view, behavioral biology provides an essential insight into understanding why. Specifically, it suggests that the most likely explanation reflects not only the existence of culture as a social cement, but also the way in which evolutionary processes built the human brain to care in nonrandom ways about things that had important effects on reproductive success in ancestral social environments.

For all the differences we amplify through cultural variation, the fact remains that we are a relatively homogeneous species genetically.[188] Although we have spread across disparate geographies on the globe—each with localized challenges—we have as an intensely social species long encountered common social problems such as forming alliances, attracting short- and long-term sexual partners, rearing offspring, deceiving without being deceived, and acquiring and maintaining resources. Evolutionary processes have equipped us with a program for constructing a human

186. While it is obviously true that some features of a legal system (such as entertainment law, for example) are much farther from biological influence than others, it is also true that a wide variety of the other main areas of law, such as employment law, business law, environmental law, intellectual property law, international law, consumer law, and the like, can easily be seen as epiphenomenal to the basic legal curriculum—a curriculum that is basic, in part, because of the way it maps onto the fundamental, evolved, human needs and desires.

187. The closest of which we are aware comes not too close. The Human Relations Area Files (of the Human Relations Area Files, Inc., a research agency at Yale University) is the leading cross-cultural database. Despite its many strengths, its utility for cross-cultural legal work of the sort here contemplated is likely limited. The database is anthropological, rather than legal, in its orientation. There are comparatively few legal dimensions coded, and these have typically been collected by and coded by researchers trained in anthropology, rather than researchers trained in law. That said, there may indeed be ways to mine this database to test evolutionary hypotheses about legal structures.

188. See generally Cavalli-Sforza et al., supra note 57.

brain that at each moment reflects both the developmental history of a unique person with a unique set of experiences and a shared history as a species that has generated broad categories of similar responses to similar challenges life provides.[189] Cultures vary, of course, in who has (or has seized) the power. But there are general patterns in who seeks power and in why, how, and under what circumstances power is shared. Similarly, there are patterns in the ends toward which power is used. These patterns reflect the species-typical brain and are manifest—in part—in basic themes of legal architecture.

But let us be more specific and invoke a comparison. As mentioned earlier, one of the main insights of the economic approach to law is to redescribe legal sanctions as prices. One of the main insights of evolutionary analysis in law is to redescribe legal predispositions as evolved information-processing pathways.[190] These reflect preference-forming, behavior-biasing algorithms that tend to create internal states of the nervous system that tended, in turn, to yield behaviors that were adaptive in deep ancestral environments.

Considering Topics and Content in light of evolutionary biology leads to the prediction that the normative content of legal systems will tend, over the entire globe, to reflect evolved, species-typical brains, even as the details of those legal systems will inevitably vary in many particulars. Legal systems will not be identical, because there is ample room for cultural differences and historical accident. But our argument can be clarified by analogy. Just as the various features of fish, mammals, and birds are nonetheless all fully consistent with the constraints of gravity, the main features of legal systems all reflect the evolved characteristics of human brains. The evolved characteristics of the brain place some constraints on the range of outcomes of legal systems and define the universe of cultural differences from which those legal systems emerge.

Here are three brief examples, in narrow but more concrete contexts. First, evolutionary analysis predicts that the ways in which legal regimes specify how to allocate the property of an intestate decedent will not be randomly distributed. In jurisdictions that attempt to give effect to the decedent's probable preferences—as most do—the property will tend to flow to relatives by marriage and blood, in priority according to degrees of relatedness. Evolutionary analysis predicts this because, on av-

189. See sources cited supra note 65.

190. This idea has arisen in many forms, not always phrased or framed this way. Some works focus primarily on the broader phenomenon of biological underpinnings of morality generally. See generally, e.g., supra note 105 (citing works by Alexander, Ridley, and de Waal). Others focus more specifically on the effects of biological underpinnings of morality and other features of human cognition on law. See generally, e.g., Law, Biology, and Culture: The Evolution of Law (Margaret Gruter & Paul Bohannan eds., 1992); The Sense of Justice, supra note 105; Jones, Proprioception, supra note 22.

erage, natural selection has inclined people to care more for relatives than for nonrelatives, all else being equal.[191]

Second, evolutionary analysis predicts that almost everywhere crimes of passion will generally be treated differently from premeditated crimes. This disparity is expected to reflect a shared sense of how the reasonable person behaves, consistent with each person's projection onto others of his or her own subjective experience of grappling with powerful behavior-influencing emotions—such as sexual jealousy, rage, and panic—that are less easily controlled than are many other behavior-influencing phenomena.

Third, evolutionary analysis predicts that—and helps explain why—within all known human cultures, rape is proscribed to a degree disproportionate to other forms of physical harm that do not implicate reproductive capacities. (Rules for treating members of *other* groups may be quite different.) Nowhere does law treat forced copulation as inconsequential or as a minor physical injury. There are variations, to be sure, in how legal systems respond to allegations of rape. Yet, absent a biobehavioral perspective, we would not expect that random cultural variation would consistently yield the circumstance, all over the globe, at all times known, and even among societies that have had no contact with each other, that forced copulation would be a uniquely heinous offense. From an evolutionary perspective, the female's loss of all control over choice of mate is an understandable source of heritable psychological revulsion. Male concern about paternity of his spouse's offspring, combined with interest in the reproductive future of closely related women—particularly evident in patriarchal societies—provides further understanding of why societal rules against rape exist.[192]

b. *Tools and Effort.* — Given foundational elements of Topics and Content, each legal system reflects choices about what legal tools should be used to achieve society's goals and the degree of effort the law must make in order to regulate behavior. "Tools," as used here, is a set that includes all the methods available to legal thinkers by which we might attempt to bring reality into line with our normative preferences. That set includes both promising and unpromising techniques. The "Effort" variable expresses how hard it may be to effect such change using any particular tool of law.

Law and behavioral biology meet most obviously in the legal tools we use to induce people to behave the ways we want. These Tools seem so intuitively obvious that it is initially difficult to appreciate how narrow the set of deployed tools is, until comparing it to the universe of hypothetical alternatives. We are accustomed to the idea that one of the best ways to

191. On kin selection, see supra Part II.B.3.

192. The large literature on biobehavioral influences on sexual aggression, and on reactions to sexual aggression, is explored in Jones, Sex, Culture, and the Biology of Rape, supra note 150, at 857–72. See also Jones, Law and the Biology of Rape, supra note 154, at 155–64.

alter behavior is by manipulating access to resources. People can be rewarded with resources for doing things deemed socially, economically, or morally desirable. For example, we can offer rewards in the form of resources for information leading to convictions or offer tax breaks for donations to particular causes. Or we can extract resources—by fines, for instance—from those who behave in undesirable ways. Or we can impose penalties through incarceration or by other restrictions on personal freedoms.

Yet whether through mechanisms affecting resources or jail time (which also imposes the costs of forgone income), we have settled on methods that are coherent from a biological perspective. We avoid those things that organisms have not evolved to care about and instead target and restrict precisely those things evolutionary processes have designed the human brain to care about most. Civil fines impede the acquisition and free use of resources. Criminal penalties limit physical freedoms, coalitional and political (associational) freedom, access to children and other relatives, reputation and status, and sexual opportunity. At times of imposed isolation, criminal penalties even wholly deny social, physical, and emotional access to other human beings.

The overwhelming number of things law does *not* do to influence human behavior reveals by silhouette the universal features of human brains, shared feelings about human needs and wants, and the likely inevitability that legal tools would ultimately center on a handful of activities of paramount importance to the evolved human brain. An evolutionary perspective should uniquely predict that the same general sets of motivational tools are central features of legal systems in virtually every human culture worldwide.

As for the Effort variable, we have already seen how evolutionary analysis, by underscoring the role of the emotions, Time-Shifted Rationality, and the Law of Law's Leverage, reveals patterns in human resistance to inducement and sanction. This framework provides a basis for explaining and predicting cross-cultural patterns in how difficult it is for law to alter various behaviors.

c. *Biolegal History.* — The argument to this point is that legal structures of human beings will reflect the effects of evolutionary processes on human brains. Yet much existing scholarship on contemporary legal systems suggests—or more often simply assumes—that the body of law a given culture displays reflects a complex and hugely variable amalgam of culture-specific norms, culture-specific religions, culture-specific morals, culture-specific politics, and general economic efficiencies. How likely is this, really?

To answer this question, one might usefully consider the distribution of the features of actual legal systems within the overall design space of all possible legal systems. One way of doing this is to imagine an enormously vast decision tree that delineates all possible variations in the four variables introduced earlier: Topics, Content, Tools, and Effort. Imagine a

two-dimensional tree that first splits into the main branches of all possible Topics, whose branches then each subdivide by all possible variations of Content, followed by similar subdivisions of all variations in Tools, likewise split by all variations in Effort.

That decision tree would define the overall design space for all potential legal systems. And thus, in principle, the core features of every legal system could be mapped onto that tree. (We are talking here about the large-scale features of legal systems—not microscopic ones, such as how long someone has to file a reply brief.) It is clear that for any single legal system—that of the United States, for instance—far more of the tree is unused than used. That is, there are some Topics we care about; most we do not. For every Topic we care about, our system reflects in its Content one normative preference or relatively narrow set of preferences rather than others, one or more types of Tools from among many, and for each legal tool a corresponding necessary Effort—the latter of which is simply the amount of resistance in the population corresponding to the Topic-specific disjunction between normatively preferred behavior and existing behavior.

Suppose we were to sketch—on giant transparencies containing the decision tree of all possible legal systems—the actual features exhibited by every legal system in the world that now is or ever was. Then suppose we were to step back to a great distance, and layer each sketch upon the other. What would we see? Legal systems, up close, obviously vary greatly. But from a distance would they appear to distribute broadly across the overall design space for all possible legal systems, or would they cluster and clump together, into a tiny fraction of the available design space?

Behavioral biology predicts the latter.[193] Indeed, it predicts that a vast expanse of all possible legal systems will go unused. Importantly, it predicts this without any reference to mere path dependence. That is, some might argue that the clumping is a function of culturally arbitrary choices that became fixed, influential, or both. Perhaps (this argument goes) legal systems could just as easily have occupied a different, distant portion of the design space.

This is, in fact, unlikely. Principles of behavioral biology, such as natural and sexual selection, affect the prior probabilities of legal systems, no matter how many times the clock is turned back to the origins of hominid sociality. Surely, hominid history would play out differently each time. Random influences, such as mutation and genetic drift,[194] could exacerbate variation. Furthermore, no feature of humanity (if humanity were to re-evolve) nor any specific feature of legal systems would be inevitable. Nevertheless, if primate heritage—roughly seventy million

193. This should at least be true among democratic governments. A separate biobehavioral analysis of behavioral patterns of individuals with effectively unreviewable power would also be possible.

194. See supra Part II.B.2.

years ago—is taken as a starting point, the varieties of eventual behavioral predispositions are not infinite. Thus, legal systems that might arise would not be infinitely malleable products of economics, accidents, path-dependence, efficiency, and infinite cultural variation in culturally contingent norms.

What bears explaining, then, is not only why the law is the way it is, but also why it is not more like the many other ways it could have been. We already know that there are some obvious constraints—political, cultural, economic, and even geographic—on probability. For example, it is very unlikely that a land-locked country would generate a well-developed law of the sea. But as we attempt to sharpen our sense of the deep structure of law, we must ask whether there are other forces at work, as yet unstudied, that can help us to better understand patterns and probabilities in law and nonlaw.

Behavioral biology is one of several disciplines that can help to reveal these comparatively unstudied and underappreciated forces shaping legal systems. Of course it is evident that such things as economic efficiencies, political developments, and path-dependent sociocultural contingencies contribute to the underlying architecture of law. But these proximate causes inevitably influence, and are influenced by, a distinctly human brain whose evolutionary history inclines us to react to and act in the world in various patterned ways.

Consider how the effects of evolutionary processes on the brains of beavers are inevitably reflected in the main features of beaver dams, even though each dam is constructed differently, accommodated to local topography and ecology. By analogous reasoning, the imprint of evolutionary processes on human neural architecture will be evident in the main features of legal systems, even though legal systems interact with an amalgam of locally varying religious traditions, ecological pressures, and political histories. In the complexities of human interactions, the veneer of cultural differences distracts us from our common evolutionary heritage.

Because this perspective suggests that the underlying architecture of law is likely to be common through the vast majority of human societies, we believe it provides a partial groundwork for a biolegal history—a bio-behavioral lens on worldwide legal history.[195] This is considerably easier

195. For more on the subject of biolegal history, see Jones, Proprioception, supra note 22. The argument advanced—that human biology affects human legal systems—builds on and extends a number of different pieces of argument trending in this direction. Among them are: Richard D. Alexander, Darwinism and Human Affairs (1979); Epstein, supra note 4; Frolik, supra note 4; Oliver R. Goodenough, Law and the Biology of Commitment, *in* Evolution and the Capacity for Commitment 262 (Randolph M. Nesse ed., 2001); Gruter, Law in Sociobiological Perspective, supra note 4; Gruter, Origins of Legal Behavior, supra note 4; Jack Hirshleifer, Privacy: Its Origin, Function, and Future, 9 J. Legal Stud. 649 (1980) [hereinafter Hirshleifer, Privacy]; Jones, Sex, Culture, and the Biology of Rape, supra note 150; A.G. Keller, Law in Evolution, 28 Yale L.J. 769 (1919); John O. McGinnis, The Human Constitution and Constitutive Law: A Prolegomenon, 8 J. Contemp. Legal Issues 211 (1997); Rodgers, Bringing People Back, supra note 4; Wilson,

to assert than to demonstrate, and our goal is to raise the issue, not to prove it. But Table 1 provides one way of thinking about it. The left side of the table lists some of the core concerns likely to emerge in social species as a product—in large measure—of evolutionary processes. The right side of the table lists the areas of law corresponding to those concerns. Note that many areas of law—property, contracts, torts, and criminal—constitute what we consider (in the United States, at least) to be core topics in any legal curriculum.

TABLE 1

Evolutionarily-Influenced Concerns	**Legal Features**
Private Resources (Goods; Territory)	Property Law
Exchanges (Goods; Services)	Contract Law
Non-Injury (Body; Resources; Reputation)	Tort Law
Security (Body; Family; Resources)	Criminal Law
Sex (Sexual Behavior)	Criminal Law; Family Law
Reproduction (Sexual Behavior; Mating; Childcare)	Family Law
Conflict Resolution (Domestic)	Family Law
Conflict Resolution (Intra-Group)	Procedural Law
Conflict Resolution (Inter-Group)	International Law
Health (Body; Environment)	Health Law; Environmental Law
Shared Resources (Natural Resources)	Environmental Law; Water Law
Relatives (Provisioning)	Estate Law

Not every legal system will reflect every one of these legal features. Some issues loom larger or play out differently in different cultures. Nonetheless, behavioral biology—and the insights it offers about the relentless effects of evolutionary processes on species-typical patterns of predispositions—provides ample support for believing that biolegal histo-

Impact, supra note 178; Margo Wilson & Martin Daly, The Man Who Mistook His Wife for a Chattel, *in* Adapted Mind, supra note 56, at 289.

ries connect the world's disparate legal systems together.[196] Those systems are different, but as closely related as are all human populations on the planet.

2. *Identifying Selection Pressures that Law Creates.* — In the prior subsection we discussed how evolutionary processes affected human brains and, through commonalities in those brains, contributed to the common architecture of human legal systems. Here we discuss how human legal systems themselves change environments in ways that change selection pressures. We turn first to the general case, in which laws change selection pressures on organisms that matter to humans, and then to the specific case in which laws may affect gene frequencies in humans themselves.

a. *Other Organisms.* — The effects of selection pressures can lead to very important changes in the world—regardless of whether policymakers are aware of them.[197] Failing to understand selection pressures can therefore render well-intentioned policies disastrous.

Consider fishing. It is obvious that fishing technology that is too efficient at catching fish can drive a population to extinction. So it might seem superficially appealing—even environmentally enlightened—to regulate the minimum dimension of the openings in fishing nets to ensure that while larger fish are caught, smaller ones will escape, the better for them to grow into big and reproductively capable fish later. This is actually a very poor solution. Such nets, which are widely used and tremendously efficient, create a strong selection pressure *against being big.*[198] So over time the average size of adults decreases, commensurate with the mesh of the nets. And then things get worse. As the average size of adults decreases, fish become reproductively active at a smaller size. Smaller females make fewer eggs. So the population size drops further than might otherwise have been predicted. In the end, regulations establishing minimum take size in fish create a fish population that is both smaller in number and smaller in average size.

Consider antibiotics. Antibiotics are used to kill hostile organisms. They also create a severe negative selection pressure on all bacteria—good, bad, and neutral—that are reproducing within a person's body. Whenever antibiotic treatment is stopped before *all* the hostile organisms are dead—or whenever it is overused, as it often is, to treat viruses rather

196. For constructive discussions of both the promise and limits of this approach, see Steven Goldberg, Evolutionary Biology Meets Determinism: Learning from Philosophy, Freud, and Spinoza, 53 Fla. L. Rev. 893 (2001) [hereinafter Goldberg, Evolutionary Biology]; Erin Ann O'Hara, Brain Plasticity and Spanish Moss in Biolegal Analysis, 53 Fla. L. Rev. 905 (2001); Stake, Pushing, supra note 91; Ulen, Evolution, supra note 24.

197. See, e.g., Stephen R. Palumbi, The Evolution Explosion: How Humans Cause Rapid Evolutionary Change (2001).

198. This selection pressure appears to have contributed to the gradually reduced size of Atlantic cod and Pacific salmon. For experimental confirmation of this effect, see David O. Conover & Stephan B. Munch, Sustaining Fisheries Yields over Evolutionary Time Scales, 297 Science 94 (2002); see also Carl Zimmer, Rapid Evolution Can Foil Even the Best-Laid Plans, 300 Science 895 (2003) (reviewing studies).

than bacteria—only the most antibiotic-resistant hostile bacteria survive, reproduce, and spread to other people.[199] The result is the emergence of strains of bacteria that are resistant to antibiotics. Thus, when many people misuse antibiotics, they can impose great externalities on others.

In both of these examples, the effects of selection pressures are finally becoming more widely understood, and different policies are at least being considered.[200] But the potential effects had long been more obvious to those with a basic understanding of evolutionary biology. If legal policymakers had earlier considered the selection pressures that policies can create (as in the fishing example) as well as the selection pressures that the absence of a legal intervention can allow (as in the antibiotics example), things might have been better sooner.

The Environmental Protection Agency has already gotten this message. It has, for example, an "Insect Resistance Management" (IRM) approach that applies to crops that have been genetically modified to be toxic to insect pests that feed on those crops. The concern about the potential evolution of insect resistance is heightened in the genetic modification context because an entire crop of toxic plants can create a much stronger selection pressure than does the necessarily uneven spraying of insecticides. It can therefore enable faster evolution of resistance. To reduce the likelihood that a future population of insects may evolve resistance to the features of the modified crops, the IRM requires among other things that there be a plot of unmodified crops planted near any modified crops. This increases the chances that insects vulnerable to the toxin will continue to proliferate and mate with any toxin-resistant insects. This in turn decreases the probability of potential pairings of toxin-resistant genes and thereby helps to decrease the chances of widespread resistance in that species.[201]

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199. See Madeline Drexler, Secret Agents: The Menace of Emerging Infections 119–57 (2002); see also Stuart B. Levy, The Antibiotic Paradox: How the Misuse of Antibiotics Destroys Their Curative Powers (2002).

200. See, e.g., Linda Bren, Battle of the Bugs: Fighting Antibiotic Resistance, FDA Consumer Magazine (Sept. 2003), available at http://www.fda.gov/fdac/features/2002/402_bugs.html (describing 1999 Public Health Plan to Combat Antimicrobial Resistance, developed by interagency task force); U.S. Food & Drug Admin., Dep't of Health & Human Servs., Antibiotic Resistance, at http://www.fda.gov/oc/opacom/hottopics/anti_resist.html (last visited Jan. 20, 2005) (on file with the *Columbia Law Review*) (providing background information and current news); U.S. Food & Drug Admin., Dep't of Health & Human Servs., Labeling Requirements for Systemic Antibacterial Drug Products Intended for Human Use (Feb. 6, 2003), available at http://www.fda.gov/OHRMS/DOCKETS/98fr/00n-1463-nfr00001.pdf.

201. See, e.g., U.S. EPA, Biopesticides Registration Action Document: Bt Plant-Incorporated Protectants (Oct. 15, 2001), available at http://www.epa.gov/pesticides/biopesticides/pips/bt_brad2/4-irm.pdf (on file with the *Columbia Law Review*); U.S. EPA, Pesticides: Regulating Pesticides: EPA's Regulation of *Bacillus thuringiensis* (*Bt*) Crops (May 2002), at http://www.epa.gov/pesticides/biopesticides/pips/regofbtcrops.htm (on file with the *Columbia Law Review*).

Notwithstanding laudable efforts at the EPA, however, our point is that broader familiarity with biological processes is necessary in the legal profession to better anticipate effects and consequences—intended or unintended—of legal policies. Legal policies can produce changes in gene frequencies that in turn affect heritable traits relevant to the policies that law is attempting to regulate. Seeing this is better than missing it.

b. *Humans.* — The foregoing naturally prompts a question about the potential effects of laws on human evolution. To be clear, neither we nor anyone of whom we are aware is suggesting that legal policymakers should affirmatively use laws to shape human populations. But can legal policies create unrecognized selection pressures on humans as an unintended by-product?

The answer is yes and no. The "yes" part concerns theoretical possibilities, because of the clear influence laws can have on survival and reproduction. The "no" part concerns practical limitations on the abilities of that influence to affect the frequencies of genes—particularly genes relevant to behavior—in material ways.

The obvious place to start concerns medical advances. These often affect the ability of individuals to survive as well as the ways in which individuals reproduce. Consequently, medical advances doubtlessly have changed gene frequencies in the past and will likely do so in the future.

Consider, for example, surgeries to repair the heart or excise malignant cancers, antibiotics that fend off deadly infections, and a host of other technologies enabling everything from eyesight correction to automatic and properly timed delivery of insulin. Consider contraception, fertility treatments, sex- and trait-selection technology, abortions to save the life of the mother, and abortions of fetuses with genetic abnormalities. All of these constitute aspects of an environment very different from that of even a mere thousand years ago. Legal policies, in turn, can importantly affect the development of and access to such medical technologies through such vehicles as science funding, intellectual property protection, healthcare regulation, and even the presence or absence of legal bans. To the extent these medical advances alter the likelihood of reproductive success of individuals, they can contribute to shifts in gene frequencies.

Laws can also change the social environments in which people live in ways that affect whether and how they reproduce. It is important to understand that, in theory, any legal decision that impacts the reproductive options available to people might lead to alterations in gene frequencies. A recent example, facilitated by changes in law in several places in the world, will make this obvious: The growing empowerment of women in developing countries to control their own reproductive lives will change the geographical distribution of some genes as the relative sizes of human populations in different parts of the world are altered. But to put the outcome in perspective, the impact on the *size* of the human population

is far more important than changes in human gene frequencies. In other words, law's principal impact on the evolutionary stage is likely to play out through the slowing of population growth, rising economic expectations, and continued alteration of ecological systems, as discussed in the preceding subsection on the effect of law on selection pressures.

The possible effects of law on changes in human gene frequencies require further discussion. First, the relationships between legal changes and characteristics of human reproduction are complex. For example, we develop asthma-reducing drugs alongside social, agricultural, and technological developments that exacerbate the incidence of asthma.

Second, affecting reproduction—even dramatically—does not necessarily lead to material changes in gene frequencies. One must attend to the degree of genetic variation within the population, as well as to the breadth and strength of the selection pressure—including both its consistency and the magnitude of the change in reproductive success—effected by a legal change. Human populations are very large, very mobile, and fairly homogeneous genetically. Moreover, most changes effected by law—at least in nontotalitarian regimes—are unlikely to create severe selection pressures. So the relationships between legal policies and selection pressures are likely in most instances to be subtle, and analytic techniques will need to be developed to assess sensibly whether concern is warranted.

Third, even identifying a selection pressure created by law provides no normative guidance on what to do about it. We elaborate further below why what is "natural" is in no way necessarily "good," and vice versa.[202] But the distinction between recognizing a selection pressure—and the possibly unintended consequences it may create—and manipulating it intentionally should not be underestimated. Ultimately, we are responsible for our actions.

Fourth, it is particularly unlikely that legal policies would meaningfully affect the distribution of heritable *behavioral* traits. In the past, for example, some have proposed a eugenic argument for the sterilization or incarceration of criminals with "bad genes." But there is little evidence to suggest, and little reason to believe, that criminal behavior arises because of small groups of people with mythical "genes for criminality" as distinct from "genes for law-abidingness."[203] The more accurate view is that criminal behavior arises from widely shared species-typical brains—built by

202. See infra Part IV.A.

203. Complex, contingent behavior is the work of minds that contemplate outcomes, weigh odds, sometimes consider consequences, and then make decisions. This is not simply the work of a subset of evolved genes. It is the work of individual brains with their own histories of development and experience. It is therefore important to distinguish the concept of genes for criminality from those mutant genotypes or developmental abnormalities that are associated with impairment of normal mental functioning and that may, in some cases, materially reduce responsibility for one's actions in the conventional legal sense.

gene/environment interactions—that have the *capacity* to exploit productive criminal tactics in situations that seem particularly advantageous. So long as those situations exist, so will the temptation to engage in behavior deemed criminal.[204]

3. *Highlighting Legal Changes Through Evolutionary Metaphor.* — To this point, our exploration of the uses to law of behavioral biology has attended to the literal effects of evolution on bodies, brains, and behaviors. Something should also be said, however, regarding the value of metaphorical uses of evolution in law.[205] In this subsection we first examine the scope of their value generally and then look at some of the ways in which the legal system may be said to evolve.

The word "evolution" is frequently used in everyday speech to convey the idea simply of change, or of nonrandom change.[206] Many such uses are casual; others are conventional. For example, military personnel frequently characterize military engagements as evolving. Astronomers refer to the evolution of stars, but here the meaning refers to a particular natural process. Likewise, biological evolution refers to another natural process.

Some popular uses are deliberately metaphorical, inviting comparisons with biological evolution. But when common or casual use does not correspond closely with biological evolution, it can create a false sense of familiarity that undermines an understanding of evolutionary processes that are based on changing frequencies of genes. We can illustrate the similarities and the differences between metaphorical and nonmetaphorical uses with an example from so-called "cultural evolution." Figure 2 provides a framework on which to visualize these ideas.

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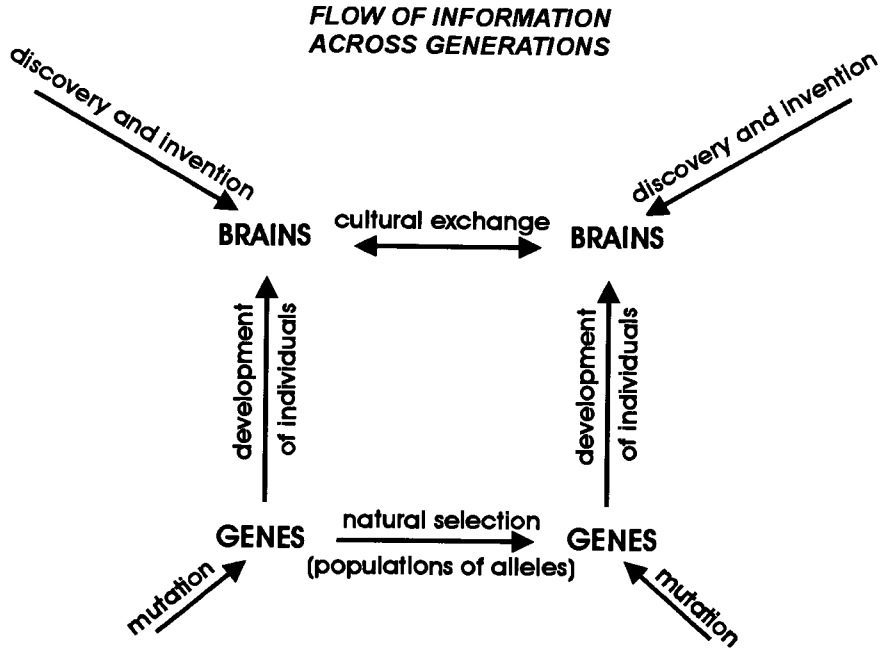
204. The issue of genetics may still arise in some contexts, however, such as when attempting to determine the extent of personal responsibility where a criminal defendant is congenitally mentally handicapped or suffers from a severe psychiatric disability.

205. "Evolution," in today's parlance, refers to at least three different things: (1) changes in the populations of living organisms over generations; (2) changes in nonliving things that vary over time (such as software); and (3) change generally (as in one's personality). The first meaning probably predominates, and we will here refer to the other two as metaphorical. Of course, reasonable people differ over whether (a) the principal meaning of evolution is biological, rendering nonbiological uses metaphorical, or (b) biological evolution is merely a subset of a larger corpus of evolutionary processes. The use of the word evolution reportedly predated Darwin by roughly two centuries, in both nonbiological and biological contexts. Nothing here, except perhaps the title of this subsection, turns on which of these semantic positions is preferred.

206. See, e.g., Janice Breen Burns, From Safari to Classic Style: The Evolution of a Politician, The Age, July 24, 2004, available at 2004 WL 86104082; Evolution of an Engine, Weston & Worle News, July 24, 2004, available at 2004 WL 61838270. In the year 2003 alone, the word evolution appeared in over 52,300 different news articles available in the ALLNEWS Westlaw database and over 3,800 different articles in the JLR database (law reviews and similar materials).

FIGURE 2: THE RELATION BETWEEN GENETIC AND CULTURAL INFORMATION AND THEIR TRANSMISSION ACROSS GENERATIONS[207]



Cultural features pass from generation to generation, and many change over time. What transfers across generations, however, is information—information that is the product of human minds. Some of this information is in the form of spoken or written words, some appears in physical objects that are products of human creation. Information can change in each generation, and subsets of information can be selected for further transmission, processes that also suggest a similarity with biological evolution. Packets of information providing the raw material for selection have been called "memes" to emphasize this similarity.[208] New information arises constantly through the creative powers of human minds, and minds can also select what information is best to propagate. Cultural change is therefore frequently goal-directed.

In biological evolution, in partial contrast, information is also transmitted from generation to generation, but only forward, in the direction of time. The information is in the form of physical entities—genes—and new information arises through mutation. Genes and their information

207. Modified from Goldsmith & Zimmerman, supra note 43, at 315.

208. Richard Dawkins, The Selfish Gene 206 (1976) (coining "meme"). The "meme" meme continues to this day. See generally Susan Blackmore, The Meme Machine (1999). Jeffrey Stake has continued the exploration of the relevance of memetic thinking for law, which he began in Stake, Buyers or Hosts?, supra note 4. See generally Stake, Pushing, supra note 91.

exist independently of human minds. The process by which information is selectively transmitted to the next generation is different as well. It is a filtering process in which those genes responsible for heritable features of the organism that increase the probability of the organism's reproductive success tend to increase in frequency—relative to alternative alleles—in succeeding generations. This process is not directed toward any goal, but neither is it blind chance. The nature of the filter is identifiable, and in each population of each kind of organism it is selecting on the basis of physical and behavioral traits that are statistically the most successful at enhancing reproduction. Because the creation of useful new information through mutation is a slow process in biological evolution, the rate of evolutionary change in humans is much slower than the rate of cultural change.[209]

The comparison of cultural change and biological evolution is interesting for an additional reason: There is a clear connection between the two processes. First, culture and cultural change are the products of minds, but minds are themselves biological entities that have both developmental and evolutionary histories. As discussed earlier in this Article, minds therefore create cultural features that reflect this evolutionary heritage.[210] Second, as we have also seen in the previous subsection, cultural change can also feed back on biological evolution. There are even historical examples of cultural practices that can change gene frequencies in human populations. For example, adult lactose intolerance is higher in societies that consume fewer dairy products.[211]

This discussion highlights an important point. Creating culture is one of the most dramatic manifestations of what it means to be human. The capacity for complex culture is made possible by two other features

209. To be more precise, the background rate of mutation is not inconsequential, but natural selection is efficient in selecting against mutations that are deleterious in the prevailing environment. Many mutations, however, are neutral in the sense that there is not a strong selection for or against them. One outcome is that natural populations of organisms contain genetic diversity, and in a changed environment selection may operate rapidly. The more complex the phenotype (the feature of the organism for which genes under consideration are responsible), however, the more genes are likely to be involved, and the more likely it is that a mutation in any one of these genes will not be useful and will be selected against. Thus the qualification in the text "the creation of useful new information through mutation is a slow process."

210. For interesting explorations of gene-culture coevolution, see generally Robert Boyd & Peter Richerson, Culture and the Evolutionary Process (1988); William H. Durham, Coevolution: Genes, Culture, and Human Diversity (1991); Peter J. Richerson & Robert Boyd, Not by Genes Alone: How Culture Transformed Human Evolution (2004).

211. On the effects of cultural practices on genes, see generally Durham, supra note 210. Regarding the milk example, see id. at 226–85; Frederick J. Simoons, The Geographic Hypothesis and Lactose Malabsorption: A Weighing of the Evidence, 11 Am. J. Digestive Diseases 963, 968–70 (1978); MedlinePlus, Lactose Intolerance (Dec. 25., 2002), at http://www.nlm.nih.gov/medlineplus/ency/article/000276.htm.

of our species: the capacity for language[212] and a "theory of mind."[213] But a comprehensive perspective also suggests that these features of humans, although likely unique among species, are the result of the natural process of evolution and are therefore, in a deep sense, part of our biology. This is another way of saying that biology means much more than genetics or physiology.

We turn now to the specific use of evolutionary metaphors in law. Among legal scholars, the metaphorical uses of evolution have ranged from the casual (as when someone mistakenly uses evolution as a synonym for progress) to the rigorous (as when someone highlights the effects of differential "reproduction" of statutory features on the overall development of statutory law).[214] As Elliott noted, the earliest metaphorical uses in law can be sorted into three categories, which emerged roughly in the following sequence.[215] Social theories of legal evolution, associated with thinkers such as Savigny[216] and Maine,[217] favor the view that as society changes, law changes correspondingly. Doctrinal theories of legal evolution, associated with thinkers like Holmes,[218] Corbin,[219] and

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212. See generally Steven Pinker, The Language Instinct: How the Mind Creates Language (2000).

213. "Theory of mind" means the capacity to recognize that others have minds with thoughts and feelings like our own. This feature of the brain is essential for the complex social arrangements that humans create. See generally Donald R. Griffin, Animal Minds: Beyond Cognition to Consciousness (2001); Peter Mitchell, Introduction to Theory of Mind: Children, Autism and Apes (1997). The phrase "theory of mind" is often attributed to David Premack & Guy Woodruff, Does the Chimpanzee Have a Theory of Mind?, 1 Behav. & Brain Sci. 515 (1978).

214. Indeed, as Elliott noted, "the idea that law 'evolves' is so deeply ingrained in Anglo-American legal thought that most lawyers are no longer even conscious of it as a metaphor." E. Donald Elliott, The Evolutionary Tradition in Jurisprudence, 85 Colum. L. Rev. 38, 38 (1985) [hereinafter Elliott, Evolutionary Tradition].

215. See generally id. (providing, among other things, an overview of the metaphorical use of evolution in law since the 1880s). In his article, Elliott also addressed a fourth and often nonmetaphorical use of evolutionary theory in law (of the sort discussed in Part III, supra), discussing the important contributions of A.G. Keller, Hirshleifer, Epstein, and Rodgers. See generally Keller, supra note 195; Hirshleifer, Privacy, supra note 195; Epstein, supra note 4; Rodgers, Bringing People Back, supra note 4.

216. See, e.g., Frederick von Savigny, Of the Vocation of Our Age for Legislation and Jurisprudence (Abraham Hayward trans., The Lawbook Exch. 2002) (1831).

217. See, e.g., Henry Sumner Maine, Ancient Law (Transaction Publishers 2002) (1861).

218. See Oliver Wendell Holmes, Jr., The Common Law (Dover Publ'ns 1991) (1881). Holmes is famously associated with this language:

> The life of the law has not been logic: it has been experience. The felt necessities of the time, the prevalent moral and political theories, intuitions of public policy, avowed or unconscious, even the prejudices which judges share with their fellowmen, have had a good deal more to do than the syllogism in determining the rules by which men should be governed.

Id. at 1. Elliott described additional bases for thinking Holmes's approach "evolutionary" in Elliott, Evolutionary Tradition, supra note 214, at 51–55.

219. See, e.g., Arthur L. Corbin, The Law and the Judges, 3 Yale Rev. 234 (1914).

Clark,[220] propose that legal rules, principles, and statutes themselves evolve. These theories emphasize the substantive patterns of changes in law, arising through the decisions of judges. Economic theories of legal evolution, associated with Rubin,[221] Priest,[222] and the team of Cooter and Kornhauser,[223] emphasize the process by which legal doctrines change through the economic decisions of litigants, analogizing the process to natural selection.[224] More recently, other scholars, such as Jeffrey Stake[225] and Michael Fried,[226] have begun exploring the possible uses in law of the meme analogue to the gene.[227]

There is thus a long history of legal scholars using evolutionary metaphors. Today, the wide variety of the more rigorous metaphorical and analogical applications of evolution defy reasonable summary in a work of this length.[228] The important point is that a great many of these uses—particularly those that employ an explicitly selectionist approach—have made manifestly valuable contributions to legal analyses. They do this by offering comparatively novel ways of explaining the present and predicting general future trends.

These perspectives, derived in part from knowledge or impressions of evolutionary processes, offer ways of looking at the legal landscape from a broader and more temporally rich perspective than do most con-

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220. See, e.g., Robert C. Clark, The Interdisciplinary Study of Legal Evolution, 90 Yale L.J. 1238 (1981); Robert Charles Clark, The Morphogenesis of Subchapter C: An Essay in Statutory Evolution and Reform, 87 Yale L.J. 90 (1977). In a related vein, see E. Donald Elliott et al., Toward a Theory of Statutory Evolution: The Federalization of Environmental Law, 1 J.L. Econ. & Org. 313 (1985).

221. See, e.g., Paul H. Rubin, Why is the Common Law Efficient?, 6 J. Legal Stud. 51 (1977).

222. See, e.g., George L. Priest, The Common Law Process and the Selection of Efficient Rules, 6 J. Legal Stud. 65 (1977).

223. See, e.g., Robert Cooter & Lewis Kornhauser, Can Litigation Improve the Law Without the Help of Judges?, 9 J. Legal Stud. 139 (1980).

224. For some recent commentary on these subjects, see generally Paul H. Rubin, Judge-Made Law, *in* 5 Encyclopedia of Law and Economics: The Economics of Crime and Litigation 543 (Boudewijn Bouckaert & Gerrit De Geest eds., 2000); Jeffrey Evans Stake, Status and Incentive Aspects of Judicial Decisions, 79 Geo. L.J. 1447, 1485–93 (1991); Todd J. Zywicki, The Rise and Fall of Efficiency in the Common Law: A Supply-Side Analysis, 97 Nw. U. L. Rev. 1551 (2003).

225. See generally Stake, Buyers or Hosts?, supra note 4. Stake offers additional uses for evolutionary analysis in Stake, Pushing, supra note 91, at 884–89 (including ways to use memetic analysis to better understand traditional doctrine and to develop new doctrine).

226. Michael S. Fried, The Evolution of Legal Concepts: The Memetic Perspective, 39 Jurimetrics J. 291 (1999).

227. Professor Jack Balkin has explored the utility of the meme metaphor beyond legal contexts in J.M. Balkin, Cultural Software: A Theory of Ideology (1998).

228. See generally, e.g., Oona A. Hathaway, Path Dependence in the Law: The Course and Pattern of Legal Change in a Common Law System, 86 Iowa L. Rev. 601 (2001); Rodgers, Environmental Law, supra note 107; Ruhl, Fitness of Law, supra note 4; Julie Seaman, Form and (Dys)function in Sexual Harassment Law: Biology, Culture, and the Spandrels of Title VII, 37 Ariz. St. L.J. (forthcoming 2005); Stake, Buyers or Hosts?, supra note 4.

temporaneous theories of legal change. In this they provide a valuable supplement to existing approaches. One of the principal strengths of evolutionary metaphors is that they enable commentary at a systemic level,[229] despite occasional shortcomings at the technical, mechanistic level. While it cannot be said that the value of the contribution necessarily depends on the accuracy of evolution's invocation, it is reasonable to assume that greater knowledge of evolution is positively even if imperfectly correlated with greater potential for valuable contribution. This is due, in part, to the fact that metaphorical models tend to rely on selection pressures, and selection pressures are perhaps best studied and understood within the life sciences.

IV. CAUSE FOR PAUSE: SOME CONCERNS ADDRESSED

Because our linkage of law and behavioral biology may arouse a number of concerns, we offer in closing a few words about what this approach is not, and what it does not imply.[230] In Part IV.A, we address an overarching concern about the blurring of boundaries between description and prescription, is and ought, explanation and justification. In Part IV.B we examine several specific issues to which assumptions or concerns about these boundaries are particularly salient.[231]

A. *The Realms of Fact and Meaning: Separating "Is" from "Ought"*

Whether at conferences or in conversation, each of us has regularly encountered concerns that what is "natural" or "biological" will come to be thought "good," or at least inevitable.[232] The tendency to link facts with meanings is not new; people have sought normative implications in natural phenomena for centuries. Nonetheless, our preferences in the normative world of meaning cannot create scientific facts, and the bare existence of facts cannot alone support any normative conclusions whatsoever. To put this more bluntly, description is not prescription, and ex-

229. See Elliott, Evolutionary Tradition, supra note 214, at 90–91.

230. See generally Jones, Evolutionary Analysis in Law, supra note 4; Owen D. Jones, Evolutionary Analysis in Law: Some Objections Considered, 67 Brook. L. Rev. 207 (2001); Owen D. Jones, Law, Evolution and the Brain: Applications and Open Questions, 359 Phil. Transactions: Biological Sci. 1697 (2004); Jones, Sex, Culture, and the Biology of Rape, supra note 150.

231. To our knowledge, the best single source for an overview of these and a variety of other concerns is Pinker, Blank Slate, supra note 21.

232. Typically, a person may be troubled because he or she tends to equate the biological with the good and therefore concludes that something obviously bad cannot be biological. Or a person may be troubled because he or she believes that third parties will believe that anything labeled biological is good—with obvious implications for efforts at social reform. Or a person may be troubled by the possibility that other people will—either from a failure to comprehend the situation clearly, or from a willingness to bend scientific messages to the purposes of political agendas—attempt to prop up unwelcome social edifices on biological foundations.

planation is not justification.[233] "Is" cannot alone support "ought-to-be" any more than an "ought-to-be" can alone create an "is." Arguments to the contrary have long been recognized as committing the logical error labeled the "naturalistic fallacy."[234]

One cannot move from facts to normative conclusions without passing through a prism of human values. Values arise, of course, from many social and political influences. And, perhaps confusingly at first, some values are themselves inevitably influenced by biological and evolutionary processes. But wherever values come from, it is clear that facts are never good or bad in themselves. What is natural, therefore, is never good or bad in itself—except to the extent that it is interpreted against a normative background that originates from somewhere else.[235] Reasoning that is blind to this axiom is both logically unsupportable and a recipe for trouble.

The potential benefits of folding some insights from behavioral biology into law can be significant, and we believe that some of the costs of doing so can be minimized by equipping all citizens to know the emperor's clothes when they see them. Such preparation greatly reduces some, though by no means all, of the concerns raised in the next subpart.

B. *Some Specific Concerns*

In this subpart we briefly discuss why a modern understanding of behavioral biology affords no legitimate support to genetic determinism, sexism, Social Darwinism/Social Spencerism, eugenics, or racism.

1. *Genetic Determinism.* — One of the most common concerns about the implications of behavioral biology appears under the label "genetic determinism" (sometimes "biological determinism" or "genetic essentialism").[236] Although there are some extremely useful treatments of the

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233. This is a point that one of us (Jones) has underscored in several articles, beginning with Owen D. Jones, Reproductive Autonomy and Evolutionary Biology: A Regulatory Framework for Trait-Selection Technologies, 19 Am. J.L. & Med. 187, 197 (1993), and most recently in Jones, Law's Leverage, supra note 22, at 1168.

234. The term was apparently coined by G.E. Moore in *Principia Ethica.* See G.E. Moore, Principia Ethica 90 (Thomas Baldwin ed., rev. ed. 1993). But the concept traces back to David Hume's *A Treatise of Human Nature.* See David Hume, A Treatise of Human Nature 469–70 (L.A. Selby-Bigge & P.H. Nidditch eds., Oxford, 2d ed. 1978) (1739–1740).

235. Relatedly, biology is neither inherently conservative nor liberal. Historically, biology appears to have been more readily, aggressively, and creatively invoked by those of conservative persuasions. See Peter Singer, A Darwinian Left: Politics, Evolution, and Cooperation 10–11 (2000) (describing the "right-wing takeover" of Darwin's ideas). Yet the opposite is often true. For example, eugenics policies were, counterintuitively, supported more enthusiastically by socialists and progressives than by conservatives. See Pinker, Blank Slate, supra note 21, at 153. For further discussion of the relationship between political views and affinity for Darwin's ideas, see generally id. at 283–305; Singer, supra.

236. See, e.g., Richard Lewontin et al., Not in Our Genes (1984); Steven Rose, Lifelines: Biology Beyond Determinism (1998); Stephen Jay Gould, Biological Potential vs. Biological Determinism, *in* Ever Since Darwin: Reflections in Natural History 251 (1977);

subject,[237] it has proven a difficult topic to lay to rest. There are at least three reasons. First, critics deploy the label more frequently than they define it[238] (although it seems generally to be associated with an unchangeable fate[239]). Second, third parties have tended to take at face value—without substantial documentary support—the critics' claims that such a notion is implicit whenever genes are invoked in a behavioral context.[240] Third, it is often unclear whether those who employ the phrase believe that behavioral biology (or some subset thereof) actually holds, finds, or assumes that genes determine behavior, believe that others will (even if wrongly) so believe to bad effect, or both.

If one were to assume—or to believe that others would assume—that genes actually control behavior, this would pose at least four challenges for law. First, it would suggest there is no free will, and that this inevitably means no legal or other responsibility for one's actions.[241] Second, it would suggest there is no freely determined morality on which to act, and on which to base legal programs. Third, it would suggest there is no real hope for changing human behavior, meaning that opportunities for social reform through law may be more limited than society would prefer. Fourth, it would suggest that various groups will inevitably be marginalized.[242]

These are all important matters. Yet most people who have studied the issue conclude that it is a fundamental misunderstanding of basic biology to ascribe to it the view that genes determine complex human behavior.[243] If anything, the basic view that neither genes nor environments determine behavior is iterated, reiterated, and re-reiterated endlessly in the biological literature.[244] Behavior arises from the activity of brains, which are in turn products of an *interaction* of genes and envi-

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Joan Vogel, Biological Theories of Human Behavior: Admonitions of a Skeptic, 22 Vt. L. Rev. 425 (1997).

237. See, e.g., Richard Dawkins, The Extended Phenotype: The Gene as the Unit of Selection 9–29 (1982) [hereinafter Dawkins, Extended Phenotype]; Pinker, Blank Slate, supra note 21, at 112–15, 174–85; Ullica Segerstråle, Defenders of the Truth 391–96 (2000); Kuklin, supra note 4, at 1163–82; see also, e.g., Ridley, Nature Via Nurture, supra note 53 (explaining why genetic determinism is an incoherent concept).

238. Pinker, Blank Slate, supra note 21, at 112; Michael Ruse, Evolution and Ethics, *in* Evolutionary Naturalism 223, 252 (1995).

239. Pinker, Blank Slate, supra note 21, at 112.

240. Segerstråle, supra note 237, at 391.

241. For discussion, see Pinker, Blank Slate, supra note 21, at 174–85; Segerstråle, supra note 237, at 390–93; Rochelle Cooper Dreyfuss & Dorothy Nelkin, The Jurisprudence of Genetics, 45 Vand. L. Rev. 313, 321, 327-33 (1992); Goldberg, Evolutionary Biology, supra note 196, at 902.

242. See generally Vogel, supra note 236; sources cited supra note 237.

243. See, e.g., Pinker, Blank Slate, supra note 21, at 112–14; Segerstråle, supra note 237, at 391; John Alcock, Unpunctuated Equilibrium in the *Natural History* Essays of Stephen Jay Gould, 19 Evolution & Hum. Behav. 321, 324–25 (1998).

244. Even from the beginning, concludes Segerstråle, many behavioral biologists "took pains to point out that the involvement of genes did *not* mean unchangeability of behavior." Segerstråle, supra note 237, at 391.

ronments that occurs during development and, indeed, throughout life. This is why it is a fundamental mistake to assume that "biological" and "genetic" are synonyms. Scientists have amply demonstrated that all biological processes, including normal development of the brain, ultimately depend upon rich environmental inputs. Similarly, sensory inputs are perceived, sorted, mentally analyzed, and understood through evolved brains that genes helped build.[245] So to claim that behavioral biology actually assumes or supports genetic determinism is to miss the central, modern message by a mile.

What then causes continued concern about genetic determinism? It probably arises from misunderstandings about modern biology,[246] disciplinary turf squabbling, and politically motivated mischaracterizations[247]—as well as from understandable sensitivity to obvious historical events in which biology was invoked for political purposes. At the same time, behavioral biology clearly does have something to do with genes, and some may feel that the essence of genetic determinism is when genes have a nonzero—even if incomplete—influence over human behaviors. For some commentators, the existence of multiple causes, none alone dispositive, undermines the idea that our choices are uncaused.[248] Because there is already an extensive literature on causes, free will, and the law,[249] we limit our response to two comments.

First, note that—as both Richard Dawkins and Steven Pinker have demonstrated—even if the influence of genes over behavior poses problems for free will, it poses no problem more troublesome than the

245. See, e.g., Plomin et al., supra note 58, at 90, 92 ("[H]eritability does not imply genetic determinism"; "[G]enetic influence on behavior involves probabilistic propensities rather than predetermined programming"; "Genetic influence on behavior is just that—an influence or contributing factor, not preprogrammed and deterministic.").

246. This can be traced, for instance, to the prevalence in popular culture of false dichotomies, such as those that pit nature against nurture, genes against environment, or genetic influences against cultural ones. See Segerstråle, supra note 237, at 3. A classic example is an argument pitting the "biological potentiality [of] a brain capable of the full range of human behaviors and rigidly predisposed toward none—against the idea of biological determinism—specific genes for specific behaviors." Gould, supra note 236, at 257–58. As Pinker aptly notes, these are not the real choices, nor are they the only alternatives. Pinker, Blank Slate, supra note 21, at 122. Misunderstandings can also be traced to shorthand terms of art. See, e.g., Dawkins, Extended Phenotype, supra note 237, at 18, 21; John R. Krebs & Nicholas B. Davies, The Evolution of Behavioural Ecology, *in* Behavioural Ecology 10–11 (J.R. Krebs & N.B. Davies eds., 4th ed. 1997).

247. On the extent to which differences in political views underlie the debates, see generally Segerstråle, supra note 237.

248. See, e.g., Goldberg, Evolutionary Biology, supra note 196, at 895.

249. See, e.g., Moore, supra note 24, at 350–65; Deborah W. Denno, Human Biology and Criminal Responsibility: Free Will or Free Ride?, 137 U. Pa. L. Rev. 615 (1988); Thomas A. Green, Freedom and Criminal Responsibility in the Age of Pound: An Essay on Criminal Justice, 93 Mich. L. Rev. 1915 (1995); Stephen J. Morse, The Moral Metaphysics of Causation and Results, 88 Cal. L. Rev. 879 (2000). See generally Neuroscience and the Law: Brain, Mind, and the Scales of Justice (Brent Garland ed., 2004).

influence of environments over behavior.[250] Put another way: Genetic determinism can be no more troublesome than environmental determinism, if determinism itself is the root of the concern.

Second, from among the four principal approaches to the problem of free will and determinism that scholars have identified—reconciliation by fiat, libertarianism, incompatibilism, and compatibilism[251]—we share the view of most moral philosophers that the last is the most sensible.[252] Namely, the existence of natural causes that underlie and influence behavior neither eviscerates personal responsibility for one's actions nor materially erodes freedom of thought, choice, and will. Put another way, the brain is responsible for behavior and the brain is a computational organ that works by material causes. It uses circuitry that is the result of both species-specific evolutionary history and individual assembly during development. It acquires information about the world through the sense organs, it stores information for later retrieval and use, it assesses new information against a backdrop of previous experience, and it actively contemplates consequences of behavior. From a practical standpoint, this processing of information is what is meant by free will. The challenge for law, then, is not to determine whether will is or is not binarily free, but to assess with all the tools at its disposal whether will was sufficiently free in a given circumstance for the legal system to impose the consequences that careful policy considerations suggest are appropriate. Recognizing that genes do not determine behavior renders this task less fraught with dire implications for moral and legal systems than is sometimes thought.

2. *Sexism.* — A major aim of behavioral biology is to achieve a better understanding of both the proximate causes of behavior—sensory, neuronal, genetic, hormonal, and the like—and of the ultimate evolutionary causes by which various patterns of behavior became species-typical responses to commonly encountered suites of environmental circumstances. This work focuses on how brains are built, how they operate, and why they came to incline us toward behaviors that solve problems common to the species, such as those associated with acquisition of nutritional resources, motor and language skills, and the capacity to thrive in social environments through cooperation, resolution of conflict, formation of alliances, and detection of deception.

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250. Dawkins, Extended Phenotype, supra note 237, at 13; Pinker, Blank Slate, supra note 21, at 185.

251. For a brief overview, see Goldberg, Evolutionary Biology, supra note 196, at 897–99.

252. Id. at 899 ("[C]ompatibilism appears to be the most widely supported view among moral philosophers today."). Among biologists who have considered the free will question, most appear to endorse compatibilism. See, e.g., Charles J.L. Lumsden & Edward O. Wilson, Promethean Fire: Reflections on the Origin of Mind 182 (1983); Michael S. Gazzaniga & Megan S. Steven, Free Will in the Twenty-First Century: A Discussion of Neuroscience and the Law, *in* Neuroscience and the Law, supra note 249, at 51.

Despite such evolved commonalities, human populations are not homogeneous. The existence of two sexes, for example, is important because sexual reproduction necessarily leaves males and females differently situated in ways relevant to the effects of evolutionary processes on behavior.[253] Furthermore, it is problematic because the process of discovering precisely how differently situated the sexes are, and what the implications of that might be, is conducted by humans who are themselves members of one sex or the other. This raises at least the possibility that the sometimes competing interests of the sexes may bias what is studied, what is discovered, how discoveries are interpreted, and how those interpretations lead to social, legal, and political changes.[254] This is one of the reasons that research into sex differences has attracted consistent attention from various feminist perspectives.

Feminism takes many forms. And within biology itself there are self-identifying feminists whose work both reconciles easily with the broad fundamentals of behavioral biology and also raises important feminist critiques of some aspects of biology.[255] So it is difficult to particularize about the relationship between feminism and biology,[256] particularly because a very great deal of behavioral biology has little or nothing to do with sex differences. But most of the general antisexism concerns might usefully be sorted into three categories.

First, there are concerns about methods. Some commentators question what we can ever really know from science, pointing out that true objectivity in scientific research generally, and in the biology of sex differences in particular, is probably impossible.[257] They raise concerns regarding what science is, the nature of knowing, and how anything put forward as a fact can be supported absent political agendas. Other commentators concerned with methodology have argued that research into sex differences, in contrast to research into other matters, dramatically

253. See supra Part II.B.2.

254. Some specific sex differences that biologists occasionally have assumed, or have claimed to have found, have been later called into serious question, narrowed, or dismissed. For example, it is now known that females in many species often play an even more active role in mate selection than was previously thought—often procuring offspring-rearing resources from one male while procuring genes for that offspring from another male. See Sarah Blaffer Hrdy, Empathy, Polyandry, and the Myth of the Coy Female, *in* Feminist Approaches to Science 119 (Ruth Bleier ed., 1986).

255. See Gowaty, supra note 21, at 1, 5. See generally Feminism and Evolutionary Biology, supra note 21.

256. See Anne Fausto-Sterling, Feminism and Behavioral Evolution: A Taxonomy, *in* Feminism and Evolutionary Biology, supra note 21, at 42, 49–50; Gowaty, supra note 21, at 1; Sue V. Rosser, Possible Implications of Feminist Theories for the Study of Evolution, *in* Feminism and Evolutionary Biology, supra note 21, at 21. See generally Feminism and Evolutionary Biology, supra note 21; Sex, Power, and Conflict, supra note 87. For an intentionally provocative view on these relationships, see Robert Wright, Feminists, Meet Mr. Darwin, New Republic, Nov. 28, 1994, at 34.

257. Caitilyn Allen, Inextricably Entwined: Politics, Biology, and Gender-Dimorphic Behavior, *in* Feminism and Evolutionary Biology, supra note 21, at 515.

increases the possibility, and indeed the occurrence, of unrecognized but incorrect gender-biased assumptions.[258]

Second, there are concerns about how research into and findings about alleged sex differences are reported in the media[259] and understood by the public.[260] Some are particularly worried about the ways in which news sources tend to sensationalize sex-difference findings. Others are particularly concerned that people lack a sufficient education in and understanding of the fundamentals of behavioral biology to be able to interpret results, or reports of results, in a fashion faithful to the underlying science.

Third, there are concerns focusing on the uses—social, economic, legal, or political—of sex difference literature. Some commentators believe, for example, that all such theories and findings will inevitably reflect and support political agendas,[261] potentially being used as "battle weapons against women,"[262] in order to maintain an inequitable status quo, erode progress into equality,[263] and support conclusions that males are inherently superior to females.[264]

All of these concerns are warranted because, in most cultures and throughout history, women have generally had less access to political power and resources than have men. In the United States, women did not receive the right to vote in national elections until 1920,[265] and for long periods of time (generally excepting wartime) married women were deemed categorically incompetent to contract on their own.[266] Such social asymmetries have frequently been "explained" by appeal to biological arguments. Obvious examples include the ways in which the exclusively female capabilities to become pregnant and nurse a child, assertions of female fragility, or presumptions of emotionality have played pivotal roles

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258. See, e.g., Marcy F. Lawton et al., The Mask of Theory and the Face of Nature, *in* Feminism and Evolutionary Biology, supra note 21, at 63, 69–81.

259. See, e.g., Allen, supra note 257, at 519–20.

260. Id. at 515–20 (expressing concern about how the "general public" and the "unsophisticated audience" will understand reported biology).

261. See, e.g., id.; Alice H. Eagly, The Science and Politics of Comparing Women and Men, 50 Am. Psychologist 145 (1995). Some commentators have even argued that research on sex differences should be discouraged. See generally, e.g., Richard D. Ashmore, Sex, Gender, and the Individual, *in* Handbook of Personality: Theory and Research 486 (Lawrence A. Pervin ed., 1990); Ray F. Baumeister, Should We Stop Studying Sex Differences Altogether?, 43 Am. Psychologist 1092 (1988).

262. J. Bernard, Sex Differences: An Overview 13 (1974) (quoted in Eagly, supra note 261, at 149).

263. See, e.g., Ruth Bleier, Science and Gender, *in* A Reader in Feminist Knowledge 249, 251 (Sneja Gunew ed., 1991).

264. See, e.g., Eagly, supra note 261, at 155.

265. U.S. Const. amend. XIX.

266. See Ward Farnsworth, Women Under Reconstruction: The Congressional Understanding, 94 Nw. U. L. Rev. 1229, 1251–52 & n.51 (2000). See generally Elizabeth Bowles Warbasse, The Changing Legal Rights of Married Women 1800–1861, at 273–306 (1987).

in restricting women's abilities to participate in the workforce.[267] In the legal profession, it was long possible to deny women a license to practice law on grounds that some, including a concurring Supreme Court Justice, rooted firmly in female biology and general appeals to "nature."[268]

Given this context, we offer these observations. Researchers need to exercise care in presenting findings on putative sex differences in order to minimize how their work can be exaggerated and distorted by others and to encourage consumers of scientific findings to be at least initially

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267. The proposition will not surprise readers. But a reminder may be useful. For example, in Muller v. Oregon, 208 U.S. 412 (1908), the Supreme Court affirmed an Oregon Supreme Court decision that labor and hour restrictions for women did not violate the Constitution; women were structurally weaker than men and needed special protection since they were capable of bearing children. In a striking passage, the Court said,

> The reasons for the reduction of the working day to ten hours—(a) the physical organization of women, (b) her maternal functions, (c) the rearing and education of the children, (d) the maintenance of the home—are all so important and so far reaching that the need for such reduction need hardly he discussed.

Id. at 419 n.1 (internal quotation marks omitted).

268. Bradwell v. Illinois, 83 U.S. 130, 139, 141 (1872) (Bradley, J., concurring). The Court held that the Fourteenth Amendment did not prevent Illinois from denying a woman a license to practice law on the basis of sex. The language of Justice Bradley's concurrence is sufficiently jarring to modern sensibilities that it is worth quoting at length:

> [T]he civil law, as well as nature herself, has always recognized a wide difference in the respective spheres and destinies of man and woman. Man is, or should be, woman's protector and defender. The natural and proper timidity and delicacy which belongs to the female sex evidently unfits it for many of the occupations of civil life. The constitution of the family organization, whicb is founded in the divine ordinance, as well as in the nature of things, indicates the domestic sphere as that which properly belongs to the domain and functions of womanhood. The harmony, not to say identity, of interest and views which belong, or should belong, to the family institution is repugnant to the idea of a woman adopting a distinct and independent career from that of her husband. . . . One [common law principle is] that a married woman is incapable, without her husband's consent, of making contracts which shall be binding on her or him. This very incapacity was one circumstance which the Supreme Court of Illinois deemed important in rendering a married woman incompetent fully to perform the duties and trusts that belong to the office of an attorney and counsellor.
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> It is true that many women are unmarried and not affected by any of the duties, complications, and incapacities arising out of the married state, but these are exceptions to the general rule. The paramount destiny and mission of woman are to fulfill the noble and benign offices of wife and mother. This is the law of the Creator. And the rules of civil society must be adapted to the general constitution of things, and cannot be based upon exceptional cases. . . . [I]n view of the peculiar characteristics, destiny, and mission of woman, it is within the province of the legislature to ordain what offices, positions, and callings shall be filled and discharged by men, and shall receive the benefit of those energies and responsibilities, and that decision and firmness which are presumed to predominate in the sterner sex.

Id. at 141–42 (Bradley, J., concurring).

skeptical of claims about both the nature and importance of male-female differences. Underlying assumptions require continuous reexamination.

On one hand, sex differences are "real" at the chromosomal and anatomical levels.[269] There is overwhelming evidence at both the theoretical and empirical levels, and across the animal kingdom, that evolutionary processes have led to divergences between the sexes in some behaviors relevant to human existence, such as propensities for physical aggression.[270] Thus, in contexts of parent-offspring conflict, aggression, sexual behavior, and the like, some sex differences can be relevant to law. On the other hand, history reminds us that some individuals and groups will appeal to presumed sex differences in order to justify particular social arrangements. As described in Part IV.B.1 above, it is essential that behavioral biology not be thought to provide normative support for particular legal outcomes. Only society can legitimate normative preferences.

3. *Social Darwinism; Social Spencerism.* — Darwinian reasoning, which recognizes natural selection as a major force in evolutionary processes, is but one of many components of behavioral biology. Moreover, there have been countless advances and refinements in evolutionary theory in the nearly 150 years since Darwin published *On the Origin of Species*. Nonetheless, the terms "Darwinian" or "Darwinism" are often used in casual ways that can mislead. For example, just as the term evolution is sometimes invoked as an importantly oversimplified but fancy synonym for "change," the term Darwinian is sometimes colorfully but imprecisely used as a synonym for "competitive."[271] The term "Social Darwinism" warrants special mention because it is particularly misleading and misnamed.

As is widely known among scientists and historians, Social Darwinism as an idea had little to do with Darwin, his writings, his thinking, or his approach.[272] The label "Social Darwinism" in fact is a largely retrospective epithet flung by more modern social reformers and historians against the repugnant but already dying or dead social philosophies of the British sociologist and philosopher Herbert Spencer.[273]

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269. See supra Part II.B.2.

270. For overviews, see Daly & Wilson, Homicide, supra note 47; Geary, supra note 179; Goldsmith & Zimmerman, supra note 43; Mealey, supra note 179; supra Parts II.B.2 and III.A.1.

271. See, e.g., Partington v. Broyhill Furniture Indus., Inc., 999 F.2d 269, 271 (7th Cir. 1993) ("Broyhill does not claim that Partington was dismissed because of poor performance, but rather as the result of a Darwinian struggle among three salesmen for two positions."); CBS v. Am. Soc'y of Composers, 400 F. Supp. 737, 767 (S.D.N.Y. 1975) ("Indeed the snippets of testimony on which CBS relies are replete with the Darwinian imagery of cutthroat competition among hungry publishers and writers . . . .").

272. See Carl N. Degler, In Search of Human Nature: The Decline and Revival of Darwinism in American Social Thought (1991); Eric Foner, Introduction to Richard Hofstadter, Social Darwinism in American Thought ix, xix (1992) [hereinafter Hofstadter, Social Darwinism].

273. Foner, supra note 272, at xix. On the "vogue" of Spencer generally, see Hofstadter, Social Darwinism, supra note 272, at 31–50; Richard Hofstadter, The Vogue of

Spencer was championing conservative laissez-faire politics in opposition to the welfare state before Darwin published *On the Origin of Species* and had already developed a "powerful critique of all forms of state interference with the 'natural' workings of society, including regulation of business and public assistance to the poor."[274] Although Darwin's scientific work was inherently a "neutral instrument" equally capable of supporting opposite ideologies (or none),[275] Spencer and his followers attempted to annex themselves to its scientific respectability.[276]

In Spencer's hands, Darwin's biology was warped and twisted to serve as justification for Gilded Age capitalism and individualism.[277] It was for this reason that Spencer's ideas became immensely popular among United States industrialists, such as John D. Rockefeller and Andrew Carnegie.[278] Darwin was invoked to buttress an already existing conservative outlook—that nature would ensure that the best competitors would win competitive situations—and to give the supposed force of natural law to an already rampant class struggle.[279] Spencer claimed that the distribution of rewards within society reflected individual merit, so that the less fortunate merely suffered the fate of their own failings. In arguing against governmental aid to the poor, he asserted,

> The whole effort of nature is to get rid of such, to clear the world of them, and make room for better. . . . If they are sufficiently complete to live, they do live, and it is well they should

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Spencer, *in* Darwin 489 (Philip Appleman ed., 1970). Among Spencer's more influential writings were Herbert Spencer, Social Statics (1851) [hereinafter Spencer, Social Statics] and his three-volume *A System of Synthetic Philosophy*. The term Social Darwinism reportedly originated in Europe in the 1880s and spread in the United States in the early 1890s. Foner, supra note 272, at xviii.

274. Foner, supra note 272, at xiv. It was Spencer—not Darwin—who coined (seven years before *Origin*) the phrase most commonly associated with Darwin: "survival of the fittest." Hofstadter, Social Darwinism, supra note 272, at 39 (citation omitted).

275. Hofstadter, Social Darwinism, supra note 272, at 201. For an argument that Darwinism can support the liberal left, see Singer, supra note 235.

276. Foner, supra note 272, at xiv.

277. Spencer's cultural evolution was directed toward a goal; natural selection has no goal. In nineteenth-century England, Spencer's "selection" was measured by economic success and was bound up with social class. Darwinian fitness has to do with reproductive success and is rooted in genetics.

Darwin himself was repulsed by Spencer's politics, and was acutely aware of how his ideas were being misrepresented. In a letter to Charles Lyell, he commented, "I have received in a Manchester newspaper a rather good squib, showing that I have proved 'might is right,' and therefore that Napoleon is right, and every cheating tradesman is also right." Hofstadter, Social Darwinism, supra note 272, at 85.

278. Pinker, Blank Slate, supra note 21, at 16. On the role of academic William Graham Sumner in amplifying these ideas in the United States, see Hofstadter, Social Darwinism, supra note 272, at 51–66; see also Foner, supra note 272, at xiv.

279. Hofstadter, Social Darwinism, supra note 272, at 6, 201; see also Foner, supra note 272, at xix.

> live. If they are not sufficiently complete to live, they die, and it is best they should die.[280]

Given this history, many believe that Social Darwinism, as it came to be known following its decline in the 1880s, is more properly known as Social Spencerism.[281] Regardless of what it is called, however, the idea that people always deserve whatever successes or short shrift they experience has properly been left on the scrapheap of history.[282] Social Spencerism provides a lasting testament to the errors that follow from facile, agenda-driven notions rooted in the naturalistic fallacy.

4. *Eugenics.* — Any discussion that combines human behavior, biology, and evolution may inspire concerns about eugenics.[283] Such concerns are not wholly unfounded. Decoupled from history and humans, eugenics is about achieving some set of characteristics deemed desirable through a process of selective breeding—in much the way racehorses are bred for speed, strength, and stamina. But eugenics in the human context, of course, cannot be meaningfully decoupled from the history and policies with which it has been associated. Revolutions in molecular biology and reproductive technology have served to augment concerns (about genetic enhancement, for example), and some have stretched the definition of eugenics to encompass these issues.[284]

Although the idea that the human race could be improved through selective breeding has been around at least since Plato,[285] the term "eugenics" was not coined until 1883, by the English scientist Francis Galton.[286] Eugenics came into vogue during the late 1800s, when the educated classes embraced it with all the enthusiasm afforded sciences today.[287] By the early 1900s, eugenic ideas were particularly popular in

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280. Hofstadter, Social Darwinism, supra note 272, at 41 (quoting Spencer, Social Statics, supra note 273, at 414–15).

281. Degler, supra note 272, at 11; see also Dorothy Ross, The Origins of American Social Science 85–91 (1991).

282. See, e.g., Joseph L. Graves, Jr., The Emperor's New Clothes: Biological Theories of Race at the Millennium 75 (2001) ("Today we know that [Spencer's] incorporations [of Darwin] were invalid; yet Herbert Spencer would have far more impact on American social thought than Darwin ever did.").

283. See, e.g., Vogel, supra note 236, at 430.

284. See, e.g., Tabitha M. Powledge, Toward a Moral Policy for Sex Choice, *in* Sex Selection of Children 201, 211 (Neil G. Bennett ed., 1983); Michael H. Shapiro, The Technology of Perfection: Performance Enhancement and the Control of Attributes, 65 S. Cal. L. Rev. 11, 46 n.110 (1991).

285. See Plato, The Republic, *in* The Portable Plato 281, 469–73 (Scott Buchanan ed., 1950); William T. Vukowich, The Dawning of the Brave New World—Legal, Ethical, and Social Issues of Eugenics, 1971 U. Ill. L. Rev. 189, 189.

286. Francis Galton, Inquiries into Human Faculty and its Development 17 n.1 (AMS Press 1973) (1907). Galton defined eugenics as "the study of the agencies under social control which may improve or impair the racial qualities of future generations physically or mentally." Harper Encyclopedia of Science 423 (James R. Newman ed., 1967).

287. See generally Elof Axel Carlson, The Unfit: A History of a Bad Idea 161–277 (2001); Daniel J. Kevles, In the Name of Eugenics: Genetics and the Uses of Human Heredity (1985) [hereinafter Kevles, Name of Eugenics].

the United States, where they not only had spawned a large number of eugenic societies, journals, and laboratories, but had also found expression in approximately 350 colleges and universities.[288]

American eugenicists helped obtain passage of the notorious Immigration Restriction Act of 1924,[289] which sharply reduced immigration of "undesirables" from Eastern and Southern Europe. By the mid-1930s, eugenicists had helped to motivate the passage—in nearly half the states of the Union—of the world's first compulsory sterilization laws.[290] The Supreme Court upheld such legislation as constitutional in *Buck v. Bell*, making famous the phrase "[t]hree generations of imbeciles are enough."[291] Pursuant to these laws, the states performed between thirty thousand and seventy thousand sterilizations of mentally retarded persons.[292] These sterilization laws, and ones like them in Canada and the Scandinavian countries,[293] provided the model for German eugenicists, who implemented a sterilization measure just before Hitler came to power.[294] Nazi officials quickly expanded their eugenic programs to further "purify" the Aryan race.[295]

Given this history, it is important to keep two points in mind. First, we are aware of no one who suggests that an accurate understanding of behavioral biology provides any justification for eugenics. The consensus among behavioral biologists is that it does not. Second, even if some society instituted a eugenics program, behavioral biology would provide no practical aid. This is partly because evolved behavioral predispositions are generally context-dependent, more likely to be manifest in some circumstances than in others, and frequently dependent on the personal history of each individual, even among people with personality traits that have significant heritability. And it is partly because there is currently very little knowledge of the complex developmental process by which multiple genes participate in the construction of a brain that is capable of generating specific behaviors in response to particular stimuli. Together, this would make eugenic efforts to select for complex behaviors excessively difficult.

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288. Kevles, Name of Eugenics, supra note 287, at 89.

289. Immigration Act of 1924, ch. 190, 43 Stat. 153 (repealed 1952).

290. Edward J. Larson, Sex, Race, and Science 18–29 (1995); Daniel J. Kevles, Vital Essences and Human Wholeness: The Social Readings of Biological Information, 65 S. Cal. L. Rev. 255, 263 (1991) [hereinafter Kevles, Vital Essences].

291. Buck v. Bell, 274 U.S. 200, 207 (1927) (Holmes, J.).

292. Philip R. Reilly, The Surgical Solution: A History of Involuntary Sterilization in the United States 94 (1991) (giving figure of at least sixty thousand); Elyce Z. Ferster, Eliminating the Unfit—Is Sterilization the Answer?, 27 Ohio St. L.J. 591, 594 (1966); P. Marcos Sokkappa, Comment, Sterilization Petitions: Developing Judicial Guidelines, 44 Mont. L. Rev. 127, 128 (1983).

293. Pinker, Blank Slate, supra note 21, at 16.

294. Kevles, Vital Essences, supra note 290, at 264.

295. See id. See generally Benno Müller-Hill, Murderous Science: Elimination by Scientific Selection of Jews, Gypsies, and Others in Germany, 1933–1945 (1988); Robert Proctor, Racial Hygiene: Medicine Under the Nazis 95–117 (1988).

5. *Racism.* — For someone who misguidedly believes in genetic determinism, advocates the politics underlying Social Spencerism, or believes the human species can and should be improved by a combination of positive and negative eugenics, the move into racism requires only a small step. For someone who already is racist, genetic determinism, Social Spencerism, and eugenics can become appealing because, through a racist lens, they appear to offer both justifications for existing attitudes and mechanisms for pursuing a racist's utopian dream. Either way, people have at times pressed caricatured versions of Darwin's ideas into racist service.[296] For example, the ideas have been invoked by racists in favor of white supremacy[297] and by those seeking justification for imperialist urges.[298] Moreover, arguments invoking supposed biological predicates of supposed racial differences, such as in the context of intelligence, have a long history and continue to reemerge.[299] And such arguments blend at the edges into other powerful social forces that have led to discriminatory policies, such as proscriptions against interracial marriage.[300] This is why, in part, it is difficult—and indeed should be difficult—to consider biology and behavior, on one hand, without pausing to consider the historical relationship of biology and behavior to race issues, on the other.

The evidence of past and continuing racism throughout the world serves as an important and constant backdrop to all science and policy regarding human behavior. Racism is the pervasive notion that people can be categorized by racial groups differing in definable physical traits as well as intellect and features of personality, that these traits are inherited, and (generally) that some racial groups are therefore inherently superior to others. Yet biology offers no support for the existence of discrete, genetically distinct populations of humans differing from each other in important ways.[301] Put simply, using standard definitions of modern biol-

296. See generally Pat Shipman, The Evolution of Racism: Human Differences and the Use and Abuse of Science (1994).

297. See generally Graves, supra note 282, at 74–85.

298. On the relationship between biology, racism, and imperialism, see generally Hofstadter, Social Darwinism, supra note 272, at 170–200.

299. See generally Graves, supra note 282, at 157–72. For example, the extreme right National Front in Britain has sought to base its views on biological foundations. "[W]e racialists declare that man and society are the creation of his biological nature. We insist . . . that genetic inheritance determines inequality. . . . We all know that differences between the races in the capacity for rational thought are explained by inherited differences in the physical structure of the brain." Richard Verrall, Sociobiology: The Instincts in Our Genes, 127 Spearhead 10, 10 (1979); see also Richard J. Herrnstein & Charles Murray, The Bell Curve: Intelligence and Class Structure in American Life (1994); J. Philippe Rushton, Race, Evolution, and Behavior (3d ed. 2000).

300. See, e.g., Loving v. Virginia, 388 U.S. 1, 12 (1967) (overturning proscription).

301. See generally Cavalli-Sforza et al., supra note 57, at 19–20; Eliot Marshall, DNA Studies Challenge the Meaning of Race, 282 Science 654 (1998); see also Graves, supra note 282, at 155–56; Olson, supra note 57, at 5; K.K. Kidd et al., Understanding Human DNA Sequence Variation, 95 J. Heredity 406, 407 (2004); Alan R. Templeton, Human Races in the Context of Recent Human Evolution: A Molecular Genetic Perspective, *in*

ogy races do not exist in humans. Because of geography (including latitudinal differences in sun exposure) and historical isolation, people differ in depth of coloration of skin and other superficial features such as the color and texture of the hair or the shape of the nose, but these features do not always vary together. In fact, and as Darwin himself concluded,[302] it is quite difficult to assign the world's population to discrete racial groups based on physical appearance. At the genetic level the human species is relatively homogeneous, exhibiting more variation within even small populations than exists between the major traditional racial groups.[303] There is no credible evidence for genetic differences in average cognitive capacity of humans from different parts of the world and from different cultures. Even the vast differences in technology appear to have historical origins in ecological advantages.[304]

In fact, there has been very little time in which evolutionary processes could have given rise to significant differences among localized human populations. The last hundred thousand years, the period during which modern humans have migrated over the earth from an origin in East Africa, is but a moment in evolutionary time.[305] Moreover, although natural selection is capable of producing large changes in short periods (given sufficient genetic variation), fast changes typically require strong differences in selection pressures that do not appear to have existed for humans. Instead, the social and other challenges confronting ancestral humans, such as finding mates, forming social coalitions, and procuring

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Genetic Nature/Culture: Anthropology and Science Beyond the Two-Culture Divide 234 (Alan H. Goodman et al. eds., 2003).

302. Darwin, The Descent of Man, supra note 75, at 214–50 (Chapter VII: On the Races of Man).

303. See generally sources cited supra note 57. Interestingly, there is sufficient variation in minor traits that variants of common genes have been used to track the likely paths of movement since *Homo sapiens* migrated out of Africa. This work is based on polymorphisms in genes for blood antigens and other proteins. A polymorphic gene exists in a population as a suite of alleles of a single gene. In this instance the polymorphisms arose from mutations that predate modern humans' migration out of Africa. The present-day geographic variation in the frequencies of the different alleles can therefore be used to track the history of human movement over the surface of the earth during the last 100,000 years. See generally L. Cavalli-Sforza & F. Cavalli-Sforza, The Great Human Diasporas: The History of Diversity and Evolution (1995).

304. See generally Jared Diamond, Guns, Germs, and Steel: The Fates of Human Societies (1997).

305. Race and sex are different in this respect. As described in the text, the small differences among individuals that have been used to classify races could only have arisen within the last 100,000 years. By contrast, sexual reproduction and associated differences between the sexes are much older. Fossil embryos in early stages of development that reveal fertilized eggs and are essentially identical to embryos of animals living today have been dated to 570 million years ago. Most groups of multicellular organisms reproduce sexually (for example, all mammals), and morphological and behavioral differences between the sexes are common. The earliest evidence for multicellular organisms is 1.8 billion years old. Carl Zimmer, Evolution: The Triumph of an Idea 66–68 (2002). Sex differences have therefore existed for roughly 6,000 to 20,000 times longer than the superficial differences ascribed to human races.

reproductively important resources, are generally thought to be widespread rather than localized in ancestral populations, just as they are among current ones.[306] There is, in any event, little empirical evidence to suggest material differences among human populations in cognitive abilities,[307] and there is no evidence that low-technology cultures are unable to capitalize on innovations when they have the opportunity and perceive it to be to their advantage. Historically, the pace of change has usually been determined by cultural forces, frequently imposed by colonial powers with their own agendas and racist views.

There is a second aspect of racism that needs to be discussed within the framework of behavioral biology. The component of racism that asserts that the believer's group is superior to other groups is far older than any of the latter-day rationales for this behavior that have been cast in the language of "Darwinism" or "genetics." Intergroup conflict has likely been important during human evolution,[308] and it remains a significant feature of today's world.

It is a common experience that people tend to see value in their group and frequently harbor unease or suspicion in the presence of individuals whose appearance or behavior is unfamiliar. It is a short step from there to invidious comparisons with other groups. Groups can be defined by family, religious belief, nation-state, presumed racial identity, or other features, real or imagined. But when the groups come into actual conflict, there is usually some underlying issue of control of resources—often propelled by the group leaders' perceptions of interests—and group identity becomes a label for unity of support. None of this is inevitable, but it is simply common enough to open the question of why the human mind behaves this way with such regularity. This question is seldom asked and, when it is, it frequently devolves into a meaningless debate about genetic determinism. If we are correct that evolution has shaped the mind to evaluate self-interest in a context of group identity, then there is a compelling argument for expanding humanity's sense of group identity. This is bardly a new idea, and it is the basis for resolving conflicts that lie within the reach of legal systems, but the larger the groups, the greater the obstacles become.

306. Written records are relatively recent, but they demonstrate that the human brain's capacity to recognize and deal with social problems is unchanged as far back as written accounts extend. Furthermore, human conceptions of the world, although enormously varied, are equivalently complex wherever they are encountered. See generally Pascal Boyer, Religion Explained: The Evolutionary Origins of Religious Thought (2001).

307. See Diamond, supra note 304, at 19–22, for further discussion.

308. See Lawrence H. Keeley, War Before Civilization 36–39 (1996); Steven A. LeBlanc, Constant Battles: The Myth of the Peaceful, Noble Savage 219–21 (2003).

C. *Balancing Risks*

For many of the issues raised in Part IV.B, scientific education and careful scrutiny of purported links between science and politics would lessen the risks of behavioral biology being misused. An uneasy reader, however, might note that we have not demonstrated how such improved education and vigilance can be brought about. The reader might therefore conclude that although this Article makes good points about the potential utility of behavioral biology to law, the potential risks might outweigh the expected benefits. To this challenge we cannot offer a dispositive refutation. It is indeed possible that a particular application of science will be misconstrued.

Yet to reject the advancement of human knowledge—with its associated improvements of the human condition—based on such a risk would be self-defeating. Science promises an unpredictable future, yet futures are inevitably unpredictable. For centuries society has accepted the uncertainties and difficulties along with the benefits of new discoveries, sometimes in haste and with unanticipated consequences, sometimes in the face of objections and fears from portions of society. We cannot claim that behavioral biology as applied to law will inevitably improve society. We must in the end state simply that, as scholars, we believe that more knowledge is better than less, and that society should apply *sensibly* the tools and understandings science provides.

CONCLUSION

Society uses law to encourage people to behave differently than they would behave in the absence of law. This fundamental purpose makes law highly dependent on sound understandings of the multiple causes of human behavior. The better those understandings, the better law can achieve social goals with legal tools.

Current understandings, tbough clearly improving, are imperfect in a variety of ways. One imperfection accompanies the prevalent, often unexamined assumption that law can gain accurate and sufficient understanding of human behavior by using only the tools of the social sciences, the humanities, or both. Every day we leave further behind a world in which that assumption was excusable. Knowledge in behavioral biology is growing rapidly, and it has laid a significant foundation for understanding how the brain works and how it came to work as it does. It affords a deeper understanding of what behavior is, where it comes from, what evolutionary and developmental causes underlie species-typical brains, what influences yield species-typical patterns of behavior, how the brain develops at the temporal intersection of genes and environments, how the brain functions, and bow evolutionary biology and culture inevitably intertwine, reciprocally affecting one another.

To be clear, we have not suggested that behavioral biology deserves a place at the head of the table. Nor are we claiming that it will solve every

problem. We have argued, instead, that trying to understand behavior at any deep level, while simultaneously ignoring an enormous and growing store of relevant scientific information, is a path to certain obsolescence. We have argued that building more accurate and more robust models of human behavior that can improve law's effectiveness requires integrating traditional perspectives with perspectives from behavioral biology. And we have argued that this is an interdisciplinary enterprise in which legal thinkers should participate.

Specifically, we have attempted to contribute to the growing body of legal scholarship that explores the uses of behavioral biology and the advantages of evolutionary analysis in law. We have offered a broad vision of the many ways that knowledge of readily accessible fundamentals of behavioral biology can be useful to legal thinkers. By helping to improve law's behavioral models, behavioral biology can aid efforts to increase law's effectiveness and efficiency. In doing so, behavioral biology promises to help discover useful patterns in regulable behavior, uncover policy conflicts, sharpen cost-benefit analyses, clarify causal links, increase understanding about people, provide theoretical foundation and potential predictive power, disentangle multiple causal influences, expose unwarranted assumptions, assess comparative effectiveness of legal strategies, reveal deep patterns in legal architecture, identify selection pressures that law creates, and also usefully highlight legal features through evolutionary metaphors. Any one of these functions, standing alone, could justify greater attention to behavioral biology. Taken together, they make a geometrically stronger case.

APPENDIX A

FIGURE 3: GENES AND ENVIRONMENT IN THE GENERATION OF BEHAVIOR

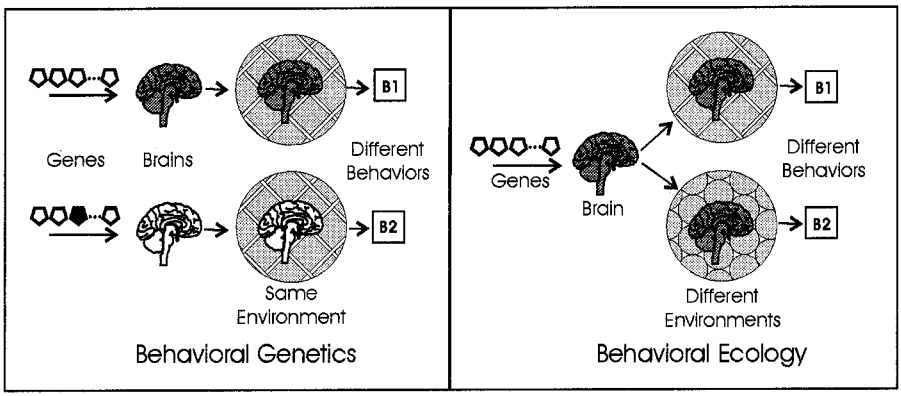

Figure 3 captures several important principles about genes and behavior. As both panels suggest, genes contribute to the formation of the brain during development of each individual animal, human or otherwise. As the left panel indicates, a mutation in a gene can lead to a brain that manifests a different behavior, even when exposed to a common environmental stimulus. Behavioral geneticists are interested in understanding the roles of specific genes in the brain's generation of behavior. This diagram is not meant to suggest that specific genes cause specific behaviors. In such a complicated organ as the brain, single mutations generally cause some abnormality. Nevertheless, over evolutionary history, mutations are essential for creating the genetic variation on which natural selection can act.

The right-hand panel shows another outcome: A brain, or even all members of the same species sharing a common genetic heritage, may generate alternative but predictable behaviors when confronted with two different environmental conditions. This observation, by itself, does not tell us anything about the interplay of genes and environment—internal and external programming—that is required during development for the brain to possess these properties. At one extreme the animal may learn to make different responses to different environmental challenges, or alternatively, what is likely to be learned may be itself channeled by evolutionary history. At the other extreme, the animal may respond in an adaptive way to different environmental conditions without the involvement of any learning whatsoever. These forms of flexibility are studied in humans by psychologists and in other animals by behavioral ecologists and others.

APPENDIX B

By agreement of the authors, the *Columbia Law Review*, and the Society for Evolutionary Analysis in Law (SEAL), some material originally appended to this Article has been separately published on the SEAL website at http://www.sealsite.org and will also remain accessible through Professor Jones's website at http://law.vanderbilt.edu/faculty/jones.html.

That material includes, among other things, brief overviews of fundamental principles of behavioral biology, as well as recommendations for further reading. The advantage of this arrangement over printing is that the material can be updated.