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Economics and the Biologists: A Review of Geerat J. Vermeij's *Nature: An Economic History*

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This essay reviews and criticizes Vermeij's Nature: An Economic History *and places it in the context of evolutionary economics. Vermeij presents a natural history written in what he considers economic terms and argues that biologists should know more about economics. While the exchanges between economics and biology can sometimes be hazardous and misleading, quite a bit could be learned by economists from reading this book.*

Economic science has always had symbiotic relationships with other disciplines. From the fruitful marriage with classical physics in the works of Leon Walras and Alfred Marshall, to the adoption of formal techniques from mathematics and engineering, to the growing interest in experimental methods borrowed from psychology, interdisciplinary spillovers and recombinations of economics with other disciplines have been common. Economics has exported as much as it has imported, enriching sister social sciences and history with its insights. Its relationship with biology has been more of a problem. Despite repeated calls that economists and biologists should interact, not much seems to have been done in this regard. The best-known of these efforts have been attempts by economists to adapt an evolutionary perspective to a variety of economic entities, such as Richard Nelson and Sidney Winter's seminal 1982 book. Many other attempts to use evolutionary theory in economics have been made, although few economists have actually invested heavily in the study of evolutionary biology.[1] There are two journals dedicated to this kind of economics, the *Journal of Evolutionary Economics* and the *Journal of Bioeconomics*.[2] After all, many economists feel intuitively that it makes sense to look at the economy as an evolving entity in which firms and individuals compete for resources and are subject to differential survival and thus to "natural selection." Many issues remain unresolved, and while there is an active subfield (or should we call it a "niche?") of evolutionary economics with its own organization and a serious literature, much of the profession has not found a good

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[1] One notable exception is the work of Geoffrey M. Hodgson. See, for example, Hodgson (1995) and Hodgson (2005) for a summary of many of the issues at stake.

[2] For some recent notable contributions, see Jack J. Vromen (1995), Nelson (1995), Ulrich Witt (2003), and Kurt Dopfer (2005).

way to make an evolutionary approach to economics operational.

The idea of a useful conversation between the two disciplines has a venerable pedigree. Marshall (1930 [1890], p. xiv) famously felt that biology, not physics should be "the Mecca of Economics"—through he did little more than apologize for subsequently going to the Medinah of comparative statics. More than a century after Thorstein Veblen (1898) wrote his classic essay "Why Economics Is Not an Evolutionary Science," it has not lost its basic appeal. Many traditional neoclassical economists "feel" that they should be importing some of the concepts of evolutionary science, but even with some important exceptions, such as in evolutionary game theory (e.g., Herbert Gintis 2002, ch. 7) and in recent growth theory (Oded Galor and Omer Moav 2002), it still has not made it to the mainstream of economics. It simply has turned out to be difficult to operationalize evolutionary theory in what most of economics is about.

This is not to belittle the work that has been done in evolutionary economics. Following Nelson and Winter's seminal opus, a flurry of work, much of it originating in Europe, has tried to create a new paradigm that sets itself apart from what its authors call "neoclassical" economics. This is a mode of analysis that eschews equilibrium analysis, and that takes its inspiration from evolutionary biology and nonlinear open systems in physics rather than classical analysis. It recognizes that all economies have a past and that the past constrains the choices open to the present. It emphasizes not only the optimal choice from a menu, but also the need to understand how the menu was written in the first place and why some things that could be on the menu are not. It is suspicious of "representative agents" or "firms" and instead finds the variance in the distribution, often significantly referred to as "diversity," more interesting as the source of creativity and progress. It cites Joseph Schumpeter and Nicholas Georgescu-Roegen rather than Kenneth Arrow or Paul Samuelson, and is more occupied with concepts such as knowledge, technology, and "dynamic change" than with traditional microeconomic equilibrium analysis. It has had some important achievements, but displacing the "neoclassical paradigm"—whatever one might mean by that—has not been one of them.[3] Such a project would have been foolhardy. If anything, evolutionary and neoclassical economics are complements, not substitutes, addressing different questions. The success of the evolutionary brand of economics will be judged in the end by how well it picks the topics in which it seems to have a comparative advantage and whether it does better in them than the "standard" approach.

One indication of how limited the success of evolutionary economics has been is the paucity of application of evolutionary economics to historical issues. If evolutionary economics should have appeal, it might be first and foremost among economic historians. If this mode of investigation appeals to scholars interested in the historical evolution of economies and firms, it should be expected that economic historians would be the first to embrace an economic doctrine that unambiguously places history at the center of economic analysis. After all, can one imagine evolutionary biology without natural history and paleontology? Yet this has not happened. To be sure, some historical work, especially in the economics of technological change, has been influenced or inspired by evolutionary concepts, but a full-fledged evolutionary theory, comparable to standard tools of economics such as partial and general equilibrium, political economy, and game theory has not emerged to enlighten the work of economic historians.[4]

[3] For some of the most notable examples of this research, see J. Stanley Metcalfe (1998) and Witt (2003).

[4] On the other hand, in the history of technology and science there is a serious attempt to apply concepts of evolutionary biology. See, for instance, Walter G. Vincenti (1990), Joel Mokyr (1990), and many of the articles in John Ziman (2000).

Geerat J. Vermeij, a distinguished biologist, feels that the flow of trade should be reversed: natural history should import the concepts of economics, not the other way around. The world of living beings, he notes, is a world of scarcity, of competition, of exchange, of opportunity costs, but also one of organization, of technology and innovation, of growth, of changes in productivity and efficiency. He has written a learned and detailed book, subtitled "An Economic History." It is, however, quite clearly *not* a book of economic history that any practitioner of that fields would recognize unless one was deeply interested in the economic history of mollusks or arthropods. It is a book about the history of the world of living beings, written in economic terms. It is above all a book that seems aimed at Vermeij's fellow biologists, who are admonished to look at economic concepts—at least as Vermeij perceives them—to deepen their understanding of how the natural world evolves. The idea that biologists should learn from economics is not altogether new. Charles Darwin himself, after all, famously wrote that he hit upon the idea of natural selection after reading Thomas Malthus's *Essay on Population*, the quintessential statement of scarcity in a dynamic context. Without a binding constraint of population pressure, natural selection is deprived of its main mechanism, and while there can still be change or "evolution," it will not be Darwinian in nature (Michael Ruse 1986, p. 24). The theory of natural selection is, of course, closely related to Adam Smith's idea of an invisible hand, which through uncoordinated competition amongst individuals struggling for their own benefit, created a higher order.[5] Thirty years ago Michael T. Ghiselin (1974, ch. 4), a noted biologist, made an argument similar to Vermeij's and called for a more serious use of concepts from economics in the study of natural history. Vermeij's book is more up-to-date, with an emphasis on historical phenomena and thus far more wide-ranging, but he would surely agree with Ghiselin's statement that "the value of analogical reasoning can scarcely be overestimated . . . evolutionary principles may be generalized, allowing us to apprehend a far greater unity among natural phenomena than has hitherto been possible" (Ghiselin 1974, p. 9).

In a series of magisterial chapters full of fascinating details about the history of living beings, Vermeij outlines his "economic" view of nature. Many of the concepts seem at first blush to carry over without much difficulty: among many others, inequality, competition, efficiency, and consumption, he maintains, find close analogs in nature. Economic as well as biological systems are subject to "disturbances" (economists would call them "supply shocks") that lead to adaptation, migration, or extinction. Indeed, in one amusing instance, he seems to have independently discovered real business cycles when he maintains that "recessions" result from exogenous shocks to productivity (p. 204). Terms such as "phenotypic plasticity," in which an organism can adapt to a changing environment without changing its genetic make-up, will be recognized by economists as the analog of substitution (p. 74). Whether the toolkit he proposes will be useful to other biologists or not, Vermeij's astonishing knowledge of the world of living beings serves him as an inexhaustible reservoir of examples that he adduces to illustrate the "principles of economics"—as he sees them—at work in the biosphere.

The question that this books needs to face is whether the similarities between economics and biology reflect the fact that the same basic forces are at work in the history of life on this planet and the history of human economies, or whether these are superficial resemblances at worst and metaphors and analogies at best. Vermeij makes the best

[5] Stephen J. Gould (1980), who points this out, adds caustically that "Darwin may have cribbed the idea of natural selection from economics, but it may still be right" (p. 68).

case possible for the former: in all aspects of biology he sees economic principles at work and, whenever he can, he uses economic terminology. At times this seems a bit stretched (for instance, a section entitled "plankton and the consumer age" (p. 261)), but on the whole this seems to a nonbiologist a helpful method of analyzing nature. Both the competitive economy and the world of living beings are decentralized systems in which uncoordinated individuals make decisions based on their needs, preferences, or instincts, but in which nonetheless there is order of sorts and trends emerge. Competition, Vermeij argues, is a ubiquitous phenomenon, both in biology and in economics. In both cases, success is measured in terms of what he calls "performance," which he defines as the surplus available beyond mere survival, available for growth, reproduction, or consumption. This concept is quite similar to the idea of a surplus above subsistence, central to the analysis of economies in the long run.

Even technological progress can be readily found in nature. Vermeij tells us (p. 117) that agriculture was invented ten times, nine of which involved fungus-farming insects which grow their crops in galleries and mounds, improving growing conditions by fertilizing and protecting the crops from predators. Symbiosis between different species (such as the pollination of plants by insects) are equivalent to mutually beneficial exchange relations in society (p. 47). Above all, what nature and economics share is the budget constraint and the pervasive idea of opportunity costs. To that Vermeij adds that in neither nature nor the economy are there perfect solutions, and that true optimality is rarely if ever achieved and that both systems are conservative in that there is a great deal of resistance to change (p. 48), a process known as "canalization" (Jack Cohen and Ian Stewart 1994, p. 92). Systems settle down when they are "good enough" to survive, which is not to say that they are perfect. To be sure, human decisions are conscious whereas the "selection" in natural selection is metaphorical, but Vermeij (p. 55) feels that there is a "seamless transition" between the two. Adaptation, as he sees it, involves the formulation and testing of hypotheses about the environment (and presumably the ability to do something about them).

Not all analogies are equally persuasive. No more than any of his predecessors does Vermeij resolve one of the central difficulties in an evolutionary approach to economics: what is the appropriate "unit" on which selection occurs, much like the "specimen" in nature? Some economists, following Armen A. Alchian's (1950) classic paper, have proposed that selection occurs on firms. More recent work, such as Nelson and Sidney Winter (1982) and Mokyr (1990), have proposed that selection occurs at the level of a unit of knowledge or technique. The problem is that there is no obvious analog to "species" or any higher classes of entities in these units. Units are neither "born" nor "die" in the way living beings do, nor is it clear how an entity goes extinct. Vermeij's proposed solution (p. 44) is to liken a species to human occupations, but this analogy sounds lame and mercifully Vermeij relies on it nowhere else in the book. Equally serious for those who try to fit every concept of biology in the straightjacket of economic homologies is the lack of the concept of "generation." Biological evolution works because genetic information is transmitted from generation to generation, or "descent with modification" as the standard definition of evolution goes (p. 2). But in human economies the concept of "descent" or a generation is not easy to define. One might also raise some eyebrows regarding the use of the term "technology" to describe (p. 47) organic architecture, which allows living beings to convert energy and materials into biological work. Technology evolves in nature, he explains, through natural selection whereas human technology evolves through the decisions of engineers and market forces. Some animals, to be sure, use some tools, but these are but differences of

degree, in Vermeij's view. This approach, however, seems to avoid the fundamental difference between the two, which is that human technology is the result of *knowledge*, that is the conscious realization that there are regularities in nature that can be exploited. No such consciousness exists in nature, although of course all life is based on behavior that involves "as if" type of actions.

Do such quibbles about the analogies matter to the basic idea that the worlds of natural history and human history are in many ways similar? What should be recognized is that evolution is bigger than either biology or economics (Geoffrey M. Hodgson and Thorbjørn Knudsen 2005). It is a pervasive property of all systems that have a history, a budget constraint, and in which the process that generates innovation is stochastic (Daniel C. Dennett 1995). Language, religion, and culture can and have been viewed in the same way, most famously in Richard Dawkins's "memes." Vermeij is quite right, then, in recognizing that they are subject to similar principles, but fails to stress that biology itself is a very special case of evolutionary systems—one in which inheritance takes places through a one-shot transmission of genes, one in which a specimen gets its features from at most two parents, and one in which species can be defined, at least practically if not always precisely, by reproductive incompatibility. In general, however, evolutionary systems can be compatible with information flowing in many directions and do not depend on strict limits to species and generations. The literature of cultural evolution is a good example of such models (Robert Boyd and Peter J. Richerson 1985).

A good example of the fascinating way in which Vermeij thinks is the chapter on the role of exogenous shocks, or "disturbances" as Vermeij calls them. Evolution and adaptation are not the only forces in determining historical outcomes, they may not even be the primary ones. Equally important are exogenous changes in the environment in which life occurs. Some such changes are brought about through the activities of life itself and can thus result in feedback loops that determine the characteristics of the trajectory and possibly its outcome. But some catastrophic shocks are purely exogenous, such as collisions with celestial bodies or volcanic events. Economic history is full of similar events, such as the invasion of the American continent by European "explorers." These explorers did for the indigenous populations what the meteorite that slammed into Yucatan at the end of the Cretaceous did for about 50 percent of all species living on the planet, including the dinosaurs. But as Vermeij points out, there are "bottom-up" extinctions in which "primary production" is interrupted and the habitat of species is altered faster than they can adapt or migrate, and there are "top-down" extinctions in which a more adapted species drives a weaker competitor out of the game. These top-down extinctions, he feels, have become more typical of recent evolution, due primarily, of course, to the activities of homo sapiens.

In its last two chapters, the book takes an unambiguous position on the long debate of whether or not the history of life on this planet displays a significant trend, one that we might call progress even if no necessary normative judgment is implied. Many scholars, most vocally the late Stephen J. Gould, have denied that such a trend existed and that the movements toward greater complexity, efficiency, or diversity in natural history are all illusory (Gould 2002; see also, for example, G. Ledyard Stebbins 1969, p. 133). Vermeij will have none of this. He sees "a historical link between the general trend in economic systems toward increased diversity and a general trend toward increases in the power of consumers and the rate of production" (p. 256). However, when he looks at the final culmination of the process, Vermeij gets worried. He makes the perceptive point that an intelligent observer five million years ago would likely have concluded that life on

earth had approached the limits of resource extraction (p. 293). Such an observer would have been quite wrong, as humans have totally changed the way life evolved on the planet. It is quite clear, he feels, that in three and a half billion years of evolution, nothing like humans have occurred, and that the rate and the pervasiveness of change that their activities have brought about is totally unprecedented. Like so many others, he asks whether this rate of change is sustainable. Humans are altering ecosystems on a global scale, and these changes are irreversible. Biological resources are mined beyond the point of sustainability, and Vermeij gives us a long list of pollutants (p. 297) that are either introduced at unprecedented rates into the environment or involve totally new substances that the earth has never encountered before. This might look to the casual reader as a scare-list worthy of a Paul Ehrlich or a Barry Commoner, but the difference is that Vermeij knows what he is talking about. While his policy recommendations read fairly commonplace (he is in favor of the scientific way of knowing and democratic, representative political organization—who would ever admit being anything else?), his concerns are genuine and his predictions are well-enough informed that anyone who is concerned with the long-run future of life on the planet should constantly remind himself of the points made in the last chapters.

The paradoxical point about this book is that, while written by an expert biologist who has read a fair amount of history and economic history, the parallels between economics and biology are based on the way Vermeij imagines economics should be or might have been, not on what economics really is. There are few references in his huge bibliography to serious work in economics and here and there he makes a serious slip. Thus, among his list of seven obstacles and objections to economic growth he mentions (p. 301) that the modern economy is characterized by a pervasive imbalance between production and demand, and that the capacity of industry and agriculture has outstripped the capability of consumers to absorb production. This "stagnationist" view, briefly held by a few economists in the 1930s and since then abandoned, is supported by the notion of an inequitable distribution of wealth, a view that can be traced to Karl Marx and John Hobson but is not held nowadays by any reputable economist. Nor is it clear what on earth is the basis of his ex cathedra pronouncement that "human curiosity is a far more potent weapon of [technological] progress than is inquiry motivated only by economic gain" (p. 308).

But apart from such mistakes, this lack of understanding of economics prevents Vermeij from understanding how central the price system is to economic adaptation and how it operates as a mechanism of market clearing. There is nothing like a "market" in the natural history that Vermeij describes.[6] Indeed, one would wish that he would have read the works of such economists as Friedrich von Hayek (1979), Armen Alchian (1950), Milton Friedman (1953), and Jack Hirshleifer (1977) who have all suggested to write about economics in "biological terms" but realized and appreciated the importance of markets and prices in allocative processes. His view of markets seems to be that the free market is free mostly for those in power, as he feels that "the European economic system about which Adam Smith wrote depended in large measure on the toil of slaves in the New World." Whether historically correct or not (the matter is disputed),

[6] In recent years, attempts to develop a concept such as "biological markets" have emerged in the literature. In these models the idea of market clearing and the all-important informational functions of the price mechanism are abandoned, and instead the terms of trade in mutually advantageous exchange are central to the discussion (Peter Hammerstein and Ronald Noë 1995; Samuel Bowles and Hammerstein 2003). The problem with such biological markets is that contracts are often unenforceable, though nature does provide some examples in which provisions are made for contracts to be "enforced." But human markets are successful precisely because humans have developed institutions that make contracts enforceable and resolve disputes.

this is simply a confused way of thinking about what a market economy does. Similarly, the book spends considerable time on arms-races and positive feedback and coevolution but is not informed by the models that have been proposed by economists to analyze arms-races and similar models of what he calls "escalation." Vermeij is ambivalent about the future of economic growth. He is deeply worried about the consequences of economic growth, yet he seems to believe that in a zero-sum society there is a reduced ability to adapt and to reduce inequality (p. 312). Elsewhere he cites W. Arthur Lewis to the effect that wealth does not necessarily increase happiness but rather increases human choice and "the opportunities for dictators to control men's bodies through highly organized police services" (p. 148).

Arguably, these are minor flaws in an otherwise hugely informative and innovative book. The analogies it proposes are worth investigating, even if not all of them will hold up. Words and terms can sometimes mislead; while concepts such as "power" or "efficiency" or "hierarchy" are used in economics and have analogs in biology, their meanings are often sufficiently different to make homologies of this kind tricky. There are indeed many isomorphisms between economics and biology, but one cannot help but wonder sometimes whether they are substantive or superficial. Of course, nature is a competitive system in which units operate under scarcity. A recent paper by Michele Piccione and Ariel Rubinstein (2005), for instance, shows that one does not need voluntary exchange economies to get equilibrium allocations that in some ways mimic the market allocation. The "law of the jungle" in which stronger agents take resources from weaker ones (presumably describing a world similar to what Vermeij describes) will lead to a unique equilibrium that is Pareto efficient. Yet caution is called for: as soon as one introduces production into the Rubinstein–Piccione model, their conclusions becomes problematic.

Moreover, economies are not like ecologies in that the main purpose of life seems to be life itself. Species struggle to survive and reproduce, and "success" is measured in those terms. There is no real analog in biology to the economist's concept of utility. In economics, survival is essential, but the purpose of economic activity is not just survival and reproduction, but to maximize a definable objective function, which seems to have no real analog in living systems even if animals can demonstrably feel pleasure and pain. Whether or not this really matters to the biologists remains to be seen; it is possible to write down economic models of "satisficing" and of "getting by" in which "good enough" survives. But in ignoring the central concept of "utility" (and replacing it by such concepts as "power"), Vermeij's concern with inequality makes little sense. Central to consumer theory is the concept of conscious choices between alternatives, and this concept does not play an equally central role in natural history. It is hard to find in the natural world any example of altruism (beyond the obvious concern with one's offspring), whereas in human society such a tendency as "being nice to strangers" can be shown to exist and may have strong evolutionary roots, but roots that are specific to humans and very rare in other living beings (Alexander Field 2001; Ernst Fehr and Joseph Henrich 2003). A narrow focus on biology also gets in the way of dealing with the fact that homo sapiens does not seem to conform to the central dictate of nature, which is that when the environment allows, maximize surviving offspring. Instead, as technology improves and income rises, people reduce the number of their offspring. This seemingly puzzling fact can be explained using utility theory but not in Vermeij's framework.

Should economists read this book? Surely not if they think that the subtitle implies that they will learn much about economic history. But perhaps it would not hurt economists to branch out a bit. After all, they have learned a great deal of mathematics and routinely

cite publications in physics and engineering. Might it not be useful to learn something more about natural history as well? It may get economists to think about the analogies and differences between the economic system and living beings. In one of his most thought-provoking passages, Vermeij cites biologist Jacques Monod's classic *Chance and Necessity* (1971): how do we really distinguish between the contribution of a deterministic set of factors, and of those random events that may steer the economy onto a permanent and altogether different trajectory? Vermeij suggests that "Comparative history provides a way of dissecting the roles of chance and necessity, of assessing how and to what extent the time invariant and space invariant laws intersect with the unique attributes of individuals and their surroundings" (p. 250). Some pages later he adds disparagingly that "comparative history is in its infancy," a statement to which some practitioners might object. But there is no denying that many of the issues he raises will be thought-provoking to economists.

But more important, this book may persuade (if nothing has before) that thinking about very long-term historical change in terms of equilibrium models is not very helpful, that history is not a random walk but really does have a trend and is going somewhere. Some shocks can throw history permanently off course and may cause outcomes that look dramatically different from what they could have been. If economic history shares its nonergodicity with natural history, the two literatures may learn from one another. A further isomorphism between evolution and economic history was pointed out by Ziman (2000): evolutionary models stress that what matters to history is not necessarily representative agents and central tendencies but rather very rare or singular events that get amplified and ultimately determine the course of history. The challenge to historians then becomes to try to understand *which* rare events and unusual agents take on that function, and under what circumstances they get "selected."

Moreover, and most remarkably, both natural and economic history represent striking nonlinearities and acceleration in their historical trajectory. Much of the change that has occurred since the beginning of time took place in a relatively short period at the very end. It should persuade people that in such a world, even if we can understand trends and fluctuations, the issue of timing remains a central part of the puzzle. While we can analyze the origins of homo sapiens in terms of selection processes in the Pleistocene after some sixty million years of mammalian development, there is no theory that explains why it arose *when* it did and not, say, in the middle of the Eocene. Above all, it underlines the contingencies of history. There is nothing about the actual outcome that made it inevitable (or even likely) ex ante that highly intelligent life should have emerged on our planet.[7] There is, to be sure, a trend toward bigger size and perhaps greater complexity, but the emergence of consciousness and high intelligence appear—as far as we know—to be a fluke. Quite similarly, and here Vermeij's analogy is quite convincing, there was no a priori inevitability about the Industrial Revolution and the beginning of sustainable, rapid growth in the West in the past two centuries. In retrospect, we can analyze why and how it came to pass that we happen to be where we are as we are, but there was nothing inexorable about it.[8] After all, if that asteroid that hit Yucatan at the end of the Cretaceous had veered just an epsilon to either side of the planet, the dinosaurs or their descendants would still rule the planet. It is a sobering thought.

[7] For a strongly argued contrary view, see Robert Wright (2000).

[8] For a series of case-studies analyzing the possible counterfactual scenarios to the "rise of the West" see Philip Tetlock, Ned Lebow, and Geoffrey Parker forthcoming.

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