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# Third Nature: The Co-Evolution of Human Behavior, Culture, and Technology

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***Abstract:*** *Within a dynamical-systems framework, human behavior is seen as emergent from broad evolutionary processes associated with three basic forms of nature. First nature, matter, emerged from the big bang some 12-15 billion years ago; second nature, life, from the first bacteria up to 4 billion years ago; third nature, ideology and cultural artifacts (e.g., institutions and technology), with a shift to self-reflective, symbolic thought and agrarianism in humans some 8-40 thousand years ago. The co-evolution of these three natures has dramatically altered human behavior and its relationship to the whole planet. Third nature has infused human minds with several powerful ideas, or memes, including the idea of progress. These ideas have fueled the evolution of a complex institutional order (e.g., political systems and technology) and myriad attendant global problems (e.g., wars and environmental degradation). The human brain/mind is seen as the primary medium by which third nature governs human behavior and, therefore, self perpetuates.*

***Key Words:*** three natures, co-evolution, institutional order, fitness landscapes

## INTRODUCTION

Psychology is the study of behavior, primarily human behavior. How is human behavior to be understood? Consider my behavior of composing and typing this manuscript. Is it to be understood reductionistically by examining what is going on inside my body (e.g., brain)? This reductionistic approach has been a major one in psychology, especially in the area of neuropsychology. Although it can be informative, reductionistic psychology is limited because the brain is, for the most part, only the medium by which the external world can influence behavior. So

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far as we know, this medium in anatomically modern humans has remained basically the same for at least two hundred thousand years, yet human behavior has changed dramatically over this time span. No one even 50 years ago, let alone thousands of years ago, would be behaving the way I am right now if for no other reason than that personal computers and word processors were not yet invented. In order to understand human behavior, we must move outside the medium and consider a broad range of external factors on which brain (or *brain/mind*) activity and human behavior are ultimately dependent.[1]

In part, my current behavior can be understood by examining both my immediate environment and my personal history, including all of the events several decades ago that encouraged me to go into psychology in the first place. The consideration of external stimuli and personal experiences is well represented in different areas of psychology, including behaviorism and psychotherapy. However, it too is limited because the ambient stimuli and one's personal experiences are themselves shaped by broad, evolutionary processes. Why do we behave differently than any of our hunter-gatherer ancestors did, say, 40 thousand years ago? To answer this question, we must understand the evolutionary processes, cultural as well as biological, that have caused our environments, personal experiences, and brain/mind activity to change so much over the millennia. The present paper outlines a framework within which the broad, historical shaping of human behavior might be understood.

An improved understanding of human behavior may be vital in today's world because human behavior is implicated in the vast majority of the problems, henceforth referred to as the *big problems*, that place many forms of life on the planet, including humanity, in jeopardy. Two of the big problems on which this paper focuses are environmental degradation, including the decimation of species and whole ecosystems, and the possible impoverishment of the human mind. Why do we pollute the air we breathe by excessive use of automobiles in lieu of alternative means of transportation, including walking? Why do we live in homes that are much larger and consume much more energy than is necessary? Why do we support legislation, leaders, and industries that promote war, destruction of natural habitats, and consumerism? Why do we connect so much with our technological artifacts like computers, television, and cell phones in lieu of "natural" systems like deserts, forests, streams, and other living systems? Why do we spend so much of our lives trying to "get ahead"? Why were Americans shocked by the events of "9/11" when they seem to be complacent about the millions of deaths each year due directly or indirectly to the use of automobiles? Why do we get in life-style ruts and become so unable and unwilling to change?

I suggest that traditional approaches to psychology must be supplemented by the sort of approach outlined herein if psychology is to provide answers to questions like these and contribute substantially to an understanding and potential remediation of the big problems. Indeed, one of the theses developed in this paper is that contemporary psychology and the Western scientific and cultural paradigms that it represents themselves contribute to these problems. I will argue that Western epistemology along with the world view with which it has co-evolved must undergo a paradigm shift if the planet and our participation in it are to be understood in a way that may offer deep insights into the big problems. In what follows, I outline a framework or point-of-view in which humankind is seen as inextricably interconnected with the rest of nature and in which the human/nature system is to be understood as a dynamical, self-organizing, co-evolutionary process. [2]

Within a quasi-dynamical-systems framework, I attempt to reconstruct in broad outline form how we contemporary humans got to be the way we are and how the origin and evolution of the big problems are to be found in our own history. I decompose *human nature* into three underlying natures. Because they emerged at different times, we may refer to them as *first, second,* and *third natures*. First nature is *material*; we are made of atoms. Second nature is *biological*; we are living organisms. Third nature is, for lack of a better word, *ideological*; we are creators and carriers of belief systems and their artifacts. I develop a general scenario of the emergence and co-evolution of these three natures and how they have altered human behavior and led to the big problems. Although it is cast within a dynamical-systems framework, this scenario is pieced together by integrating the findings of different fields of Western science, some of which have relied extensively on reductionistic approaches. Thus, the paper illustrates how reductionistic and systemic epistemologies and the currently isolated specializations of science might be fruitfully integrated to put in broad perspective the nature and origins of human behavior and the big problems.

The remainder of the paper is organized into five main parts. The first section, *The Dynamical Framework,* outlines a general framework based on dynamical-systems theory, especially complexity theory. In the spirit of the recent approach to the study of history, called *big history* (see Christian, 2004), the section, *Our Three Natures*, applies this framework to a description and interpretation of the history, co-evolution, and co-dependency of our three natures, embracing cosmological, geological, biological, and cultural evolution. The next section, *The Roots and Rise of Third Nature,* focuses in more detail on third nature, especially on human cultural and technological evolution over just the last 8,000 years. The section, *Evolution of the Big Problems,* examines the co-evolution of third nature, human behavior, and the big problems. The *Conclusions and Implications* section summarizes the major themes of the paper, discusses their implications for psychology and current global dynamics, and draws some tentative conclusions.

## THE DYNAMICAL FRAMEWORK[3]

Systems are not viewed as static structures. Indeed, natural systems are sufficiently interdependent and fluid that the consideration of any set of relationships as a separate system is somewhat arbitrary. Systems may be conceptualized as dynamic and continually renewing or reorganizing webs of relationships whose life trajectories are guided by two arrows of time (e.g., Coveney & Highfield, 1990). The positive arrow moves systems away from thermodynamic equilibrium, via a process of self-organizing complexification, and the negative arrow moves them back toward thermodynamic equilibrium according to the second law of thermodynamics. Along the positive arrow of time, systems settle into self-perpetuating *attractors*, or *basins of attraction*, where they jitter in a *dynamic stasis* (i.e., continually self perpetuate) until they encounter perturbations sufficient to either dissolve them or force them through *phase*, or *state*, *transitions* into new attractors, usually more complex, higher *energy-dissipating* attractors (e.g., Prigogine & Stengers, 1984). Many, if not all, of the phase transitions entail *new, emergent properties*, that is, system characteristics not evident prior to the transitions. Human morphogenesis is a familiar example of self-organizing complexification of a dynamical web of relationships (e.g., between biological cells, tissues, organs, and systems) across multiple phase transitions involving various emergent properties. Indeed, the evolution of second nature from first nature and of third nature from the first two are regarded as major phase transitions involving immensely powerful emergent properties.

The behavior of a system may be fairly predictable in the short run so long as it remains in the same attractor, but because of nonlinearities and a degree of flux in the whole web of systems in which it is imbedded, it is likely to be unpredictable over the long run. Although the co-evolutionary trajectory of just two interdependent systems can be mathematically tractable and wind up in dynamic stasis (e.g., a limit-cycle attractor), this is not representative of natural systems because, among other things, there are always many more than just two systems involved. Indeed, natural systems are sufficiently interdependent and fluid that the consideration of any set of relationships as a separate system is somewhat arbitrary. The addition of even just one more equation to the mix leads to the well-known "three-body problem" in physics. A multiplex of systems is likely to produce *deterministic chaos, butterfly effects*, and *strange attractors*.[4] The general properties of dynamical systems have been observed in simulations of a variety of natural systems, including weather, earthquakes, economies, families, and ecosystems.

There are two hybrid principals of dynamical systems that appear to characterize many natural systems and that I shall refer to at various points below. The first may be called a *house-of-cards* effect. It is similar to the idea of self-organized criticality (e.g., Bak, 1996). In particular, as systems complexify beyond what may be an optimal level, they can become so complex and so sensitive to cascading butterfly effects that they are vulnerable to dissolution and may succumb to the negative arrow of time. The other hybrid principal is what may be called *action at the edges*. Many important dynamics involved in system self-perpetuation, change, and growth seem to entail activity at the edges or boundaries of either the system itself (e.g., a living cell or a rainforest) or of some larger system in which a subsystem is imbedded (e.g., life e-merged on the outer skin of the earth and presumably along shorelines or deep-sea vents). Information is often highest along edges, a fact that our visual systems and pattern-perception processes have evolved to exploit.

Kauffman (1993) suggests that dynamical systems in general tend to thrive near a more abstract edge, the *edge between order and chaos* (see also Lewin, 1992). This abstract edge may be the zone of optimal system plasticity and is reminiscent of the *stability/plasticity dilemma* and the costs and benefits of expertise (Johnston & Hawley, 1994; Johnston, Strayer, & Vecera, 1998). Experts and specialists dwell in the ordered regime; they tend to perform very well within the particular domains and contexts to which they have become precisely attuned and adapted, but they do so at some loss of flexibility or plasticity. Novices and generalists dwell near the edge of chaos; they are not precisely attuned to any particular niche, but they may be sufficiently flexible that they can move with a changing, evolving web and not become marooned in obsolete attractors.

## OUR THREE NATURES

The origin and evolution of the relationship between human behavior and the big problems are likely to be found primarily in the history of our third nature. But third nature did not arise out of whole cloth;

it emerged from first and second natures. These natures are still with us and are to some extent implicated in the big problems. Moreover, the three natures are now dynamically intertwined in a co-evolutionary web of relationships and it is not possible to completely disentangle their contributions. Finally, as we shall see, many of the major dynamics of first and second natures apply as well to third nature, and there are important lessons to be learned from a review of our more "primitive" natures. Thus, an initial step toward understanding dynamical systems, the big problems, and ourselves may be to review our first and second natures.

## First Nature

First nature is what we have in common with rocks and rain storms. All natural phenomena arise from the basic particles, energy, and forces that emerged with the big bang some 12-15 billion years ago. The self-organizing complexification of the universe has comprised many important phase transitions including the formation of atomic nuclei, the "freezing out" of atoms from radiation, the aggregation of atoms into molecules and, eventually, more complex structures including stars, galaxies, and complex organisms. The intensely hot cores of stars have fused lighter elements like helium into heavier ones like oxygen and carbon, without which elements life on earth would not be possible. Several generations of rising and dying stars led to formation of our solar system and our planet some 5 billion years ago.

Since its accretion from the tiny portion of the ashes of spent stars that were not pulled into our sun, the earth itself has undergone self-organizing geological complexification. Some of the important perturbations and transitions included the formation of the moon (possibly from the fragments of a protoplanet that collided with the nascent earth), the emergence of water, the formation of continents, and the continuous, slow shifting of continents due to plate tectonics. Early earth was a virtual caldron of activity involving constant bombardment by meteors and volcanic eruptions. Eventually, this tumultuous activity led to the emergence of second nature.

## Second Nature

Second nature is what we have in common with all the other life forms that blanket the planet. We all arise from DNA self-replicating processes and biological evolution. Somewhere on the still young and volatile earth, some 3.5 to 4 billion years ago, one of the billions of experiments running in parallel day and night millennium after millennium paid off with life. The action was at the edges, on the skin of the planet, in the natural chemical laboratories along deep-sea vents and the vast shorelines of the young continents.[5] We do not know what led to the big-bang creation of the universe, and we do not know the precise details of the experiments that produced life. However, we do know something about the self-organizing course of complexification that life took and its evolutionary underpinnings.[6]

## *The Course of Biological Evolution*

Margulis and Sagan (1986) distinguish between two grand phases of life: the *microcosmos*, comprised of single-celled organisms, and the *macrocosmos*, comprised of multi-celled organisms. The microcosmos held exclusive reign for at least 2 billion years. Bacteria, or *prokaryotes*, ruled alone for most of that time and later sprouted an evolutionary branch that led to larger, nucleated cells, or *eukaryotes*. A little over a half-billion years ago, life underwent a remarkable phase transition in which eukaryotes began to colonize and form multicellular organisms. Since then, the macrocosmos has itself undergone self-organizing complexification defined by increasing diversity of species, impressive emergent properties (e.g., flight and, perhaps, consciousness), and several mass extinctions and resurrections. Biological evolution is still underway today and, as we shall see, it is being powerfully influenced by one of its products, namely, humans.

## *Evolutionary Dynamics*

### Dynamical Features of Biological Evolution

Biological evolution is prototypical of dynamical, complexifying, self-organizing systems. The "organism" and the "environment" should not be understood as categorically discrete entities in which the former unilaterally adapts to the latter. Nor should the organism be conceived of as an additive ensemble of modularized traits, each of which can be modified independently of the others.

**Interdependent, Co-Evolving Species and Traits.** Biological evolution is typically characterized by complex, co-evolutionary relationships involving multiple species and multiple, interdependent traits. The evolution of domesticated dogs from wolves over the last million or so years was, at least to some extent, due to a systematic, but probably unintentional, process of selective breeding of camp-following wolves by the human hunter-gatherers who occupied the camps. The humans and the wolves apparently entered into a co-dependent, symbiotic relationship in which each assisted the survival of the other. One probable aspect of this co-dependency was the avoidance of those wolves that were more aggressive and less approachable, leading to the "natural selection" of more docile wolves. Across thousands of generations, this process yielded the domesticated dog. However, even though the single trait of wolves on which this domestication process focused may have been "friendliness" or docility, research on foxes suggests that a whole host of other traits were dragged along with it, including those associated with hair color and texture, muzzle length, cranium width, tail curling, whining and barking, licking, and blood and brain chemistry (Trut, 1999). Thus, many traits are bound together in complex webs and do not evolve independently. Moreover, some of the co-evolving traits may be incidental to the selection pressures but be fortuitously *preadapted*, or *exapted*, for some later selection event and, thereby, constrain the subsequent course of evolution (Gould & Vrba, 1982).

**Interacting Natures.** Not only does second nature respond to changes in first nature, but it can dramatically affect first nature as well. In a process that has been referred to as *niche construction*, organisms can alter their habitats in a way that imposes new selection pressures on subsequent inhabitants, including their own descendants (Odling-Smee, Laland, & Feldman, 2003). Thus, organisms and their environments are locked in continuous, co-evolutionary relationships. From the start, first and second natures entered into a complex, dynamical relationship full of feedback loops, nonlinearities, and emergent phenomena.

One example of second nature affecting first nature was what may have been an *oxygen holocaust* in the microcosmos. Margulis and Sagan (1986) suggest that bacteria originally evolved in an atmosphere that was relatively free of oxygen, a very toxic, corrosive element. But the metabolic processes of these organisms began to produce oxygen in massive quantities that eventually saturated the natural sinks of first nature, causing the gas to spill out into the air, changing the composition of the atmosphere, and decimating a large portion of the microcosmos. Of course, life rebounded from this self-imposed selection pressure and, indeed, found ways of exploiting atmospheric oxygen. Thus, second nature altered first nature in a way that fed back onto second nature. All of today's dry-land creatures, including humans, depend on atmospheric oxygen and owe their existence, in part, to the oxygen holocaust.

The microcosmos also played a vital role in rendering the soil fertile by fixing nitrogen in it. If bacteria did not fix nitrogen in the soil, plants would not flourish there and the first, vital link in the entire food chain on which land-based animals depend would not exist. The macrocosmos also entered into a dynamical relationship with first nature. The plants contributed to the oxygenation of the atmosphere that had been initiated by the microcosmos. In addition, their root systems held soil in place, increased its retention of water, and reduced its rate of erosion, thereby facilitating the growth of even more plants. Whole dynamical ecosystems of plants, animals, and microbes changed the chemistry and texture of the earth and, thereby, changed the course of biological evolution.

**Fitness Landscapes and the Stability/Plasticity Dilemma.** At any given time, any region of the planet may be conceived of as an evolutionary landscape comprised of peaks and valleys of fitness (e.g., Kauffman, 1993). Natural selection tends to move species out of the valleys and up the slopes of the peaks. Organisms at the summit of a peak are maximally adapted to the ecological niche represented by that peak. Any genetic mutation would only reduce fitness and be automatically eliminated from the gene pool. These organisms are specialists. They are ideally suited to their ecological niche but not particularly well suited to any other niche in the landscape. Other species are generalists. They are more diversified genetically and are found on the slopes of different peaks but not at the apex of any one. Compared to the specialists, the generalist species are more flexible and reside nearer to the edge of chaos. As long as the landscape remains unchanged, the specialists residing atop the peaks will fare better than the generalists struggling on the slopes. However, should a major perturbation, like a prolonged drought or the impact of a large meteor, sufficiently re-sculpt the landscape, then the generalists might have the advantage. They can survive in a wider range of ecosystems and are generally less vulnerable than the specialists to environmental change. This general scenario has received empirical support in laboratory studies of bacteria (Buckling, Wills, & Colegrave, 2003).

**Evolutionary Dominos and Spirals.** Because ecosystems have increased in biodiversity and complexity over the eons since the oxygen holocaust, biological evolution has gained more participants, more domino effects and feedback loops, and more nonlinear dynamics. In complex ecosystems, any evolutionary change that occurs in one species at one point in time can launch a cascade of effects that radiate through the ecosystem, perhaps altering first nature along the way, and impose new selection pressures on other organisms at some later point in time. The metabolic processes of certain bacteria in Israel's Negev desert render the soil sufficiently crusty that water runs off into depressions made by desert porcupines and beetles. Windblown seeds can then germinate in these moist borrows leading eventually to species rich oases (Alper, 1998).

A biomechanical innovation in a predator forces a counteractive innovation in its prey which imposes a new selective pressure on the predator resulting in a spiraling "biological arms race" (Dawkins, 1986). Innovations in insect camouflage can lead to more acute vision in birds, and innovations in the evasiveness of antelopes can lead to counteractive changes in the predatory effectiveness of cheetahs. Various "ecosystem engineer" species, like beavers, can alter first nature in a way that launches major phase transitions in whole ecosystems. These ripple effects can travel full circle, feed back onto, and require another evolutionary change in the very species that triggered the cascade of adaptations in the (arbitrarily-defined) first place (Laland, Odling-Smee, & Feldman, 1999). As already noted, the evolved metabolic processes of ancestral bacteria changed the chemistry of the earth and the atmosphere, which changes fed back onto and altered the metabolic processes of bacteria. Over time, these recurrent dynamics create a self-organizing spiral of ever-changing fitness landscapes.

**Biological Evolution is Systemic and Dynamical.** Thus, biological evolution must be understood at the level of whole, vibrant, self-orgainzing ecosystems replete with feedback loops and butterfly effects. The "environment" is itself a complex, dynamical, and evolving fitness landscape composed of myriad co-dependent and co-evolving products of first and second nature. Any particular species of interest is enmeshed in a complex web of first- and second-nature systems, all strands of which evolve together.

As is characteristic of self-organizing systems, biological evolution is often punctuated, with long periods of dynamic stasis interrupted by bursts of change (e.g., Gould, 1989). Some of these bursts are massive, as evidenced by the Cambrian explosion, and they are reminiscent of the remarkable phase transitions characteristic of complex, dissipative systems (e.g., Prigogine & Stengers, 1984). Thus, ecosystems may complexify to critical, threshold levels at which they undergo massive phase transitions into new ordered regimes with powerful emergent properties. Indeed, it has been suggested that new traits may sometimes evolve spontaneously owing to the constraints imposed by the evolving webs in which the organisms are imbedded (e.g., Kauffman, 1993).

### *Ecosystem Dynamics*

Ecosystems exemplify all of the basic properties of complex, dynamical systems, including arrows of time, house-of-cards effects, action at the edges, and dynamic stasis. Further below we shall see that these same dynamics may be reflected in modern human systems, perhaps including the human mind.

**Arrows of Time in Ecosystems**

Reice (1994, 2001) distinguishes between unhealthy and healthy ecosystems. Unhealthy ecosystems are characterized by relatively low species diversity and by relatively infrequent and weak perturbations. These systems have a low degree of physical-chemical heterogeneity, or *patchiness*, and tend to be dominated by specialist species that can make a living in these relatively homogeneous environments. Like narrow minds (e.g., Johnston, Strayer, & Vecera, 1998) and specialist species, unhealthy ecosystems tend to become entrenched in deep attractors, close to equilibrium, and far from the edge of chaos. Because they lack resiliency, they are unlikely to recover in the event that they are beset by major perturbations. They tend to follow the negative arrow of time, stagnate, and die.

By contrast, healthier ecosystems are characterized by greater biodiversity and are perturbed more regularly by such events as floods, droughts, and fires. Like broad minds and generalist species, these systems are more resilient and, thus, more likely to recover from perturbations. Indeed, as noted below, biodiversity often increases during the process of recovery as new and previously subordinate species begin to occupy niches left open by vanquished, formerly dominant species. Healthy ecosystems never reach equilibrium. Rather, they are always recovering from the last perturbation, jittering in dynamic stasis or self organizing along the positive arrow of time.

**Houses of Cards in Ecosystems**

However, even healthy ecosystems can become so complex that they become vulnerable to a house-of-cards effect; that is, they can reach the threshold of self-organized criticality and teeter on the edge of chaos (Bak, 1996; Snyder, 2000). For example, while the infusion of new species often helps to keep a given ecosystem healthy, the introduction of exotic species from remote ecosystems can lead to its demise (Vitousek, D'Antonio, Loope, & Westbrooks, 1996). Although healthy ecosystems can withstand most such intrusions, those foreign invaders that happen to be particularly well suited to their new environment can upset the complex, recurrent dynamics on which native species depend. The result is often a reduction in the biodiversity and vitality of the whole ecosystem.

Even in the absence of non-native invaders, Snyder (2000) has observed a house-of-cards effect in the form of the collapse of an ecosystem when biodiversity reaches a threshold level. Beyond a critical level of species diversity, successful replacement of vanquished, keystone species becomes less likely and a cascade of extinctions across the whole ecosystem becomes more likely. Thus, the vitality of ecosystems appears to be an inverted U-shaped function of biodiversity. On a grander scale, some of the mass extinctions that have occurred across the eons may represent house-of-cards effects.

**Action at Ecosystem Edges**

The biodiversity in healthy ecosystems is attributable, in part, to an evolutionary action at the edges; in this case, edges between symbiotic ecosystems (e.g., the margins, or ecotones, that separate different, but interdependent ecologies such as jungles and savannas). It is in these zones of transition between ecosystems that biological experiments are most likely to occur and new species born, species that may then move into the interior of an ecosystem and inject it with new life (e.g., Enserink, 1997). Indeed, ecosystems that are too isolated from other ecosystems are at risk of stagnation because they do not receive enough infusion of new species to maintain a sufficient level of biodiversity. Isolation is why biodiversity tends to be less on smaller islands than on larger ones and reduced in ecosystems fragmented by third-nature intrusions like freeways and farms (e.g., Foreman, 1998).

**Dynamic Stasis of Ecosystems**

Healthy ecosystems are always jittering. Like human faces and Galapagos finches (Weiner, 1994), the whole pattern remains roughly stable even though there is turnover in many of the individual components (e.g., cells and beak sizes). Thus, an optimal level of biodiversity serves whole ecosystems but not necessarily individual species (Moffat, 1996; Tilman, 1996). The turnover of species renders ecosystems equal-opportunity and even affirmative-action employers. Interestingly, the most vulnerable species are often the most dominant ones, the specialists at the apex of the fitness peaks. They have become so precisely attuned to the patches they occupy that they suffer the costs of expertise and fail to survive the physical changes that major disturbances can produce. The niches left open by the vanquished species can be exploited by previously subordinate, generalist species and new, opportunistic immigrant species from nearby ecosystems. Thus, the overall ecosystem pattern may remain more-or-less the same even though the individual species are always changing.

## *Human Evolution*

**Chaotic Path to Humankind**

The vast, chaotically unfolding webs of first and second natures, with all of their fortuitous twists and turns, eventually led to a bipedal ape, a protohuman. The first primitive humans, *Australopithecus*, emerged from the intertwined dynamics of first and second nature. Countless butterfly effects rippled across the web of first and second nature and paved the way for this emergence. Potts (1996) suggests that humans emerged during a particularly turbulent time in the earth's history, a time when several of the earth cycles (e.g., of tilt, spin rate, and orbit) entered into a phase relationship that led to dramatic fluctuations in first (e.g., climate) and second (e.g., food sources) natures. This turbulence favored generalists, organisms that could make a living in various ways, resolve the stability/plasticity dilemma, and stay within the optimal zone between order and chaos. The new primate was one such generalist, a species that could survive in very different habitats and exploit different resources.

Even the first-nature process of plate tectonics may have played a major role in the emergence of humans.[7] Leakey (1994) highlights the tectonic activity that created the Great Rift Valley in eastern Africa, the possible cradle of humankind. On the up-lifted western side of the valley remained the dense forests and jungles to which most of the primates at the time had been adapted for millennia. By contrast, the eastern side now lay in a rain shadow and became a patchy mosaic of clumps of forest and open savannas. This patchy valley witnessed the demise of several species of ape that were specialized for rain-forest dwelling and not well suited to the arid terrain in which they were stranded. However, as is characteristic of massively disturbed ecosystems, these same conditions favored a new, generalist species, one that could exploit different niches in the valley. Thus, it may have been there, in the Great Rift Valley during a particularly turbulent time in the history of the earth, that the first protohumans emerged.

**Adaptations and Exaptations of Upright Stance**

Lucy and her Australopithecus kin stood upright. As in the case of fox domestication, this adaptation carried many other traits along with it, including important exaptations that only many millennia later would effect profound behavioral changes (e.g., Diamond, 1992; Tattersall, 2001). Lucy was able to walk out onto the savanna in the noonday, equatorial sun without overheating (because of the reduced exposure of body surface), with freed up hands to manipulate objects, and enhanced panoramic views.

In addition, because of a narrower hip structure and more restricted birth canal than her primate ancestors, Lucy had to give birth comparatively prematurely. Because the heads of new-born Australopithecus infants had to be small enough to move through the more restricted birth canal, the development of their brains continued long after birth, allowing the patterns of neural growth and connections to be molded by the particular environments into which they were born. This neural plasticity may have allowed their neural networks to be somewhat liberated from their long, evolutionary shaping so that these infants could adapt more readily to the disturbed, variable, and unique new environments of the Great Rift valley. The upright stance also contributed to a repositioning of the vocal apparatus, an exaptation that permitted speech-like vocalizations and would lead a few million years later to complex language and symbolic thought.

**Phases of Human Evolution**

Over the course of around four million years of human evolution, different species of humans branched off from Australopithecus, and brain size, and presumably cognitive potential, tended to increase from lower to upper branches. Each branch may be considered an attractor, destined in time to become obsolete and succumb to the negative arrow of time. The longevity of the different species varied, and two or more might have co-existed for a time even as a new species began to branch out from one of them. A few species managed to spread out of Africa and into Eurasia. Then, perhaps as many as 250,000 years ago, *anatomically-modern* humans emerged and, in relatively short order, all other hominid attractors disappeared from the evolutionary landscape (Tattersall, 2000). We contemporary humans are the beneficiaries of the apparent competitive advantage of our anatomically-modern ancestors.

## Third Nature

For most of their history, humans have been relatively commonplace participants in the global drama and have not played a particularly starring role (e.g., Diamond, 1992). Even we anatomically-modern humans did not appear to make much use of our bigger brains and unique articulatory apparatus for thousands of years. The primary tool on which we appear to have heavily relied was a crude hand axe that smaller-brained humans had perfected a million years earlier. Our dramatic behavioral divergence from Chimpanzees and our Paleolithic ancestors had to await the third great transition in the self-organizing planet, namely, the emergence of third nature. The emergence of third nature has dramatically altered the web of life, given a whole new twist to the drama, and made our role considerably more influential than it was before. We emerged from the complex dynamics of first and second natures and are now having a powerful influence on those dynamics, an influence that is likely to alter our continuing co-evolution with the rest of nature. The basic nonlinear, domino, butterfly and other dynamical phenomena that characterize first- and second-nature systems are evident also in third-nature systems. Third nature was ushered in by two major phase transitions in modern human history: the *upper-Paleolithic* and *Neolithic revolutions.*

### *Upper-Paleolithic Revolution*

About 40,000 years ago the first major phase transition to third nature occurred in what Diamond (1992), borrowing a phrase, refers to as *the great leap forward.* It was then that the butterfly effects and preadaptations of Lucy's upright stance began to dramatically alter the minds and behaviors of her descendants (e.g., Tattersall, 2001). Anatomically-modern humans started to draw pictures on cave walls (indicating symbolic thought) and create a wide assortment of tools, weapons, body adornments, and other artifacts (indicating "intelligence" and self-reflective thought), and they probably started to use a more sophisticated and complex language.

### *Neolithic Revolution*

After its birth, third nature appears to have remained in a relatively stable attractor, for about 30,000 years. Then, about 8,000 years ago, another major phase transition in human history moved third nature on a rapidly complexifying course. Until then, humans continued to lead the tried-and-true, hunter-gatherer lifestyle. As nomadic hunter-gatherers, roaming in small kin-based bands, our ancestors would discover areas with relatively abundant resources (e.g., wild plants and animals), dwell there until they depleted the resources (which their improved tools and weapons allowed them to do relatively swiftly), and then move on.

In the course of this process, one or more bands of hunter-gatherers stumbled on an area in the Near East called the *Fertile Crescent,* an area rich with consumable and potentially domesticatable resources. They were able to dwell there for a sufficiently long period of time that they began to "tame" native plants and animals and lead a more sedentary, agrarian lifestyle. Diamond (1997) suggests that the initial domestication of plants and animals was an accident of natural selection. The seeds of the wild grains and berries that the hunter-gatherers preferred would tend to be widely distributed in their "latrines" giving these plants a competitive edge over less preferred ones. By this process, the more tasteful and edible plants proliferated, leading ultimately to intentional horticulture and agriculture. Later on, humans began to exploit the different species of domesticatable animals in the region, of which there was a relatively abundant supply, to assist them with their agrarian chores and provide an additional source of protein. The transformation of wild to tame animals probably bore some of the same systemic characteristics of the domestication noted above with respect to foxes and wolves.

### *Memes*

One way to begin thinking about third nature is in terms of the distinction between genes and memes made originally by Dawkins (1976). Memes play a role in cultural evolution that is in some ways similar to that played by genes in biological evolution. In general, memes are self-replicating ideas and the artifacts and institutions to which they give rise. They can invade and, depending on how contagious they are, spread rapidly across individual minds and lives (e.g., Csikszentmihalyi, 1993). Particularly powerful memes can evolve into complex institutions like religions, governments, and economies, and they can take material form in technological artifacts like automobiles, computers, televisions, and cell phones. In just the 8,000 years since the Neolithic revolution, simple memes have complexified and self-organized in ways that now impose widespread feedback effects and selective pressures on the human minds and the first- and second-nature webs from which they arose. I turn now to a review of the dramatic rise of third nature and how it has profoundly altered the planet and human behavior.

## THE ROOTS AND RISE OF THIRD NATURE

The planet in general and humanity in particular have been reconfigured by the self-organizing complexification of third nature. It has profoundly affected how we think and behave and, in a deep sense, who we are. It has drastically transformed the planet and our relationship to it. I first outline some of the memetic roots of third nature and then review the self-organizing course that it has taken and how it has infiltrated and transformed the human mind. I focus primarily on Western civilization, arguably the most important, but certainly not the only, third-nature source of the big problems.

### Memetic Roots of Third Nature

The rise of third nature has been governed from the beginning by various powerful memes. Three of the most significant memetic strands out of which third nature has been woven are the ideas of progress, anthropocentrism, and property ownership.

## The Idea of Progress

A keystone meme in the evolution of third nature is the idea of progress. Nisbet (1994) examines the idea of progress and traces its history. This meme probably arose in the human mind at least as early as the upper-Paleolithic revolution, but it began to rapidly complexify and spawn various ancillary memes (e.g., the concepts of freedom and power) during the Neolithic revolution and the rise and spread of Western civilization. Basically, the idea is that humanity can and should control its own destiny in ways that promote the "good life" (e.g., human happiness, contentment, and comfort).

## Anthropocentrism

At some point early on in the rise of third nature and the idea of progress, another important meme began to take shape. We humans began to see ourselves as a privileged species, distinct from the rest of nature, superior to it, in conflict with it, and capable of "subduing" it. Our privileged status entitled us to achieve progress by exploiting and otherwise controlling first and second natures. Although this viewpoint may have begun to take shape in upper-Paleolithic times with the emergence of self-reflective thought, language, and tool making, it became especially powerful during the Neolithic revolution. We began systematically to tame what we could of "wild" nature and physically separate and "protect" ourselves from the rest.

Whereas the hunter-gatherers were to a large extent at the mercy of the vagaries of first and second natures, the new, modern humans were much more in control. Agrarian communities could rely on domesticated crops and animals for their sustenance rather than depend on the uncertain provisions of first and second natures. Foods and supplies could be stockpiled to guard against particularly harsh weather conditions and variable seasons, water could be transported from remote sources by aqueducts and canals, domestic plants and animals were a source of hides, skins, and textiles, minerals could be mined and processed to form various weapons and tools, trees could be harvested to make more room for crops and used to build durable shelters and provide firewood. In time, a vast complex of third-nature systems would conspire to promote our "harnessing of nature". We even became ethically obligated to subjugate nature; hence the biblical imperative to multiply ourselves and subdue the earth.

## The Idea of Property Ownership

The transition to an agrarian lifestyle led to, among other things, the construction of fences and the concept of property rights and ownership. Fences are of considerable symbolic value. They symbolize the attempt by humans to separate and protect themselves from the beasts and the wild, from the yet untamed first and second natures. Since the Neolithic revolution, the amount of the earth's crust that is enclosed within fences or other human-defined boundaries has steadily grown to the point that the entire planet is now presumed by humanity to be its private property. Most of what once were the exclusive domains of wild plants and animals have been usurped and altered by humans.

## Rise of Third Nature

### Recency and Rapidity of the Rise

The recency and rapidity of the rise of third nature may be made more understandable by re-scaling the history of the universe to a 24-hour day, in which each hour represents approximately 500,000,000 years and the end of the day, midnight, is the present. First nature burst into existence at the onset of the day, just as the clock began to tick. Atoms separated from radiation a second or so later, and after over 14 hours of cosmological complexification and several solar generations, at about 2:30 p.m., our solar system and earth finally formed. A half-hour later, at about 3:00 p.m., second nature self organized out of first nature and biological evolution began its course. The microcosmos held sway until just before 11:00 p.m. at which time the macrocosmos began to complexify and diversify. Protohumans did not branch off from chimpanzees until about 30 sec before midnight. Third nature did not make its appearance until less than 1/3 sec before midnight, at which time the upper-Paleolithic revolution began. The Neolithic revolution took place just 58 msec before the present, the industrial revolution about 1 msec ago, and most of the current technological artifacts and electronic wizardry with which we interact and on which we depend only microseconds before now. The rest of this paper focuses primarily on processes that have been unfolding in the course of this last tick of the clock.

### The Evolution of Culture and Institutions

**The Population Boom.** The Neolithic shift to an agrarian lifestyle led to an increase in the size and social complexity of communities. Population growth may be considered to be a *control parameter* or *forcing agent* in the dynamics of third nature. It may be the primary impetus to cultural evolution (Johnson & Earle, 1987). Prior to the Neolithic revolution, all economic, political, legal, religious, educational and other such matters were handled by the only social institution around, the kinship group. However, the new agrarian and sedentary lifestyles and the relative abundance and dependability of resources supported larger communities, and this, in turn, forced a separation out of kinship of various social and cultural institutions and of new, specialized ways of making a living (Turner, 1997). Whereas human lives and behaviors had previously been controlled primarily by their genetic memories and the forces and exigencies of first and second natures, they now began to be shaped by the new, self-organizing, self-perpetuating, complexifying institutions of third nature.

**Species Generalist, Individual Specialists.** Nearly all of our hunter-gatherer ancestors knew practically everything there was to know about how to make a living. They were generalists, a quality that gave them an adaptive edge during turbulent times in the Great Rift Valley and for millennia thereafter. However, with the Neolithic revolution, the transition to individual specialists had begun. Because the new, larger, genetically more diverse communities had to depend on common resources, supplies, and technologies (e.g., canals, boats, tools), some form of centralized, political coordination was necessary. Political self-organization is thought to have started with relatively simple (e.g., big-man) political systems and, as community size continued to grow, to have evolved across various phase transitions (e.g., *chiefdoms* and *city-states*) into the complex national and global political institutions of today (Johnson & Earle, 1987).

Similarly, community growth led to the need for new institutions to manage the flow and distribution of capital, maintain the social hierarchy, settle interpersonal disputes, provide community protection, enforce community standards and mores, facilitate technical production and innovation, disseminate information and knowledge, and organize religious activities, among other things. Each of these institutions fostered new livelihoods and domains of expertise, including politician, policeman, soldier, merchant, lawyer, craftsman, engineer, architect, teacher, and priest. Once they took hold, these institutions began to co-evolve symbiotically and become intermeshed in the dynamic and complex *institutional order* that is evident today (Turner, 1997). This institutional network may be thought of as a self-perpetuating collective intelligence (e.g., Franks, 1989; Lovelock, 1979), one that now transcends individual human minds and, in some measure, dominates, controls, and defines them.

The concept of fitness landscapes may apply to third nature as well as to the ecosystems of first and second natures. As a species we have become very effective generalists. Thanks to third nature, we now occupy virtually every niche and command nearly every resource on the planet. But as individuals we have become evermore specialized and are resolving the stability-plasticity dilemma in favor of stability. In reaping the benefits of expertise by filling a niche and making a living in and contributing to the institutional order, we may suffer the cost of a commensurate loss of plasticity. The rise of third nature has witnessed the demise of the individual generalist. As the institutional order continues to evolve, the fitness landscape of third nature will continue to change. As new forms of expertise and specialization emerge, old forms and the experts and specialists that filled them may become marooned in obsolete attractors.

**The Evolution of Technology**

Technology has played a major role in the evolution of third nature. It has infiltrated virtually every aspect of our daily lives and plays a central role in the dynamics of the institutional order and the big problems.

**Technology Self-Perpetuates.** Diamond (1997) suggests that technological evolution is an autocatalytic process in which each new innovation sets the stage for the next one such that invention is as much the "mother of necessity" as necessity is the "mother of invention". What may begin as a novelty may wind up as a mushrooming necessity, one that plays a central role in the institutional order. For example, the invention of the automobile has spawned a technological and institutional web that includes not only the automobile industry, but vast freeway systems, suburbia, and the fossil fuel industry. Technology may be seen as another example of self-organizing complexification, beginning with the primitive hand axe of premodern humans and moving through the upper-Paleolithic, Neolithic, industrial, and information revolutions to the wide diversity of present-day technological wonders. Each technological innovation suggests new ones, and what begins as a means to better human lives may take on a self-perpetuating and self-serving life of its own. We may now reasonably ask who is master and who is slave, our technological artifacts or ourselves?

**Technology Guides Epistemology.** Rothenberg (1993) traces the co-evolution of technology, epistemology, and the Western world view, especially as it pertains to the relationship between humans and the rest of nature. He suggests that what we "know" about nature and even how we know about it have been driven by how we have exploited it in the course of technological evolution.

Throughout the history of third nature, technology has revealed aspects of nature, in part by breaking it down and "harnessing" it and in part by providing metaphors for how nature and our own bodies and minds work. Heraclitus made metaphorical use of the bow and the lyre, and Plato of the wheels of lathes, looms, and pottery wheels. Later on, the clock would become the dominant metaphor for the whole "clockwork universe" (e.g., Crosby, 1997). Descartes promoted the idea that all material entities, including human bodies, were just machines, albeit often very complicated ones. Still later, technology infiltrated conceptions of the mind as well as matter, a role that today is played primarily by the digital computer. We began to understand the world and ourselves in terms of the physical artifacts generated by technology.

The co-evolution of technology and scientific reductionism altered and constrained what and how we know. Indeed, human "knowledge" is itself a dynamical, self-organizing, complexifying system; it may be regarded as a meme complex that is no longer just a means to an end, but an end in itself, "knowledge for the sake of knowledge".

**Technology Alters the Planet.** Guided by the idea of progress, technology has not only revealed some of the dynamics of first and second nature, but it has also dramatically changed them. A high-speed video replay of the surface of the earth over the last 8,000 years would reveal a massive re-sculpting, including the removal of forests, a "browning" of the earth and atmosphere, and the spread of rectangular, fenced-in patches of land, gaping mines, dams and reservoirs, freeways, factories, and cities. Guided by the idea of progress, technology has enabled the reshaping of a large portion of first and second natures to make them fit within our third-nature world-views and serve our ever-growing population and perceived needs. This reshaping is to some extent literal. Prior to the arrival of third nature and technology, the geography of the earth was to a large extent geometrically fractal, but since the Neolithic revolution, the earth has witnessed a rapid increase in rectilinear patches and structures. We are molding first and second natures into our platonic, Euclidean ideals.

### Co-Evolving Memes and Institutions

**Intertwining Institutions.** Turner (1997) examines some of the complex dynamics within the institutional order, in particular the interconnections among kinship, economy, religion, polity, law, and education. Other major institutions have no doubt entered the mix, including the entertainment industry, the media, the military, medicine, and science. The institutions have differentiated out of kinship at different times, and the patterns of connectivity have changed throughout the self-organizing history of third nature. Although tensions, at times fierce ones, have existed, and continue to exist, between various institutions (e.g., religion and polity), the institutional order has adaptively self-organized and evolved mostly symbiotic relationships. For example, the system of law has codified many religious and political principles and regulates the flow of capital, and all institutions work together to keep human behavior under control and in conformity with the survival needs of the order as a whole.

Owing to its symbiotic interconnections and feedback relationships, the institutional order self-perpetuates. However, like any other dynamical system, if the institutional order strays too far from the edge of chaos, then it risks becoming rigid, stagnant, and unable to adapt to changes within the global systems, including those of first and second natures, in which it participates and on which it continues to rely. Likewise, if the institutional order becomes too complex, then it may become correspondingly fragile and vulnerable to the house-of-cards effect. Indeed, the last 8,000 years have witnessed the rise and fall of several complex institutional orders, including the classical Mediterranean empires and, more recently, the Soviet Union.

**The Power of Progress.** The idea of progress has played a particularly central role in the dynamics of third nature. Along with anthropocentrism, it has taken center stage in the collective human mind and led to a world view in which humans are seen as distinct from and rulers of the rest of nature. The quest for a better life ignited the evolution and complexification of the entire web of third nature. It is in the interest of progress that technology has evolved and spurred the economy, population growth, and the differentiation out of kinship of the whole institutional order. It is in the interest of pursuing and protecting the good life, that property rights have evolved, fences have been constructed, first and second nature have been somewhat tamed and subdued, and the meme has spread throughout the human population, often with the aid of organized religion, that humans are the superior, end-product of and reason for all of creation.

Feedback loops among the various memes and institutions with which the idea of progress has co-evolved may have validated the idea and accelerated its effects. As technology mushroomed and humans gained more control over first and second nature, the idea that humans were special creatures, superior to other species, and even divinely created, gained apparent empirical support and momentum. The meme complex revolving and self-organizing around the idea of progress empowered us, made the dominion over the planet our "manifest destiny" and justified the conquest, and even extinction, of any "inferior" beings that could be exploited or that stood in the way. The victims of progress have been many and varied, including whole species and ecosystems and even vast human populations (e.g., slaves and indigenous populations). For a tragic recent example of human victims of progress, see the epilog of "The Harmless People" by Thomas (1989). As third nature continued to self-organize and complexify, progress was no longer just an idea; it was a powerful ethic, an obligation, and an inevitable "fact of nature".

## EVOLUTION OF THE BIG PROBLEMS

The injection of third nature into the planetary dynamics has launched an enormous cascade of big problems. Through its effects on the human mind and human behavior, third nature has entered into and perturbed the long-standing, tried-and-true dynamical interplay between first and second natures. The big problems did not reach the threshold of our collective consciousness until the 24-hr cosmological clock had already started its last tick. The primary sources of the big problems may be the memes of progress and anthropocentrism, the ideas that the earth belongs to humans and that we must exploit the earth in our continual quest for progress. Many of the biggest and most fundamental problems to which these primary memes have led are associated with overpopulation and environmental degradation. I shall first review some of these problems, next examine some of the ways in which they are intertwined, and finally consider a relatively neglected candidate for the category of big problems, the possible impoverishment of the human mind.[8]

### Overpopulation

#### Selfish Genes

Second nature is self-perpetuating. The "selfish genes" of organisms usually help to keep species in the optimal zone between order and chaos. Various dynamics of first and second nature, such as resource limitations and predator-prey interdependencies, have operated effectively for billions of years to prevent or, at least, minimize the deleterious effects of overpopulation. However, with respect to the human species, third nature has disrupted the checks and balances of first and second natures and set the species on what may be an unsustainable growth rate.

Our second-nature propensity to reproduce and seek short-term, survival gains may be what has been described as "evolution's fatal flaw" (Potter, 1990). The idea of progress fueled technological innovations and accelerated the cultivation, domestication, and harvesting of first and second natures and, as a result, sustained an ever-growing human population. However, it is becoming painfully evident that the dynamical interplaying of the idea of progress, anthropocentrism, technology, the institutional order, and population growth is having severe deleterious feedback effects on the first- and second-nature dynamics on which humans and countless other species ultimately depend.

**Population Bottleneck**

According to Wilson (2002), our population growth has rendered the immediate future a bottleneck that severely limits the living systems that may pass through it. The depletion of resources and the destruction, disruption, and fragmentation of ecosystems that our soaring population has occasioned has already led to the decimation of species of up to 1000 times the base rate of species extinctions. Humans and their memetic artifacts have steadily displaced other natural systems and have taken up an increasing ratio of the biomass that the earth is capable of sustaining. The bottleneck will take its toll on humanity as well. Wilson estimates that if the entire human population consumed at the same rate as the United States, then the equivalent of four replicas of our planet would be required to sustain it. So third nature, especially in Western cultures, will have to undergo a profound transformation in the near future if life is to pass through the bottleneck with sufficient vitality to sustain not only a healthy human population but, perhaps, the capacity of biological evolution to replace the tremendous loss of living systems that the bottleneck will necessitate.

**Environmental Degradation: The Costs of Technology**

Overpopulation, the institutional order, and their impact on the planet are attributable in large part to the dynamical partnership between the idea of progress and technology. Although technology may have improved the quality of life for an elite minority of the human population, it is arguable that even these marginal benefits are only short-term ones and that, in any case, the costs of technology far outweigh the benefits with respect to the planet as a whole. The costs of military technology and of emissions, wastes, and accidents associated with automobiles and industries are reasonably well known.[9] Global warming, air pollution, massive decimation of species, and the depletion and contamination of fresh-water sources are some of the better-known side effects of technology and overpopulation (e.g., Erlich & Erlich, 2004;

Gleick, 2001, Wilson, 2002). To further illustrate the costs of technology, I review four less well-known examples: costs associated with the use of synthetic fertilizers, the harvesting of wildlife, invasions of non-native species, and the use of pesticides and antibiotics. To varying degrees, all of these costs are examples of evolutionary spirals, of first- and second-nature systems "biting back" and undermining third nature.

**Too Much of a Good Thing**

Consider the initial phase of the food chain, namely, plants (primarily domesticated ones). We consume the products of plants (e.g., roots, leaves, and seeds) either directly or indirectly via other animals that themselves live off of plants. As already noted, plants depend on the cleaving or fixing of nitrogen in the soil, a task that for millions of years has been performed by certain bacteria in the soil. The first farmers thousands of years ago relied on these bacteria, and they have served the growth of third nature up until very recent times. Just a microsecond ago on our cosmic clock, when the human population began to grow exponentially with the approach of the twentieth century, this "natural" process was no longer sufficient to produce the crops needed to sustain humans and their livestock.

Until the arrival of third nature, a natural resource limit such as this would constrain population growth and require it to level off or even decline, thereby bringing a species more in balance with its ecosystem. However, in the early part of the twentieth century, technology intervened in the form of a process, called *Haber-Bosch synthesis*, which uses ammonia and other elements to produce synthetic nitrogen fertilizers (Smil, 1997). Across the decades of the twentieth century, a succession of technological innovations increased the production efficiency of synthetic fertilizers, allowing them to sustain the exponentially growing population. Smil (1997) estimates that around 2 billion of us would not be alive today had the Haber-Bosch technology not intervened to feed our mushrooming population. The discovery and application of synthetic fertilizers is just one example of the intrusion of third nature into a long-standing dynamical symbiosis between first and second natures, an intrusion with very serious and unanticipated side effects.

According to Smil (1997), the mass production and distribution of synthetic fertilizers may have been "too much of a good thing...Problems range from local health to global changes and...extend from deep underground to high in the stratosphere" (p. 79). These fertilizers have overdosed the earth with reactive nitrogen that has nowhere to go but into the air and water. The runoff of nitrogen fertilizers has contaminated well water and aquifers, caused many lakes, ponds, estuaries and increasing areas in oceans to be taken over by algae and grow stagnate, chemically degraded the soil in some places, and contributed to acid rain, a buildup of nitrates in the atmosphere, and the problem global warming. Ironically, and echoing the dynamics of ecosystems, the side effects of nitrogen fertilizer appear to be traveling full circle and damaging plants in terrestrial systems including large forests that have stood for millennia (Moffat, 1998). So the 2 billion additional human lives that the Haber-Bosch process made possible have been gained at a considerable, and growing environmental expense.

**Imperiled Fish**

When upper-Paleolithic humans spread across the globe to islands and continents never before visited by humans, armed with their improved tools and weapons, they decimated various species and whole ecosystems in which these species played a critical role (e.g., Diamond, 1992, 1997). These "over-kills" were early examples of the counterproductive use of technological innovations. Unfortunately, technology-driven over-harvesting of wild species continues today, a prime example being what Safina (1995) refers to as the "the world's imperiled fish".[10] Fish provide a large share of the protein diets of humans worldwide. Competitive commercial harvesting of the more desirable fish such as salmon and cod had become so intense by the middle of the twentieth century that their populations began to decline sharply, resulting in smaller catches and lower commercial profits. Rather than investing in efforts to conserve and revive fish populations, the fishing industry invested in more effective harvesting technologies, including huge (50-mile) fishing nets, sonar fish finders, and satellite locating devices. Other components of the institutional order facilitated this process by providing low-interest loans and government subsidies for commercial fishermen to invest in more effective technologies. Of course, the result has been a quickening of the decimation of various species of fish and, indirectly, the fishing industry itself.

This decimation of fish has launched butterfly and more conspicuous effects across the complex, dynamical ecosystems in which fish have long participated and evolved. For example, the commercially valuable fish are generally near the top of the oceanic food chain, and their reduction has allowed previously minor players to take over their place in the food chain, multiply, and upset the whole ecology (e.g., Levin & Schiewe, 2001). In addition, indiscriminate nets and deep trawling have more directly damaged ocean ecosystems. Although some efforts have recently been made to remedy this situation, they tend to be strenuously resisted by the fishing industry, and may be "too little too late".

### *Invading Species*

Technology has enabled a massive and continual movement of people and products of third nature across the globe. Various other living organisms have been passengers in this movement, either intentionally or as unintended hitchhikers. As a result, countless ecosystems are being invaded by non-native species. The potential deleterious, house-of-cards effects of invading species on even healthy ecosystems were noted in the *Our Three Natures* section above. Vitousek et al. (1996) state that "Our mobile society is redistributing the species on the earth at a pace that challenges ecosystems, threatens human health and strains economies" (p. 468).

The Eurasian zebra mussel stowed away in the ballast water of ships and is now thriving in North American rivers, lakes, and municipal and industrial waterworks. The Asian tiger mosquito entered the United States via imported automobile tires. Various foreign plants are thriving in "the new world", such as European cheatgrass in the Great Basin and the tamarisk trees that are now clogging and stagnating many river beds. Even some of the plant and animal species intentionally introduced to benefit human life have had unforeseen, devastating consequences on native ecosystems, often due to the insects and microorganisms that they brought with them. Some of these invaders are particularly prolific and can take over whole ecosystems, decimating native species, reducing biodiversity, and rendering the invaded territory more susceptible to natural disasters such as fires and floods. Of course, the most devastating invading species of all may be humans.

## The Resistance Movement

Weiner (1994) begins a chapter entitled The Resistance Movement by recounting the adverse effects of DDT on cotton crops. When cotton farmers began using this pesticide in 1940, they succeeded in eliminating the pests that had been infesting their crops but, in so doing, left the fields open to the invasion of an even more virulent pest, a species of moth that had been making a living in nearby ecosystems. Although the DDT killed most of the moths, some were naturally resistant and they and their descendants flourished. As the pesticide industry has developed more lethal chemicals, more robust and resistant moths have been "naturally" selected. The same scenario has been playing out with other pests and pesticides. It is a battle with second nature that third nature appears to be losing. "Before human beings had heaped up a mountain of pesticides in the 1940s...farmers in the United States were losing about 7 percent of their crops to insects. During the blitz of the 1970s and 1980s the insects did not lose any ground. Instead they nearly doubled their share, to 13 percent" (Weiner, 1994, p. 265).

The same evolutionary dynamics are building a powerful resistance movement in the various bacteria against which we have waged an escalating antibiotic warfare. Because of its fecundity, mutation rate, and ability to exchange DNA, the microcosmos can evolve new, resistant strains of bacteria overnight. Not only do antibiotics select for more virulent microbes, they can kill off more friendly bacteria in our bodies that compete with and hold down the proliferation of pathogenic bacteria. Our war against insects and germs is basically a war of third nature against second nature. Although the technological accomplishments of third nature are sophisticated and awe-inspiring, they pale in comparison to the design marvels and plasticity of second nature. Unless we find ways of co-existing peacefully with these tiny opponents, they are almost certain to win the war, perhaps in the not too distant future.

**Co-Evolving Big Problems**

Fueled by the idea of progress, technology has supported a growing human population, which has led to a complexifying institutional order, which in turn has validated the idea of progress and fostered more technological innovations in an on-going, self-perpetuating spiral. This rise of third nature has intruded into and perturbed the original dynamics of first and second nature, launching a cascade of interdependent environmental catastrophes. The dynamics of third nature have extinguished some species, brought others on the brink of extinction, and disrupted the ecosystems in which these species have played a vital role for millennia. Forests and woodlands have been removed, rivers have been dammed, and wetlands have been drained. Mines have tunneled into the earth's crust and carved into mountains and ocean floors. Freeways, fences, ditches and canals have been etched in the terrain, and reconfigured the fractal landscape into Euclidean third-nature grids. Pollutants from industries, automobiles, and other third-nature sources have seeped into the earth, water, and air.

Over fishing is imperiling fish populations and rendering ocean ecologies vulnerable to invading species which are contributing further ecological destruction including oxygen depletion and stagnation of ocean ecosystems. Nitrogen run-off and fossil-fuel emissions can pollute the atmosphere, contribute to global warming, acid rain, contamination of water, and ozone holes, all of which can lead to more ecological disasters. Indeed, nitrogen run-off also destroys fish and aquatic environments, exacerbating the problems caused by over fishing, and fossil-fuel emissions and industrial waste are feeding into the destructive dynamics of both over fishing and over fertilizing.

The re-landscaping of the planet into third-nature geometry comes with considerable direct and indirect environmental costs. Not only are native ecosystems directly destroyed to make room for farms, factories, cities, highways, and other products of third nature, but they suffer from indirect effects as well. Some of the native ecosystems that are not directly destroyed are cut up into isolated patches. As already noted, isolated systems are often characterized by low biodiversity and are especially vulnerable to take-over by invading species. As a result, an increasing percentage of millennia-old ecosystems are stagnating and dying.

Rather than attempting to remedy its destructive effects by investing heavily in conservation and revitalization programs, third nature has intensified the problems either by ignoring them, trivializing them, or pursuing counterproductive technological solutions. Remedial efforts cost money, and very powerful elements of the institutional order regard this money as better spent on other third-nature interests. However, these problems are not restricted to first and second natures; many are feeding back into third nature itself. Over-fishing is negatively impacting not only fish populations and ocean ecosystems but also the fishing industry, fishing communities and the quality of life of the people who live and work in these communities. Likewise, overuse of synthetic fertilizers and pesticides is harming not only farm lands, rivers, water tables, and the atmosphere but also the farming industry, farming communities, and the quality of life of farmers. The resistance movement of insects and microbes is reducing the effectiveness of pesticides and antibiotics and resurrecting various blights and diseases in crops and humans. Because fishing, farming, and human health participate in global economy and the institutional order, these negative effects radiate throughout the web of third nature, impacting human lives the world over. In brief, the big problems are themselves co-evolving in a nonlinear web of relationships.

Of course, at least in the short run, some facets of third nature suffer less than others from the complexifying web of big problems. Indeed, some may even be reaping short-term benefits. Pharmaceutical and chemical industries, insurance companies, Western science, engineering, medicine, and many other participants in the institutional order make a living off of the attempts of third nature to wage technological war against what it perceives to be the first- and second-nature causes of the big problems. More generally, a global economy has partitioned the enormous human population into a tiny minority of "haves" and a large majority of "have nots". The "haves" are more privileged and entitled than the "have nots"; they may be considered to be the more important "survival machines" of the institutional order. The consumptive appetites, desires, ambitions, ethics, and commitment to the idea of progress of the "haves" are to a significant degree responsible for the rise of third nature and the big problems, including the impoverishment and virtual enslaving of the "have nots" (e.g., Quinn, 1992).

## Alteration of the Human Mind

The human body may not have changed much in the last 40,000 years, but the human mind certainly has. Like other systems imbedded in complex, dynamic webs, the human mind has launched a number of ripple effects that have looped around the web and affected the mind itself. Third nature arose from the human mind and now deeply infiltrates and controls it. The human mind, especially in Western civilization, has co-evolved with third nature and the big problems and may itself have become a big problem.

### Mind as Medium

Of course, we are participants in third nature, and the institutional order and technological "progress" have dramatically altered us as well as the rest of the earth. Within just the last fraction of a second before midnight of our 24-hr universe, we have found ourselves disconnected from the lush and vibrant ecosystems in which our Paleolithic ancestors thrived, and we are now inextricably connected to and interacting with the rectilinear structures, institutions, world views, and technological artifacts of third nature. We have become the media by which third nature self perpetuates; it lives through us by invading our minds and controlling our behavior. Our minds are the carriers of the self-organizing and self-perpetuating memes of third nature.

Like other natural systems, the human mind may be conceptualized as a dynamical, self-organizing system or network. The mind is imbedded in and interconnected with the grand webs of all three natures. Across the millennia, the human mind has co-evolved with and, to some degree, has been co-opted by, third nature. Our dynamical, self-organizing minds reflect the third nature into which we are born. Our mental (and neural) networks are attractors that mediate the constraints on our behavior imposed by our native languages, our cultural values, and our professional specializations, among myriad other aspects of third nature. The infusion of third nature into the human mind may be another exaptation of Lucy's upright stance. The considerable post-natal growth and plasticity of our brains renders our neural networks especially sensitive to cultural inputs.

The mind is a self-perpetuating system. That is, our beliefs and values bias our perception, attention, memory, learning, and behavior in ways that strengthen and perpetuate these same beliefs and values. Because the mind is infiltrated and controlled by third nature, its own self-perpetuating processes assist in the self-perpetuation of third nature. The mental rigidity that comes with the deep, specialized attractors that we occupy in the institutional order only strengthens the role that the mind plays in the self-perpetuation of third nature. Thus, the human mind is implicated in the big problems and has itself become a big problem. The first step toward solutions to the big problems may require a phase transition in the human mind and world-view.

**Mental Content**

In general, the minds and behaviors of humans are seen as emergent from the dynamical intertwining of all three natures. We are still bound by the laws of first nature, and we are still influenced by our second-nature genes. However, our mental and behavioral departure from our Paleolithic ancestors began when third nature was added to the mix. One's "stream of consciousness" today is heavily influenced by the various memes that have been acquired over one's lifetime and that, in their material forms, fill one's environment, memes that did not exist in Paleolithic times.

Third nature now infuses most of our sensory inputs, our perceptions, our memories, and our thoughts (e.g., Johnston & Strayer, 2001). This infusion has changed how we conceptualize ourselves, the rest of nature, and ourselves in relation to the rest of nature; it has led to our reclusion inside our fences (both literal and metaphorical), surrounded by countless artifacts of third nature; and it has led to our reconstruction of reality in ways that perpetuate third nature and the big problems. Those of us locked inside our third-nature minds cannot imagine what the subjective experiences of our Paleolithic ancestors were like. Whatever may have been on their minds, it had relatively adaptive consequences on their behavior and relatively benign consequences on the rest of nature. They experienced a world composed primarily of first and second natures, along with whatever rudiments of third nature lay within their kinship-based social order. They clearly did not experience anything approaching what I am experiencing now, as I sit within my home office facing my computer screen, making use of a word-processing program to write this paper. In another room stands a television set, mindlessly facing which I spend many evenings. Outside I hear a siren and traffic noise, and when I gaze out the window I see a neighborhood of other houses similar to mine, surrounded by parked cars and landscaped lawns and other non-native species of plants. Below in the valley, I see a whole city laid out in a large, rectilinear grid. In the distance, through a smog-filled haze, I can make out the fractal geometry of a lake shoreline and verdant mountains, a distorted glimpse of the first and second natures in which our Paleolithic ancestors were immersed and to which they were closely connected.

The task in which I am engaged in writing this paper and the thoughts that run through my mind are obviously nothing like what our Paleolithic ancestors experienced. Unlike them, I think mainly third-nature thoughts. Third nature controls and infiltrates my mental experiences both when I am awake and when I am dreaming. The third-nature ideas of progress, achievement, "making something of one's self", and the "American dream", among others, began to infiltrate my mind and shape my behavior decades ago. Because I am immersed within and controlled by the powerful institutional order, I have become a specialist and will receive a paycheck today. The pay we receive for the roles we play in sustaining the institutional order is itself used to sate our culturally-based appetites for other artifacts of third nature and, thus, to further sustain the institutional order. Our paychecks, our professional specializations, our minds, and our behaviors exemplify media by which third nature and the big problems self perpetuate.

**Costs of Expertise**

As already noted, because the institutional order has evolved and complexified across the millennia, increasingly specialized ways for humans to make a living have arisen. The niches and fitness peaks of the institutional order have grown exponentially in the last 100 years, and because the landscape is always changing, those who manage to ascend to the tops of peaks are at risk of a catastrophic fall. Our institutional roles have become increasingly disintegrated, fragmented, and esoteric. The impressive and powerful collective intelligence of the institutional order has been gained at some cost in the plasticity of individual minds. My profession yields a paycheck and validates and reinforces my place in the institutional order, but over the years it has isolated me within a narrow institutional niche.

As they mature from infants to adults, many organisms gain knowledge and expertise that permit them to survive relatively independently. They move upward on a continuum from novice to expert. Humans move further along this continuum than any other organisms. We are totally helpless in the beginning and are dependent on our caretakers for many years. This is especially true in today's world because third nature has made the process of becoming an expert considerably more difficult and time-consuming than it was in Paleolithic times. Many of us devote a quarter of our lives to formal education and another quarter trying to climb the career ladder in the specializations for which we are trained.

This ascension of the continuum of expertise comes with a commensurate cost in mental, and presumably neural, plasticity. Within the first year of life, human infants lose the ability to discriminate between vocalizations that are not in their native language (Werker, 1989). In reaping the benefit of learning their native language, they suffer a commensurate cost in ability to learn other languages. Expert radiologists have excellent recognition memory for abnormal radiographs, those that reveal pathologies, but cannot recognize normal radiographs as well as novice radiologists (Myles-Worsley, Johnston, & Simons, 1988). Apparently, as one's mind becomes more precisely attuned to the "relevant" inputs in the specific domains of one's expertise, one begins to lose sensitivity to other inputs and finds it increasingly difficult to gain expertise in other domains (e.g., Johnston, et al., 1998). Just as a healthy ecosystem requires an optimal level of species diversity to be able to rebound from major perturbations, a healthy mind may require an optimal level of diversity of knowledge and perspective to be able to keep pace with a changing third nature.

Contemporary humans may not be resolving the stability/plasticity dilemma as optimally as did their Paleolithic ancestors. As individual specialists, we have moved far away from the edge of chaos into the rigid attractors that represent our domains of expertise. However, third nature is still evolving at a rapid pace. As we grow older and settle more deeply into these attractors, we run the risk of obsolescence, stagnation, and the inability to keep pace with third nature and an ever-changing fitness landscape. We can become stranded in obsolete specialties and rigid world views, at the mercy of the negative arrow of time. In contrast, because our hunter-gatherer ancestors adapted to a relatively stable world of first and second natures, their minds probably remained more viable and fit ecologically throughout their lives.

**Disconnection**

The loss of plasticity may be one way in which third nature has impoverished the human mind. In addition, the shift to self-reflective thought and the infusion of the memes of third nature may have impoverished the mind by profoundly changing its long-standing relationship with first and second natures. In becoming enmeshed in the institutional order and connected most closely with the memes and artifacts of third nature, the human mind may have become alienated from the first- and second-nature ecosystems with which it originally co-evolved

Whatever benefits the plastic brains of our hunter-gatherer ancestors may have gained in allowing them to control first and second natures, they perhaps cannot outweigh the third-nature costs with which we are left. Third nature has loosened some of our ancient bonds with the rest of nature by transforming our minds into its survival machines and binding us to the institutional order. Thus, like other systems that emerged from the long, co-evolutionary processes of first and second natures, the human mind may be a casualty of the arrival of third nature.

**Potential Big Problem**

The basic nonlinear dynamics of first and second natures apply as well to third nature, including butterfly effects, evolutionary dominos and spirals, and ever-changing fitness landscapes. The confluence of the problems of overpopulation, environmental degradation, and the subjugation of the human mind to the self-perpetuation of third nature may be rendering the planet vulnerable to a massive house-of-cards effect. Technology has placed the various teeming human populations of the world in dangerously close contact. Cultures with incommensurable world views are now capable of mutual annihilation. World history since the Neolithic amply testifies that countless human lives are readily sacrificed in the self-perpetuationing interests of third-nature systems. If we do not destroy ourselves, then second nature may rise to the occasion. As the AIDS epidemic and many prior plagues illustrate, powerful agents of the microcosmos are capable of dealing a fatal blow to millions, perhaps billions, of people. Just as normally vibrant ecosystems can be demolished when the proliferation of a dominant species reduces biodiversity below a critical level, the whole biosystem of the earth may be on the verge of collapse owing to the environmental havoc that a mushrooming humanity is producing. Of course, the survival of third nature requires a degree of environmental integrity and biodiversity; so the damage that third nature does to first and second natures is apt to travel full circle.

## CONCLUSIONS AND IMPLICATIONS

In this final section, I examine the field of psychology as a dynamical, third-nature system, summarize the history of our three natures and the big problems, note signs of what may be a phase transition currently underway in third nature, and conclude with some final thoughts, caveats, and ethical considerations.

### Psychology as a Third-Nature, Dynamical System[11]

The dynamical-systems framework has, in recent years, been applied to various areas of psychology (e.g., Robertson & Combs, 1995), including clinical psychology (e.g., Butz, Chamberlain, & McCown, 1997), social psychology (e.g., Vallacher & Nowak, 1994), organizational psychology (e.g., Guastello, 2002), developmental psychology (e.g., Fogel & Lyra, 1997), and both cognitive psychology and neural psychology (e.g., van Gelder, 1997). Rather than reviewing these applications of the framework to specific areas of psychology, I shall apply it to the field of psychology as a whole.

#### Self-Organizing Complexification of Psychology

Psychology, along with the whole web of systems in which it is imbedded, has self-organized and complexified from its humble inception near the end of the nineteenth century into a vast, multifaceted system with firm footholds in academia, science, and society in general. This complexification is revealed by the large increase in books, journals, areas of specialization, professional organizations, and the membership within these organizations. Throughout the brief history of psychology, the theories and metaphors of mind have evolved with the prevalent technologies (e.g., thermodynamics, switchboards, communication channels, and computers). The rapidly diversifying specializations of psychology may be thought of as professional attractors, each with its own specialty journals, theoretical issues, research methodologies, concepts and language. The permeability of the membranes separating these specialty areas has steadily decreased, rendering them more insulated and unable to reap the full benefits that a more free-flowing cross-talk and interchange of ideas could potentially provide.

The theories, tools, and methods of psychology have also complexified. For example, consider the classification systems of "mental illness" or psychopathology such as those represented by the various renditions of the *Diagnostic and Statistical Manual of Mental Disorders* or, DSM (e.g., DSMs I-IV). The standard system prior to the DSM series had 97 categories compared to the 108 in DSM-I, 182 in

DSM-II, 265 in DSM-III, and over 400 in DSM-IV, all of this over a period spanning just 60 or so years (e.g., Blashfield, 1984). Assuming that relatively few of the current DSM categories would have applied to our Paleolithic anscestors (or would apply today to our primate cousins), to what might this diagnostic complexification be attributed? It is likely that some new forms of psychopathology have emerged from and co-evolved with third nature. At least the relative incidence of some of the categories, such as anorexia, post-traumatic stress, and occupational disorder, might have grown with third nature. However, it is doubtful that third nature is responsible for some 50 new pathologies every decade. Rather, the whole concept of psychopathology may be viewed as a dynamical system, a meme complex, that is co-evolving with other systems (e.g., cultural values) along the positive arrow of time.

**Third-Nature Properties of Psychology**

In many ways, psychology reflects the third-nature world view and value system that characterizes much of Western civilization. This is reflected in, among other things, its epistemological reductionism and anthropocentric values.

***Reductionism.*** As already noted, psychology subscribes to the epistemological reductionism that characterizes Western science in general. The focus on internal processes is not confined to neuropsychology. Cognitive processes and phenomena such as memory, attention, thinking, attitudes, phobias, decision making, and judgment are also generally assumed to reside somewhere inside individual humans. The reductionistic approach is revealed also in the linear and additive assumptions underlying its statistical and methodological tools. If human organisms are dynamical systems in a co-dependency relationship with all three natures, then it is unlikely that brain/mind processes can be manipulated and measured independently of one another and be elucidated under the controlled, artificial, laboratory conditions that are typically employed in psychological research.

***Anthropocentrism.*** The memes of progress and human superiority to and separation from the rest of nature are evident in modern psychology. Psychology seeks to improve the *human* condition, and it does so, at least in part, via scientific reductionism and at some expense to the lives and welfare of other organisms. For example, scientific ethics allow for the isolation, containment, physical suffering, and ultimate sacrifice of other animals. However one may attempt to justify the exploitation of animals for medical research, most of the arguments would not apply to psychological research, the majority of which is motivated more by intellectual curiosity than any sincere interest in finding cures for human diseases. Infant monkeys have been separated from their mothers in order to study the role of "contact-comfort" in normal development. Rats have been forced to swim through underwater mazes, endure electric shock and other painful "reinforcers", have parts of their brains stimulated or extirpated, and ultimately killed in order to study learning and memory processes and bring data to bear on various esoteric theoretical issues and controversies. Even most animals used in behavioral research entailing no need for post-mortem examination are euthanized because they are considered insufficiently "naive" to be of use in further research. Those that are saved for further research must live out their lives in caged isolation. In any event, if an understanding of human behavior cannot be found by studying the brains of humans, then it would appear to be even more futile to seek this understanding in the brains of rats, pigeons, and other animals. I suggest that science, rather than actually having a well-developed and reasoned position on the ethics of animal research, has simply been infected, like most other strands in the institutional web, with third-nature, anthropocentric memes. Animal research is just one manifestation of the long held meme complex underlying the "war against nature" and the bending of natural systems to our third-nature purposes.

### The Future of Psychology

Psychology has already undergone various phase transitions (e.g., the "cognitive revolution") and is destined to undergo additional ones in the future. I suggest that psychology is currently on the brink of a major transition. It is not possible to predict with precision what the next attractor will be. It might even suffer a house-of-cards effect, with some of its remains being siphoned off into other areas like computer science and biology. Phase transitions are often effortful, painful, and strongly resisted by systems. This paper represents an attempt to encourage us to bite the bullet and pursue change, to try to render psychology better able to address the big problems, and to consider the dynamical, evolutionary approach developed herein as an alternative direction in which to move.

## History of Our Three Natures

We humans, as well as virtually everything else on the planet, are living memories of the entire history of our three natures. We began to take form with the birth of first nature at the beginning of space and time some 12 billion years ago, 24 hours ago on our compressed time scale, and its subsequent self-organizing complexifications across such phase transitions as the freezing out of atoms, the generations of ancestral stars that cooked up the heavy elements of which we and the rest of earth are composed, and the experiments on early earth that led to the birth of second nature some 3.5 to 4 billion years ago. We then began to be molded by the phase transitions in living systems that led to nucleated cells, multicellular life forms, the successive waves of mass extinction and resurrection, the radiation of mammalian species after the last wave, and the emergence of the upright ape several million years ago whose body and brain became anatomically modern as many as 250,000 years ago. Finally, between 8 and 40 thousand years ago, just a fraction of a second before midnight on our compressed time scale, our minds and behaviors began to undergo profound transformations with the emergence of third nature and the various phase transitions associated with the shift from hunter-gatherer to agrarian and urban lifestyles, population growth, the idea of progress, the self-organizing complexification of technology, knowledge, and the institutional order, and the onset of a new wave of mass extinction of species.

We are the living memories not only of the history of the idea of progress and the evolution of technology and the institutional order but also of the consequences and manifestations of these dynamics of third nature throughout their brief history. We are living memories of the Crusades, of the trial of Galileo, of the expansions into new worlds and the decimation, via our technology and germs, of indigenous humans and other living systems, of world wars, the holocaust, the invention and use of atomic and other horrendously lethal weapons, and of the events of 9/11, 2001. We are living memories of consumerism, global warming, slavery, racism, and ghettos. We are the vehicles through which third nature and the big problems have evolved and continue to self perpetuate. If we want to understand ourselves and the big problems, then we must look at ourselves not just reductionistically in the tradition of Western science, but also in relation to the whole evolving web, the grand pattern with which we have co-evolved and in which we are imbedded and actively participate.

## The Future of Our Three Natures: A Reconciliation

A major theme of this paper is that third nature has spawned a powerful, dynamic institutional order. This order infuses our minds with a meme complex, including a socially-constructed world view, that shapes our thoughts, moods, ambitions, behaviors, values, and life trajectories in ways that support the order and allow it to self perpetuate. The evolution of third nature appears to have inflicted considerable damage on the planet as whole, perhaps including human minds. Third nature may have to undergo a major phase transition if the wounds are to be healed. Indeed, from the perspective developed in this paper, because third nature is a complex, dynamical system, it will necessarily change, either by self-organizing across multiple phase transitions or succumbing prematurely to the negative arrow of time.

If psychotherapy were to somehow be effectively administered to humanity, it might well reconsider the underlying assumption that effective socialization into third nature is the primary, and perhaps only, road to psychological health. Perhaps it should examine an alternative road, one that encourages a reconciliation of third nature with its older, time-tested parent natures. Psychology might play a leading role in seeking ways to disentangle humanity from the memes and artifacts of third nature enough to forge a reconnection with and renewed appreciation of the remaining vestiges of first and second natures. In general, third nature, which includes the human species, may have to undergo a phase transition that brings it into a healthier alignment with the rest of nature. Let us consider a few of the indications that this process may already have begun.

**The End of Progress**

The idea of progress may be considered the taproot of the self-organizing growth of third nature and the big problems. It is an idea that may have run its course and have to undergo a major transformation if the three natures are to be reconciled in a way that preserves the integrity of the planet. Indeed, Nisbet (1994) concludes his book on the history of the idea of progress by reviewing various sources of evidence of a growing skepticism to the idea that progress, as it has been defined and pursued across the centuries, is a necessary and noble pursuit. Increasingly over the last half-century, scholars have begun to question the value and wisdom of continued technological, economic, and human-population growth. If the idea of progress is to be resurrected and continue to play a major role in the evolution of third nature, it may have to be thoroughly revised. I suggest that progress will have to be defined with respect to the planet as a whole, all three natures, rather than just with respect to the human species and third nature.

**Population Growth**

Ever since the shift to agrarianism some 8,000 years ago, the human population has grown exponentially. Over six billion humans are currently living on the planet. As noted above, the planet cannot sustain this burden indefinitely. Technological innovations, like fertilizers and insecticides, that attempt to circumvent natural limitations tend to compound the problems. Fortunately, at least in most developed nations, population growth has begun to level off and in some cases drop (e.g., Erlich & Erlich, 2004). If this trend were to continue to the point that the size of the population began to decline and, perhaps, be cut in half, many of the big problems would likewise subside. There would be a commensurate reduction in the use of synthetic fertilizers, fossil fuel emissions, human waste, destruction of ecosystems, and decimation of species.

**The New Generation**

With few exceptions, members of the establishment, the primary vehicles through which third nature survives and grows, are still committed to the idea of progress and technological and economic growth. However, a skeptical attitude and keen environmental sensitivity are clearly evident in today's college students, the power brokers of the future. And even if many youthful idealists fall victim as new members of the establishment to the ideas and incentives of the institutional order, a seed of doubt will have been planted in them. A cursory glance at the environmental themes of many recent children's books suggests that this seed will take even deeper root in their children. If third nature is to undergo the profound transformation that will be necessary to begin to reduce the big problems, it will be in the minds and behaviors of successive generations.

**Environmental Movement**

Concern for the environment has grown sharply over the last 50 years. Today there are many organizations that are committed to and lobby for protection of the planet and remediation of the damage that third nature has dealt it. There are movements to simplify our life styles and reduce our materialistic values and consumption of resources. International treaties and pacts have been organized in an effort to change our collective behavior in ways that preserve and sustain first- and second-nature systems. Although there continues to be considerable resistance to these movements from the institutional establishment, the tide and momentum may be turning.[12]

**Essential Tension**

I suggest that the global effects of a fledgling third nature, still suffering growing pains in the course of just the last tick of our compressed cosmological clock, have become increasingly apparent and are no longer so easily denied, ignored, or benignly interpreted (e.g., as God's will, manifest destiny, slight costs offset by massive benefits, or problems for which science will soon find solutions). At the present time, the voices of progress still shout the loudest, dominate the media, and control the reins of power. But a backlash is being felt and a tension is rapidly growing. The tension will have to be resolved one way or another. In terms of the dynamical-systems framework offered here, third nature has been perturbed and is entering a turbulent, effortful, phase transition. Whether the transition is a major one, one that transforms the entire institutional order, the human mind, and the planet as a whole remains to be seen. This paper may itself be considered a small reflection of a transition in progress.

## ENDNOTES

[1] I do not know what the mind is and how it might be related to the brain, so to finesse the issue, I will bail out as others have done by referring to the brain and mind together as the brain/mind system. Although the basic brain/mind architecture and processes probably have not changed much over the millennia, a primary thesis of this paper is that what goes on in the brain/mind (e.g., mental content) clearly has. In addition, although the brain/mind is the medium by which external factors can influence behavior, it is not necessarily a passive one. As we shall see, what happens to the brain/mind, individually or collectively, can influence behavior in ways that loop back onto the external factors and affect them in ways that alter their subsequent effects on the brain/mind.

[2] Like any general paradigm, including reductionistic science, the dynamical-systems approach outlined here is not itself subject to direct empirical assessment and falsification. It is a metatheoretical perspective within which various hypotheses may be generated. However, in many cases, the methodologies may need to be appropriate for the paradigm (e.g., naturalistic observation in lieu of laboratory studies, and nonlinear mathematics in lieu of orthodox statistics). Moreover, reductionistic and nonreductionistic approaches are not mutually exclusive and may be fruitfully integrated to form a more thorough understanding of natural systems, including complex, biological systems (e.g., special section on *Systems Biology* in the journal *Science*, 2002).

[3] I must offer a disclaimer here. I suspect that most readers are more familiar than I am with the quantitative methods and original data of dynamical systems theory. I have been informed primarily by popular accounts of this approach, and the framework that I offer here is largely an amalgam of these secondary sources (e.g., Coveney & Highfield, 1990, 1995; Fewell, 2003; Gleick, 1987; Goerner, 1994; Kaufmann, 1993; Prigogine & Stengers, 1984).

[4] Three properties of deterministic chaos are extreme sensitivity to initial conditions, boundedness, and non-repeatability (Kaplan & Glass, 1995).

The term *butterfly effect* refers to the drastic alteration in system evolution that can be wrought by a very tiny change in initial conditions (e.g., Gleick, 1987). More generally, the term refers to the fact that, owing to nonlinearities in system dynamics, tiny causes can have big effects (and vice versa). The self-organizing course of chaotic systems in *phase space* can map out apparent form and order (e.g., the well-known Lorenz attractor) even though they never retrace the same point and their subsequent moves are unpredictable. The *fractal* geometry of strange attractors describes many natural systems (e.g., mountains and shorelines) better than does Euclidean geometry.

[5] Of course, it is also possible that life did not originate on earth but was imported on debris from space.

[6] As Gould (1994) has argued, biological complexification is not the only direction that biological evolution can follow; it can radiate horizontally as well as vertically along the phylogenetic scale. Indeed, bacteria have speciated and thrived much more than have multicellular creatures. However, the complexification of biological and ecological systems has occurred and may be a probable, if not inevitable, outcome of biological and ecological evolution.

[7] Diamond (1992) suggests that plate tectonics also played a major role in the evolution of third nature. In particular, the east-west axis of Eurasia may have been responsible for the conquest by Europeans of Native Americans by allowing for better transmission of crops, animals, germs, tools, and memes which gave Europeans the edge not only in terms of "guns, germs, and steel" (Diamond, 1997), but also in terms of imperialistic and anthropocentric memes

[8] The various claims, evidence, and prognostications concerning the dire state of the planet have been resisted by various quarters of the institutional order. The massive transformations that would be required to try to correct the big problems would naturally be resisted by the self-perpetuating forces and vested interests of the institutional order. For this reason, apparent "scientific" challenges to the environmental movement, such as are garnered in the book entitled *The Skeptical Environmentalist* (Lomborg, 2001), have been warmly received by the vanguards of the institutional order. Unfortunately, the various critical reviews of these challenges have not received the same degree of media attention (e.g., Rennie, 2002).

[9] The costs of automotive technology on human life and limb have recently been compounded by a more recent technological innovation, namely, the cell phone. The mushrooming use of cell phones while driving has been shown to decrease driving performance and increase the

rate of accidents (e.g., Strayer & Johnston, 2001).

[10] For dynamical-systems treatments of problems associated with declining fish populations, see Guastello (1996) and Rosser (2002).

[11] Journals dealing with various applications of dynamical systems to psychology and related fields include "Nonlinear Dynamics, Psychology, and Life Sciences" and "Cybernetics and Human Knowing".

[12] I have spent nearly all of my adult life, some 40 years, engaged in reductionistic science and committed to the idea of progress. As this paper should testify, I am undergoing rather profound intellectual phase transitions. Virtually all of my students in recent years are keenly aware of and deeply concerned about the planet and the big problems. Today there are whole educational programs on "environmental studies", as well as "women's studies" and "ethnic studies". Ralph Nader has run for the presidency of the United States on an "environmentalist" platform.

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