Human Natures, Nature Conservation, and Environmental Ethics

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There is little dispute within the knowledgeable scientific community today about the global ecological situation and the resultant need for nature conservation (e.g., NAS 1993, UCS 1993). Now is a time of unprecedented, escalating, and well-documented environmental danger. There is general agreement among environmental scientists that the accelerating loss of biodiversity—populations (Hughes et al. 1997), species, and communities—should be a matter of great concern. They have concluded that nature must be conserved not just for its own sake but also for the sake of *Homo sapiens*, to which it supplies an indispensable array of ecosystem services (Daily 1997, Chapin et al. 2000) and products (Beattie and Ehrlich 2001). And for most of those scientists, and large numbers of environmentalists, conservation is a major ethical issue (Rolston 1988, Nash 1989). In addition, the scientific consensus is that the major driving forces of the destruction of humanity's natural capital are population growth, overconsumption, and the use of faulty technologies combined with inappropriate socio-political-economic arrangements to service that consumption (Holdren and Ehrlich 1974, Holdren 1991, NAS 1993, UCS 1993)—what might be called the three horsemen of IPAT (Impact = Population x Affluence x Technology; Ehrlich and Holdren 1971, Ehrlich and Ehrlich 1990).

But the seriousness of the environmental dimensions of the human predicament is still unknown to the vast majority of the general public and decisionmakers worldwide. Although scientists understand the general directions in which humanity should be moving to solve its environmental problems, the policy response of society remains pathetic. As a result the cutting edge of the environmental sciences is now moving from the ecological and physical sciences toward the behavioral sciences, which seem to have the potential to develop ways to improve that response.

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> CULTURAL EVOLUTION IS REQUIRED, IN BOTH THE SCIENTIFIC COMMUNITY AND THE PUBLIC AT LARGE, TO IMPROVE SIGNIFICANTLY THE NOW INADEQUATE RESPONSE OF SOCIETY TO THE HUMAN PREDICAMENT

The key is finding ways to alter the course of cultural evolution—change in the vast body of nongenetic information that humanity possesses and passes around between and within generations (Ehrlich and Holm 1963, Keesing 1974). Cultural evolution in this sense means more than what is usually called "history." For example, the divergence of languages or the refinement of an aircraft's design is not ordinarily studied by historians, but these are part of cultural evolution. The critical importance of cultural evolution in understanding behavior has been reinforced by the discovery that there may be only some 26,000–38,000 genes in the human genome (Venter et al. 2001). It is now even more obvious that this "gene shortage" (Ehrlich 2000) is the final nail in the coffin of "evo

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has been long on psychology, but it's based on a distorted view of evolutionary theory (e.g., Ketelaar and Ellis 2000a, 2000b) that puts too much emphasis on inclusive fitness (Cavalli-Sforza and Feldman 1978, Lloyd and Feldman 2001).

But beyond the weak evolutionary underpinnings of evolutionary psychology, gene shortage shows that we cannot look to our genes to either explain or modify most of our behavior. Not only are there too few genes to account for the vast complexity and flexibility of behavior, but given the enormous diversity of processes in which the genome must participate, it follows that many (if not most) genes must be involved in multiple tasks. This certainly greatly complicates the "programming" of all phenotypic characteristics and makes it rather difficult to change one such characteristic (such as a preference for a certain type of mate) without changing others, which may seriously affect fitness. The unitary, unchanging behavioral "human nature," once thought invented by gods and later assumed to be a product of genetic evolution, is nonexistent. Our complex and flexible behavior is largely determined by our environments, and especially by the extragenetic information embodied in our cultures. Thus what is desperately needed now is much better understanding of the ways in which culture evolves and determines most interesting human behavior, including humanity's treatment of its life support systems. We need to comprehend how cultural evolution produces the vast diversity of human natures—different fundamental attitudes, beliefs, proclivities, preferences (in the economic sense), and behaviors (Ehrlich 2000). That should help us discover how to reconfigure social, political, and economic incentives and cut through barriers of ignorance and denial, allowing society to turn onto a path toward sustainability. Some of the most important products of human cultural evolution are ethical concerns, including concerns for nonhuman organisms and the environment in general. Cultures already have been evolving in the direction of broader environmental ethics (Ehrlich 2000), and that process needs to be accelerated.

Now that it is obvious that the details of our ethical evolution cannot be seriously constrained by genetic proclivities, it behooves us to try to understand how cultural evolution operates on the ethics of environmental preservation. We are also free to concentrate on finding ways to consciously direct cultural microevolution. We should of course keep in mind the genetically evolved background that has permitted us to acquire language and morality and that may have given people the tendency not only to recognize but to favor kin, and indeed to invent "pseudokin" (Ehrlich 2000, p. 193). Exactly which, if any, of our diverse behaviors are in some sense genetically programmed or for which we have genetic proclivities remains one of the great unanswered questions of human biology. Apart from kin recognition and preference and a penchant for group living, I suspect most other behaviors can be most parsimoniously explained by cultural evolution in a very smart, language-possessing animal with a need for food, sex, and security. It is an animal that lives in a vast diversity of habitats and that has certain constraints on its perceptual systems (Ornstein and Ehrlich 1989) and on its mental abilities (e.g., limits to the number of relationships and obligations it can keep track of). Traits that are universal or near universal in human beings (Brown 1991) are not necessarily innate—a classic example being the use of capital punishment (Otterbein 1986).

That same background may also have made us basically a small-group animal by limiting the recordkeeping capabilities of our brains and forcing us to culturally develop legal systems in order to live in large groups and still maintain a sense of social stability (for an interesting discussion of moral structures in early hunter–gatherers and later civilizations, see Black 1976, 1998). Human beings have a nervous system with perceptual constraints that impede dealing with slowly developing environmental problems. But this should not prevent the steering of cultural microevolution in a manner that induces humanity as a whole to do much more to husband its natural capital and the flow of essential services it generates. It is to be hoped that this can be done rapidly, while a relatively smooth transition to a sustainable society is still possible.

The role of the social sciences

The job of social scientists is daunting, since the interactions among the elements of culture rival in complexity those of the global ecosystem of which humanity is an increasingly dominant component. The mechanisms driving cultural evolution are little understood in detail, but in broad outline they include cultural macroevolutionary influences such as the geographic distribution of resources, discussed long ago by Montesquieu ([1748] 1989) and more recently brilliantly analyzed by Diamond (1997). More important in the current context, they also include factors causing cultural microevolution— "changes within and among human societies in terms of human actors, motives, and actions" (Ehrlich 2000, p. 228). Trying to understand cultural microevolution has been largely the domain of economists, anthropologists, sociologists, psychologists, historians, and other social scientists, although it has been of interest to biologists since Darwin—see, for example, the classic book of Cavalli-Sforza and Feldman (1981) and a long series of subsequent papers (e.g., Li et al. 2000, Laland et al. 2001).

There is now a clear need to recruit many social scientists to collaborate with environmental scientists in seeking solutions to the menacing dilemma of the destruction of humanity's life-support systems. More social scientists must join the quest for sustainability and help to construct an interdisciplinary theory of cultural microevolution that will provide background for efforts to consciously and democratically influence its trajectory (Ornstein and Ehrlich 1989). Fortunately, the needed collaborations are beginning and gathering support, as exemplified by the growing cooperation between ecologists and economists (Ehrlich et al. 1992, Arrow et al. 1995, Perrings et al. 1995, Hanna et al. 1996) and the emergence of the entire field of ecological economics (e.g., Daly 1973, Costanza 1991, Dasgupta 1993, Krishnan et al.

emergence of the entire field of ecological economics (e.g., Daly 1973, Costanza 1991, Dasgupta 1993, Krishnan et al. 1995). Gradually, issues such as how economic factors influence reproductive behavior or how markets for ecosystem services can be created are being worked out. Also cheering is the genesis of the field of ecological anthropology (Orlove 1980, Orlove and Brush 1996, Douglas 2001) and the increasing interest in illuminating and solving the problems of cultural evolution in an environmental context shown by other social scientists (Pirages and Ehrlich 1974, Black 1976, Pirages 1996), historians (White 1992, 1995), and legal scholars (Thompson 2000).

Despite these beginnings, scientists are still a long way from understanding the evolution of attitudes toward the conservation of nature and natural resources. Those attitudes have changed dramatically over time and now vary substantially among cultures and individuals, providing a spectacular example of the diversity of human natures.

Environmental scientists' attitudes toward environmental ethics

Environmental ethics has evolved to the point where many scientists believe they have a major responsibility to help society deal with the human predicament (Bazzaz et al. 1998, Lubchenco 1998). Nonetheless, there are considerable differences in attitudes within the concerned scientific community on exactly what the commitments of scientists today should be. Some question whether, for example, scientists can ethically be advocates on environmental or other social issues (Wiens 1997, Slobodkin 2000). They claim advocacy reduces the credibility of scientists (Kaiser 2000). For instance, Warren Wooster (1998) criticized Bazzaz et al. (1998), who state that good scientists should inform the public of the relevance of their work, for announcing the "subjective" judgment that "all field research is done in systems altered by *Homo sapiens*." Wooster stated, "I am not so sure that *all* field research is done in systems altered by man," claiming that the authors of the Bazzaz statement are mostly terrestrial ecologists and that their point "might be difficult to demonstrate everywhere in the open ocean" (Wooster 1998). But no general scientific principle ever will be discredited because it can't be demonstrated everywhere. Except perhaps for tiny areas at very great depths where field research is *not* done, everywhere else we have seen the impacts of anthropogenic changes in concentrations of carbon dioxide, nitrogen, eolian iron, and oil, and the arrival of human-produced radionuclides or synthetic pesticides and chemicals leaching from plastics (Simonich and Hites 1995, Colborn et al. 1996, Prospero et al. 1996, Vitousek et al. 1997a, 1997b, Wu et al. 2001). Attempts by scientists to analyze the global situation, and criticisms of those evaluations, such as Wooster's, should not be discouraged, but they should be subject to the customary care and review that is traditional in scientific discourse. Individual and team credibility comes with accumulated scientific accomplishment, which is continuously assayed by the scientific community through formal and informal peer review.

I and others believe not only that, like any other citizens, environmental scientists *can* be advocates but also that they ethically must be advocates, at least to the extent of informing the general public about their work and conclusions. I think the credibility of ecologists, for example, has been enhanced as many of them have tried to diagnose environmental ills and suggest cures. After all, biomedical scientists can gain prestige by diagnosing public health problems and recommending ameliorative steps—and, interestingly, they aren't accused of advocacy. But scientists should be careful to inform their audiences when they are representing a consensus of the knowledgeable scientific community on a state of the world and when they are expressing their own opinions about actions that should be taken. And they should be very careful not to present data selectively (Wiens 1996) and careful to see that their work and public positions are reviewed by other scientists.

Scientists' attitudes toward conservation

How well have ecologists, evolutionists, behaviorists, and taxonomists responded to the destruction of nature? I think it is fair to say that the community as a whole has attempted to inform the public and politicians as rapidly as any diverse group of human beings could in reaction to a hard-to-perceive, slow-motion crisis (Ornstein and Ehrlich 1989). That itself is a sign of recent rapid evolution of the ethics of scientific responsibility, a spurt triggered by the concern of physicists working on the atomic bomb during World War II and perpetuated by leading molecular biologists (Berg et al. 1974). In response to that ethical evolution, it took only a decade or so for scattered voices warning of the plight of biodiversity (Raven 1976, Myers 1979, Soulé and Wilcox 1980, Ehrlich and Ehrlich 1981) to evolve into a scientific consensus (Lubchenco et al. 1991, Heywood 1995, Lubchenco 1998).

Nonetheless, despite that consensus, compelling evidence for the diversity of human natures can still be seen in the varied responses toward conservation even among the scientists most knowledgeable about biodiversity. I think they should have been changing at least part of their research agenda to meet the newly recognized challenges presented by the accelerating growth of the human enterprise. Some have done so, as indicated by the establishment and rapid growth of the field of conservation biology (Soulé and Wilcox 1980, Avise and Hamrick 1996, Meffe et al. 1997, Mooney and Hobbs 2000), including most recently its subdiscipline, countryside biogeography (Daily et al. 2001). But many have not.

Despite encouraging attempts, the overall scientific response of two fields, ecology and taxonomy, has remained inadequate. This is traceable in part to the persistent failure of those disciplines, in the face of clear need (Ehrlich 1964, 1997, Raven 1980, Phillips and Raven 1996), to emulate geneticists and other biologists by concentrating their efforts on carefully chosen sample systems—the biodiversity equivalents of *Escherichia*, *Arabidopsis*, *Caenorhabditis*, *Drosophila*, and *Mus*. Instead, ecologists and taxonomists have mostly taken within the scientific community). And now humanity is suffering because of the resultant paucity of scientific information on such key topics as the impacts of population and species extinctions on ecosystem services. Those impacts are known to be extensive and serious, but information is inadequate to provide accurate long-range predictions. Indeed, even the goals of conserving biodiversity for its own sake and for preserving ecosystem services for humanity's sake have not been adequately differentiated (Balvanera et al. 2001).

Taxonomists have been especially unresponsive to the threats to humanity's critical store of natural capital. We probably will not be able to add much to the existing crude overview of the vast panoply of eukaryote diversity because the required support seems unlikely to materialize (Raven and Wilson 1992). But it is not too late to develop a substantially more detailed and useful understanding of a limited number of sample groups. Comprehensive pictures of the diversity, distribution, and ecological relationships of such groups could provide grist for evolutionists and ecologists' mills in a century or so when most of today's biota will be studied by paleontologists.

But in the face of the disappearance of much of what they study, professional taxonomists are not switching in large numbers to working on obvious sample systems—vertebrates, butterflies, bees, ants, tiger beetles, vascular plants, and the like. One does not need to search far for the reasons. The training of professional taxonomists produces mostly workers who are taxon-bound, many of whom persist in doing alpha (species description) and beta (simple classificatory operations) taxonomic studies of groups in which they happen to be interested (or that are related to taxa worked on by their major professors). Many of them occupy themselves churning out largely useless hypothetical phylogenies of those taxa—something that advances neither science nor conservation, in contrast to the interesting results that can flow from cladistic research when it is connected to a significant question (Harvey et al. 1996, Becerra 1997, Farrell and Mitter 1998, Kelley and Farrell 1998). Others spend their time trying to replace the functional Linnaean system for general communication about organisms with one based on estimates of times of phylogenetic divergence; a sillier enterprise is hard to imagine (Pennisi 2001).

The training of professional ecologists also does not usually emphasize the importance of working with test systems, so the literature is clogged with dribs and drabs of information on a vast variety of organisms and communities—increasingly sophisticated studies of more and more trivial problems. And taxonomists and ecologists have not been able to get together to do even the most basic and obvious exercises—such as "May inventories," thorough all-taxa censuses on a geographically stratified sample of a few dozen 1-hectare plots—that would give science a reasonable picture of the ratios of abundance of different kinds of organisms and how those ratios vary geographically (May 1988).

In response to the extinction crisis, conservation biologists are beginning to take their taxonomic problems into their own hands. Many working with less-known groups have stopped trying to deal only with named species, but in their studies simply sort their material to morphospecies (Beattie and Oliver 1994), which prove fully adequate to support important conclusions (Daily and Ehrlich 1996b, Hughes et al. 2000, Ricketts et al. 2001). And while they are more limited in the direct application of their discipline to conservation, population geneticists have been actively looking at issues related to the preservation of biodiversity (Soulé 1987, Avise and Hamrick 1996, Landweber and Dobson 1999) and at the impacts of failure to conserve on the future of evolution (Myers 1996).

Public attitudes toward conservation

Despite the near consensus among scientists on most environmental issues, some nonscientists with full access to that consensus have persisted in the belief that perpetual growth in the human enterprise will not threaten our life support systems. Perhaps the most dramatic expression of that view is found in the statements of the late economist Julian Simon, who declared that the human population can grow for "the next 7 billion years" (Myers and Simon 1994, p. 65) or "forever" (Simon 1995, p. 26); the former, more explicit proposition implies growth to the unlikely point at which the mass of people exceeds that of the universe (Ehrlich and Ehrlich 1996). Simon was educated and had full access to the environmental literature. He and numerous others who to one degree or another share his views (e.g., Easterbrook 1995, Huber 2000) make palpable the diversity of human natures.

The Simon example is extreme, but denial is a common human response to threats that seem obvious to a portion of the population. Just consider the numbers of Americans who build their homes on floodplains or in chaparral. Some people recognize and act to avoid the clear threats of flood and fire; others ignore them. Some try to minimize the seriousness of the threats simply to make a profit, perhaps by selling real estate in a dangerous area (or by taking money from the fossil fuel lobby and denigrating the threat of global warming). Others, of course, may try to maximize the threats in order to sell insurance, buy property cheap, or—as I and other environmental scientists have been accused of doing—get government grants or sell books.

The disparities of human natures displayed in attitudes toward the environment and conservation are found virtually everywhere. Australia provides an interesting example because of the range of views on demographic issues openly aired there. The impacts of the human population on ecosystem services are probably more obvious in Australia than in any other developed nation. Its large land area consists mostly of desert, and the vast majority of its 19 million people are concentrated in five coastal urban areas. Australian environmental scientists are world class, and many have repeatedly warned of the deterioration of their nation's fragile life support systems. Australia already has lost more of its unique mammal fauna than any other continent. Recently, Harry Recher (1999) predicted that "Australia will lose half of its terrestrial bird species in the next century." Frank Talbot (2000) wrote that "without fresh thinking and fundamental attitudinal and management changes the Great Barrier Reef will not 'survive' as we enjoy it today.... It will be slowly and continuously degraded both biologically and aesthetically."

But some Australian academics have ignored the message of their ecological community. For example, Australian sociologist Jerzy Zubrzycki, in an address before the Australian Population Association in November 2000, called on Australians to have more babies to keep the population young and growing. He gave no indication of being familiar with Australia's precarious ecological situation. Zubrzycki thus joined "a growing chorus of academics, commentators and politicians concerned about the number of women having fewer children" (*The Australian*, 29 November 2000, p. 3). Those, and many other Australians, are unaware that they live in an overpopulated Leopoldian "world of wounds"—a world whose ecologists see the "marks of death in a community that believes itself well and does not want to be told otherwise" (Leopold 1966, p. 197).

Why the diversity of attitudes?

The reasons for the diversity of attitudes toward conservation has been the subject of substantial speculation. People have been presumed to be either innate conservationists or innate exploiters on the basis of differing ideas about "human nature." One common notion is that hunter–gatherers and subsistence agriculturalists had a deep cultural, perhaps genetically based understanding of their relationship to their environments, and were thus "natural" conservationists (see examples in Krech 1999). Because they were in close contact with their environments, nonindustrial people would tend to detect the effects of damaging behavior and, in their own self-interest, correct it. In this view, subsequent urbanization and the intensification of agriculture separated people from natural systems and led to most people having little or no appreciation of the importance of those systems. Without tight feedback loops, a diversity of opinions could thrive and our natures could undergo cultural drift (Binford 1963)—especially since the most serious environmental problems are the result of gradual changes on a decadal time scale or longer and our genetic and cultural heritages make them difficult to perceive (Ornstein and Ehrlich 1989). The view that tight feedbacks make preindustrial people natural conservationists is reflected in the opinion of Rodney Dillon, a spokesman for the Aboriginal and Torres Strait Islander Commission in Australia, who said he was "very, very sorry for those in power here and abroad. They had taken us on a journey, with growing racism, global conflict, and unsustainable practices...to the brink of environmental global catastrophe." He contrasted aboriginal culture that was self-evidently sustainable for 40,000 years with the European one, which became unsustainable in Australia in a few hundred years (Dillon 2000).

But is this widely held view of the "ecological aboriginal" (Krech 1999, White 2000) correct? I doubt it. The evidence is strong that after the "great leap forward" some 50,000 years ago, ancestors of modern peoples wiped out much of the Pleistocene megafauna, completely changing the biota of much of our planet, although climate change may also have played a role. For instance, Diamond (1984) was able to use information on historic extinctions to cast light on prehistoric ones, documenting in the process a widespread absence of a conservation ethic in preindustrial peoples. While Dillon is clearly correct that the original Australians did not have a lifestyle remotely as unsustainable as today's inhabitants of the continent, the aboriginals nonetheless modified Australia dramatically. But the relative sustainability of the two cultures may simply have been a matter of their respective technological capabilities, rather than fundamentally different attitudes toward conservation. Aboriginals, too, could have been "natural" exploiters.

Like aboriginals, Native Americans are often cited as being natural conservationists (e.g., Deloria 1970, Lester 1986). But, as in Australia, invading *Homo sapiens* clearly had a dramatic impact in the western hemisphere. There were more megafaunal extinctions in North America than there were in Europe, where *Homo* had been present for many tens of thousands of years, and the animals had much greater evolutionary experience with human hunting. Overall, careful reconstruction of their behavior does not indicate that Native Americans were natural born conservationists who strove to preserve the Western Hemisphere's primeval condition. "By the time Europeans arrived, North America was a manipulated continent. Indians had long since altered the landscape by burning or clearing woodland for farming and fuel. Despite European images of an untouched Eden...[its] nature was cultural not virgin, anthropogenic not primeval" (Krech 1999, p. 122). A fundamental problem with all of this is that the whole concept of conservation (or exploitation) is a culture-bound one today, originating in the modern West and in the science of ecology, so the question of whether their behavior was ecologically sound is itself partly culture-bound (White 2000).

How can today's diversity of views among both scientists and the general public on the issues central to environmental conservation most parsimoniously be explained? It seems to me the diversity merely reflects the unique environments in which every human being matures, and the diverse (and sometimes perverse) incentives to which they are exposed. We haven't lost a specieswide ethic evolved in an "environment of evolutionary adaptedness" (EEA; Tooby and Cosmides 1992, p. 69) that made human beings similar to each other in attitudes toward conservation. An EEA is largely a figment of the imaginations of evolutionary psychologists; there never was a uniform hunter–gatherer environment in which natural selection created a single human nature (Foley 1997). Their research claims also have been strongly criticized from within the psychological community (Bussey and Bandura 1999).

Here, as in the case of moral behavior toward our fellows, I think strained and untestable hypotheses about human nature simply cloud issues of ethical evolution (e.g., Boehm's hypothesis that anatomically modern human beings "were innately aversive to social conflict in their immediate social environments" [2000, p. 87]; for more examples, see Krebs [2000] and Thornhill and Palmer [2000]). Our genes have more than enough to do just assembling our bodies, making them functional and reproducible, and providing the structural basis for very high intelligence and the use of language with syntax. They appear to me to be too few, and too constrained by the delicate developmental processes they must help guide, to dictate the exact forms of behavior we practice toward our environments or each other, behavior that if highly programmed would be maladaptive in any case.

Can we learn anything from the history of change in ethical attitudes toward the environment? I think the main lesson is that none are predetermined or innate. Cultures evolve in response to environmental circumstances and people's perceptions of them; sometimes this leads to the husbanding of resources, sometimes to their overexploitation. This is not surprising, since the building blocks of standard ethics—empathy, sympathy, social attribution, and so forth—evolved during our long primate past entirely within a context of treatment of conspecific individuals, not other elements of their environments (de Waal and Roosmalen 1979, de Waal 1989, 1996, Flack and de Waal 2000). There is no sign of any genetically evolved caring for the latter. But cultures have shown the capacity to evolve quite rapidly in response to changing environmental information and circumstances. In preliterate societies, the rapid adoption and spread of agriculture, starting at several foci, is an obvious example (Smith 1995). In literate societies, the historically much more rapid growth of the environmental movement is another. But can such information be used to help speed conscious evolution (Ornstein and Ehrlich 1989) toward the view by most people and cultures that preservation of humanity's natural capital should be a top priority?

Mechanisms of cultural evolution: From individuals to groups

To answer this question we must know much more about the machinery of cultural microevolution. Variations in individual attitudes and motivations are bound to persist, as they do even within such narrowly defined cultural groups as the community of ecologists. And it seems unlikely that we soon will understand that diversity at the individual level. Patterns of individual differences are at best understood in a general way (Bandura 1986); indeed, children of the same family are often very different in personality and attitudes. Even identical twins sharing the same environment can develop very diverse natures—as the case of the conjoined twins Chang and Eng so dramatically illustrated long ago (Wallace and Wallace 1978). And finding rules to explain individual behaviors has proven ever more difficult. For instance, the appealing notion of economists that people could reasonably be viewed as rational utility maximizers has yielded increasingly to evidence that they often are not. A large literature has developed around attempts to discover whether human beings in some sense act rationally and have more or less stable preferences (Tversky and Kahneman 1974, 1986, Stigler and Becker 1977, Goetze and Galderisi 1989, Thaler 1992, Hines and Thaler 1995, Siegel and Thaler 1997, Gintis 2000, Bowles 2001). But such things as radically different assessments of the environmental situation by individuals sharing the same information remain extremely difficult to explain.

Furthermore, it is often virtually impossible to aggregate individual behaviors to determine group preferences (Arrow 1951), although rational choice theorists assume that group behaviors are the collective result of individual choices (with the individuals usually thought to be maximizing utility). Moreover, for many reasons common interests do not necessarily produce collective actions (Olson 1971, Kerr 1996). Sorting out motives, such as why people are willing to bear the costs of free riders, can be difficult (Bandura 1997).

The cultural evolution of groups is in some ways more readily interpreted than that of individuals—just as climate is more predictable than weather, which in turn is more predictable than the effects of a beat of a butterfly's wing on the surrounding air. Apart from the averaging effects of large sample sizes, group behavior is better documented historically, depends less on interview data, and can be observed over longer periods than the development of individual natures. Group behavior is a paradigmatic example of biocomplexity—of the emergence of macroscopic organization from interactions at a more microscopic level (Levin 1999). The literature on social revolutions provides an instructive example by showing that many regularities can be discerned in the conditions that lead to revolutions, without reference to the interacting preferences of individuals (Skocpol 1979, Goldstone 1991, Braithwaite 1994, Collins 1994). Similarly, historians can document shifting attitudes on biological topics—such as animal rights, race, the place of women in society, and approaches to conservation—over centuries, tracing their cultural microevolution without aggregating the views of individuals, just as Peter Grant (1986) could document genetic microevolution in Galápagos finches without knowing anything of the shifting frequencies of nucleotide sequences that, in aggregate, produced the observed trends.

Explaining how different human natures evolve could help humanity deal with myriad human issues from abortion to zealotry. There is abundant evidence that different behaviors toward the environment are not in any significant way programmed into the human genome. The environmental factors that do lead to the cultural evolution of diverse attitudes and behaviors are unknown in detail and only vaguely perceivable in outline—the interactions of some trillion chemically changing, shrinking, growing, and reconnecting neurons are even tougher to sort out than those of tens of thousands of relatively stable genes. But understanding those cultural interactions becomes ever more crucial as the expanding scale of the human enterprise increasingly presses on our life-support systems, weapons of mass destruction become more widely available, the epidemiological environment deteriorates (Daily and Ehrlich 1996a), and diverse cultures confront each other in a communication-rich, rapid-transportation, globalizing world (Barber 1995).

The mechanisms of cultural evolution: General drivers

The complexity of cultural evolution dwarfs that of genetic evolution—if for no other reason than the amount of information that is being recombined and modified is vastly greater. There are, after all, more than a thousand times as many parts in one expression of human culture, a Boeing 747, as there are genes in the human genome. A vast literature has accumulated on cultural evolution broadly defined (for a sample, see references in Cavalli-Sforza and Feldman 1981, Lumsden and Wilson 1981, Dunbar et al. 1999, Ehrlich 2000) and a substantial one on the evolution of ethics and norms—which is of special interest to those of us concerned with human behavior toward the environment (Bischof 1978, Axelrod 1986, Alexander 1987, Boyd and Richerson 1992, Cronk 1994, Boehm 1997, Katz 2000). I can only make a few observations here, not cleanly differentiate cultural evolution in areas such as technology from that in morals (which may proceed quite differently); nor can I address here the lively and interesting debates concerning, for example, the role of group selection in cultural evolution (Wilson and Sober 1994, Boehm 1997, Sober and Wilson 1998, Laland et al. 2000).

Leadership. Among the several general drivers that appear to be operating in cultural microevolution is leadership. For example, the importance of leaders—who, if they are sufficiently single-minded about reforming society, sociologists give the wonderfully descriptive label "moral entrepreneurs" (Becker 1963)—seems quite clear in the evolution of American culture toward greater caring about the environment. Just consider the impact of individual environmental leaders as diverse as George Perkins Marsh (1874), William Vogt (1948), Aldo Leopold (1966), Rachel Carson (1962), Donella and Dennis Meadows (Meadows et al. 1972), and David Brower (McPhee 1971, 2001). Moral entrepreneurs have vision and motivate others to attempt to change the world. Because we are visual creatures, television may have given moral entrepreneurs much more power to promote the models (conceptions of action, including rules for innovative behavior, that are displayed to be symbolically interpreted and copied) that the entrepreneurs consider superior (Braithwaite 1994, Bandura 2001b).

Enlightened political leadership obviously can play a key role in changing cultures. Perhaps the best current example on the environmental front is provided by the nation of Bhutan. Its king, His Majesty Jigme Singye Wangchuck, in June 1998 voluntarily transferred much of his power to the National Assembly (which now can remove him with a vote of no confidence) (Sen Gupta 1999) and is leading the country in developing a program of gross national happiness (GNH). The program is based on four principles: economic development, environmental preservation, cultural promotion, and good governance (Thinley 1999). On a visit in early 2000 my colleagues and I were impressed with the implementation of this program, and especially with the goal of retaining some two-thirds of the nation's forest cover intact. Forest-clad mountain ranges stretching as far as the eye could see were the most common vista in Bhutan, in stunning contrast to neighboring Nepal. Ignorant political leadership, however, can have the opposite effect—as is clear from the environmental mess created in many sections of the United States, attitudes in the Bush administration toward global warming, and the horrible mismanagement that has undermined the efficacy of laws designed to protect the Great Barrier Reef in Australia (Talbot 2000). And leadership operates through what is one of the most potent and widely discussed processes of cultural microevolution, diffusion of ideas and their frequent spread through interconnected people via a social diffusion or "contagion" process (Bandura 1986, 2001b, Rogers 1995, Walt 2000).

Social diffusion and contagion. Ideas, innovations, and attitudes may diffuse by symbolic modeling (drawing on conceptions of behavior portrayed in words and images [Bandura 1986]) along networks, often gradually infecting most or all of a population, sometimes propagating with unexpected rapidity (Gladwell 2000). Such a process, of course, can be very beneficial if, for example, the new ethic of trying to safeguard ecosystem services continues to spread rapidly through publications and meetings of scientists forming networks with each other and with members of the business community. But social diffusion and contagion often can be the enemy of environmental quality; emulation of the development patterns of today's rich nations by those struggling to "develop" is a clear example (Ehrlich and Ehrlich 1991). Some, such as Bhutan, are looking for different trajectories. But Bhutan has only some 900,000 people sandwiched between a billion in India and 1.3 billion in China, and it is starting to face pressures from a globalizing economy (e.g., road connections to the outside are only four decades old, and television has just been introduced). Bhutan's political and intellectual leaders are being linked in networks to their counterparts in the rest of the world. Whether social diffusion will lead Bhutan's campaign for GNH to fail and cause the standard mistakes on the road to development remains to be seen.

Social diffusion and contagion have been traced in specific instances, as in the spread through networks of physicians of use of the antibiotic tetracycline when it was first introduced (Coleman et al. 1966). Social diffusion and contagion can explain how ideas and attitudes get around when they do, but they do not explain either their origins or their frequent failure to propagate. For instance, we do not understand fully the long gap between Captain James Lancaster's experiment demonstrating the efficacy of lemon juice in warding off scurvy in 1601 and its confirmation by Dr. James Lind in 1747, and the use of citrus fruits to wipe out the vitamin C deficiency disease in the British Navy (1795) and merchant marine (1865) (Mosteller 1981). Even though naval officers presumably could have formed a kind of network to promote the contagious spread of the use of citrus, this did not occur and diffusion of the idea was very slow. One reason may have been that Dr. Lind was not an influential figure in the navy, and Captain James Cook, who was, did not report that citrus fruits were an effective antiscorbutic.

Indeed, failure of ideas to propagate often may be traced in part to class barriers and relationships. An interesting case put forth by sociologist Katherine Betts (1999) is the failure of increasing anti-immigration sentiment to have a strong influence on government policy in Australia in the past few decades. Her basic argument is that there has arisen a new prosperous cosmopolitan liberal class that is antiracist, unlike many more parochial Australians. This internationally oriented class has been able to "buy immunity from the costs of growth and even make a profit as growth boosts property values" (p. 10). This group sees high levels of immigration as antiracist (politically correct), an attitude promoted by a consortium of pro-growth interest groups centered around the housing and construction industries. That much of anti-immigration sentiment in Australia *was* racist in origin added to the pro-immigration bias of the cosmopolitan liberals, most of whom were not in a position to perceive the nonracist and environmental reasons to question an open door immigration policy.

Failure to propagate, called "stickiness" by economists, is a metaphor (but not an explanation) for traditional ways of thinking and acting that do not change in response to even the most compelling arguments for change (Kuper 1999), especially if new ideas require repudiation of current cultural beliefs (Richard White [Department of History, Stanford University], personal communication, 1 March 2001). The preoccupation of taxonomists with generating useless hypothetical phylogenies is an example of stickiness in the scientific community; the current "we can't be advocates" school of ecologists is another.

Longevity. Patterns of social diffusion and contagion can help us to understand why ideas spread at different rates, but they are of little help in explaining the differential longevity of ideas, attitudes, and trends. Why has Christianity lasted so long when many other religions faded from the ancient Roman scene? Why does religion persist even in a substantial minority of the scientific community, although most leading scientists consider it of no interest in explaining how the world works (Angier 2001)? One sociological explanation for persistence that seems especially applicable to religion is centered around how groups construct notions of deviance to define themselves (Adler and Adler 2000). In standard religions, deviance is often called heresy, but in science disapproval of deviance is still a major factor in group definition, a generator of stickiness, despite the rewards that may eventually accrue to scientific heretics like Galileo, Darwin, Wegener, and Prusiner (Kuhn 1962). The great sociologist Max Weber partially agreed with Marx that the fate of ideas was closely coupled to those of associated interests: "Not ideas, but material and ideal interests, directly govern men's conduct" (Weber 1948, p. 280). In this context one can certainly trace the longevity of many religions to combinations of group solidarity feelings and the ideal and material interests of the believers. The persistence of many environmental and anti-environmental groups may well have the same roots—the Sierra Club and Western Fuels Association have different degrees of receptivity to news of greenhouse warming. Can we learn from successful religions how to make environmental ethics stronger and more persistent? Perhaps, but it is distressing to note that experiments have suggested that obviously fictitious notions may be perpetuated over generations, even without the efforts of moral entrepreneurs or other obvious forces for conformity (Jacobs and Campbell 1961).

Ideation. Finally, social diffusion and contagion do not explain the origin of new ideas. Are they analogs of mutations, more or less random ideas that are put together in the minds of random individuals? Is their propagation determined by a combination of chance and some measure of adaptive value? This is the notion behind the "memes" of Dawkins ([1976] 1989) and most other attempts to build a view of cultural evolution roughly modeled on classical population genetics. But a major problem is that ideas suffer random mutation much more rapidly than genes, which normally are copied error free. This is illustrated by the game of whispering an idea to the first of a series of children with the rule that the idea be passed on. The originator whispers to the second child, who in turn whispers it to the next, and so on until the originator and final recipient compare ideas and all are astonished at how dramatically the original has been altered. But how much greater would be the alteration if the rules were changed so that each participant could change the message according to her intentions, prejudices, or whims? That, in part, is how the world tends to work (Cronk 1999). Another key issue, in addition to how ideas originate, is why some are promptly absorbed into cultural "noise," while others seem virtually mutation proof. Utility is obviously a major factor, especially where the idea is embodied in an artifact. The idea of the wheel is a classic example. Intentional change and differential mutability are two of the reasons why the "meme" approach has done so little to illuminate cultural microevolution (for a recent series of discussions, some of which reveal a more positive view of memetics than my own, see Aunger 2000).

Thus, while there has been a lot of research on the spread of ideas, the much more difficult problem of discovering their origins has yet to yield any interesting generalities—perhaps because, aside from chance observations that led to innovations (aluminum smelting? transistors?), few ideas arise full-blown in a single head. Indeed, they usually consist of combining existing knowledge in novel or provocative ways (Bandura 1997). A classic example is seen in the way various precursor notions on evolution culminated in Darwin's proposal of a mechanism, natural selection, accompanied by a wealth of supporting information. That ripeness of the time was presumably a factor is suggested by the near-simultaneous proposal of the same mechanism by Alfred Russell Wallace. The acceptance, within a decade and a half of the publication of *On the Origin of Species*, of the basic idea that evolution had occurred (Mayr 1991) suggests that ripeness as well. It also speaks to the relative weakness of suppression of deviance as a binding factor in scientific communities as compared with religions, presumably because of the adversarial nature of the scientific enterprise, the potential for acclamation of those who generate new ideas (as opposed to reinforcing traditional ones), and the agreement that nature serves as a final arbiter. The long struggle for acceptance of the mechanism of natural selection was not against guardians of an orthodoxy but rather the existence of other proposed mechanisms.

We have no useful theory of the neurophysiology of ideation. Perhaps new ideas are generated by more or less random creation of new neural networks when observing a phenomenon or thinking about a topic creates new chemical and physical patterns in the brain—sometimes perhaps even during dreaming. How people come to those "eureka" events is one of the many enduring mysteries about the brain and consciousness. Having a truly novel idea is a rare event—as a general lack of neo-Archimedeans running naked through the streets suggests.

Where do we go from here?

Two major efforts are required of the environmental science community. The first is recruiting more scientists into the task of improving understanding of cultural evolution. The second is to get scientists and others to use that knowledge to change its course. The latter will involve a variety of efforts that range from trying to generate sufficient concern among decisionmakers and laypersons to dedicating portions of their scientific careers to the hard sociopolitical–biological tasks necessary to preserve humanity's natural capital, as exemplified by Dan Janzen's "growing" of the Guanacaste Conservation Area (Janzen 1988, 1999).

Accomplishing all of these tasks will require accelerating change in the norms and ethics of both the biophysical and social sciences. They will involve fighting stickiness both within the scientific community and without; the world is changing too rapidly to count on yesterday's norms serving effectively tomorrow. This could be a difficult struggle—one need only think of the persistence of "scientific" racism and "scientific creationism" or, at a less dramatic level, the tenacity of ridiculously outdated disciplinary structures in universities. I hope ways can be found to realign incentives to overwhelm stickiness where change can improve the chances of reaching sustainability. Often these will be economic incentives (Daily et al. 2000), but within science peer approval is extremely important and is increasingly accruing to those who break with antiquated traditions. With the public at large, innovative techniques such as televised serial dramas based on psychological theory are one way to promote such positive changes as raising the status of women, adoption of family planning, or increasing condom use to limit the spread of AIDS (Bandura 2001a).

Interestingly, the business community is providing some clues through developments in the relatively new science of marketing (Kotler and Levy 1969, Kotler and Zaltman 1971, Kotler and Andreasen 1996, Kotler 1999). Scientists should not ignore the findings of marketing simply because they may disapprove of some of the uses to which business puts them; rather, they should combine them with science-based approaches such as those exemplified by the TV serials. We need to help steer cultural evolution by "marketing" a set of environmental ethics: doing the necessary psychological and market research, selecting appropriate goals, and carefully monitoring the performance of the "product" in a free marketplace of ideas. If the campaign fails, we are unlikely to be able to maintain the flow of ecosystem services upon which society depends.

Some of the needed actions are already under way in the frontline, more holistically oriented biological disciplines, and it is cheering to see that even the results of more reductionist science increasingly are being gainfully employed in aid of conservation (Palumbi and Baker 1994, Baker and Palumbi 1996, Palumbi and Cipriano 1998, Baker et al. 2000). Furthermore, the Aldo Leopold Leadership Program, an organized effort cosponsored by the Ecological Society of America, is now training environmental scientists to operate in the policy arena. But much more needs to be done to change the basic ethos of ecology so that more rewards flow to those who deal directly with the human predicament in general and biological conservation in particular (Ehrlich 1997). Generating concern and appropriate actions will require a much heavier participation in public debate than most scientists are accustomed to, but it can be done, as shown by the success of the "nuclear winter" efforts of the early 1980s (Ehrlich et al. 1983). The activities of the Intergovernmental Panel on Climate Change (IPCC), which involves hundreds of scientists from diverse disciplines in a continuing evaluation of the global warming situation to reach consensus on the technical issues related to that contentious topic, could serve as a partial model of a basic mechanism to expose society to the full range of population–environment–resource issues.

A start in this direction has been made by a group of environmental scientists organizing an Intergovernmental Panel on Ecosystem Change (IPEC). It, like the IPCC, is geared toward a process that is transparent to all participants as well as to the general public and decisionmakers. IPEC will also need to achieve very broad participation from nonscientists, ranging from ethicists to ordinary citizens, more than was done in the nuclear winter and IPCC examples. We certainly now have tools for speeding social diffusion and contagion: satellite TV, the Internet, fax machines, conference calls, and so on. They make wide communication, debate, and consensus building feasible. Many of the necessary ideas have already been generated, even though the process by which they originated remains mysterious, and environmental leadership is increasingly appearing within and outside the scientific community. The needed changes in ethics are under way, and with focused effort we may learn how to accelerate them while maintaining open democratic debate. Although it is highly unlikely that human beings will ever create a utopia, collectively we could do a lot better than we are today.

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