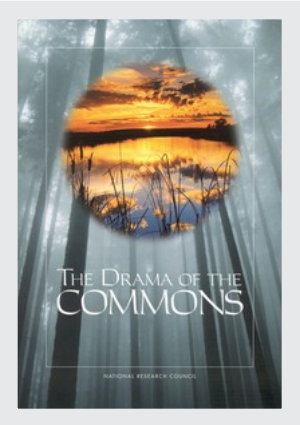

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THE DRAMA OF THE COMMONS

Committee on the Human Dimensions of Global Change

Elinor Ostrom, Thomas Dietz, Nives Dolšak,
Paul C. Stern, Susan Stonich, and Elke U. Weber, Editors

Division of Behavioral and Social Sciences and Education
National Research Council

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Contents

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An Evolutionary Theory of Commons Management

Peter J. Richerson, Robert Boyd, and Brian Paciotti

Common property and common-pool resources dilemmas are examples of the broader problem of cooperation, a problem that has long interested evolutionists. In both the *Origin* and *Descent of Man*, Darwin worried about how his theory might handle cases such as the social insects in which individuals sacrificed their chances to reproduce by aiding others. Darwin could see that such sacrifices ordinarily would not be favored by natural selection. He argued that honeybees and humans were similar: Among honeybees a sterile worker who sacrificed her own reproduction for the good of the hive would enjoy a vicarious reproductive success through her sibling reproductives. Humans, Darwin (1874:178-179) thought, competed tribe against tribe as well as individually, and the "social and moral faculties" evolved under the influence of group competition:

> It must not be forgotten that although a high standard of morality gives but slight or no advantage to each individual man and his children over other men of the tribe, yet that an increase in the number of well-endowed men and an advancement in the standard of morality will certainly give an immense advantage to one tribe over another. A tribe including many members who, from possessing in a high degree the spirit of patriotism, fidelity, obedience, courage, and sympathy, were always ready to aid one another, and to sacrifice themselves for the common good, would be victorious over most other tribes; and this would be natural selection.

More than a century has passed since Darwin wrote, but the debate among evolutionary social scientists and biologists is still framed in similar terms—the conflict between individual and prosocial behavior guided by selection on individuals versus selection on groups. In the meantime, social scientists have devel-

oped parallel theories of cooperation—rational choice theory takes an individualistic approach while functionalism analyzes the prosocial aspects of institutions.

In this chapter we review the evolutionary theory relevant to the question of human cooperation and compare the results to other theoretical perspectives. Then we review some of our own work distilling a compound explanation that we believe gives a plausible account of human cooperation and selfishness. This account leans heavily on group selection on *cultural* variation but also includes lower level forces driven by both micro-prosocial and purely selfish motives. Next, we review the empirical literature in commons management. Although much work remains to be done on the problem, we conclude that the existing evidence is consistent with our account. Then, we use our hypothesis to derive lessons for applied research in institution building for commons management. On the one hand, the theory of cultural group selection suggests that humans have cooperative sentiments usually assumed to be absent in rational choice theories. On the other hand, the slow rate at which cooperative institutions evolve suggests that considerable friction will afflict our ability to grow up commons management institutions if they do not already exist and to readapt existing institutions to rapid technological and economic change. A better understanding of the way cooperative institutions arise in the long run promises better tools to foster their more rapid evolution when needed and to regulate their performance as necessary.

THEORIES OF COOPERATION

Our ideas about cooperation are drawn from many sources. Folk sources include diverse religious doctrines, norms and customs, and folk psychology. Anthropologists and historians document an immense diversity of human social organizations and most of these are accompanied by moral justifications, if often contested ones. Johnson and Earle (1987) provide a good introduction to the vast body of data collected by sociocultural anthropologists. The cross-cultural study of commons management is already a well-advanced field drawing on the disciplines of anthropology, political science, and economics (Agrawal, this volume:Chapter 2; Baland and Platteau, 1996; Bardhan and Dayton-Johnson, this volume:Chapter 3; Berkes, this volume:Chapter 9; McCay, this volume:Chapter 11; (Ostrom, 1998).

Human Cooperation Is Extensive and Diverse

Human cooperation has a number of features begging explanation:

- *Humans are prone to cooperate, even with strangers.* Thus many people cooperate in anonymous one-shot prisoners' dilemma (PD) games (Marwell and Ames, 1981), and often vote altruistically (Sears and Funk, 1990). People begin

contributing substantially to public goods sectors in economic experiments (Falk et al., this volume:Chapter 5; Kopelman et al., this volume:Chapter 4; Ostrom, 1998). The experimental results accord with common experience. Most of us have traveled in foreign cities, even poor foreign cities filled with strange people for whom our possessions and spending money are worth a small fortune, and found risk of robbery and commercial chicanery to be small.

• *Cooperation is contingent on many things.* Not everyone cooperates. Aid to distressed victims increases substantially if a potential altruist's empathy is engaged (Batson, 1991). Being able to discuss a game beforehand and to make promises to cooperate affect success (Dawes et al., 1990). The size of the resource, technology for exclusion and exploitation of the resource, and similar gritty details affect whether cooperation in commons management arises (Ostrom, 1990:202-204). Scientific findings again correspond well to personal experience. Sometimes we cooperate enthusiastically, sometimes reluctantly, and sometimes not at all. People vary considerably in their willingness to cooperate even under the same environmental conditions.

• *Institutions matter.* People from different societies behave differently because their habits have been inculcated by long participation in societies with different institutions. In repeated play common property experiments, initial defections induce further defections until the contribution to the public-goods sector approaches zero. However, if players are allowed to exercise strategies they might use in the real world, for example to punish those who defect, participation in the commons stabilizes (Fehr and Tyran, 1996). The strategies for successfully managing commons are generally institutionalized in sets of rules that have legitimacy in the eyes of the participants (Ostrom, 1990:Chapter 2). Families, local communities, employers, nations, and governments all tap our loyalties with rewards and punishments and greatly influence our behavior.

• *Institutions are the product of evolution.* The elegant studies by Nisbett's group show how people's affective and cognitive styles become intimately entwined with their social institutions (Cohen and Vandello, 2001; Nisbett and Cohen, 1996; Nisbett et al., in press). Because such complex traditions are so deeply ingrained, they are slow both to emerge and to decay. Many commons management institutions have considerable time depths (Ostrom, 1990:Chapter 3). Throughout most of human history, institutional change was so slow as to be nearly imperceptible by individuals. Today, change is rapid enough to be perceptible. Even universities, impeded as they are by conservative faculties deeply suspicious of change, change measurably on the time scale of a generation.

• *Variation in institutions is huge.* Already with its very short list of societies and games, the experimental ethnography approach of Henrich et al. (2001) and Nisbett et al. (in press) has uncovered striking differences. The cross-cultural commons work has uncovered much more, suggesting that a rich trove awaits the experimentalists. Agrawal (this volume:Chapter 2) describes the large number of conditions (38 and counting) that have been shown to affect whether local coop-

eration in commons management arises. Plausibly, design complexity, coordination equilibria, and other phenomena generate multiple evolutionary equilibria and much historical contingency in the evolution of particular institutions (Boyd and Richerson, 1992c). We all have at least some experience of how differently different communities, different universities, and different countries solve the same problems.

Evolutionary Models Can Explain the Nature of Preferences and Institutions

These facts present a challenge to rational actor theories. High levels of cooperation are difficult to reconcile with the usual assumption of self-regarding preferences, and the diversity of institutional solutions is a challenge to any theory based on a universal human nature. The "second generation" bounded rational choice theory championed by Ostrom (1998), and the "situated" rational choice characterized by McCay (this volume:Chapter 11), address these challenges from within the rational choice tradition. These approaches add a psychological basis and institutional constraints to the standard rational choice theory. Although psychological and social structures are invoked to explain individual behavior and its variation, an explanation for psychology and social structure is not part of the theory.

Evolutionary theory permits us to address the origin of preferences. A number of economists have noted the neat fit between evolutionary theory and economic theory (Becker, 1976; Hirshleifer, 1977). Evolution, they observed, explains what organisms want, and economics explains how they should go about getting what they want. Without evolution, preferences are exogenous, to be estimated empirically, but not explained. To do a satisfactory job of explaining human social behavior, we need to expand the spare concept of preferences to include the conceptually richer properties of individuals and institutions of bounded and situated rationality. Then, to explain why humans have the unusual forms of social behavior depicted in our list of stylized facts, we need to appeal, we believe, to the special properties of *cultural* evolution.

Evolutionary models have both intellectual and practical payoffs. The intellectual payoff is that evolutionary models link answers to contemporary puzzles to crucial long time-scale processes. The most important economic phenomenon of the past 500 years is the rise of capitalist economies and their tremendous impact on every aspect of human life. Expanding the time scale a bit, the most important phenomena of the past 10 millennia are the evolution of ever more complex social systems and ever more sophisticated technology following the origins of agriculture. A real explanation of both current behavior and its variation must be linked to such long-run processes, where the times to reach evolutionary equilibria are measured in millennia. More practically, the dynamism of

the contemporary world creates major stresses on the institutions that are used to manage commons. Evolutionary theory often will be useful because it will lead to an understanding of how to accelerate institutional evolution to better track rapid technological and economic change. (For an analogous argument in the context of medical practice, see Nesse and Williams, 1995.)

Evolutionary Models Account for the Processes That Shape Heritable Genetic and Cultural Variation Through Time

Evolutionary explanations are *recursive*. Individual behavior results from an interaction of inherited attributes and environmental contingencies. In most species genes are the main inherited attributes, but in humans inherited cultural information is also important. Individuals with different inherited attributes may develop different behaviors in the same environment. Every generation, evolutionary processes—natural selection is the prototype—impose environmental effects on individuals as they live out their lives. Cumulated over the whole population, these effects change the pool of inherited information, so that the inherited attributes of individuals in the next generation differ, usually subtly, from the attributes in the previous generation. Over evolutionary time, a lineage cycles through the recursive pattern of causal processes once per generation, more or less gradually shaping the gene pool and thus the succession of individuals that draw samples of genes from it. Statistics that describe the pool of inherited attributes, such as gene frequencies, are basic state variables of evolutionary analysis. They are what change over time.

Note that in a recursive model, we explain individual behavior and population-level processes in the same model. Individual behavior depends, in any given generation, on the gene pool from which inherited attributes are sampled. The pool of inherited attributes depends in turn on what happens to a population of individuals as they express those attributes. Evolutionary biologists have a long list of processes that change the gene frequencies, including natural selection, mutation, and genetic drift. However, no organism experiences natural selection. They either live or die; reproduce or fail to reproduce. If, in a particular environment, some *types* of individuals do better than others and if this variation has a heritable basis, then *we* label as "natural selection" the resulting changes in gene frequencies. We use abstract categories like selection to describe such specific events because we wish to build up, concrete case by concrete case, some useful generalizations about evolutionary process. Few would argue that evolutionary biology is the poorer for investing effort in the generalizing project.

Although the processes that lead to cultural change are very different from those that lead to genetic change, their logic is the same. For example, the cultural generation time is short in the case of ideas that spread rapidly, but modeling rapidly evolving cultural phenomena like semiconductor technology presents no special problems (Boyd and Richerson, 1985:68-69). Similarly, human choices

include ones that modify inherited attributes directly rather than indirectly by natural selection. These "Lamarckian" effects are added easily to models, and the models remain evolutionary so long as rationality remains bounded. The degenerate case, of course, needs no recursion because everything happens in the first generation (instantly in a typical rational choice model). Evolutionary models are a natural extension of the concept of bounded rational choice. They help explain how the innate and cultural constraints on choice and on rationality arise (Boyd and Richerson, 1993).

Evolution is Multilevel

Evolutionary theory is always *multilevel;* at a minimum it keeps track of properties of individuals, like their genotypes, and of the population, such as the frequency of a particular gene. Other levels may also be important. Phenotypes are derived from many genes interacting with each other and the environment. Populations may be structured, perhaps divided into social groups with limited exchanges of members. Thus, evolutionary theories are systemic, integrating every part of biology. In principle, everything that goes into causing change through time plays its proper part in the theory.

This in-principle completeness led Mayr (1982) to speak of "proximate" and "ultimate" causes in biology. Proximate causes are those that physiologists and biochemists generally treat by asking *how* an organism functions. These are the causes produced by individuals with attributes interacting with environments and producing effects on them. Do humans use innate cooperative propensities to solve commons problems or do they have only self-interested innate motives? Or are the causes more complex than either proposal? Ultimate causes are evolutionary. The ultimate cause of an organism's behavior is the history of evolution that shaped the gene pool from which our samples of innate attributes are drawn. Evolutionary analyses answer *why* questions. Why do human communities typically solve at least some of the commons dilemmas and other cooperation problems on a scale unknown in other apes and monkeys? Human-reared chimpanzees are capable of many human behaviors, but they nevertheless retain many chimp behaviors and cannot act as full members of a human community (Temerlin, 1975). Thus we know that humans have different innate influences on their behavior than chimpanzees, and these must have arisen in the course of the two species' divergence from our common ancestor.

In Darwinian evolutionary theories, the ultimate sources of cooperative behavior are classically categorized into three evolutionary processes operating at different levels of organization.

- *Individual-level selection.* Individuals and the variants they carry are obviously a locus of selection. Selection at this level favors selfish individuals who

are evolved to maximize their own survival and reproductive success. Pairs of self-interested actors can cooperate when they interact repeatedly (Axelrod and Hamilton, 1981; Trivers, 1971). Alexander (1987) argued that such reciprocal cooperation also can explain complex human social systems, but most formal modeling studies make this proposal doubtful (Boyd and Richerson, 1988, 1989; Leimar and Hammerstein, 2001; Nowak and Sigmund, 1998).

- *Kin selection*. Hamilton's (1964) papers showing that kin should cooperate to the extent that they share genes identical by common descent offer one of the theoretical foundations of sociobiology. Kin selection can lead to cooperative social systems of a remarkable scale, as illustrated the colonies of termites, ants, and some bees and wasps. However, most animal societies are small because individuals have few close relatives. It is the fecundity of insects, and in one case rodents, that permits a single queen to produce huge numbers of sterile workers and hence large, complex societies composed of close relatives (Campbell, 1983).
- *Group selection*. Selection can act on any pattern of heritable variation that exists (Price, 1970). Darwin's model of the evolution of cooperation by intertribal competition is perfectly plausible, as far as it goes. The problem is that genetic variation between groups other than kin groups is hard to maintain unless the migration between groups is very small or unless some very powerful force generates between-group variation (Aoki, 1982; Boorman and Levitt, 1980; Eshel, 1972; Levin and Kilmer, 1974; Rogers, 1990; Slatkin and Wade, 1978; Wilson, 1983). In the case of altruistic traits, selection will tend to favor selfish individuals in all groups, tending to aid migration in reducing variation between groups. The success of kin selection in accounting for the most conspicuous and highly organized animal societies (except humans) has convinced most, but by no means all, evolutionary biologists that group selection is of modest importance in nature (see Sober and Wilson, 1998, for a group selectionist's eye view of the controversy).

We could make this picture much more complex by adding higher and lower levels and cross-cutting forms of structure. Many examples from human societies will occur to the reader, such as gender. Indeed, Rice (1996) has demonstrated elegantly that selection on genes expressed in the different sexes sets up a profound conflict of interest between these genes. If female *Drosophila* are prevented from evolving defenses, male genes will evolve that seriously degrade female fitness. The genome is full of such conflicts, usually muted by the fact that an individual's genes are forced by the evolved biology of complex organisms to all have an equal shot at being represented in one's offspring. Our own bodies are a group-selected community of genes organized by elaborate "institutions" to ensure fairness in genetic transmission, such as the lottery of meiosis that gives each chromosome of a pair a fair chance at entering the functional gamete (Maynard Smith and Szathmáry, 1995).

Culture Evolves

In theorizing about human evolution, we must include processes affecting *culture* in our list of evolutionary processes alongside those that affect genes. Culture is a system of inheritance. We acquire behavior by imitating other individuals much as we get our genes from our parents. A fancy capacity for high-fidelity imitation is one of the most important derived characters distinguishing us from our primate relatives (Tomasello, 1999). We are also an unusually docile animal (Simon, 1990) and unusually sensitive to expressions of approval and disapproval by parents and others (Baum, 1994:218-219). Thus parents, teachers, and peers can rapidly, easily, and accurately shape our behavior compared to training other animals using more expensive material rewards and punishments. Finally, once children acquire language, parents and others can communicate new ideas quite economically. Our own contribution to the study of human behavior is a series of mathematical models in the Darwinian style of what we take to be the fundamental processes of cultural evolution (e.g., Boyd and Richerson, 1985). The application of Darwinian methods to the study of cultural evolution was advocated forcefully by Campbell (1965, 1975). Cavalli-Sforza and Feldman (1973) constructed the first mathematical models to analyze cultural recursions (see also Durham, 1991).

The list of processes that shape cultural change includes:

- *Biases*. Humans do not passively imitate whatever they observe. Rather, cultural transmission is biased by decision rules that individuals apply to the variants they observe or try out. The rules behind such selective imitation may be innate or the result of earlier imitation or a mixture of both. Many types of rules might be used to bias imitation. Individuals may try out a behavior and let reinforcement guide acceptance or rejection. Or they may use various rules of thumb to reduce the need for costly trials and punishing errors. The use of a conformist rule of the form "when in Rome do as the Romans do" is an example that is important in our hypothesis about the origins of cooperative tendencies in human behavior.
- *Nonrandom variation*. Genetic innovations (mutations, recombinations) are random with respect to what is adaptive. Human individual innovation is guided by many of the same rules that are applied to biasing ready-made cultural alternatives. Bias and learning rules have the effect of increasing the rate of evolution relative to what can be accomplished by random mutation, recombination, and natural selection. We believe that culture originated in the human lineage as an adaptation to the Plio-Pleistocene ice-age climate deterioration, which included much rapid, high-amplitude variation of just the sort that would favor adaptation by biased innovation and imitation (Richerson and Boyd, 2000).
- *Natural selection*. Because selection operates on any form of heritable variation and imitation and teaching are forms of inheritance, selection will influence cultural as well as genetic evolution. However, selection on culture is liable

to favor behaviors different from those favored by selection on genes. Because we often imitate peers, culture is liable to selection at the subindividual level, potentially favoring pathogenic cultural variants—selfish memes (Blackmore, 1999). On the other hand, rules like conformist imitation have the opposite effect. By tending to suppress cultural variation within groups such rules protect variation between them, potentially exposing our cultural variation to much stronger group selection effects than our genetic variation (Henrich and Boyd, 1998; Soltis et al., 1995). Human patterns of cooperation may owe much to cultural group selection.

Evolutionary Models Are Consistent with a Wide Variety of Theories

Evolutionary theory prescribes a method, not an answer, and a wide range of particular hypotheses can be cast in an evolutionary framework. If population-level processes are important, we can set up a system for keeping track of heritable variation, and the processes that change it through time. Darwinism as a method is not at all committed to any particular picture of how evolution works or what it produces.

The view that many social scientists have of Darwinism is influenced too heavily by the work of human sociobiologists. Many things can be said in defense of this enterprise (Borgerhoff-Mulder et al., 1997) and much useful work goes on under its major research programs, human behavioral ecology (Cronk et al., 2000) and evolutionary psychology (Barkow et al., 1992). However, these research programs have two major weaknesses: neglect of culture and a taboo against group selection.

Sociobiologists typically assume that culture is a strictly proximate phenomenon, akin to individual learning (e.g., Alexander, 1979), or constrained so strongly by genes as to be virtually proximate (Wilson, 1998). As Alexander (1979:80) puts it, "Cultural novelties do not replicate or spread themselves, even indirectly. They are replicated as a consequence of the behavior of vehicles of gene replication." Commons institutions are deeply rooted in cultural traditions. Theoretical models show that the processes of cultural evolution can behave differently in critical respects from those only including genes. If such effects are important in the real world, neglecting them is a bad bet to get the approximately correct answers we hope to win using evolutionary theory.

Most evolutionary biologists believe that group beneficial behavior is always a side effect of individual payoffs. We have already noted the problems with maintaining variation between groups in theory and the seeming success of alternative explanations. Persuaded by the biologist's arguments, most social science scholars from the Darwinian tradition have followed the argument forcefully articulated by Williams (1966) and have anathematized group selection.[1] However, *cultural* variation is more plausibly susceptible to group selection than is genetic variation. For example, if people use a somewhat conformist bias in acquiring important social behaviors, the variation between groups needed for group selec-

tion to operate is protected from the variance-reducing force of migration between groups (Boyd and Richerson, 1985:Chapter 7). We believe considerable evidence supports the hypothesis that cultural group selection has played an important role in human social evolution (Richerson and Boyd, 2001).

Evolutionary Models Are Widely Used in the Social Sciences

Although evolutionary tools are not yet commonplace in the study of human behavior, the general approach we advocate has a long history (Campbell, 1965, 1975) and several vigorous currently active branches. We mentioned evolutionary psychology and human behavioral ecology already. Others include evolutionary economics (Alchian, 1950; Day and Chen, 1993; Gintis, 2000; Hodgson, 1993; Witt, 1992), evolutionary sociology (Dietz and Burns, 1992; Luhmann, 1982; Maryanski and Turner, 1992; McLaughlin, 1988), evolutionary organization science (Baum and McKelvey, 1999; Hannan and Freeman, 1989), evolutionary epistemology (Callebaut and Pinxten, 1987; Derksen, 1998; Hull, 1988), evolutionary behavior analysis (Baum, 1994), and applied mathematics (Vose, 1999). The concepts of the meme (Blackmore, 1999), of complex adaptive systems (Holland, 1995), and of universal Darwinism (Dennett, 1996) have attracted much attention. Some of the most interesting evidence for the importance of evolutionary theory in the study of culture comes from the not infrequent reinvention of basic Darwinism when scholars in the social sciences find themselves in need of it. Empirical research traditions with strongly Darwinian overtones include historical linguistics (Mallory, 1989), sociolinguistics (Labov, 1973), studies of the diffusion of innovations (Rogers, 1995), human social learning theory (Bandura, 1986), experimental cultural evolution (Insko et al., 1983), and religious demography (Roof and McKinney, 1987). Weingart and colleagues (1997) attempt a comprehensive survey of the issues involved in integrating the historically abiological and non-Darwinian theories of the social sciences with Darwinian theory from biology.

EVOLUTION OF COOPERATIVE INSTITUTIONS

Here we summarize a theory of institutional evolution that we have developed elsewhere in more detail (Richerson and Boyd, 1998, 1999, 2001). The theory is rooted in a mathematical analysis of the processes of cultural evolution and is, we argue in these papers, consistent with much empirical data. We make limited claims for our particular hypotheses, although we think that the thrust of the empirical data as summarized by the stylized facts already noted is much harder on current alternatives. We make a much stronger claim that a dual gene-culture theory of some kind will be necessary to account for the evolution of human cooperative institutions.

Understanding the evolution of contemporary human cooperation requires attention to two different time scales. First, a long period of evolution in the

Pleistocene shaped the innate "social instincts" that underpin modern human behavior. During this period, much genetic change occurred as a result of humans living in groups with social institutions *heavily influenced by culture*, including group-selected culture (Richerson and Boyd, 2000). On this time scale genes and culture *coevolve*, and cultural evolution is plausibly a leading rather than lagging partner in this process. Then, only about 10,000 years ago, the origins of agricultural subsistence systems laid the basis for revolutionary changes in the scale of social systems. The evidence suggests that genetic changes in the social instincts over the past 10,000 years are insignificant. Rather, the evolution of complex societies has involved the relatively slow cultural accumulation of institutional "work-arounds." These take advantage of a psychology evolved to cooperate with distantly related and unrelated individuals belonging to the same symbolically marked tribe while coping more or less successfully with the fact that these social systems are larger, more anonymous, and more hierarchical than the tribal scale ones of the late Pleistocene (Richerson and Boyd, 1998, 1999).

Tribal Social Instincts Hypothesis

Our hypothesis is premised on the idea that group selection plays a more important role in shaping culturally transmitted variation than it does in shaping genetic variation. As a result, humans have lived in social environments characterized by high levels of cooperation for as long as culture has played an important role in human development. To judge from the other living apes, our remote ancestors had only rudimentary culture (Tomasello, 1999) and lacked cooperation on a scale larger than groups of close kin (Boehm, 1999). The difficulty of constructing theoretical models of group selection on genes favoring cooperation matches neatly with the empirical evidence that cooperation in most social animals is limited to kin groups. In contrast, rapid cultural adaptation can lead to ample variation among groups whenever multiple stable social equilibria exist, due to conformist social learning, symbolically marked boundaries, or moralistic enforcement of norms (Boyd and Richerson, 1992a). Such models of group selection are relatively powerful because they only require the social, not physical, extinction of groups. Formal theoretical models suggest that conformism is an adaptive heuristic for biasing imitation under a wide variety of conditions (Boyd and Richerson, 1985:Chapter 7; Henrich and Boyd, 1998; Simon, 1990). Similarly, symbolic group marking arises for adaptive reasons in cultural evolution models in which either ecological differences or different solutions to games of coordination make the imitation of behaviors common in neighboring groups maladaptive in one's own group (Boyd and Richerson, 1987; McElreath et al., no date). Models of moralistic punishment (Boyd and Richerson, 1992c) lead to multiple stable social equilibria and to reductions in noncooperative strategies if punishment is prosocial. A consequence, we believe, is that a growing reliance on cultural evolution led to larger, more cooperative societies among humans over the past 250,000 years or so.

Consistent with this argument, late Pleistocene human societies were organized on a tribal scale (Bettinger, 1991:203-205; Richerson and Boyd, 1998). To judge from the ethnographic study of living hunter-gatherers, tribes were composed of several non-co-resident bands speaking the same dialect and numbering in the aggregate a few hundred to a few thousand people. Tribal-level institutions typically maintained peace between bands, made provision for emergency aid to fellow tribe members, celebrated communal rituals, defended the tribe against predatory raids by neighbor tribes (and often a specific territory from encroachment by other tribes), and legitimated the punishment of tribal miscreants. Institutions for making collective consensus decisions about war, peace, resource exploitation, institutional changes, and the like existed. Egalitarian social relations between males were maintained by the collaboration of potential subordinates to curb the impulse of the ambitious and skilled to dominate or exploit others (Boehm, 1999). Some ethnographically known hunter-gatherer societies, such as those of California and the Northwest Coast, had stronger leadership institutions and considerable inequality, and some late Pleistocene societies could have resembled them (Price and Brown, 1985). Our argument only requires that the central tendency of Pleistocene and post-Pleistocene societies differs sharply on these dimensions. Some sense of belonging to a delimited group was typical. Political, economic, and cultural alliance with culturally similar, or even not-so-similar, tribes was common. On the other hand, tribes often had hereditary enemies. The rule of law extended to a rather limited number of people by modern standards and self-help violence was commonly needed to secure justice even within societies when custom, public opinion, and weak leadership failed to find solutions to problems (Horowitz, 1990). The strength of such institutions and details of their implementation were likely highly variable (Kelly, 1995) if ethnographic hunter-gatherers are any indication. Unlike complex societies, division of labor (except between men, women, and different age groups) was modest.

We believe that the human capacity to live in tribes evolved by the coevolution of genes and culture. Rudimentary cooperative institutions created by cultural group selection would have favored genotypes that were better able to live in more cooperative groups. At first, such populations would have been only slightly more cooperative than typical nonhuman primates. However, genetic changes, such as a more docile temperament, would allow the cultural evolution of more sophisticated institutions that in turn enlarged the scale of cooperation. These rounds of coevolutionary change continued until eventually people were equipped with capacities for cooperation with distantly related people, emotional attachments to symbolically marked groups, and willingness to punish others for transgression of group rules. Mechanisms by which cultural institutions might exert forces tugging in this direction are not far to seek. Cultural norms affect mate choice and people seeking mates are likely to discriminate against genotypes that are incapable of conforming to cultural norms (Richerson and Boyd, 1989). People unable to control their self-serving aggression ended up exiled or

executed in small-scale societies and in prison in contemporary ones. People whose social skills embarrass their families have a hard time attracting mates. Of course, selfish and nepotistic impulses never were suppressed entirely; our genetically transmitted evolved psychology shapes human cultures, and as a result cultural adaptations often still serve the ancient imperatives of inclusive genetic fitness. However, cultural evolution also creates new selective environments that cause *cultural imperatives to be built into our genes*.

Paleoanthropologists believe that human cultures were essentially modern by the Upper Paleolithic, 50,000 years ago (Klein, 1999). So even if the cultural group selection process began as late as the Upper Paleolithic, such social section easily could have had extensive effects on the evolution of human genes by this process. More likely, Upper Paleolithic societies were the culmination of a long period of coevolutionary increases in a tendency toward tribal social life.

We suppose that the resulting "tribal instincts" are something like principles in the Chomskian linguists' "principles and parameters" view of language (Pinker, 1994). The innate principles furnish people with basic predispositions, emotional capacities, and social dispositions that are implemented in practice through highly variable cultural institutions, the parameters. People are innately prepared to act as members of tribes; but culture tells us how to recognize who belongs to our tribes; what schedules of aid, praise, and punishment are due to tribal fellows; and how the tribe is to deal with other tribes—allies, enemies, and clients. The division of labor between innate and culturally acquired elements is poorly understood and theory gives little guidance about the nature of the synergies and tradeoffs that must regulate the evolution of our psychology (Richerson and Boyd, 2000). The fact that even human-reared apes cannot be socialized to behave like humans guarantees that some elements are innate. Contrariwise, the diversity and sometimes rapid change of social institutions guarantees that much of our social life is governed by culturally transmitted rules, skills, and even emotions. We beg the reader's indulgence for the necessarily brief and assertive nature of our argument here. The rationale and the ethnographic support for the tribal instincts hypothesis are laid out in more detail in Richerson and Boyd (1998, 1999). The same authors, (Richerson and Boyd, 2001) review a broad spectrum of empirical evidence supporting the hypothesis.

Work-Around Hypothesis

Contemporary human societies differ drastically from tribal societies in which our social instincts evolved. Pleistocene hunter-gatherer societies were small and egalitarian and lacked powerful leaders. Modern societies are large and inegalitarian and have coercive leadership institutions (Boehm, 1993). If the social instincts hypothesis is correct, social instincts are part building blocks and part constraints on the evolution of complex social systems (Salter, 1995). To evolve large-scale, complex social systems, cultural strategies take advantage of

whatever support the instincts offer. For example, families willingly take on the essential roles of biological reproduction and primary socialization. At the same time, cultural evolution must cope with a psychology evolved for life in quite different sorts of societies. Appropriate larger scale institutions must regulate small-group subversion of large-group favoring rules. To do this, cultural evolution often makes use of "work-arounds"—mobilizing tribal instincts for new purposes. For example, large national and international (e.g., great religions) institutions develop ideologies of symbolically marked inclusion that often fairly successfully engage the tribal instincts on a much larger than tribal scale. Such work-arounds are often awkward compromises, as is illustrated by the existence of contemporary societies handicapped by few loyalties outside the family (Banfield, 1958) or by destructive loyalties to relatively small tribes (West, 1941).

The most important cultural innovations required to support complex societies are command and control institutions that can systematically organize cooperation, coordination, and a division of labor in societies consisting of hundreds of thousands to hundreds of millions of people. Command and control institutions lead to more productive economies, more internal security, and better resistance to external aggression. Note that command and control are separable concepts. Command may aim at quite limited control. For example, a predatory conquest state may use command almost exclusively for the extraction of portable wealth, not for prosocial projects. Institutions often exert control without commands. Markets, most famously, control behavior by price signals from a diffuse world of anonymous buyers and sellers. Market enthusiasts do sometimes forget that command systems generally are needed to make markets function, ranging from mandatory use of calibrated weights and measures to central banks (Dahrendorf, 1968:Chapter 8). The main types of work-arounds seem to be the ones described in the following subsections.

Coercive Dominance

The cynics' favorite mechanism for creating complex societies is command backed up by force. The conflict model of state formation has this character (Carneiro, 1970), as does Hardin's (1968) recipe for commons management.

Elements of coercive dominance are no doubt necessary to make complex societies work. Tribally legitimated self-help violence is a limited and expensive means of prosocial coercion. Complex human societies have to supplement the moralistic solidarity of tribal societies with formal police institutions. Otherwise, the large-scale benefits of cooperation, coordination, and division of labor would cease to exist in the face of selfish temptations to expropriate them by individuals, nepotists, cabals of reciprocators, organized predatory bands, and classes or castes with special access to means of coercion. At the same time, the need for organized coercion as an ultimate sanction creates roles, classes, and subcultures with the power to turn coercion to narrow advantage. Social institutions of some

sort must police the police so that they will act in the larger interest to a measurable degree. Such policing is never perfect and, in the worst cases, can be very poor. The fact that leadership in complex systems always has at least some economic inequality suggests that narrow interests, rooted in individual selfishness, kinship, and, often, the tribal solidarity of the elite, always exert an influence. The use of coercion in complex societies offers excellent examples of the imperfections in social arrangements traceable to the ultimately irresolvable tension of selfish and prosocial instincts.

Although coercive, exploitative elites are common enough, there are two reasons to suspect that no complex society can be based purely on coercion. The first problem is that coercion of any great mass of subordinates requires that the elite class or caste be itself a complex, cooperative venture. The second problem with pure coercion is that defeated and exploited peoples seldom accept subjugation as a permanent state of affairs without costly protest. Deep feelings of injustice generated by manifestly inequitable social arrangements move people to desperate acts, driving the cost of dominance to levels that cripple societies in the short run and often cannot be sustained in the long run (Insko et al., 1983; Kennedy, 1987). Durable conquests, such as those leading to the modern European national states, Han China, or the Roman Empire, leaven raw coercion with more prosocial institutions. The Confucian system in China and the Roman legal system in the West were far more sophisticated and durable institutions than the highly coercive systems sometimes set up by predatory conquerors and even domestic elites.

The modern commons literature has taken up this theme from its inception in Hardin's (1968) article, but even more so in his later work (e.g., Hardin, 1978; see also Low, 1996). The underlying model is one of selfish rationality that requires a leviathan to motivate self-interested actors to conserve commons. We think this analysis is flatly self-contradictory. Leviathans can't be drummed up simply because they would be useful; they must evolve. If evolution produces self-interested actors that need leviathans, then any leviathans will be selfish too, and so they may conserve commons in their own interest, but not in the interest of anyone else. In the modern world, there are many kleptocratic leviathans—Mobutu, Suharto, Marcos—men who take advantage of weak national institutions to exploit commons for their own narrow ends, and preside over corrupt bureaucracies that cannot even manage efficiently in the kleptocrat's self-interest—everyone cheats as much as they can. No one sensible person desires this kind of leviathan. Coercive elites can manage commons efficiently only if they are embedded in fundamentally prosocial institutions. A process like cultural group selection acting in the past and in the present puts the possibility of prosocial attitudes and institutions to work. In fact, costly prosocial behavior is common. Resistance to kleptocrats is often newsworthy, as their abuses of human rights are generally conspicuous and heavy handed. Not inconsiderable numbers

of people resist such governments at the very real risk of brutal and often deadly repression.

Segmentary Hierarchy

Late Pleistocene societies were undoubtedly segmentary in the sense that supra-band ethnolinguistic units served social functions, although presumably they lacked much formal political organization. The segmentary principle can serve the need for more command and control by hardening up lines of authority without disrupting the face-to-face nature of proximal leadership present in egalitarian societies. The Polynesian ranked lineage system illustrates how making political offices formally hereditary according to a kinship formula can help deepen and strengthen a command and control hierarchy (Kirch, 1984; Sahlins, 1963). A common method of deepening and strengthening the hierarchy of command and control in complex societies is to construct a nested hierarchy of offices, using various mixtures of ascription and achievement principles to staff the offices. Each level of the hierarchy replicates the structure of a hunting and gathering band. A leader at any level interacts mainly with a few near-equals at the next level down in the system. New leaders usually are recruited from the ranks of subleaders, often tapping informal leaders at that level. As Eibl-Eibesfeldt (1989) remarks, even high-ranking leaders in modern hierarchies adopt much of the humble headman's deferential approach to leadership.

Commons management institutions sometimes make use of segmentation. Hundley (1992) describes the importation of Spanish water management customs into the Northern Mexican borderlands, including California. According to Hundley, the Royal decrees sought to establish a Spanish economy in the New World to support other Spanish institutions. These decrees included an elaborate section on water management, codified as the *Plan of Pitic*, a model water ordinance. Water management was to be the responsibility of town councils. The details of management were left to the town under a few basic principles. First, no individuals were to have independent rights; water was to be managed as common property of the duly constituted town. Second, in times of scarcity, water was to be divided equitably among all users. Royal authorities were to resolve any disputes that escaped local management, such as disputes between upstream and downstream users according to the same two principles. Thus, the division of authority between town and royal officials was carefully crafted. The plan was consciously modeled on the successful Iberian tradition of local management of water, the modern manifestations of which Ostrom (1990:69-82) discusses.

The hierarchical nesting of social units in complex societies gives rise to appreciable inefficiencies (Miller, 1992). In practice, brutal sheriffs, incompetent lords, venal priests, and their ilk degrade the effectiveness of social organizations in complex societies. Squires (1986), elaborating on Tullock (1965), dissects the problems and potentials of modern hierarchical bureaucracies to perform consis-

tently with leaders' intentions. Leaders in complex societies must convey orders downward, not just seek consensus among their comrades. Devolving substantial leadership responsibility to subleaders far down the chain of command is necessary to create small-scale leaders with face-to-face legitimacy. However, it potentially generates great friction if lower level leaders either come to have different objectives than the upper leadership or are seen by followers as equally helpless pawns of remote leaders. Stratification often creates rigid boundaries so that natural leaders are denied promotion above a certain level, resulting in inefficient use of human resources and a fertile source of resentment to fuel social discontent.

Young (this volume:Chapter 8), Berkes (this volume:Chapter 9), and Baland and Platteau (1996:Chapter 13) devote considerable attention to the problem of vertical linkages between small-scale commons management institutions and the larger ones in which they are necessarily embedded in a complex society. Kleptocratic behavior frequently infects the whole political and bureaucratic system. In states with inefficient national-level institutions, corruption often exists up and down the chain of command (Baland and Platteau, 1996:235 ff). Commons management bureaucracies, even in relatively successful democracies such as India, often legislate away tribal-scale commons management systems and replace them with bureaucracies that do a much worse job. Tightly organized, large command and control bureaucracies only function properly when the institutions that regulate their behavior favor efficiency and honesty. Otherwise, the ever-present selfish, nepotistic, and tribal-scale motives will support the emergence of corruption at every level of the hierarchy.

These authors identify two sets of issues. Looked at from the bottom up, higher level interference in the affairs of local communities can be catastrophic, but, from the top down, is at the same time often important for proper function. Catastrophes occur when, through ignorance or malevolence, larger scale institutions damage or destroy small-scale ones. Success is achieved, as in the *Plan of Pitic*, when the roles of higher and lower levels are complementary and when their interests largely coincide. We would only stress more than these authors that the most important feature of small-scale institutions is that they can tap most directly, free of problematical work-arounds, the tribal social instincts. High degrees of cooperation, buttressed by nuanced systems of monitoring and punishment, make for high-morale, highly effective systems. Self-interest not only does not explain such cooperation, but also may be dangerous if used in an effort to strengthen or change institutions. We believe that hierarchical systems cannot dispense with tribal solidarity at any level without losing important elements of function. This is a claim worth testing, as it is a linchpin of our hypothesis but inessential to those based on rational choice, in which hierarchical organization serves merely communication and monitoring function. On our view there is much more to segmentary hierarchies than a telephone tree down and surveillance information up.

On the other hand, failure to properly articulate tribal-scale units is often highly pathological. Tribal societies often must live with chronic insecurity because of intertribal conflicts. One of us once attended the *Palio*, a horse race in Siena in which each ward, or *contrada*, in this small Tuscan city sponsors a horse. The voluntary contributions necessary to pay the rider, finance the necessary bribes, and host the victory party amount to half a million dollars. The contrada clearly evoke the tribal social instincts: They each have a totem—the dragon, the giraffe, special colors, rituals, and so on. The race excites a tremendous, passionate rivalry. One can easily imagine a medieval Siena in which swords clanged and wardmen died, just as they do or did in warfare between New Guinea tribes (Rumsey, 1999), Greek city-states (Runciman, 1998), inner city street gangs (Jankowski, 1991), and ethnic militias. Natural resources are frequently sources of conflict that can lead to violence in the absence of superordinate institutions to resolve disputes. "Wars" between fishermen from different ports occur occasionally despite modern justice services. When fishermen from different nations are involved, fish wars cause major diplomatic tangles even between otherwise friendly nations. The three fish wars that occurred between Britain and Iceland over cod fishing rights after the Second World War (Kurlansky, 1998), and the ethnic-controlled fisheries in 19th-century California, included vigorous defense of each group's territory (Baland and Platteau, 1996:328). Territory defense is an ancient function of tribes, to judge from its high frequency in ethnographically known hunter-gatherers (Cashdan, 1992) and territory incursion is a frequent cause of violent conflict.

Exploitation of Symbolic Systems

The high population density, division of labor, and improved communication made possible by the innovations of complex societies increased the scope for elaborating symbolic systems. The development of monumental architecture to serve mass ritual performances is one of the oldest archeological markers of emerging complexity. Usually an established church or less formal ideological umbrella supports a complex society's institutions. At the same time, complex societies extensively exploit the symbolic ingroup instinct to delimit a quite diverse array of culturally defined subgroups, within which a good deal of cooperation is routinely achieved. Ethnic group-like sentiments in military organizations often are reinforced most strongly at the level of 1,000 to 10,000 or so men (British and German regiments, U.S. divisions) (Kellett, 1982). Typical civilian symbolically marked units include nations, regions (e.g., Swiss cantons), organized tribal elements (Garthwaite, 1993), ethnic diasporas (Curtin, 1984), castes (Gadgil and Malhotra, 1983; Srinivas, 1962), large economic enterprises (Fukuyama, 1995), civic organizations (Putnam, 1993), and many others (Stern, 1995).

How units as large as modern nations can tap the tribal social instincts is an

interesting problem. Anderson (1991) argues that literate communities, and the social organizations revolving around them (e.g., Latin-literates and the Catholic Church), lend themselves to creating "imagined communities" that in turn elicit significant commitment from members of the community. Because tribal societies were often large enough that some members were not known personally to any given person, common membership sometimes would have to be established by the mutual discovery of shared cultural understandings. The advent of mass literacy and print media—Anderson stresses newspapers—made it possible for all speakers of a given vernacular to have confidence that every reader of the same or related newspapers shared many cultural understandings, especially when organizational structures such as colonial government or business activities really did give speakers some institutions in common. Nationalist ideologists quickly discovered the utility of newspapers for building several variants of imagined communities, making nations the dominant quasi-tribal institution in most of the modern world. If Wolfe (1965) is right, mass media also can be the basis of a rich diversity of imagined subcommunities using vehicles such as specialized magazines, newsletters, and, nowadays, web sites. Subcommunities of the imagined type are often important for commons management, ranging from environmental pressure groups to professional communities with a role in environmental management.

Many problems and conflicts revolve around symbolically marked groups in complex societies. Official dogmas often stultify desirable innovations and lead to bitter conflicts with heretics. Marked subgroups often have enough tribal cohesion to organize at the expense of the larger social system. The frequent seizure of power by the military in states with weak institutions of civil governance is probably a byproduct of the fact that military training and segmentation, often based on some form of patriotic ideology, are conducive to the formation of *relatively* effective large-scale institutions. Wherever groups of people interact routinely, they are liable to develop a tribal ethos. In stratified societies, powerful groups readily evolve self-justifying ideologies that buttress treatment of subordinate groups that ranges from neglectful to atrocious. White Southerners had elaborate theories to justify slavery and Jim Crow and Westerners found brutal treatment of Indians legitimate and necessary. The parties and interest groups that vie to sway public policy in democracies have well-developed rationalizations for their selfish behavior. A major difficulty with loyalties induced by appeals to shared symbolic culture is the very language-like productivity possible with this system. Dialect markers of social subgroups emerge rapidly along social fault lines (Labov, 1973). Charismatic innovators regularly launch new belief and prestige systems, which sometimes make radical claims on the allegiance of new members, sometimes make large claims at the expense of existing institutions, and sometimes grow explosively. Or, contrariwise, larger loyalties can arise, as in the case of modern nationalisms overriding smaller scale loyalties, sometimes for

better, sometimes for worse. The ongoing evolution of social systems can evolve in unpredictable, maladaptive directions by such processes (Putnam, 2000). The worldwide growth of fundamentalist sects that challenge the institutions of modern states is a contemporary example (Marty and Appleby, 1991; Roof and McKinney, 1987). Ongoing cultural evolution is impossible to control, at least completely.

The literature on commons management is rich in cases where tribal-scale institutions effectively govern commons. Gadgil and Guha (1992) describe the village-level management of forests and other commons by villages in traditional India and contrasts the successes of the traditional regime with failures under the bureaucratic institutions brought by the British and retained by independent India. Ruttan (1998) describes the successful management of a pearl-shell fishery by a village community. Acheson (1988) describes the management of a fishery by local fishermen. Ostrom's (1990:Chapter 3) cases all describe village-scale institutions. She mentions the existence of clear boundaries and sophisticated institutions for monitoring commons and assessing punishments to transgressors. She also notes that higher authorities have to leave local communities sufficient autonomy to exercise such institutions. The review by Baland and Platteau (1996:Part II) of many cases of local-level management of commons underscores these points. Bardhan and Dayton-Johnson (this volume:Chapter 3) note that egalitarian village-scale systems often have more successful commons management institutions than ones with an inegalitarian distribution of income.

So far as we can tell, the literature on commons management institutions has not yet tackled the precise role of *symbolically marked* groups in commons management. The fact that commons frequently are managed effectively by tribal-scale groups might be only because the scale of resources being managed is small and/or because efficient policing of commons requires clearly signifying who is and who is not entitled to participate in the commons, resulting in clearly defined boundaries (Ostrom, 1990:91). We believe that emotional bonds of the individual to the group frequently buttress these rational choice effects. One of us has observed that the Altiplano villagers around Lake Titicaca have distinctive costumes, especially women's but also sometimes men's. These villagers also effectively manage lake commons despite opposition from Peruvian authorities (LeVieil, 1987). We suspect that around the world, tribal-scale communities often have a sense of pride in their local corporate community, exemplified by wearing its "colors," which helps generate levels of cooperation and trust that are efficacious in providing many kinds of public goods. Experimentalists do not seem to have used symbolic marking of groups to test for whether such effects stimulate cooperation in public goods contexts (but see Kramer and Brewer, (1984). In the classic minimal group experiments of Tajfel (1981; see also Turner, 1995), very simple grouping and symbolic labeling of subjects caused substantial discrimination in favor of ingroup members. This experimental evidence dovetails nicely with the field data, very superficially reviewed in the two previous

paragraphs. We predict that if experimental subjects are led to believe they are playing a commons game with any even thinly plausible ingroup, rates of participation in common property economy will rise significantly above base rates. If the game has even a minimal element of competition between symbolically marked groups, such as a nominal or symbolic prize for most money earned, participation should be especially high.

Legitimate Institutions

In small-scale egalitarian societies, individuals have considerable autonomy, considerable voice in community affairs, and can enforce fair, responsive—even self-effacing—behavior by leaders (Boehm, 1999). At their most functional, symbolic institutions, a regime of tolerably fair laws and customs, effective leadership, and smooth articulation of social segments can roughly simulate these conditions in complex societies. Rationally administered bureaucracies, lively markets, the protection of socially beneficial property rights, widespread participation in public affairs, and the like provide public and private goods efficiently, along with a considerable amount of individual autonomy. Many individuals in modern societies feel themselves part of culturally labeled tribal-scale groups, such as local political party organizations, that have influence on the remotest leaders. In older complex societies, village councils, local notables, tribal chieftains, or religious leaders often hold courts open to humble petitioners. These local leaders in turn represent their communities to higher authorities. To obtain low-cost compliance with management decisions, ruling elites have to convince citizens that these decisions are in the interests of the larger community. As long as most individuals trust that existing institutions are reasonably legitimate and that any perceived needs for reform are achievable by means of ordinary political activities, there is considerable scope for large-scale collective social action.

However, legitimate institutions, and trust of them, are the result of an evolutionary history and are neither easy to manage or engineer. The social distance between different classes, castes, occupational groups, and regions is objectively great. Narrowly interested tribal-scale institutions abound in such societies, as we have seen. Some of these groups have access to sources of power that they are tempted to use for parochial ends. Such groups include, but are not restricted to, elites. The police may abuse their power. Petty administrators may victimize ordinary citizens and cheat their bosses too. Ethnic political machines may evict historic elites from office but use chicanery to avoid enlarging their coalition.

Without trust in institutions, conflict replaces cooperation along fault lines where trust breaks down. Empirically, the limits of the trusting community define the universe of easy cooperation (Fukuyama, 1995). At worst, trust does not extend outside family (Banfield, 1958) and potential for cooperation on a larger scale is almost entirely foregone. Such communities are unhappy as well as poor. Trust varies considerably in complex societies, and variation in trust seems to be

the main cause of differences in happiness across societies (Inglehart and Rabier, 1986). Even the most efficient legitimate institutions are prey to manipulation by small-scale organizations and cabals, the so-called special interests of modern democracies. Putnam's (1993) contrast between civic institutions in Northern and Southern Italy illustrates the difference that a tradition of functional institutions can make. The democratic form of the state, pioneered by Western Europeans in the past couple of centuries, is a powerful means of creating generally legitimate institutions. Its success attracts imitation all around the world. The halting growth of the democratic state in countries ranging from Germany to those in Sub-Saharan Africa is testimony that legitimate institutions cannot be drummed up out of the ground just by adopting a constitution. Where democracy has struck root outside of the European cultural orbit, it is distinctively fitted to the new cultural milieu, as in India and Japan.

Legitimate institutions have a huge role to play in commons management. One of us has had considerable positive experience with the burgeoning system of Cooperative Resource Management Committees (CRMCs) that bring local, state, and federal agencies together regularly with interested citizens and citizen groups to deal with their joint commons (Richerson, with Lake County, California's Clear Lake Watershed CRMC). Although the resolutions of such committees have no weight of law at all, in the Clear Lake case they usually represent a strong consensus of the participants and thus often generate appropriate action. The most conspicuous absentee from the process at Clear Lake has been the U.S. Environmental Protection Agency (EPA), whose Superfund Program has charge of cleaning up a large abandoned mercury mine on the shore of the lake. Levels of trust even between technical professionals at EPA and other agencies are very low. From this one case, it is impossible to decide whether EPA's poor reputation is simply a result of nonparticipation or if nonparticipation itself is part of a wider malaise in the agency. Some evidence suggests that the culture of EPA derives more from the norms and habits of the legal community than from the engineering and science community, mainly because of choices made by its first administrator, William Ruckelshaus (Richerson, 1988). As a result, the agency has trouble attracting and retaining the highest caliber technical staff and hence has trouble dealing professionally with technical issues when they arise.

Hundley (1992) describes the many institutions created to manage the California water commons. On the small scale, towns created water companies, entrepreneurs created mutual water companies and platted the accompanying town, and farmers organized irrigation districts. On the medium scale, growing cities, especially Los Angeles and San Francisco, organized municipal water companies that seized water rights on distant drainages and built long aqueducts to the city. On the largest scale, the Federal Central Valley Project and the State California Water Project routed southward most of the flow of the state's largest river, the Sacramento. All of the large projects and many smaller ones were intensely controversial, and had to survive votes in legislatures, city councils, and boards of

supervisors. Most faced general elections to approve bonds for construction financing. Many had to survive legal challenges. Chicanery was common, although often by public servants acting in what they believed was the general interest. Self-interested malfeasance was also common. Large landowners zealously exploited economies of scale in manipulating government decisions in their own favor. Despite bitter reversals, such as the then-new Sierra Club's failure to save the Hetch Hetchy Valley from San Francisco's dam, few losers stepped outside of the realm of legal forms of resistance. The citizens of the Owens Valley became so embittered at Los Angeles' massive diversion of water into its aqueduct that they dynamited the main pipeline on several occasions. The publicity resulting from these acts portrayed Los Angeles in such a bad light that the city ultimately bought out not water right holders but all of the private landholders in the Valley.

Thus, successful commons management on any scale requires a system of legitimate institutions. Where these do not exist, appropriate organizations may arise spontaneously at the tribal level, especially if the state does not actively interfere. In cases where the scale of the problem is larger, the whole panoply of work-arounds must act with enough efficiency to create large-scale management systems, such as ministries of the environment. When such bureaucracies work well, they are likely to adopt some tribal attributes. Individuals will have high loyalty to the organization and a deep commitment to making it function. In many societies, these institutions remain distressingly lacking in such attributes. Indeed, the contemporary enthusiasm for conservation-and-development projects to protect biodiversity in poor countries is an effort to cope with weakness in national institutions, which are the backbone of biodiversity conservation in the wealthy nations. The institutional basis for managing the global commons is still, of course, quite problematic.

REPRISE: TESTING THE HYPOTHESES

How much confidence should we have in the tribal social instincts and work-around hypotheses? We argue elsewhere that much evidence from a number of domains is more consistent with the tribal social instincts hypothesis than with its best articulated competitors (Richerson and Boyd, 1998, 2001; Boyd and Richerson, no date). Soltis et al. (1995) used data on group extinctions in Highland New Guinea to estimate potential rates of group selection. The details of New Guinea extinctions are consistent with assumptions made in our conformity-based model of cultural group selection. Kelly (1985) and Knauft (1985; 1993) provide particularly good case studies describing the operation of cultural expansions at the expense of one group by another and pinpointing the institutional reasons for the group fitness differentials. We have tested the work-around hypothesis by drawing on the analytical history of the performance of World War II armies (Richerson and Boyd, 1999).

We think the empirical data on commons management institutions also con-

form to the patterns predicted by these hypotheses. In particular, both field and experimental evidence show that people cooperate in ways that are hard to reconcile with the behavior of selfish actors. We believe that cultural group selection is the best existing explanation for why humans but not other species can organize cooperation among nonrelatives on a considerable scale. Evidence from the commons literature suggests that people are neither individualist nor prosocial rational actors by nature. Given sufficient rationality and prosocial impulses, humans might leap immediately to solutions to commons dilemmas. The evidence suggests instead that we are dependent on culturally evolved institutions to make cooperation work. Institutions encode rules for operating commons that are neither innate nor learned on the spot but are cultural traditions. Successes and failures seem always to involve an institutional dimension. Some societies have evolved work-arounds that permit reasonably functional environment ministries, while others struggle.

In another sense our hypotheses are very poorly tested. The systematic application of modern evolutionary theory to human behavior is scarcely a quarter century old. The variety of evolutionary theories we can imagine is rather large, especially if cultural evolution and gene-culture coevolution play important roles. Our particular choices in formulating the tribal instincts and work-around hypotheses seem sensible to us in light of the evidence, but only a small part of the space of all possible theories is yet explored. For example, Campbell (1983) argued that simpler societies were built on the basis of kinship and reciprocity and that cultural group selection became important only with the rise of complex societies in the past few thousand years. We think the evidence supports the idea that hunting and gathering societies commonly cooperated on scales too large to be explained by reciprocity and kinship alone, but of course we have no direct data on the social organization of Pleistocene societies.

OUTSTANDING QUESTIONS

The most important payoff to better theory is that better theory poses new, interesting, and practically important questions for further research. We think the dual inheritance evolutionary theory does these things.

We believe evolutionary theory might provide helpful directions for future research in four general areas.

The Problem of Complexity and Diversity

Commons institutions are functional, complex, and unique. They appear to be deeply embedded parts of cultures and hence to have an evolutionary history of some depth. There are a myriad of ways to organize commons management (Agrawal, this volume:Chapter 2). The dominant hypothesis to explain such diversity has been the more and less advanced hypothesis. Modernist reformers

portray formal state control over natural resources as the superior modern successor to less formal, traditional, *ancien regime* commons institutions. Their local diversity and cultural embeddedness are testimony to suboptimality on this view. Overenthusiastic modernists unduly neglect alternative hypotheses. Complex design problems in artificial systems are known to have many optima, some of which are more or less equally functional. We argue that biological and cultural systems are similar (Boyd and Richerson, 1992b). As myopic evolutionary processes locally improve the function of complex systems, they explore a complex adaptive landscape, some coming to equilibrium on less functional local peaks than others. Large, simple jumps may unravel quite functional institutions without putting into place all the parts of a complex alternative, as students of commons institutions repeatedly have observed. The failures of outside reformers who advocate major change to "more advanced" institutions are common.

A major task before us is to map out the proximal details of how institutions fostering cooperation work and how evolutionary processes have shaped these details. Traditional ethnographic investigations were a fine start on this project, but more critical and quantitative methods are needed to describe function and process in more detail (e.g., Edgerton, 1971). Ostrom's (1990) analysis of commons management, based on ethnographic and historical sources, asked many of the right questions. We believe the evolution-inspired experimental comparative ethnography pioneered by Henrich et al. (2001) and Nisbett et al. (in press) provide important insights. In even the most atomistic human societies, people have some propensity to fairness in economic interchanges that can aid their transition to the modern world. The indications that social organization is deeply entangled with styles of thinking suggest that complex, historically contingent evolution does indeed create considerable evolutionary inertia in institutions. We recommend our list of work-arounds as a practical tool in assessing the strengths and weaknesses of commons institutions. For example, Young (this volume:Chapter 8) and Berkes (this volume:Chapter 9) argue that cross-scale linkages are important sources of both friction and necessary interplay using much the same terms as our discussion of the segmentary hierarchy work-around.

How Flexible Are Cooperative Institutions?

Putnam's (1993) contrast between Northern and Southern Italy suggests that some institutional systems respond more quickly to changing opportunities than others. Plausibly, an open political system that operates by either rough consensus or more formal voting is better adapted to solve a wide variety of public goods problems by using legitimate institutions to formulate plans of action adaptable to new circumstances than is a regime lacking a measure of, or interest in, popular needs and wants. Boehm (1993, 1996) argues that hunter-gatherers commonly make adaptive collective decisions by open discussion and consensus formation. Recall Inglehart and Rabier's (1986) finding that the strongest correlate

of reported happiness and satisfaction with life in the developed world (mostly Europe) is expressed levels of trust in one's fellow citizens. The happiest countries are relatively small, highly democratic societies like Sweden, Holland, and Switzerland that, we conjecture, retain strong participatory institutions at the tribal scale, however sophisticated they are in other ways (it would be hard to find a society more sophisticated than, say, Holland).

Open political systems seem to be among the most flexible of institutions for so many purposes because they maintain such a high level of local esprit and trust. Innovative ways of tapping these systems, such as Cooperative Resource Management Committees, seem to provide healthy cross-level linkages between the higher level bureaucracy and the local community. They are likely to fail either when consensus cannot be achieved at the local level or when local consensus is not acceptable to powerful actors beyond the local level; this seems to have been the case with the Quincy Library Group's consensus on logging/biodiversity conflicts in its local area. The visible precedent-setting nature of the Quincy Library exercise is perhaps not a fair test of the concept because it attracted very close scrutiny by national-level interest groups in a regionally highly polarized arena. Cooperative Resource Management Committees of our personal acquaintance operate much closer to the ground and can make local consensus work.

Other institutions have some of the same properties. Many economists claim that the market is one of the most general tools of all in managing human behavior. Tietenberg (this volume:Chapter 6) and Rose (this volume:Chapter 7) discuss the strengths and weaknesses of tradable permits as means for managing environmental resources. Tradable permits are resisted by those generically suspicious of market solutions, but to our way of thinking the most severe problem is the large amounts of wealth such rights create. Well administered by competent, honest bureaucracies, such systems have much promise. They seem, however, to be of little use in places where administering institutions are inefficient or corrupt. Crony capitalism systems will not administer such systems honestly any more than they honestly administer current commons by regulation. One again we stress Dahrendorf's (1968) point that efficient markets are the result of efficient, honest institutions, not somehow direct products of human nature set free, as some market ideologues would have us believe. Against this argument, Baland and Platteau (1996:134) review ideas suggesting that market economies cause erosion in moral norms. Henrich et al.'s (2001) data suggest the opposite. People from groups with experience with market institutions usually make fair offers in the ultimatum game, perhaps because experience in markets teaches participants that strangers are generally fair dealers. The rapid change that often accompanies market penetration to formerly isolated village societies is more likely, we suggest, the culprit in destabilizing traditional commons institutions than markets per se.

How Rapidly Can New Institutions Emerge and Spread?

The spread of complex social institutions by diffusion is arguably more difficult than the diffusion of technological innovations. The pace of innovation of institutions is likely to be relatively slow for several reasons. We have already mentioned the problem of complex design inhibiting the easy optimization of institutions. Similarly, many coordination payoff structures will cause societies to reach a variety of equilibria, some of which are relatively inefficient but also difficult to improve (Sugden, 1986). Some models of cultural group selection are quite hostile to the exchange of innovations between groups because the between-group migration necessary to carry them from one group to the other also causes mixing and lowering of the between-group variance that group selection needs to operate (Soltis et al., 1995). The data and models reviewed in Soltis et al. suggest that it would take on the order of a millennium for an institutional innovation to spread from the innovators to the bulk of the societies in a region. Other models of cultural group selection make the necessary cross-cultural borrowing more plausible (Boyd and Richerson, no date). This model shows that the existence of multiple stable states due to the existence of games of coordination does not necessarily inhibit the rapid spread of the most successful solution from group to group.

Other problems may make the diffusion of successful institutions hard. Social institutions violate four of the conditions that tend to facilitate the diffusion of useful innovations (Rogers, 1995). Foreign social institutions are often (1) not compatible with existing institutions, (2) complex, (3) difficult to observe, and (4) difficult to try out on a small scale. For such reasons, some commentators view the evolution of social institutions as a much more likely rate-limiting step than technology in the evolution of more intensive economies. For example, North and Thomas (1973) argue that new and better systems of property rights set off the modern industrial revolution rather than the easier task of technical invention itself. A difficult revolution in property rights likely also is necessary for intensive hunting and gathering and agriculture to occur (Bettinger, 1999). Slow diffusion also means that historical differences in social organization can be quite persistent, even though one form of organization is inferior. As a result, the comparative history of the social institutions of intensifying societies exhibits many examples of societies getting a persistent competitive advantage over others in one dimension or another because they possess an institutional innovation that their competitors do not acquire. For example, the Chinese merit-based bureaucratic system of government was established at the expense of the landed aristocracy, beginning in the Han dynasty (2,200 B.P.) and completed in the Tang (1,400 B.P.) (Fairbank, 1992). This system has become widespread elsewhere only in the modern era and is still operated quite imperfectly in many societies.

Consistent with such ideas, the evolution of institutions in fact has been relatively slow. More than 10 millennia separate us from our Pleistocene tribal ances-

tors. We argue elsewhere (Richerson et al., 2001) that the transition from the harsh, highly variable climate regime of the last ice age to the much more benign regime of the Holocene set off a competitive footrace that consistently has favored more efficient subsistence and better organization of social systems. The fact that the human race has not yet reached equilibrium with the economic and social-organizational potential made possible by the benign climate of the Holocene (Richerson and Boyd, in press) is testimony to the relatively stately pace of cultural evolution. Even if equilibrium is at hand (Fukuyama, 1992), 10 millennia is a long time to get here! The pace of institutional evolution seems to have accelerated toward the present, no doubt because of the spread of literacy, mass communications, and science and social science. Foreign customs are much more transparent than they once were, and scholars often make more or less sophisticated comparative appraisals of the diversity of social experiments that come to their attention. Even so, institutional revolutions are apt to be frustratingly slow. For example, the conversion of Russia from a socialist one-party state to a market economy and elective democracy is far from a success after more than a decade of work.

The study of the rates of cultural evolution prevailing in the modern world and a sophisticated dissection of the processes that regulate those rates is a project in its infancy. In evolutionary biology, the coin-of-the-realm study of evolution is a quantitative estimate of the rate of evolution of a character and an attribution of the causes of change to particular processes such as natural selection and migration (e.g., Endler, 1986). Although such experiments are not commonly done by social scientists, plenty of examples exist to indicate that the project is perfectly feasible (Weingart et al., 1997:292-297). One of the most sophisticated literatures of this sort is the "policy learning/advocacy coalition" approach to studying policy change (Sabatier and Jenkins-Smith, 1993). Several of the studies applying this approach have been studies of commons policy issues. Obviously, applied institutional development agencies would benefit enormously from a sound knowledge of the comparative natural history of institutional evolution. The practical problem is to help a society with weak institutions acquire more functional ones of a specific orientation. The record indicates that inept interventions can do more harm than good, but good interventions also occur (Baland and Platteau, 1996: 243-245, 279-283).

Is Small-Scale Cultural Evolution a Problem or a Resource?

Societies have political institutions of varying degrees of complexity for aggregating individual-level beliefs and desires to produce collectively desired outcomes (Boehm, 1996; Turner, 1995). In the limit, collective decision-making systems cause us to endow institutions such as the state with many of the attributes of an individual rational actor, although both theory (Arrow, 1963) and practical experience suggest that reaching sensible collective decisions is fraught with prob-

lems. Collective decisions, whether representative and rational or not, often have such durable effects as to constitute a form of cultural evolution. For example, the U.S. Constitution has shaped the political culture of the country for two centuries. The linkage of individual and small group-level culture with larger scale collective institutions is a complex problem with causal arrows running up and down the organizational hierarchy. The possibility of making collective decisions at all depends on some sufficient number of individual actors having norms and beliefs that support the institutions involved. If authors like Putnam (1993) are correct, the evolution of grassroots political culture is necessary to make higher levels of decision making work well. The ongoing evolution of beliefs and norms may act in concert with collective policy decisions, but some degree of friction is routine. The overextension of the state regulation of commons can wreck successful village-level systems, and the ideological and behavioral conformity demanded of all citizens by state authorities in authoritarian systems like Hapsburg, Spain, and Austria can damage the social capital on which sound policy making ultimately rests (Gambetta, 1993).

Many groups in developed nations are organized to advocate relatively narrow interests, or at least interests that seem narrow to those with other convictions. For example, wilderness advocates are accused of locking up vast tracts of land for their own pleasure, at the cost of excluding less hardy recreators and harming the interests of extractive resource users (usually claimed to be sustainable or otherwise harmless). The nature of passionate ingroups being what it is, such mud often sticks. Some of the opposition to dealing sensibly with global climate deterioration issues in the United States comes from Christians with apocalyptical beliefs. If the Second Coming is near, global climate change is either irrelevant or perhaps part of God's plan for the End Days. By some accounts, a growing appeal of ideologies with little patience with science (and likely, scientific management of natural resources) is a world-wide problem (Marty and Appleby, 1991). Developing wise large-scale policy to manage, but not overmanage or mismanage, cultural change is perhaps the most difficult and sensitive problem of statecraft. We are not convinced that much science can yet be brought to bear on the question of what cultural trends are threats and what are not by any criterion of judgment.

A few systems for collectively managed cultural evolution do stand out as possible examples of the application of sensible collective decision making to cultural change. In contemporary open societies, the harnessing of science to the public policy-making process via government-sponsored science at research institutions and research universities works splendidly when the science is tractable and social consensus as to directions to take are strong. Some other models are worth exploring. For example, Dupuy (1977) analyzed the history and operations of the Prussian and then German General Staff from the early 19th century to mid-20th century and argues that this institution typically outperformed its competitors in learning lessons from past successes and failures and applying them to

reforms. One of the main reasons the German General Staff worked so well was that the prestigious and rather scholarly staff officers routinely served in line roles and earned the respect of line officers. In a few disciplines—engineering, economics—the flow of personnel from academic to practical line and staff roles is perhaps routine enough to resemble an informal general staff. In most disciplines academic and practitioner roles are mutually exclusive, practically speaking. The various agricultural extension services and other applied science organizations could be prospected for models. A practical scheme to "grow" innovative commons management institutions is perhaps only an inspirational innovation or two away from practicality. The two senior authors, who have had considerable, interesting, and rewarding experience as staffers in applied science and policy contexts, must admit that they found no way in the end to combine such work with an academic career.

CONCLUSIONS

In this chapter, we have tried to tie together the literature on the evolution of cooperation with the literature on commons management institutions. We believe an interesting parallel exists between the sophisticated bounded rationality models necessary to account for the behavior of people toward commons and dual inheritance or gene-culture coevolutionary theory. People behave in experiments and in the field as if they have strong—perhaps innate—dispositions to cooperate, although dispositions vary considerably from person to person, society to society, and time to time. The variation is best explained by the existence of complex cultural traditions of social behavior, the collective results of which we call social institutions. Our ability to organize cooperation on a scale considerably larger than predicted by theory based on unconstrained selfish rationality, or by most evolutionary mechanisms, is one of the most striking features of our species. Another striking feature is our extraordinary facility for imitation and teaching. Our main hypothesis is that the co-occurrence of culture and cooperation in our species is not a coincidence. Group selection on cultural variation provides a plausible mechanism by which large-scale cooperation might arise. Cultural group selection is a slow process, at least in some models we have studied, so supplementary processes are likely to be more important in the shorter run evolution of cooperative institutions.

The cooperative dispositions, cultural or innate, favored originally by cultural group selection or some similar process will inevitably act as biases of cultural innovation and transmission. All else equal, people will tend to favor innovations that seem fair, that are efficient producers of public goods, and that contribute to their ingroup's position relative to competing outgroups. As team sports show, people play games of cooperation for fun. We can even organize institutions to promote desirable institutional evolution, ranging from research universities and political parties to village assemblies. Of course, people are

hardly perfect paragons of cooperation. Our mixture of altruistic and selfish propensities varies across cultures but neither element is ever suppressed entirely. Gene-culture coevolution theory has a natural account of our conditional and incomplete altruism. At root, reproductive competition between the cooperators in human societies means that selection on genes still acts strongly to favor behavior enhancing inclusive fitness. Group selection on culture can only partially mitigate selfish and nepotistic impulses, not eliminate them.

Aside from providing an ultimate explanation for the patterns of cooperation we observe in humans, we hope the application of evolutionary theory to the understanding of commons institutions will lead to means to improve commons management. If our particular evolutionary theory is correct, we have good news and bad news for the practitioner. The good news is that we have much better raw material to work with improving commons management than the selfish rationality theorists think we have. The bad news is that institutions to capitalize on our prosocial instincts and traditions evolve relatively slowly and uncertainly. Regress is possible as well as progress. Cooperation within groups is all too often devoted to unhelpful if not destructive conflicts with other groups, as in the conflict between rivalrous national goals and the regulation of the global commons.

The new theory of the commons already understands all these things. Evolutionary theory offers a program for investigating just how institutions do evolve. We have outlined a little of the complexity possible when several different evolutionary processes can be at work, some stronger and some weaker, and all depending, at least to some extent, on the case at hand. The products of evolution are not only complex but also diverse. Exploring the tempo and mode of cultural evolution is a long-term project. After all, biologists are still at work on organic evolution a century and a half after Darwin, and they're still having plenty of fun. Of course, they have so many species to work on and we are only one, albeit a more than ordinarily diverse and complex one. In some ways cultural evolution is easier to study than organic evolution. Cultures change faster than gene pools. Historians and anthropologists have compiled vast amounts of qualitative information about our evolution and diversity and some innovative scholars have produced quantitative data. We believe that all the empirical methods needed to study cultural evolution have been used effectively in some specialized application or another, even if they are not yet in every social scientist's toolkit. We believe there is nothing to lose—and everything to gain—by developing and verifying a rigorous evolutionary theory of human behavior.

NOTE

1 Several prominent modern Darwinians—Hamilton (1975), E.O. Wilson (1975:561-562), Alexander (1987:169), and Eibl-Eibesfeldt (1982)—have given serious consideration to group selection as a force *in the special case* of human ultrasociality. They are impressed, as we are, by the organization of human populations into units that engage in sustained, lethal combat with other groups, not to mention other forms of cooperation. The trouble with a straightforward group selection hypoth-

esis is our mating system. We do not build up concentrations of intrademic relatedness like social insects, and few demic boundaries are without considerable intermarriage. Moreover, the details of human combat are more lethal to the hypothesis of genetic group selection than to the human participants. For some of the most violent groups among simple societies, wife capture is one of the main motives for raids on neighbors, a process that hardly could be better designed to erase genetic variation between groups.

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