the cultural evolution of real historical communities, one has to consider economic subsystems, metabolism with the environment, corresponding energy flows, and information streams, as well as driving forces and constraints all the way down to the basic physical and thermodynamic laws. Otherwise we cannot understand the emergence, progression, and eventual collapse of these communities (see Diamond 1999; 2005). However, it should be possible to incorporate these culture-specific aspects in more advanced models of cultural evolution. The best-quality criteria are exhaustive tests of their predictive power.

Following Richerson and Boyd (2005), Mesoudi et al. adopt a rather wide definition of "culture" as "information capable of affecting individuals' behaviour that they acquire from other members of their species" (target article, sect, 1, para. 10). According to this wide definition, language should get a high valuation because language qualifies as one of the most powerful tools affecting individuals and groups. We missed all the more a discussion of language beyond cladistics and learning. Language is such a primordial and fundamental constituent of culture that it deserves closer and specific attention. Moreover, language is also a unique motor of human cultural evolution, without any parallels in the history of nonhuman life. From the phylogenetic perspective, there is clearly a close coevolution of culture and language. This causes a deep impact of language on cultural evolution. Application of spoken or written language has dramatically shaped nearly all fields of culture, especially communication, on all scales and continuously creates new selective forces with sometimes high fluctuation amplitudes. Language is also responsible for fast-changing spiritual vogues, for intellectual fashions and ideologies, all unique to the human being – again, with no counterpart in the natural history of other biota.

Language evolution and language acquisition could therefore provide interesting objects of study for cultural evolution processes: The hereditary predisposition of an infant for the acquisition of any language is a clear vertical transmission process; the fast and seemingly effortless acquisition process itself is a maturation-controlled learning process with prevalent horizontal transmission. Both processes are coupled by the unique feature of testing and reshaping of coevolving language by a co-developing brain (Wermke & Mende 2006). Language acquisition is universal and at the same time highly flexible. The mastering of native languages is one of the necessary preconditions of cultural traditions.

To illustrate the growing gap between evolution of biota and cultural evolution, one should also consider the breathtaking acceleration made by the energy technology of the nineteenth century and even more so by contemporary information technology. The hyperlinked, interlocked global village has no counterpart in biological evolution. It is threatened by an intrinsic explosion of complexity, by the outbreak of good and evil fantasies, and urgently needs new strategies of stabilisation. Supreme effort is required to model and, most important, to understand these cultural evolution processes and to make reliable predictions and decisions. Modeling approaches have to take into account that far-reaching decisions are the result of the interaction of a large number of human brains and that even individual responses are generally the result of a huge potential for imagination and fantasy inside and outside of human brains. The progeny of Darwin, vertically and horizontally fairly well instructed, has to solve this puzzle as soon as possible. A deeper understanding of the underlying mechanisms of cultural evolution might be crucial for finding the trail toward a balanced and sustainable future of humankind.

Archaeology and cultural macroevolution

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Abstract: Given the numerous parallels between the archaeological and paleontological records, it is not surprising to find a considerable fit between macroevolutionary approaches and methods used in biology – for example, cladistics and clade-diversity measures – and some of those that have long been used in archaeology – for example, seriation. Key, however, is recognizing that this methodological congruence is illusory in terms of how evolution has traditionally been viewed in biology and archaeology.

Mesoudi et al.'s general premise is that human culture exhibits central Darwinian properties. They then ask a question that grows out of this premise: What sort of structural relationship might exist between a science of cultural evolution and the science of biological evolution? They divide biological evolution into macro- and microevolution and then align various methods and approaches used to examine each with corresponding methods and approaches used to examine cultural evolution. They find a considerable fit between macroevolutionary approaches in biology and some of the approaches used in anthropology and archaeology, and less fit between microevolutionary approaches. This is not surprising, given the numerous parallels between, say, the archaeological and paleontological records, which lend themselves to macroevolutionary methods such as cladistics, seriation, and clade-diversity measures. Likewise, the history of anthropology makes it clear that macroevolutionary approaches such as comparative anthropology are the backbone of the discipline.

Because of their focus, Mesoudi et al. necessarily bypass discussion of the "evolution" of these interests, approaches, and methods in anthropology and archaeology – a topic that Lyman and I have detailed elsewhere (e.g., Lyman & O'Brien 1997; 1998; Lyman et al. 1997; O'Brien & Lyman 2000). Here I point out that the considerable fit that Mesoudi et al. find between macroevolutionary approaches, methods, and issues in anthropology/archaeology and those in biology is a recent phenomenon rather than a long-standing tradition in the social sciences. The irony is that despite the parallels between subject matter, and despite the "naturalness" of traditional anthropological and archaeological methods for addressing cultural-evolutionary issues, social scientists have often been downright hostile toward even considering cultural evolution in Darwinian terms. Rather, they retreat to the cozy confines of nineteenth-century unilinear and progressive cultural evolutionism of Tylor (1871) and Morgan (1877).

Anthropologists and archaeologists have been encouraged in this retreat by several prominent biologists and paleobiologists such as Gould (e.g., 1987; 1996; 1997) and Mayr (1982; Angier 1997), who have done what countless anthropologists have done for more than a century – moved culture from the Darwinian realm into the Lamarckian realm. Note how Gould (1996, p. 222) viewed the situation:

> [the] uniquely and distinctively Lamarckian style of human cultural inheritance gives our technological history a directional and cumulative character that no natural Darwinian evolution can possess. . . . [C]ultural change is potentially progressive or self-complexifying because Lamarckian inheritance accumulates favorable innovations by direct transmission, and amalgamation of traditions allows any culture to choose and join the most useful inventions of several separate societies.

This misguided gambit locates cause in the wrong place (O'Brien 1996). Although the mode and tempo of transmission are different when culture is involved, do these differences lead to the inescapable conclusion that humans have stopped evolving – that they somehow are beyond the reach of selection? The answer is an emphatic "no." Humans today are no more immune to evolutionary processes than they were ten thousand or fifty thousand years ago.

All that is important in Darwinian terms – and it is difficult to overemphasize this point – is that variation, however it is generated, exists, and that transmission, however it is realized, takes

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place. Reproductive success among variant forms of organisms will result primarily from selection and drift. Similarly, replicative success (Leonard & Jones 1987) among variant artifact forms will result from both selection and differences in transmission. Therefore, I cannot agree with Gould's (1996; 1997) plea that the phenomenon of cultural evolution be labeled "cultural development" rather than "evolution" because the latter carries too many biological connotations. It is precisely these connotations that it *should* carry.

Lyman and I have argued (Lyman & O'Brien 1997; O'Brien & Lyman 2000; 2002b) that archaeology today is in a period similar to that of the 1970s, when paleobiologists such as Eldredge and Gould (1972) proposed a new way of looking at the fossil record that involved some retooling of biological evolutionary theory. Despite more than a decade of squabbling, the success of their endeavors is abundantly clear. Evolutionary archaeology, too, is moving past the squabbling period, but challenges remain at both the macro- and the microevolutionary levels. Nonetheless, I suspect that within a decade we will see a modern synthesis in archaeology that will parallel what occurred in biology in the 1940s with the unification of the naturalists and the experimentalists (Huxley 1942). The basic theory requisite to archaeology, conceived of as an unabashedly historical science concerning people and their cultures, has been around since 1859, the year Darwin penned *On the Origin of Species*. The basic problem for archaeology is that Darwin did not write a theory that can be applied directly to the study of the archaeological record (O'Brien & Holland 1990). But we cannot, as Rindos (1989) put it, blame Darwin for not doing our work for us. Rather, we should heed the advice of one of the foremost archaeologists of the early twentieth century, who explained to his colleagues that:

> the sooner we roll up our sleeves and begin comparative studies of axes and arrowheads and bone tools, make classifications, prepare accurate descriptions, draw distribution maps and, in general, persuade ourselves to do a vast deal of painstaking, unspectacular work, the sooner shall we be in position to approach the problems of cultural evolution, the solving of which is, I take it, our ultimate goal. (Kidder 1932, p. 8)

Sober (1992, p. 30) pointed out that "biologists interested in culture are often struck by the absence of viable general theories in the social sciences. All of biology is united by the theory of biological evolution. Perhaps progress in the social sciences is impeded because there is no general theory of cultural evolution." Sober is correct in noting that there is no general theory of cultural evolution, but if the survey by Mesoudi et al. is any indication of the analytical landscape, then it appears that help is indeed on the way.

Darwinian cultural evolution rivals genetic evolution

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Abstract: The study of culture from an evolutionary perspective has been slowed by resistance from some quarters of anthropology, a poor appreciation of the fidelity of cultural transmission, and misunderstandings about human intentionality.

Why is it so easy to accept that Darwinian evolution characterises genetic systems but not elements of culture? Mesoudi et al. begin their welcome and thoughtful article by suggesting that biology's success relative to anthropology as a scientific discipline derives from a willingness to simplify and from the synthetic nature of the theory of evolution. An additional problem that Ruth Mace and I alluded to in 1994 is that large branches of post-war anthropology adopted the view that "facts themselves should be considered as social constructs … and much of anthropology redefined itself as an interpretive humanity rather than a science, concerned with cultural *specificity* rather than comparison across cultures" (Mace & Pagel 1994, p. 549, emphasis added).

This belief in specificity – that particular human cultural elements are each *sui generis* – suggests a reluctance to adopt functional explanations for many aspects of culture: that cultural elements serve purposes, and those purposes may promote well-being, standing, reputation, or other important social attributes that could be related to fitness. Not all elements of culture will be amenable to functional analysis, but it is a useful gambit to assume they are until shown otherwise, and to search for the common link among apparently homologous or analogous traits across cultures. Elsewhere (Pagel 1994), I have called this gambit "the adaptationist wager."

There may also be an under-appreciation and misunderstanding of the fidelity of cultural transmission. Because cultural elements can, in principle, change every generation, they are often not seen as serious candidates for study as replicators. However, language is one part of the dual-inheritance system of culture and genes that is so prominent in humans. Among the Indo-European languages, the words for *two*, *three*, *five*, *I*, and *who* each form a single cognate set across the entire language family: Every Indo-European language speaker has used a related sound for each of these meanings. Given that Indo-European probably arose as a language family about 8,000 years ago (Gray & Atkinson 2003), this translates into rates of evolution (Pagel 2000) as low as that of some genetic elements.

Because cultural elements can be transmitted with high fidelity, then perhaps where they are not, fidelity may be unimportant and not just inherently noisy. For example, we might not expect the fidelity of linguistic transmission to exceed that required for three generations to talk to each other: There is no need to invest in the replication machinery to improve on this. What we observe is that even the most rapidly evolving parts of the fundamental vocabulary of languages change slowly enough to allow communication among generations (Pagel 2000). Biologists have come to treat replication fidelity as a variable of interest in its own right. The human immunodeficiency virus has some of the highest rates of mutation (lowest fidelity) observed in a functioning replicator. Its poor fidelity may allow it to escape detection by the human immune system.

The human capacity for intentionality or goal-directedness is thought by some to undermine the study of culture from within the framework of natural selection. Mesoudi et al. demur (see also Mesoudi et al. 2004), and I would like to add that this criticism may conflate intentionality with omniscience or omnipotence. Late *Homo erectus* may have frequently wished to make fire but could not work out how to produce matches. What matters is that attempts at solving problems, whether or not underpinned by intention or goal-direction, can be placed in a list ordered along a continuum of success. If success matters, those who find their way to the top of this list will outcompete those who do not.

The existence of intentionality makes plausible the argument that horizontally transferred elements of culture can be used to study cultural adaptation. Horizontal transmission or borrowing of cultural elements is often used as a stick with which to beat those who use cultural phylogenies to study the coevolution of cultural elements. But intentionality makes it plausible to apply the research gambit mentioned at the outset: the belief that horizontally transmitted elements of culture are adopted because they serve some function. This gambit will not always pay off, such as when the element of culture has been forced upon a society, but without intentionality the gambit would be fanciful.

Human cultures seem to divide up the world as if they were so many biological species (Pagel & Mace 2004). There is every reason to believe that studying variation among these cultural groups from an adaptationist perspective will yield the same sorts of insights as it has for nonhuman organisms.

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