empirical investigations into cultural dynamics that deviate from the biological case are necessary (Richerson & Boyd 2005). As noted above, cultural phenomena such as social constructions have yet to be dealt with in evolutionary terms. At the same time, however, these deviations do not invalidate an evolutionary framework. For example, subtle refinements of traditional biological methods have been found to enhance the validity of the mathematical modelling tradition described in section 3.1.2.

Furthermore, despite the impression perhaps given in this target article, we should also bear in mind that evolutionary biology is, like any other science, far from perfect and is continually changing and updating its methods. Indeed, evolutionary biologists may well benefit from considering evolutionary systems alternative to their own, or from utilising methods developed by social scientists.

In short, we submit that the argument that culture exhibits a number of key Darwinian properties is well supported and we advocate taking advantage of this in order to use evolutionary biology as a model for integrating a multitude of separate approaches within the social sciences and, where appropriate, borrowing some of the methods developed by evolutionary biologists to solve similar problems. Putting disparate studies from presently unconnected disciplines together into a broad evolutionary context adds value to each of the individual studies because it illustrates that the degree of progress in this area is far more impressive than hitherto conceived. We suggest that these studies can now be said to be aligned within a unified "movement" and that if this Darwinian evolutionary movement could be better coordinated, a more persuasive and important direction could be given to much work in the social sciences.

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Open Peer Commentary

Culture evolves only if there is cultural inheritance

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Abstract: Mesoudi et al. argue that the current inability to identify the means by which cultural traits are acquired does not debilitate their project to draw clear parallels between cultural and biological evolution. However, I suggest that cultural phenomena may be accounted for by biological processes, unless we can identify a cultural "genotype" that carries information from person to person independently of genes.

In their Introduction, Mesoudi et al. argue that culture is socially acquired information, and that cultural evolution is the selective retention of favourable cultural variants (plus drift). They also argue that cultural phenomena exhibit the necessary characteristics of an evolutionary process: variation, selection, and inheritance. Here, I would like to suggest that the cultural evolutionary literature has not yet determined whether the inheritance relation holds for cultural traits.

The authors argue that cultural evolutionary studies are currently in the state that characterized evolutionary biology prior to identification of genes as the unit of inheritance – we merely lack our Watson and Crick to identify the "memes" of culture. However, this historical analogy is a false one, because culture need not be independent of biology – indeed, genetic evolution may be able to account for the phenomena we consider to be cultural. The lack of knowledge about inheritance relationships was not such a problem for evolutionary biology because it was obvious that some sort of transmission process was necessary to account for the intergenerational similarity of phenotypes, with variation, observed in populations of organisms. However, it is possible for genetic or environmental processes to account for what many consider to be cultural behaviour, making cultural explanation superfluous (Aunger 2002). Richerson and Boyd (2005) argue, on the contrary, that there are many cases where the only explanation for group-specific behaviours is cultural transmission, because no environmental variable correlates with the distribution of such behaviours spatially, making an environmentally determinist explanation impossible. Such a case, they believe, implies the existence of cultural genotypes being passed from person to person through a social learning process which operates independently of physical environments.

However, evolutionary psychologists counter with the "jukebox model" – the idea that evolution may have stored sophisticated behavioural repertoires in our brains through prior natural selection which are triggered by environmental cues, much as a jukebox plays a particular record when a specific button is pushed (Tooby & Cosmides 1992). In the case of jukebox-like causation, the cues could be social, and as complex as the observation that most people in the local area are exhibiting a particular behaviour. The consequence is thus a change of behaviour by the observer of conspecifics – but the cause of the behaviour itself is not acquired as a result of observing the conspecific, only the choice of the behaviour. What has occurred is simply the operation of a bias rule: "when in Rome . . ." Such rules, coupled with the retrieval of pre-existing behavioural knowledge from a mental storehouse, could account for the apparent group-specific and frequency-dependent nature of many cultural traits. Both the cultural transmissionist and jukebox accounts involve a form of social learning; however, the resulting evolutionary dynamics are quite different, because the jukebox model suggests that new behaviours are acquired only through individual learning and genetic assimilation, whereas the cultural transmissionist account can rapidly produce novel behaviours through a Lamarckian process of knowledge exchanged through imitation.

Neuroscientific advances concerning how brains acquire and store information can help us understand how individuals learn from their surroundings. However, even a precise understanding at a molecular level of how the brain stores information does not answer the central cultural evolutionary question: whether information is replicated through transmission between individuals. We need to establish that, in the process of communication, one brain produces speech (for example), and that this speech transforms the hearer's brain. But we also need to know that the communication introduces new information to the hearer's brain which resembles the information in the speaker's brain that caused the speech in the first place. That would be a true relationship of inheritance and would constitute a process of information acquisition from others through a mechanism other than gene replication (Aunger 2002). Hence, models of

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social learning must be matched to models of memory before we can determine whether units of cultural inheritance (cultural genotypes) exist.

A related argument often used to justify the assumption that there must be cultural transmission is the fact that human culture is cumulative: For each generation, there seems to be a larger store of knowledge which cannot have arisen through genetic causes; culture changes too fast to be genetic, in effect (Tomasello et al. 1993). However, it is possible that this accumulation is occurring not in people's brains but in the technological world we have created. Niche construction can result in the inheritance of information through the persistence of information-bearing artefacts from generation to generation (Odling-Smee et al. 2003). The interaction of social learning with artefacts makes humans such a powerful force for environmental change (Aunger 2002; Donald 1991). Again, the exact nature of the exchange of information between people and their technological products is not clear. It is possible that much of the "knowledge" associated with technological practices is embodied in "cognitive artefacts" themselves (Hutchins 1995), which "afford" humans the perception of increased intrinsic power (Norman 1988).

There are obvious examples of Darwinian processes involving information replication – and hence inheritance – through processes not involving genes. In one case, units of computer code – call them "instructions" – exist as states of computer memory (the instruction's genotype), but also have consequences that lead to the production of exact replicas in other machines through infection – epidemics of computer viruses, in effect. Similarly, prions are infectious proteins which can cause other proteins to acquire their information by reshaping them; the prion's genotype is an abnormal shape that can be duplicated through a process of refolding of another protein via contact with an existing prion molecule (Prusiner 1995). In both cases, non-genetic information is duplicated and spreads through a population of hosts (computer memory and protein molecules, respectively).

In some ways, it is thus clearer that evolutionary processes are occurring in the environment than in social groups of human beings. This is because it is still not known whether culture as normally considered – as a pool of information in people's heads modified via the inter-individual transmission of information – involves the transfer from person to person of a cultural genotype. As a result, it is still unclear whether culture evolves independently of DNA. We therefore need to identify a cultural inheritance process – and thereby exclude the possibilities of jukebox-like recall or niche construction as accounts of how individuals come to exhibit similar "cultural" behaviours – before the analogy the authors make between genetic and cultural evolution will be secure. How this project will be undertaken is not clear.

Vertical/compatible integration versus analogizing with biology

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Abstract: Vertical/compatible theoretical integration provides an alternative way of unifying sociocultural anthropology and related disciplines. It involves analyzing theoretical statements for their implicit and explicit assumptions at multiple levels of analysis and then determining whether these assumptions are compatible with consensus in the relevant disciplines (e.g., does the sociological theory include an assumption at odds with consensus psychology?). Incompatibilities indicate a need for further research. This approach is much more likely to salvage the bulk of humanities-oriented anthropology than is that of the authors.

Mesoudi et al. are to be congratulated for their survey of biology, and I agree with much of what they say. For example, sociocultural anthropology clearly has not progressed in the cumulative fashion of evolutionary biology. (Goody [1982, p. 8] is probably right in arguing that the former field tends to mistake mere changes in emphasis for progress.) I also agree with the authors' implicit position that training in biology (and psychology!) should be a prerequisite for training in anthropology. But here our reasons differ.

Biology may owe its integration to Darwin, but not necessarily its success. I have met biologists who know little of Darwin, whereas that branch of biology known as medicine achieved much even in its pre-Darwinian, pre-Ewald, and pre-Nesse and Williams days (Ewald 1994; Nesse & Williams 1994). No doubt the social sciences would benefit if more of its practitioners were trained in some area of biology. I suspect, however, that had the authors' expertise combined meteorology and anthropology, they would have made a similarly convincing case for the former field's probabilistic models promise of unity for the human sciences.

The authors' proposal neglects most of sociocultural anthropology and related fields. What they include is worthy, but they pay scant attention to the likelihood that very few of the field's practitioners are interested in modeling their endeavor on *any* science, whether biology or meteorology. Perhaps this is why we are reading this article where we are reading it, and not in *Current Anthropology*. Most of sociocultural anthropology has, in the past 25 to 30 years, joined the humanities. When social scientists speak of "theory" nowadays, they usually mean social philosophy and political commentary, and the research they conduct only occasionally involves hypothesis testing. This is not the place to discuss why this is true, but a glance at the table of contents of any issue of the *American Anthropologist* will confirm that it is indeed so. My point, however, is neither to condemn nor to lament this state of affairs but to recommend salvage.

Rather than seeking to rebuild the social sciences (largely) from those bits and pieces that have analogues in biology, an alternative both more modest and more feasible exists: the approach of vertical/compatible explanation (Barkow 1989a; 1989b; 2006; Cosmides et al. 1992; Walsh 1997). Not just biology but the sciences as a whole have been so successful in part because they take vertical integration for granted. This means, for example, that a chemist does not seek to reduce chemistry to physics but does assume that the principles of physics apply to every chemical process. Biologists do not reduce evolution to nothing but chemistry but do assume that biological processes are compatible with what we understand of chemistry. Scientific psychologists take care to ensure that their theories are compatible with biology (including evolutionary biology), as well as with chemistry and physics. And so forth. If we are to apply this idea to sociocultural anthropology and the rest of the human sciences, then their theories must be tested for compatibility with psychology (and biology, etc.). This is not a reductionistic argument, and "compatible" does not imply "nothing but" – each level has its own theories, and no one would think to reduce ecology to chemistry or the social sciences to psychology. The approach is not necessarily even entirely hierarchical – theories of consciousness need to be compatible with what we know of neurophysiology but they may or may not be at the same level of organization.

Vertical/compatible integration is usually ignored in the human sciences as a matter of ideology (confusingly labelled "theory"). Most of sociocultural anthropology and sociology interprets Emile Durkheim as having established the principle that one must ignore the psychological. In practice, a non-psychological (often anti-psychological) approach is a group-identity marker and hence never questioned (see Barkow 1989b for discussion and exceptions). But vertical/compatible integration can, unlike the admittedly useful analogize-with-biology approach argued by the authors, rescue (in the

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