Darwinism and Historical Archaeology

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Introduction

In its classic formulation, Darwinism is a theory about why certain organisms do better in particular environments than do other organisms and hence over time leave more descendants. The theory says nothing about the archaeological record. Thus, archaeologists interested in applying a Darwinian perspective to the study of the material record have had to spend considerable time in constructing logical theoretical and methodological arguments as to how this can be accomplished in a nonreductionistic manner (e.g., Hurt and Rakita, 2001; Lipo et al., 2006a; Lyman and O'Brien, 1998; O'Brien, 1996a; O'Brien and Lyman, 2000, 2002a, 2003a, 2003b; O'Brien et al., 1998). Here, we hope to demonstrate that because of the wealth of information they often have at their disposal—artifacts, architecture, and documents—historical archaeologists have an opportunity not only to employ Darwinism at a scale rarely encountered when dealing with materials in the prehistoric record, but also to make solid theoretical and methodological contributions to evolutionary archaeology.

We begin by briefly examining the basic tenets of evolutionary archaeology, paying particular attention to how Darwinian evolutionism in general differs from other theoretical perspectives on the natural world. Several issues are important here, especially the nature of properties and units. How one views the former dictates how one categorizes objects and events in the natural world; one's views on the latter dictate how change is measured. As we show, one method that holds considerable promise for measuring change is seriation, which has roots deep in Americanist archaeology. We then turn to the most critical issue raised in this chapter: Can we use the archaeological record to study evolution or are we restricted simply to studying change? We argue for the former and show why we believe this to be the case. We conclude with a broadened perspective of some of the differences between evolutionism and other paradigms that currently exist in archaeology.

We find it impossible to do justice to the subject of evolution without bringing in at least a brief mention of biology and paleobiology, for it was in the marriage between these two disciplines that modern Darwinian evolutionism was founded and where conceptual and methodological issues have been hashed out. However, we attempt to keep these forays into the nonarchaeological literature to a minimum so as not to obscure the point that Darwinian evolutionism is the study of descent with modification. Everything else is largely superfluous to that simple point. Descent implies *continuous* heritability. Linking change to heritable continuity and figuring out how and why change took place is the cornerstone of Darwinian evolutionism, regardless of the organisms involved.

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What Is Evolutionary Archaeology?

Darwinism, regardless of the discipline in which it is being applied, involves three steps: (1) identifying and measuring variation—that is, dividing variation

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into discrete sets of empirical units, or groups, using ideational units, or classes; (2) tracking those units through time and across space to produce a historical narrative about lineages of particular variants; and (3) explaining the differential persistence of variants and lineages in particular time–space contexts. Actually, the second step entails two substeps. What we might refer to as 2a involves creation of historical sequences—placing units in their proper time–space positions; 2b involves testing the historical sequences to see if they exhibit heritable continuity. Placing units in their correct historical sequence is important, but that in no way assures us that we are dealing with a hereditarily based sequence. Heredity is the basis of evolution, which is "any net directional change or any cumulative change in the characteristics of organisms or populations over many generations—in other words, descent with modification. It explicitly includes the origin as well as the spread of alleles, variants, trait values, or character states. Evolution may occur as a result of natural selection, genetic drift, or both" (Endler, 1986:5).

Evolutionary studies encompass "description[s] of the historical patterns of differential trait representation and arguments as to how evolutionary [processes] acted to create those patterns" (Jones et al., 1995:29). Both steps employ concepts embedded within evolutionary theory, such as *lineage*, or a line of development owing its existence to heritability; *natural selection*, which is a mechanism of change; a *transmission mechanism*, which ensures heritability and itself is a source of new variants (e.g., Eerkens, 2000); *invention/innovation*, another source of new variants; and *heritability*, which denotes continuity such that similarity is homologous. The last ensures that we are examining change within a lineage rather than merely convergence, in which case similarity is of the analogous sort. We return to the important issue of homology/analogy below.

Evolutionists study populations of things, and in archaeology the population comprises artifacts. It is "the differential representation of variation at all scales among artifacts for which [evolutionary archaeology] seeks explanations" (Jones et al., 1995:28). One might legitimately ask why analytical emphasis is placed on artifacts, when it is the makers of the artifacts who are evolving. The answer is simple. Evolutionary archaeology rests on the premise that objects in the archaeological record, because they were parts of past phenotypes, were shaped by the same evolutionary processes as were the somatic (bodily) features of their makers and users (Dunnell, 1989; O'Brien and Holland, 1995a). This is a shorthand way of saying that the *possessors* of the objects were acted on by evolutionary processes. That artifacts are phenotypic is nonproblematic to most biologists, who routinely view such things as a bird's nest, a beaver's dam, or a chimpanzee's twig tools as phenotypic traits, and it certainly is not problematic to paleobiologists, who have to rely on the hard parts of phenotypes (e.g., shells) to study the evolution of extinct organisms and the lineages of which they were a part. Archaeologists do the same thing, whether they are studying pottery, stone tools, or log houses. Historical archaeologists have even more access to past phenotypic variation because they often have at their disposal documentary information, which gives them an unparalleled means of testing for heritable continuity in the sequences of artifacts they construct.

Evolutionary archaeology treats time as a continuous rather than a discontinuous variable, although this in no way suggests that time cannot be sliced into manageable units for some kinds of analysis (O'Brien and Lyman, 1999). The important thing to keep in mind is that although time can be divided into units, there is nothing real about them. For example, we often distinguish between the prehistoric and historical periods, but there is nothing real about either unit. Rather, we have found a convenient juncture at which to slice time; the designations are simply bookkeeping devices. If the units *were* real, we would not argue about where to make the break. For example, in the United States, do we mark it with the arrival of the first Spaniards in the sixteenth century, or do we push it back to the arrival of Columbus in the western hemisphere? Is it legitimate to have a sliding scale depending on where one is in the world? The answer is, it really does not matter where we make the slice; time continues to flow regardless of how we subdivide it. What we are really interested in is using time to mark change along a continuum.

From an evolutionary perspective, change is "in terms of frequency changes in analytically discrete variants rather than the transformation of a variant" into another variant (Teltser, 1995:53). This perspective on change runs counter to the way change normally is viewed archaeologically—as a gradual or sudden transformation of a variant from one state to another. The distinction between change—the *replacement* of one variant by another—and transformation is difficult to overemphasize, stemming as it does from the deepest dichotomy in the natural sciences—the manner in which reality is viewed. There are two basic ways in which the natural world can be viewed. Failure to appreciate the distinction led archaeologists in the 1970s to follow a model of science based on the search for unvarying laws of nature (O'Brien, 1996b). Such laws exist, but they do not allow us to understand or predict evolutionary change (Wolverton and Lyman, 2000).

Darwinism is a *materialist* strategy for understanding change and it contrasts with an *essentialist* strategy. For our immediate interests, the most significant difference between the two is in how each views units (Lyman and O'Brien, 2002; O'Brien and Lyman, 2002b). Materialism—an unfortunate label to have to use here because of the existence in anthropology and archaeology of another "materialism" (e.g., Harris, 1979)—places no stock in real "kinds" of analytical units. We might create units—species, pottery types, and so on—in order to get analytical work done, but in materialism there is no natural "essence" that something exhibits and which forces us to put it in one unit versus another. Things often share properties in common, and if those properties are of analytical interest, then the empirical specimens are grouped together, but this is decidedly different than searching for natural groupings based on the presence of inherent, essential properties. Essentialism, however, *does* view reality this way—that is, the world is full of natural kinds, each of which has an essence (hence the name). Essential properties define an ideal, or archetype, to which objects are imperfect approximations—a view that renders nonessential variation between specimens as simply "annoying distraction" (Lewontin, 1974:5). Specimens grouped within natural kinds by definition always share essential properties regardless of where they are in space and time. Prediction is possible because the kinds are real and thus are always and everywhere of the same sort; they will therefore always interact in the same manner and the same result will be produced by their interaction. Thus, laws in a philosophical sense can be written (Simpson, 1963, 1970).

Ahistorical sciences, such as chemistry, employ an essentialist metaphysic; what they are measuring is *difference* among units as opposed to *change*, which is the replacement of one unit by another. Because only difference is capable of being measured, essentialism often is referred to as *typological thinking* (Mayr, 1959)—an apt description given that types are viewed as real. Biologist Ernst Mayr (1959:2) notes that because "there is no gradation between types, gradual evolution is basically a logical impossibility for the typologist. Evolution [change], if it occurs at all, has to proceed in steps or jumps." How could change be anything *but* transformational? If things have essences, the only way they could evolve is by dropping one essence and adopting another.

Materialism, however, holds that certain phenomena cannot exist as bounded, discrete entities because they are always in the process of becoming something else. With specific reference to organisms, Mayr (1959:2) points out that "All [things] are composed of unique features and can be described collectively only in statistical terms. Individuals . . . form populations of which we can determine an arithmetic mean and the statistics of variation. Averages are merely statistical abstractions, only the individuals of which the populations are composed have reality." As a direct result of its materialist metaphysic, a historical science can monitor *change* in phenomena: "For the [essentialist-thinking] typologist, the type is real and the variation an illusion, while for the [materialist-thinking] populationist the type (average) is an abstraction and only the variation is real" (Mayr, 1959:2). It is this variation between and among specimens that "is the cornerstone of [evolutionary] theory" (Lewontin, 1974:5). Note that the materialist perspective does not view *all* phenomena as constantly changing units. Biologists, for example, view organisms and their phenotypic features this way, but they readily admit that molecules, atoms, and subatomic particles fall on the essentialist side of the house.

Immanent and Configurational Properties

One criticism of evolutionary archaeology (e.g., Schiffer, 1996) has been its perceived failure to acknowledge the role analogy plays in science. Science, of whatever kind, is based on analogy, but there are different kinds of analogy. Evolutionary archaeologists have never denied the importance of analogy in science generally, nor in evolutionism specifically, but they *have* consistently maintained that each kind of analogy has its distinct role in scientific investigation (e.g., O'Brien et al., 1998). The differences among kinds of analogy often are subtle—a point made not only in the archaeological literature (e.g., Simms, 1992; Stahl, 1993) but also in the geological (e.g., Shea, 1982) and paleobiological (e.g., Gould, 1965) literature. We find paleobiologist George Gaylord Simpson's (1963, 1970) discussions helpful in this respect because he described, using different terms, the kinds of linkages between analogical reasoning and essentialism, as well as those between such reasoning and materialism:

> The unchanging properties of matter and energy [chemistry, mechanics, physics] and the likewise unchanging processes and principles arising therefrom are *immanent* in the material universe. They are nonhistorical, even though they occur and act in the course of history. The actual state of the universe or of any part of it at a given time, its configuration, is not immanent and is constantly changing. It is *contingent* . . . or *configurational*. . . . History may be defined as configurational change through time (Simpson, 1963:24–25).

Simpson's immanent properties and processes comprise, in our terms, essentialism; his configurational properties are historically contingent and comprise materialism. The dictum that "the present is the key to the past" holds only with respect to essentialist, or immanent, properties and processes: "What we know (or theorize) about the immanent characteristics of the universe is derived from observation of the present" (Simpson, 1970:81). Were it not for this simple fact, retrodiction and prediction would be impossible.

Immanent properties and processes allow us to make mechanical inferences (Wolverton and Lyman, 2000). The half life of ^{14}C is an immanent property that allows us to calculate radiocarbon dates; the validity of the radiocarbon-dating method hinges on analogical reasoning that the half life of ^{14}C is the same regardless of place or time. Similarly, processes that result in biological evolution—genetic transmission, mutation, drift, differential reproduction and survival, and selection—involve immanent properties and processes. When we duplicate the manufacture of a particular kind of early nineteenth-century pottery and then subject it to strength tests and the like to understand why a particular clay body was selected, we are using analogical reasoning based on immanent properties. This is why we have consistently applauded the technological work of people such as Michael Schiffer and his colleagues (e.g., Schiffer, 2004, 2005; Schiffer and Skibo, 1987, 1997; Schiffer et al., 1994; Skibo et al., 1989; Vaz Pinto et al., 1987), who, although they would describe themselves as behavioral archaeologists as opposed to evolutionary archaeologists, have made significant strides in understanding the nature of immanent properties of artifacts.

The history of an evolutionary lineage is, however, configurational. Every fossil has "its particular as well as its general configurational properties, its significant balance of difference and resemblance [to other fossils], not only because of immanent properties of its constituents and immanent processes that had acted on it, but also because of its history, the configurational sequence by which these individual things arose" (Simpson, 1963:27). Thus, "[h]istorical events, whether in the history of the earth, the history of life, or recorded human history, are determined by immanent characteristics of the universe [the source of laws] acting on and within particular configurations, and never by either the immanent or the configurational alone" (Simpson, 1963:29). It is the task of the evolutionist—whether studying fossils, fruit flies, or sherds from a nineteenth-century farmstead in New England—to keep immanent and configurational characteristics separate. We are *not* saying that evolutionists should ignore immanent properties; in fact, we argue just the opposite (O'Brien and Holland, 1990, 1995a; O'Brien et al., 1994; Wolverton and Lyman, 2000). Analogy, however, is useful only when immanent properties are involved.

It has been asserted (Boone and Smith, 1998:S154) that what we are advocating amounts to radical empiricism, which, if applied to evolutionary paleontology, would strip it "to its (fossilized) bones." We assume this means that paleobiologists can discuss only the morphometry of the fossils they find rather than various details of the physiology and behavior of the organisms represented by those fossils. Granting the distinction between immanence and configuration, such an argument is not credible (Lyman and O'Brien, 1998). Bone as a tissue *must* have particular immanent (essentialist) properties and respond to stimuli in particular ways to be an efficient superstructure for the organism it supports; otherwise, the lineage ends. Functional anatomy tells us about physiology and behavior precisely because of those properties. Immanent properties of teeth will inform us as to whether those teeth belonged to a carnivore or herbivore. But whether a bone is from a monogamous or polygynous organism is a different question entirely—one that concerns configurational (historically contingent) properties and processes. We might be able to address this question through careful reference to historical context, but no matter how hard we examine that context, we might not be able to answer the question. Here again, historical archaeologists have a leg up on other investigators because of their access to historical context through documentary sources.

Kinds of Units

If, as materialism holds, only variation is real, how do we study it? The answer is, by constructing a set of units that allows properties, or attributes, of phenomena to be measured. Given that we can adequately control time, we can then stack those units—each of which is an encapsulation of what happened at a particular moment in time—and examine change among them. But we have to know exactly what it is we are measuring. Here we use the term *measurement* to denote the assignment of a symbol—letter, number, word—to an observation made on a phenomenon according to a set of rules. It is these rules, sometimes referred to as *systematics*, that in our minds set evolutionary archaeology apart from other approaches that deal with change in the material record. Evolutionism demands systematics that not only can track variation and do it in unvarying fashion time after time but can also be adapted for use at different scales. Most important, the measurement units used are selected to solve a particular problem (Lyman and O'Brien, 2002).

Archaeology has a long history of unit construction (O'Brien and Lyman, 2002b; Ramenofsky and Steffen, 1998), though it is clear that many of the units routinely employed—type, group, class, tradition, period, phase, and so on—are rarely defined explicitly. Most archaeologists have an intuitive feel for what certain units represent and thus bypass clear exposition of how they employ the units and what the units are signifying. This strategy cannot be applied in a situation where change as opposed to transformation is the subject of investigation. Depending on the scale at which we are operating, that change may be difficult or relatively easy to measure. Regardless, change must be measured as alterations in the frequencies of analytical (not real) kinds, or what we have termed *ideational* units (Dunnell, 1986; Lyman et al., 1997; O'Brien and Lyman, 2000).

Our preferred system of unit construction is paradigmatic classification (Dunnell, 1971; Lyman and O'Brien, 2002; O'Brien and Lyman, 2000, 2003a) because we believe it offers the only systematic means of tracking variation at various scales. In paradigmatic classification, the analyst selects dimensions—variables—relevant to some problem—for example, color and kind of edge design on English-made pottery—and it is the attributes of those dimensions—for example, blue and green or raised and nonraised—that result in the sorting of specimens into internally homogeneous, externally heterogeneous piles. These definitional units are termed *classes*. Using our simple two-dimensional example above, four classes of pottery exist: blue/raised edge, green/raised edge, blue/nonraised edge, and green/nonraised edge. Specimens that share attributes (properties)—those that end up together in one of the analyst's piles—are grouped together because they hold in common some number of attributes *selected* by the analyst for use in a specific piece of work, not because of any essence that *makes* them similar. Importantly, there will be myriad features exhibited by the specimens that are not used in the classification because they are not of immediate analytical interest. The resulting analytical units are ideational, meaning that they are not real in the sense that they can be seen or picked up and held. The things in the units—for example, vessels with green, raised-edge decoration—*are* real, and we refer to them as empirical units.

These are significant differences between paradigmatic classification and other systems of categorization. Think of the tripartite subdivision of English-made pottery with which many historical archaeologists are familiar. At one level we would agree that when someone uses the terms *creamware, pearlware,* and *whiteware,* we have a pretty good idea of what he or she is talking about. Thus those terms serve a purpose, if none other than as shorthand encapsulations of information relative to such things as manufacture and time. But are they the kinds of units that are useful for tracking evolutionary change? They probably are not. All along the pottery-manufacturing continuum were thousands of changes in paste, glaze, firing temperature, and so on, and all we have done is select some convenient and rather visible points at which to make slices. Creamware, pearlware, and whiteware have often assumed a life of their own, or at least that is the way they are referred to in print. But they are *not* empirical units; rather, they are large, cumbersome ideational units used to slice up the pottery continuum. But they *are* ideational units. One might argue that pearlware is real[1] because Josiah Wedgwood set out in the 1770s deliberately to create a whiter-bodied pottery, but this misses the point. No one would suggest that behavior is not an important selective agent in nature, but behaviors, regardless of whether they are intentional, create *things*; they do not create *categories*. In other words, behaviors create pearlware bowls, not pearlware.

Pottery is not the only set of materials amenable to paradigmatic classification. Take, for instance, residential structures. The need to classify structures is not new in either historical archaeology or historical geography. Fred Kniffen (1965:550), for example, saw a need to construct a typology that would categorize the wide assortment of structural forms he observed throughout the eastern and southeastern United States: "To make the most of the opportunity it was deemed necessary to set up concurrently a typology quantified as to numerical importance and qualified as to areal and temporal positions, and to seek out origins, routes of diffusion, adaptations, and other processes affecting change or stability." These goals have a definite evolutionistic ring to them. Kniffen's goals were realized in a system used to classify early nineteenth-century residential structures in northeastern Missouri (O'Brien and Lewarch, 1984; O'Brien et al., 1980). We simplify the system, which originally used 31 dimensions, for use as an example here. Let us say we are interested in four dimensions of variation: (1) construction material, (2) number of stories, (3) number of rooms downstairs, and (4) roof type. Each dimension has a number of attributes attached to it, the actual number used being a product of the amount of variation we identify as analytically important:

Dimension 1: Construction Material
- Attribute states:
  1. Log
  2. Heavy timber
  3. Light timber

Dimension 2: Number of Stories
- Attribute states:
  1. One story
  2. Two stories
  3. Three stories

Dimension 3: Number of Rooms Downstairs
- Attribute states:
  1. One room
  2. Two rooms
  3. Three rooms

Dimension 4: Roof Type
- Attribute states:
  1. Gable
  2. Gable and cross gable

Based on this four-dimensional example, 54 classes are possible, each comprising four attributes. For example, there is a log, two-story house with two rooms downstairs and a gable roof (1221). Similarly, there is a log, one-story house with two rooms downstairs and a gable roof (1121). The advantage of paradigmatic classification is that it

[1] Interestingly, Wedgwood considered the addition of cobalt oxide to the glaze to be a *change in* rather than an *improvement over* what his firm had been producing (Finer and Savage, 1965:237). Towner (1957:3–4) downplays the significance of pearlware, noting that it should be classified simply as a creamware variant. The important point here is not the terminology but the recognition that there was no grand disjunction between creamware and pearlware. Rather, selection against a cream-colored body led to the evolution of vessels that were whiter in color. That evolutionary line continued back through creamware, which, as Towner (1957:1) points out, was itself the direct descendant of lead-glazed wares of the Middle Ages.

can be applied consistently. Each dimension can be analyzed separately or in concert with different combinations of other dimensions to determine the most analytically useful combination for any specific set of objects. Decisions about the relative importance of various attributes or dimensions can be based on inspection of the frequency of each attribute or various combinations of attributes rather than on preliminary inspection of the sample.

Paradigmatic classification tells us a lot more about variation, say, in early nineteenth-century structures than simply lumping them in descriptive types such as “log cabins,” “frame houses,” and the like—the point Kniffen (1965) was making when he called for a systematic procedure of categorization. Look at some of the variation noted in the sample of houses from northeastern Missouri. Figure 1 illustrates the facades and floor plans of classes of one-story, single-pen houses and story-and-a-half, single-pen houses; and Fig. 2 illustrates the facades and floor plans of classes of one-story, double-pen houses. One can immediately see that there is considerable variation among the classes—variation that is overlooked in most standard typologies of residential structures. Of course, classification in and of itself tells us nothing about why the variation exists in the first place, nor does it answer the question of why we chose to classify things one way as opposed to another. At a superficial level, we know why variation exists in house form: human intentionality and inventiveness. No one, certainly not an evolutionist, would disagree with this statement, but neither would he or she find it particularly enlightening. We *know* that residential structures are intentional products; they did not come into existence miraculously. But intent is a proximate cause of something, not the ultimate cause (Mayr, 1961), and we find it lacking as an adequate explanation for why lineages of artifacts, including houses, take the forms they do. Rather than

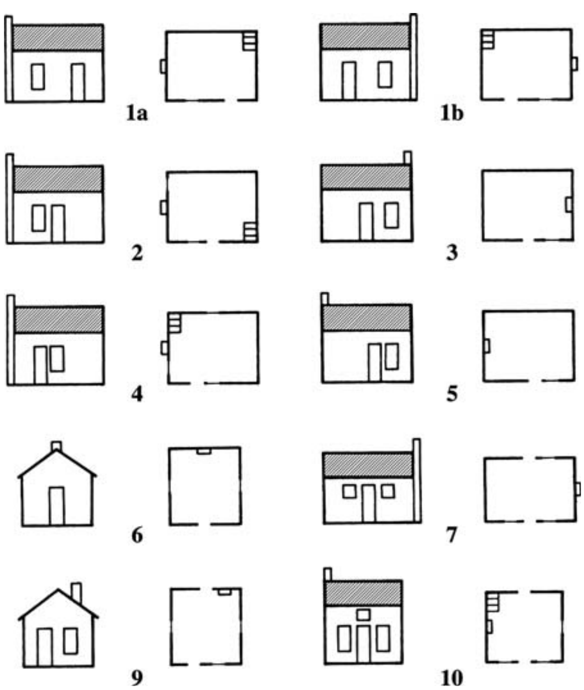

Fig. 1 Facades and floor plans of classes of one-story, single-pen houses and story-and-a half, single-pen houses created by paradigmatic classification of structures in the central Salt River valley of northeastern Missouri (after O’Brien et al., 1980; from O’Brien and Lyman, 2000:Fig. 1)

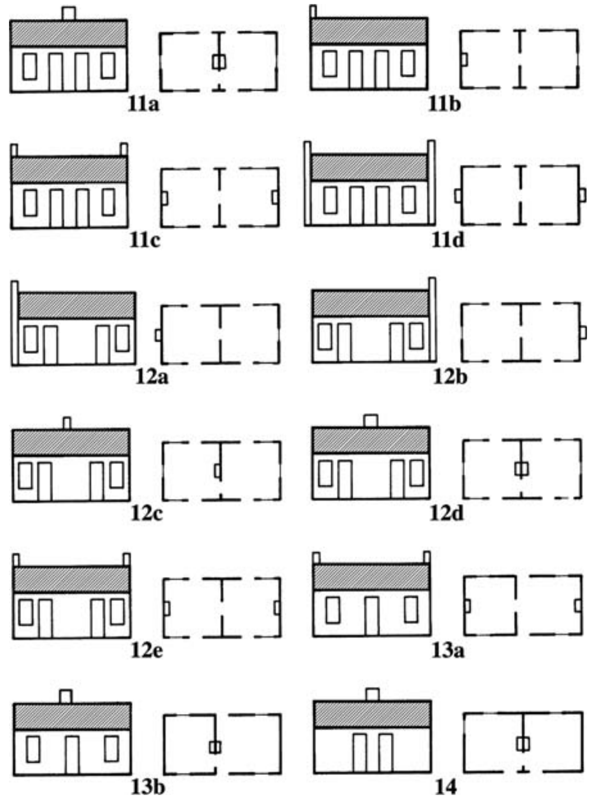

Fig. 2 Facades and floor plans of classes of one-story, double-pen houses created by paradigmatic classification of structures in the central Salt River valley of northeastern Missouri (after O’Brien et al., 1980; from O’Brien and Lyman, 2000:Fig. 2)

focusing on intent, which we find impossible to deal with archaeologically, we focus on mechanisms—such as selection and drift. The former works on features that are functional—selection affects the differential persistence of features that contribute to the fitness of organisms—whereas the latter, drift, affects the differential persistence of features that do not contribute to an organism's fitness. As we discuss a bit later, our paradigmatic classification of early nineteenth-century houses might provide the units necessary to study these evolutionary processes.

Change, Homology, and Lineages

If two things are similar but also somewhat different in form and also different in age, do they indicate that change has taken place? For example, if we chronologically align a sample of houses, does this ordering represent change? From a modern Darwinian viewpoint, change is represented *only* if two things are phylogenetically related, in which case the similarity of form and difference in age signifies inheritance and thus continuity—an ancestor-descendant lineage. If we cannot establish heritability—that two things are related by ancestry—we cannot be sure that we are not dealing simply with a historical relationship. That is, object B may follow object A in time, but such a historical relationship in no way ensures that there is a hereditarily based link between the two. It is establishing this link that is important in an evolutionistic study. How does one demonstrate a phyletic relation—that two phenomena are parts of a lineage? Paleobiologists accomplish this task by identifying homologous traits, or attributes, in the two phenomena (Lyman, 2001). If they share one or more such traits, they are by definition phyletically related. This oversimplifies matters in one important way: Not all homologous traits are used to construct hereditary relationships. Once analogous traits are separated from homologous traits—not always an easy exercise (see below)—homologous traits are subdivided into two kinds—shared ancestral (or primitive) traits and shared derived traits. It is only the latter that are used to build what are known as phylogenetic histories.

All mammals have a vertebral column, as do some animals placed in other categories, such as most fishes. The presence of vertebrae is one criterion we use to place organisms in the subphylum Vertebrata. The vertebral column is a homologous character shared by mammals and fishes, but it is a character that goes so far back in time as to be essentially meaningless in terms of helping us understand how the myriad backboned organisms of the last 400 million years are related phylogenetically. Thus, we use other characters—such as the presence or absence of hair or a four-chambered heart—to segregate mammals from other classes of organisms that have backbones. This segregation, or cut, takes us back to about 200 million years ago. Then we make another cut based on the presence/absence of other characters to subdivide the sample further, then another cut, and another, and so on. We use shared derived characters (termed *synapomorphies*) to do this; shared ancestral characters (*symplesiomorphies*) are not considered. The latter characters—such as the vertebral column—are indeed homologous, but they do not help in the construction of phylogenies precisely because they are shared by all members of all the groups of Vertebrata.

Identifying homologous traits in general is a significant analytical hurdle (e.g., Fisher, 1994; Smith, 1994; Szalay and Bock, 1991) because a trait that is shared by two phenomena may be analogous, meaning that it is the result of evolutionary convergence. Anthropologists have long been interested in the problem of separating analogs from homologs. A.L. Kroeber (1931:151) points out that the "fundamentally different evidential value of homologous and analogous similarities for determination of historical relationship, that is, genuine systematic or genetic relationship, has long been an axiom in biological science. The distinction has been much less clearly made in anthropology, and rarely explicitly, but holds with equal force." He went on to imply that a "true homology" denoted "genetic unity." In terms of how to separate homologs from analogs, Kroeber (1931:151) suggests that "where similarities are specific and structural and not merely superficial . . . has long been the accepted method in evolutionary and systematic biology." He was correct, for this was, and is, the reasoning used by biologists (e.g., Szalay and Bock, 1991). The wings of eagles and those of crows are structurally as well as superficially similar; this is homologous similarity. The wings of eagles and those of bats are superficially, but not structurally, similar; this is analogous similarity. Kroeber (1931:152–153) cautions, however, that:

> There are cases in which it is not a simple matter to decide whether the totality of traits points to a true [homologous] relationship or to secondary [analogous, functional] convergence. . . . Yet few biologists would doubt that sufficiently intensive analysis of structure will ultimately solve such problems of descent. . . . There seems no reason why on the whole the same cautious optimism should not prevail in the field of culture; why homologies should not be positively distinguishable from analogies when analysis of the whole of the phenomena in question has become truly intensive.

Despite his insights, Kroeber had a difficult time translating his proposal into practice, undoubtedly a result of perceived fundamental differences between biological and cultural evolution.

Evolutionary archaeologists have dedicated considerable energy to differentiating between homologous and analogous traits, usually referring to the former as stylistic traits and the latter as functional traits (e.g., Dunnell, 1978; Hurt and Rakita, 2001; Lyman, 2001; O'Brien and Holland, 1990, 1992; Teltser, 1995). Some archaeologists view the difference between the two kinds of traits as a continuum, but we view it as a dichotomy (O'Brien and Lyman, 2000). We expect stylistic traits to behave differently than functional ones, given that the latter are by definition those shaped by selection and as such directly affect the fitness of the populations in which they occur (Dunnell, 1978; O'Brien and Holland, 1992). Stylistic traits are not subject to selection and thus their distribution over time and space are different than the distribution of functional traits (Allen, 1996). In greatly simplified terms, we expect traits under selection to behave more or less as shown in Fig. 3: They begin life with a low relative frequency within a population, but at some point they come under selective control and increase dramatically in frequency until they become fixed within the population. Then at some point they decline rapidly in frequency as some similar but alternative feature is selected for.[2] In contrast, stylistic, or "neutral," features drift

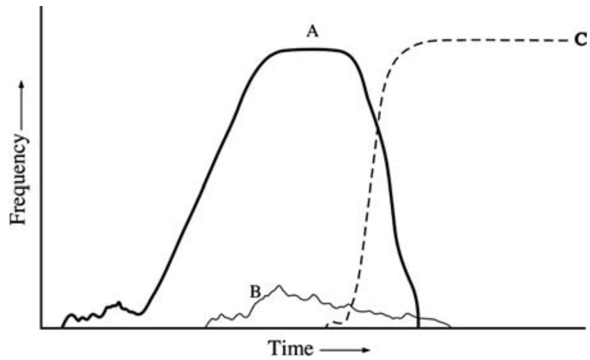

Fig. 3 Hypothetical changes in frequency of traits under selection versus traits under drift. Trait A appeared, then drifted along in the population and eventually came under selective control, leading to a rapid increase in expression. Eventually it became selected against and rapidly disappeared. Trait B never came under selective control but rather drifted through time, eventually disappearing. Trait C was also selected for, but much more quickly than was Trait A. Also, its rise to fixation within the population (the point at which the curve levels off) was more rapid than the rise of Trait A, signified by the steeper curve for Trait C (from O'Brien and Lyman, 2000:Fig. 3)

along, either increasing or decreasing in relative frequency stochastically.

We noted earlier that perhaps the units created from our paradigmatic classification of houses might give us some clues as to the role played by selection and drift on the evolutionary landscape of a portion of the midwestern United States during the early nineteenth century. House form is conditioned by a host of factors that operate at several levels of specificity, including style and function. Here, functional features refer to architectural attributes that aid, condition, or in some way relate to activities performed within or adjacent to a structure. Facade structure, especially the order of window and door placement, is usually considered part of architectural "style," but this is colloquial usage. The placement of windows and doors is probably functional. Entry placement conditions traffic flow, access, and ventilation, while window location and frequency affect available light, ventilation, and heat loss in the winter. Similarly, a second story might be considered casually as a stylistic feature, yet its construction is conditioned to some degree by economic factors, family size, control of technology, and possibly kinship ties. Numerous other features are likely also functional, including

[2] Although we use the term "selected for," no feature is really selected "for." Rather, one state of a feature is selected against, which causes an alternative state of that feature to rise in relatively frequency.

construction material and placement of chimneys. Certainly decisions about whether to place chimneys on the inside or outside of a house have to do with function. We might propose, for example, that interior chimneys, because of their ability to radiate more heat inward, would be found more frequently in northerly latitudes, whereas exterior chimneys, because of their ability to radiate more heat to the exterior, would be found more frequently in southerly latitudes.

As a first approximation, we might propose that such features as exterior trim, door moldings, and the like are nonfunctional, or stylistic, features. They play no part in the function of a house and hence have no affect on the direct fitness of the inhabitants. This seems like a reasonable proposition, but it might be wrong. What if certain features are important displays of wealth, or of apparent wealth (e.g., Neiman, 1999)? The fact that one does *not* exhibit those features certainly could affect one's fitness. So maybe the size and shape of seemingly insignificant things such as door moldings *are* functional. There is a subtle shift in scale here, and it is one that has only been alluded to by evolutionary archaeologists (e.g., O'Brien and Holland, 1990): The presence of a trait might be functional, but the states of the trait might be neutral. As long as the rooms in a house have large, ornate door moldings, it does not matter whether the molding is scalloped, double-ridged, or decorated in some other fashion. The only thing that is important from the standpoint of fitness is the presence (or absence) of ornate door moldings; there is a range of acceptable attribute states. Hence we say that the attribute states are neutral, meaning that selection does not work on them. Rather, it works at the level of the feature itself.

If we had a large enough sample of houses and had tight chronological control over them, we should be able to plot the distribution of features in a way similar to what is shown in Fig. 3 and figure out which ones were under selective control and which ones were not. In making inferences about function, it is likely that we will imply far more overt, conscious decisions about use of space and adaptation to the environment than were actually recognized by the builders, but this is irrelevant. Selection is blind to the source of variation presented to it.

If evolutionism focuses on change and heritability, then we want our sample to represent some kind of lineage. We would not, for example, want to throw in houses from unconnected time periods and geographic regions because we would have no control over how the empirical objects in the sample were related. We probably could never hope to distinguish between homologous and analogous features. In the case of the structures from northeastern Missouri used in the paradigmatic classification, there exists a battery of documentary evidence that allows us to examine relationships among families that built the structures. Most families came from the Bluegrass region of Kentucky and either were related by blood or marriage before they came or intermarried after arrival in Missouri. These interconnected units shared numerous similarities, including ownership of slaves and an agricultural base centered around tobacco and hemp—a socioeconomic pattern sometimes referred to as "Upper South" (Mitchell, 1972, 1978). We can label this pattern a "tradition" in the usual sense that it is used in archaeology. But what if we did not have such detailed documentary evidence? How could we get at homologous similarity and heritable continuity in the archaeological record? One way is through the use of seriation.

Seriation

Seriation has its conceptual roots in the comparative method of linguists working in the late eighteenth and early nineteenth centuries (Leaf, 1979:86–90), and was used for the first time in archaeology in the mid-nineteenth century (Evans, 1850). We distinguish among three techniques of seriation on the basis of the kinds of units they employ, how those units are used (Lyman et al., 1998), and the resulting manner in which time is measured (O'Brien and Lyman, 1999). The first is *phyletic seriation*, which had its proximal roots in the biological notion of anagenesis, or a single-line evolutionary sequence. Thus archaeologists who performed phyletic seriations (e.g., Kidder, 1917) spoke of one kind of artifact "developing" or "evolving" into another or "fathering" another and of kinds of artifacts going "extinct" (see more examples in Lipo et al., 2006b; Lyman and O'Brien, 2006). Phyletic seriation uses empirical units, or specimens, which are sorted to reflect a character gradient. If the character shifts states over time, the gradient so denoted comprises what is called a *chronocline*. The use of empirical units results in time being measured discontinuously because boundaries are drawn between chunks of the character gradient. Each chunk is viewed as a unit that occupies a particular and unique position in the temporo-spatial continuum. An example of a phyletic seriation built on changes in New England headstones is shown in Fig. 4.

What does such a diagram tell us? For one thing, it tells us that on the face of it there appears to be a progression from a fairly complex design to a simplified one. In this particular example, we have the very careful work of James Deetz and Edwin Dethlefsen (1965, 1971; Dethlefsen and Deetz, 1966) to assist us in constructing the phyletic sequence. We know the sequence is correct because the gravestones had dates on them, and in some cases Deetz and Dethlefsen had documentary information that allowed them to pinpoint not only who

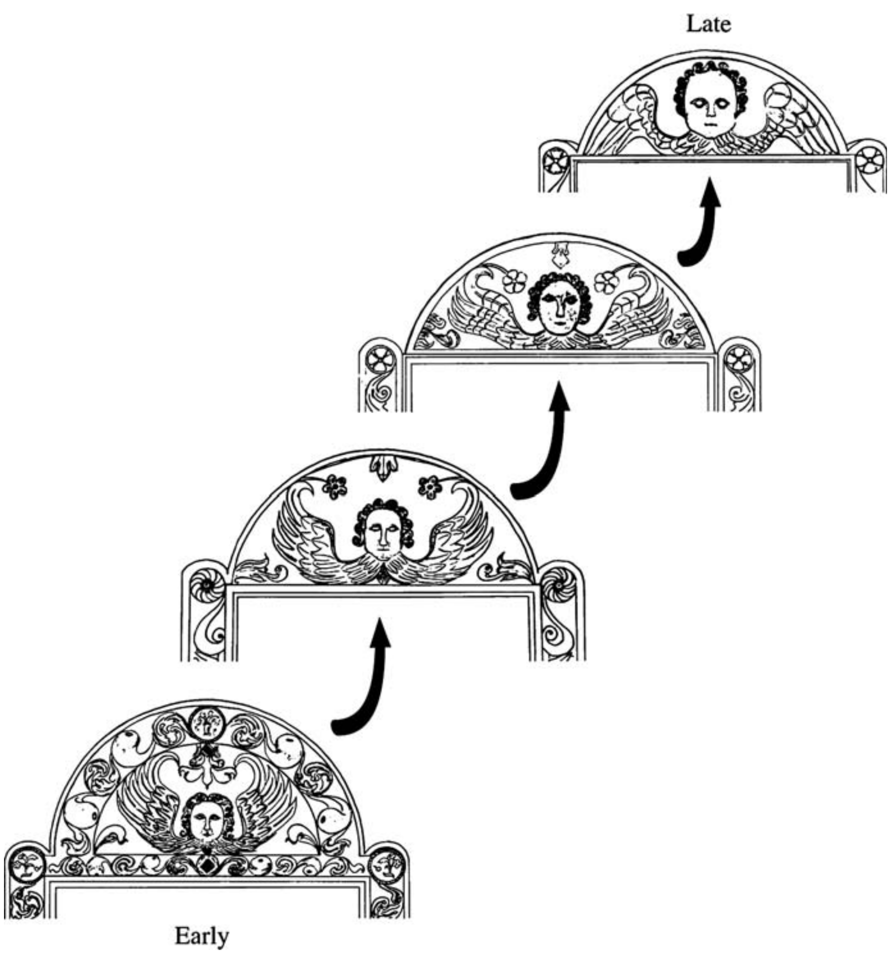

Fig. 4 A phyletic seriation of gravestones from a cemetery in Charlesdown, Massachusetts, showing reduction in cherub-head design complexity between 1720 and 1760. The actual sequence was based on headstones of known date, but it illustrates the technique of arranging groups of specimens based on a proposed evolutionary sequence, here a design sequence (after Dethlefsen and Deetz, 1966). The gravestones came from a single graveyard, thus meeting one of the criteria of the seriation model—that what is being measured is variation in time rather than variation in space. Deetz and Dethlefsen (1965) explore this important issue relative to New England headstones, pointing out the effect of distance on the appearance and disappearance of various headstone designs (from O'Brien and Lyman, 2000:Fig. 4)

carved a headstone but also when it was carved as opposed to when it was used, which could have been considerably after the stone was carved. But the point is that we could have constructed a sequence of headstones even had they not exhibited dates. We would base the sequence on suspected changes in what was being presented in terms of design and how the designs changed through time. A.V. Kidder (1917) did this with his prehistoric pottery from Pecos, New Mexico, and John Evans (1850) did it with British gold coins from pre-Roman Age and Roman Age Britain. Even if we got the sequence correct, all we would have is a historical sequence; there would be no assurance that the sequence exhibited heritable continuity. It *probably* does, but there is no guarantee that there are no gaps or discontinuities of greater or lesser magnitude in the sequence. This is so because the units arranged in a phyletic seriation are seldom defined explicitly in terms of the attributes of which they are composed and that might track heritable continuity. If such changes are not closely monitored via detailed classifications, then explanation of the perceived changes in terms of heritable continuity is difficult to warrant.

There are two other techniques for tracing heritable continuity. These are *occurrence seriation* and *frequency seriation*. Both occurrence seriation and frequency seriation are distinct from phyletic seriation because they measure similarity—and thus time—in a distinct way that reveals heritable continuity. Occurrence seriation and frequency seriation begin with theoretical units (TUs)—not empirical units (the actual objects)—each of which has a temporal distribution displayed by the empirical specimens it contains (Lyman and O'Brien, 2000, 2005, 2006). Each TU is explicitly defined at the start of analysis, and then specimens in collections are identified as a member of one TU or another based on the definitive attributes of the TUs. The definitive attributes are not extracted from the specimens on the basis of observation, but rather are imposed on the specimens in order to sort the specimens into groups, with the members of each group displaying the particular combination of definitive attributes of only one TU. The TUs are tightly defined beforehand so as to preclude confusion over categorization of a specimen. Units constructed in such a manner are referred to as *historical types* (Rouse, 1939). The trial-and-error process of constructing historical (temporal) TUs (types) in archaeology is rarely explicit (see Lyman and Harpole [2002] for review of a rare early example). Early on, archaeologists learned rather quickly that decorative attributes, such as the designs painted on pottery, worked well for constructing temporal types, but why those sorts of attributes rather than others should prove useful was not understood (Lyman et al., 1997; Neiman, 1995; Teltser, 1995).

Both occurrence seriation and frequency seriation measure the similarity of collections of artifacts on the basis of shared TUs; these are referred to as "overlapping" types (e.g., Ford, 1938; Kidder, 1924; see O'Brien and Lyman, 1998). Types that overlap are, theoretically, shared as a result of heritable continuity between collections. Occurrence seriation assumes that a historical TU will have a single, continuous distribution over time. After specimens have been identified as members of particular TUs, occurrence seriation is used to order collections such that each TU displays this continuous distribution. Units might or might not be precisely contemporaneous with one another; ideally, they will not be, which is to say that each TU will display a more or less unique temporal distribution, yet each will overlap at least partially with at least one other TU (Fig. 5). Thus the more TUs shared by two collections, the less chance there will be that multiple collections will share a particular subset of TUs and thereby occupy the same position in the ordering. Figure 5 shows an unordered set of collections at the top and an ordered set at the bottom. In this example, the set shown at the bottom is in fact the only solution to the ordering; only that ordering meets the criterion that TUs have a single, continuous distribution over time.

Frequency seriation also assumes that a historical TU will have a single, continuous distribution over time, but it assumes further that the relative frequencies of specimens within each TU will fluctuate unimodally over time. Frequency seriation involves (a) identifying each specimen as belonging to a particular TU, (b) calculating the relative frequency of each TU within each collection, and then (c) ordering collections until each TU displays a continuous, unimodal frequency distribution like that shown in Fig. 6. Here we use the same TUs as

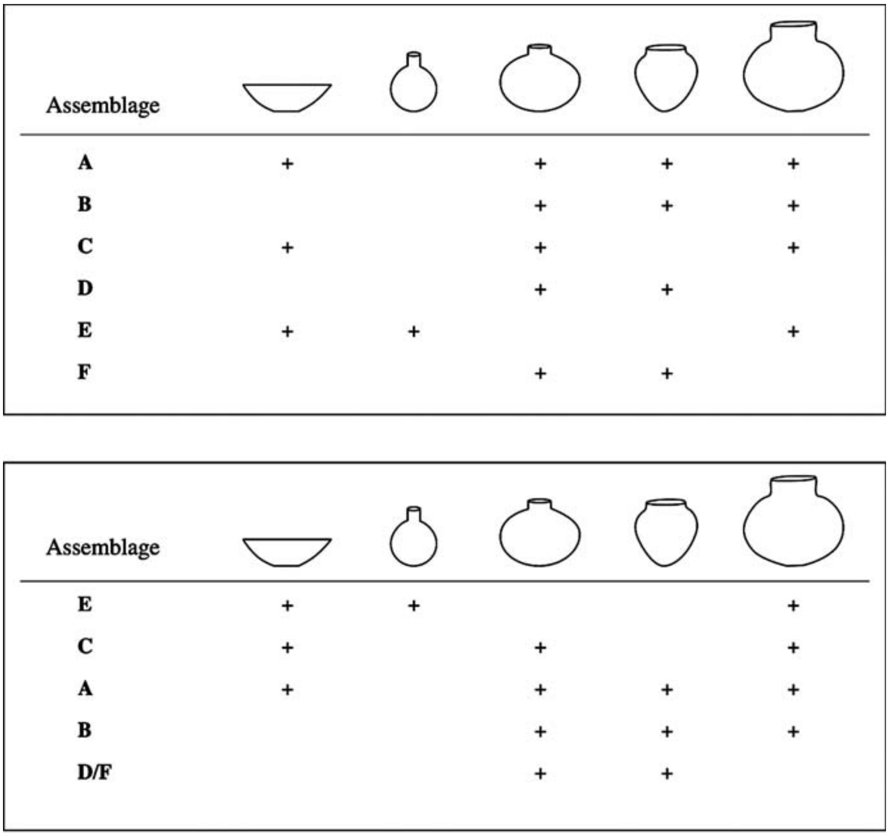

Fig. 5 An occurrence seriation of six collections using five artifact types. The upper portion of the figure shows the unordered collections. The procedure is to sort the collections (*rows*) such that each artifact type (each *column*) displays a continuous occurrence, signified by the "+" sign. The order resulting from meeting the expectations of the seriation model is given in the lower portion of the figure. Note that it makes no difference if the ordering from top to bottom is "E, C, A, B, D/F" or "D/F, B, A, C, E," because the direction of time's arrow is unknown. That knowledge must come from other data independent of the seriation, such as knowing that Types 1 and 2 occur late in time and Types 3 and 4 occur early in time, based on associated radiocarbon dates, stratigraphic excavation, or documentary evidence. Note also that Collections D and F are identical in terms of the types they contain. They cannot be sorted and in this example must be considered contemporaneous (from O'Brien and Lyman, 2000:Fig. 5)

in Fig. 5, but instead of plotting presence/absence we plot the relative frequencies of TUs in each collection (represented by the bars). Note that although we do not have complete histories for all TUs (which in this example are vessel forms), meaning that some of the series are missing bottoms or tops, they all display continuous, unimodal frequency distributions. Note also that frequency seriation allows us to separate collections D and F, which we could not do using occurrence seriation.

Another example of frequency seriation, one that will be familiar to historical archaeologists, is shown in Fig. 7, which plots J.C. Harrington's (1954) data on pipe-stem diameter. Harrington was looking for a means of dating pipes found on historical-period sites, and he found one in the diameter of the stem bore, which consistently narrowed from about 1620 to 1800. Figure 7 shows Harrington's data plotted by TUs, shown as bore-diameter classes. Notice the overlap of TUs through time, beginning with the earliest TU, 9/64-inch diameter, up through the latest TU, 4/64-inch diameter. The neatness of the solution—in terms of both overlap and unimodal distributions—indicates that we are dealing with not only a historical sequence but also one based on heredity. The sequence shows heritable continuity. We are not referring to genetic inheritance, but to inheritance that is intergenerational and intragenerational

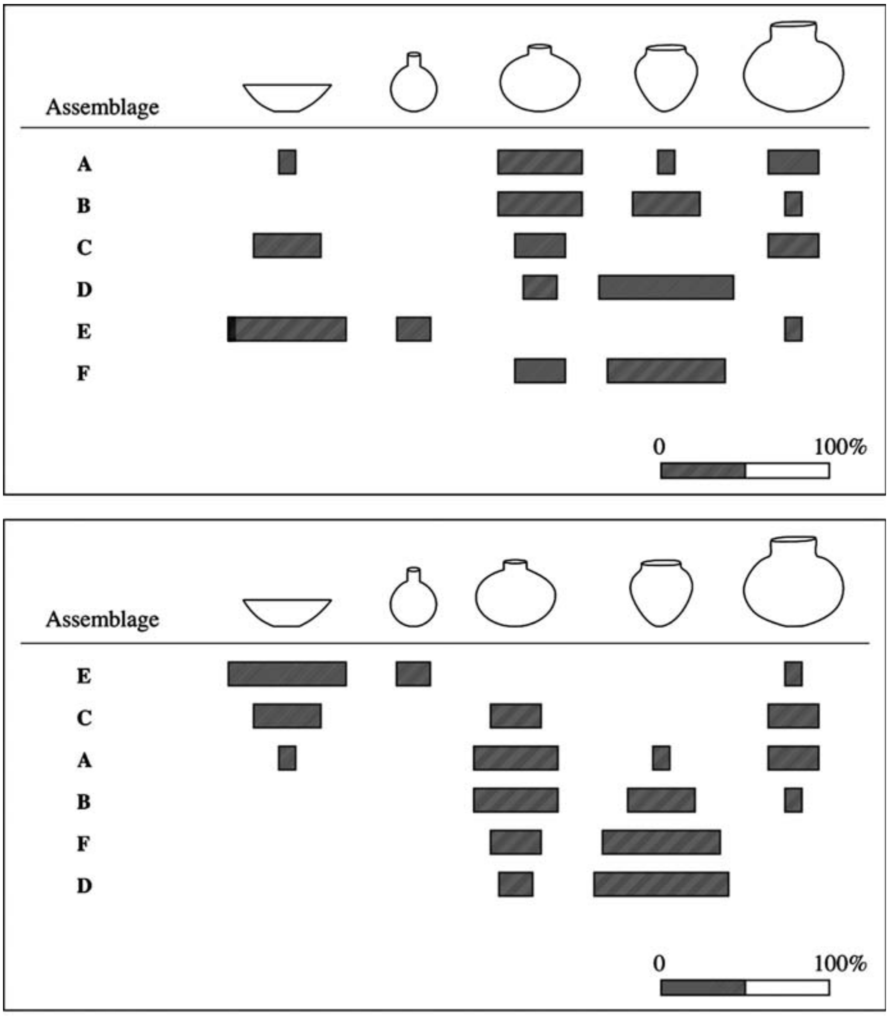

Fig. 6 A frequency seriation of the same collections is shown in Fig. 5. Again, the upper portion of the figure shows the unordered collections. The procedure is to sort the collections (*rows*) such that each artifact type (each *column*) displays a continuous and unimodal distribution in terms of the relative contribution it makes to each collection. The order resulting from meeting the expectations of the seriation model is given in the lower portion of the figure. Again, note that it makes no difference if the ordering from top to bottom is "E, C, A, B, F, D" or "D, F, B, A, C, E," because the direction of time's arrow is unknown. Note that Collections D and F can now be sorted, whereas in Fig. 5 they must be considered contemporaneous (from O'Brien and Lyman, 2000:Fig. 6)

transmission of styles among pipe makers. This is what we refer to later as the "tradition/lineage" sense of heritable continuity.

Prior to Harrington's (1954) analysis there was another means of dating pipes—using stem length—but there was a problem with this technique. Historical archaeologists noted that although the stem length of pipes changed through time, starting with 6–8-inch pipes in the early seventeenth century and progressing through ever-longer pipes, the trend reversed itself in the eighteenth century. Thus a pipestem of a certain length could date to either of two periods. TUs created on stem length would thus not be historical types because they would not yield continuous, unimodal frequency distributions.

Occurrence seriation and frequency seriation have three procedural requirements (Dunnell, 1970; Lipo et al., 1997; Teltser, 1995). In our view,

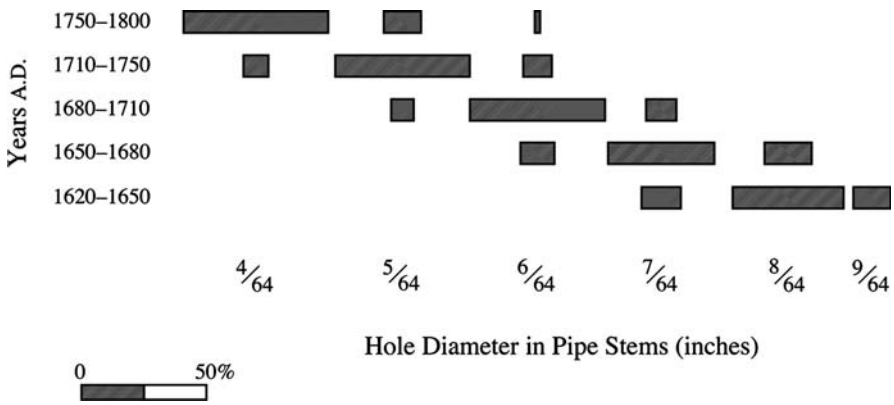

Fig. 7 A frequency seriation of classes of hole diameter in historical-period pipe stems based on data generated by Harrington (1954) (from O'Brien and Lyman, 2000:Fig. 7)

these requirements must also be met by phyletic seriation; in the following, substitution of the word artifact(s) for collection(s) recasts the requirements as applicable to phyletic seriation. The first requirement is that the collections to be seriated must be of similar duration. Meeting this requirement ensures that the placement of particular collections in an ordering is the result of age and not of duration. The second requirement is that all collections must come from the same local area. Meeting this requirement ensures that what is being measured is variation in time rather than variation in space. The second requirement explicitly attends the fact that transmission and heritable continuity have not only a temporal component, but also a spatial one (Dunnell, 1981; Lipo et al., 1997). If one wants to use seriation to measure transmission over time, then space must be controlled (its included amount must be limited); if one wants to measure transmission over space, then time must be controlled.

Given that the probability of transmission between entities increases as geographic proximity increases, meeting the second requirement increases the probability of meeting the third, which is that the collections must all belong to the same cultural tradition—defined as "a (primarily) temporal continuity represented by persistent configurations in single technologies or other systems of related forms" (Willey and Phillips, 1958:37). Implicit in this standard definition is the notion that persistence reflects cultural transmission or inheritance. Metaphorically, the seriated collections "must be 'genetically' related" (Dunnell, 1970:311; Kidder, 1916:267)—they represent an evolutionary lineage. If one meets the third requirement, then heritable continuity is assured, and phylogenetic affinities between the seriated collections are guaranteed. The key question is, how is the third requirement met? The answer is, by using theoretical units. Why? Because "similarity" is measured not as empirical units that *resemble* one another to greater or lesser degrees, such as in a character gradient represented by a phyletic seriation, but as *changes* either in the presence/absence of TUs variously held in common by distinct collections or in the frequencies of those variously shared TUs. Variation is measured with a set of analytically discrete variants rendered as distinct TUs, and time is measured continuously by the overlapping of TUs shared by collections (see Figs. 5, 6, and 7). Thus the definition of evolution as changes in variants (their presence/absence and/or their frequencies) over time is *explicitly* incorporated into occurrence and frequency seriation, and time is measured continuously.

Frequency seriation and occurrence seriation monitor transmission and heritability at two levels (Rouse, 1939). First, each artifact identified as a member of a particular TU is hypothetically related phylogenetically to every other specimen within that TU, given that they share in common the definitive attributes of the TU. The perfect correspondence of attributes displayed by specimens identified as members of a particular TU enhances the probability that they are members of the same lineage; the more character states or attributes defining a TU, the greater the chances are that homologous structures are included. We refer to this as the *type/species* sense of heritable continuity (O'Brien and Lyman, 2000). Second, the multiple TUs that are seriated are also hypothetically related phylogenetically, given the requirement that all seriated collections derive from a single cultural tradition. Traditions—just as TUs—can be conceived of and constructed at the scale of attribute of a discrete object, type of discrete object (a particular combination of attributes), or multiple types of discrete objects (Neff, 1992). Thus, in our paradigmatic classification of houses (see Figs. 1 and 2), we can track discrete houses or any attribute of any dimension. We refer to this as the *tradition/lineage* sense of heritable continuity to signify the potential for a diversity of units—of whatever scale—within a tradition or lineage. The phylogenetic implications of the hierarchical structure of the Linnaean taxonomy in biology are transferable to a similar hierarchical alignment of artifacts. Thus, "pottery" could be aligned with a biological family, "types" of pottery with biological genera, and "varieties" of pottery with biological species. TUs of pottery can be seriated *if* they comprise a pottery tradition (in biological terms, a monophyletic group, or clade).

In the preceding paragraph we emphasized that heritable continuity in both the type/species sense and in the tradition/lineage sense is *hypothetical*. This means that the phylogenetic relationships of the seriated materials must be tested. The actual ordering of a set of materials using frequency seriation comprises the test, because *if* the requirements of seriation are met, and *if* the TUs are related in both the type/species sense and the tradition/lineage sense, then the frequency distribution of each TU over time will display a unimodal curve as a result of transmission (Lipo et al., 1997; Neiman, 1995; Raup et al., 1973). The use of TUs to classify artifacts ensures heritable continuity at the type/species level—items are definitionally identical—and, with appropriate specification of the set of TUs used, at the tradition/lineage level, as well.

Discussion

If one has followed what has been said to this point, he or she has acquired an understanding not only of the basic tenets of evolutionary archaeology but also of some of the techniques that are useful for examining change over time within an evolutionary framework. Perhaps at this point two thoughts come to the reader's mind: "I follow the arguments, but I don't see them as the intellectual property solely of evolutionists"; and "I don't see where the 'evolution' is in all this." In response to the first point, individual elements of what we have discussed to this point are *not* the purview solely of evolutionists. Scientists other than evolutionists, for example, make the distinction between materialism and essentialism, and they also study change. Because of what they study—organisms—evolutionists are restricted to one view of reality (materialism) and one way of measuring change (as replacement of units). Making their job more difficult is the fact that populations of their empirical units—the actual things they study—are always changing via turnover in membership. This change goes on second by second, hour by hour, year by year, and so on. The problem is that things do not stand still long enough for us to get a good fix on them. Just about the time we think we've taken the measure of something, it has been replaced by something else. We would never argue that a chemist or physicist has an easy job of it, but at least some of the things they study—subatomic particles, atoms, compounds, and the like—do not change. That's why we say that in essentialist science, time and space merge. It doesn't matter, for example, when or where an atom of hydrogen exists; it will be hydrogen today, tomorrow, on Earth or Jupiter. Thus essentialism allows laws to be derived that not only describe the actions of empirical units, but also allow us to predict their future behavior. Time and space, however, cannot merge under a materialist framework because the empirical units—organisms—*do* have unique time–space positions. Prediction is precluded, as are most laws. The only law that applies to materialist phenomena is the law of contingency—whatever happens at, say, point D is conditioned by what happened previously at points C, B, and A. This is what makes evolutionism a historical science. It is the careful construction of that history that is of utmost importance in any evolutionistic study.

Evolutionists have a unified perspective on reality, variation, and how to measure that variation. They do not agree on all aspects of evolution or on how to study it (O'Brien and Lyman, 2000), but most points of contention are relatively minor compared to the degree of consensus that exists in Darwinism. Evolutionists share pieces of their perspective with nonmaterialists, but if we take a careful look at several disciplines where evolution has long been of analytical interest, and this includes anthropology and its subfield archaeology, we will see that most perspectives on the subject are non-Darwinian. It is the collection of particular methods, techniques, epistemology, and ontology that makes Darwinism unique.

In response to the second point raised by our imaginary reader—"Where's the evolution in all this?"—we note that this question is one that evolutionary archaeologists hear constantly (e.g., Bamforth, 2002; Boone and Smith, 1998). Part of the reason for the frequency with which it is asked is attributable to a lack of familiarity with Darwinism on the part of the questioner (e.g., Bamforth, 2002; see O'Brien and Lyman, 2002a; O'Brien et al., 2003). Misconceptions about what evolution is and how it works also stem from how it normally is presented in the popular literature: as some large-scale change that causes something eventually to become something else. Evolution is typically presented as large-scale change that takes place over a long period of time. These presentations, of course, are correct, but they are only part of the story; by focusing on them exclusively, one's impression is biased from the start. What is missing is the fact that the large-scale evolutionary results that we see so plainly are the cumulative products of countless smaller-scale, and hence much less evident, changes that occur continually.

Most of us have no problem with the concept of hominid evolution—the fact that some 7–9 million years ago the line that led to chimps and humans diverged from the line that eventually led to gorillas. Similarly, some 6 million years ago, the line that produced chimpanzees diverged from the hominid line that produced, among other creatures, australopithecines and eventually members of the genus *Homo*. When we line fossils up in a certain way, they make sense from the standpoint of morphological characteristics—that is, we can see the profound changes that hominids have gone through during the last 5–6 million years. What else but evolution could have caused such large-scale change? The answer is, nothing *but* evolution could have caused it. But what about change over the last 100,000 years? Can we see enough morphological change over that span to indicate evolution has taken place? In some cases we can, or at least our taxonomic efforts suggest that we can. But the fact of the matter is, it is much more difficult to see the cumulative changes in phenotypes separated by 100,000 years than it is in phenotypes separated by 5–6 million years. Why? Because various evolutionary processes, especially natural selection, have had 50–60 times longer to effect change in the latter sample than in the former. The effects—morphological or otherwise—are much more evident than they are when a shorter period of time is involved. If we shorten the period to 10,000 years, we do not see any change. Does this mean that evolution has stopped operating on humans? No, it means simply that the time span is too short to see the large-scale changes that we customarily associate with evolution.

What we have here is a shift in analytical scale, almost as if we were walking toward a large painting and starting to focus on smaller and smaller sections of it. At some distance from the canvas we can see the entire painting and its overall design; such a macroview is indispensable, but by itself it obscures details that become apparent only as we get closer and closer to the canvas. At close range we start to see the microstructure—individual brush marks, the layering of paint, and so forth—that undergirds the larger composite. As we begin to understand the details, do we forget that we are studying small-scale aspects of a large painting? No, but this is exactly what we have done when it comes to evolution and the archaeological record. Forgetting the simple dichotomy between long-term, cumulative evolutionary results and short-term aspects of evolution is responsible for the question, "Where's the evolution?" Skeptics are looking for the big results—the large-scale changes—and missing the point that those large-scale, cumulative results are the end products of countless small-scale changes that took place over a very long time period.

In contrast to the age of the archaeological record elsewhere, the North American record, with which many of us deal, is too short in temporal duration to exhibit many of the large-scale changes we have come to expect of evolution. Further, at most localities we see only segments of that record and not its entire expanse. Thus we are standing very close to the canvas to begin with. In some respects this might be considered a curse, but on the positive side we maintain for the most part fairly fine-scale temporal control over segments of the record we examine. We might wish that we could do better—say, break sequences down into segments of 50-year duration rather than of 300-year duration—but think how curious this must sound to a paleobiologist who is using segments of a *million* years' duration. How ironic that one group of materialists can see the macropicture and the other usually only the micropicture. Paleobiologists do not have access to the fine detail that archaeologists can see, but they do not doubt that their macroscale picture comprises literally millions of tiny structures and routine processes that went on day after day, century after century, millennium after millennium. They accept such detail as axiomatic. Conversely, archaeologists rarely have access to anything approaching the evolutionary big picture, but they should not get so lost in detail that they forget that it is those details that cumulatively *are* evolution.

We can hardly blame archaeologists for failing to recognize the complementarity of micro- and macroevolutionary perspectives, given that several prominent evolutionary biologists and paleontologists (e.g., Gould, 1996; Huxley, 1956; Mayr, 1982; Simpson, 1949) have stated that humans stopped evolving when they acquired culture. They and others of similar persuasion have done what countless anthropologists have done for well over a century: set humans aside as being something special because they possess culture—what Kroeber (1917) defined as the "superorganic" and White (1959:8) later defined as an "extrasomatic means of adaptation." Under this view, such evolutionary processes as selection and drift do not operate on humans because our capacity for culture has uncoupled us from evolution. Thus, material remains—pottery, metal tools, and the like—are viewed as adaptations; they are conceived as intentional products constructed solely to adjust humans *in a directed sense* to the environmental pressures they face. Instead of attempting to determine whether such features were indeed shaped by selection, and thus qualify as adaptations in the biological sense of the term (O'Brien and Holland, 1992), some archaeologists (e.g., Boone and Smith, 1998) view them as products of a plastic phenotype that can quickly adapt to any problem that the cultural and/or natural environment throws at it.

If such is the case, and culture and its attendant features—such as intelligence, creativity, and intentions—have created a chasm between humans and evolutionary processes, then a Darwinian perspective is nonapplicable to the vast majority of the archaeological record. We contend, however, that culture is simply one adaptive response that a particular lineage of organisms evolved; as such, it does not exempt its bearers from evolutionary processes. Further, invoking culture as a cause begs the question of when in the course of a cultural lineage's history the culture of the moment became so plastic that it created a shield that natural selection could not penetrate (Lyman and O'Brien, 1998).

Epistemologically, invoking culture as a decoupling agent locates cause in the wrong place. Yes, culture is a different mode of transmission than are genes, though we view this more in quantitative rather than qualitative terms in light of what is known of animal behavior (e.g., Bonner, 1980, 1988), and yes, there can be no doubt that the tempo of cultural transmission differs significantly from that of genetic transmission. But do these differences lead to the conclusion that humans as organisms have evolved the means to stop evolving—that they somehow are beyond the reach of selection? Do these differences indicate that other evolutionary processes such as drift play minimal roles in reshuffling *both* somatic and nonsomatic characters? In our opinion the answer to both questions is "no." Humans today are no more immune to evolutionary processes than they were 10,000 or 50,000 years ago. Thus, we agree with what one evolutionary biologist has to say about culture: It merely altered "the components of fitness [and the] directional changes" prompted by selection; "what has happened is that the [selective] environment, the adjudicator of which genotypes are fit, has been altered" (Lerner, 1959:181; see also Dennett, 1995).

Although we have dealt with materials from the historical period over the course of our careers, we do not consider ourselves historical archaeologists; thus we would not presume to tell those with more experience in the subject how to structure their research agendas to do evolutionistic studies. Even with our limited experience, however, we see enormous potential in the historical-period record for understanding past selective environments and their effects on the fitness of the human groups that inhabited them. In numerous cases, the requisite groundwork has been laid for such analyses, or at least previous investigations have pointed out interesting avenues to be followed.

One such avenue is in the broad area of pattern-recognition studies made popular by Stanley South (e.g., 1977, 1978), which rest on the assumption that similar behaviors common to two or more groups will leave similar archaeological signatures. For example, there appear to have been some similarities in the behaviors of plantation overseers in the southeastern United States that led to particular patterns in the material record, just as there appear to have been similarities in the behaviors of slaves that led to different patterns. John Otto's (1977, 1984) analysis of Cannon's Point Plantation in coastal Georgia was based on this premise and there are dozens of other similar examples that could be cited. Even the most strident evolutionary archaeologist would agree that there are threads that connect similar behaviors to similar sets of artifacts in the archaeological record. The problem is in deciding whether particular patterns are the result of homology (similarity because of heritable continuity) as opposed to analogy (convergence). Heritable continuity could be at any of several scales—household, interrelated households, and so on—and in some cases is undoubtedly tied to such things as status, ethnicity, and perhaps most important, economics (e.g., Orser, 1988a, 1988b).

Charles Orser (1989) is correct in pointing out the lack of theory behind pattern-recognition studies. Patterns are extensionally defined units, being products of a small sample of the thousands of cases that exist, and of course provide no explanation for why the patterning exists in the first place. For example, Orser (1989:30–31) points out that the "explanation" for South's (1977) British Colonial "Tea Ceremony" subpattern, represented by broken, discarded pieces of tea sets, resides, according to South, in a social-psychological need. To us, as to Orser, this is not a particularly satisfying "explanation" because it is not derived from theory. Where theory *can* help us is in understanding the role of the tea ceremony in driving the explosion in pottery production in England during the late nineteenth century. The fortunes of Wedgwood and other pottery manufacturers were in large part tied to the meteoric rise in tea and coffee drinking in England and the United States, and many of the decisions manufacturers made in renovating and expanding their pottery works were based on an exponential growth in demand for beverage services (Hower, 1932; Stone, 1984). This, as John Langton (1984) points out, was a clear-cut case of positive selection of a particular social practice. In a similar vein, consider the almost overnight success of Wedgwood's "Queen's Ware," which went through some 7,000 experiments before it was perfected. This, as Langton (1984:340) also points out, can be viewed as another case of "sociocultural selection, in which one type of pottery proliferated and displaced other, less desirable forms."

Regardless of the selective agent—whether human or nature—selection is still selection, and the outcome is the same: the increased "fitness" of one kind of artifact over another. Of course, what we are interested in is the fitness of humans, but we use the *replicative success* (Leonard and Jones, 1987) of artifacts, which are parts of phenotypes, as a proxy measure. The phenomenal success of Queen's Ware was not an accident—selection drove its ascendancy—and neither was the rise in fortunes of those who produced it. Whatever the social "need" was that drove the rise in popularity, that need was a selective agent, and it directly affected the fitness both of those who successfully manufactured and marketed Queen's Ware and those who did not. We might hypothesize that purchase and use of Queen's Ware also affected the fitness of consumers, but this remains to be tested. Some archaeologists might wonder how fitness is tied to the dishes a family purchased. Such wonder results only if the definition of fitness is so narrow and reductionistic that it applies only to the number of offspring that one organism produces relative to another. Number of offspring is but one measure of fitness. How well does one organism or group of organisms care for the offspring it *does* have, irrespective of absolute numbers, versus how another organism or group cares for its offspring? How well does one organism or group do relative to another in terms of accumulating wealth? Or in signaling the wealth it has accumulated—regardless of whether it is through the use of architecture, tableware, or some other means? These questions are nothing if not evolutionary ones, and we believe they can be addressed by historical archaeologists (e.g., Neiman, 1999).

Conclusions

History is critical to any Darwinian evolutionary study, whether undertaken in biology (see chapters in Nitecki and Nitecki, 1992) or in anthropology. From an anthropological perspective, "Darwinian theory is both scientific and historical. The history of any evolving lineage or culture is a sequence of unique, contingent events" (Boyd and Richerson, 1992:179–180). In both the biological and social domains, "'science' without 'history' leaves many interesting phenomena unexplained, while 'history' without 'science' cannot produce an explanatory account of the past, only a listing of disconnected facts" (Boyd and Richerson, 1992:201). Archaeology's claim to unique status within the human sciences is its access to portions of past phenotypes. Ethnographers, sociologists, psychologists, historians, and others who study humans are limited to living humans or written records. Only archaeologists have access to the entire time span of culture, however it is defined. The important point is that historical questions are the most obvious ones archaeologists can ask. This, of course, is hardly a strong warrant for asking them. However, we believe archaeologists should ask historical questions not only because they have access to "our only direct source of information about the course of evolution" (Stanley, 1981:72), but also because answers to historical questions are critical to gaining a complete understanding of why particular cultural manifestations occupy particular positions in time and space. The key word is "particular," for history *does* matter (e.g., Gould, 1986; Lyman and O'Brien, 1998; O'Brien and Lyman, 2003a). It is in part for that reason that since the beginnings of anthropology and archaeology as distinct disciplines, practitioners have employed analytical units that reflect cultural transmission and history (Lyman and O'Brien, 2003) and grappled with versions of evolution (Lyman and O'Brien, 1997).

To write a functional explanation for why a bird migrates south every autumn is one thing; to know the historical reasons for its heading south is something else entirely (Mayr, 1961). In the latter case, the evolutionary history of that bird matters a great deal. Similarly, to understand how and why early nineteenth-century colonists in the midwestern United States behaved a particular way requires that we know how those colonists behaved at earlier times. In other words, their evolutionary history matters. Note that it is *their* evolutionary history that matters, not the history of some other group that we attempt to use as a universal proxy for colonists. Failure to maintain this distinction is the weakness underlying previous pattern-recognition studies in historical archaeology. Without demonstrating heritable continuity among the units included in an analysis, it is impossible to untangle homologous and analogous traits.

We agree with Robert Bettinger and Peter Richerson (1996:224) that knowing the functional reason why a dog pants—to regulate body temperature—is important, but we disagree with their assertion that one need "not question that this panting is the result of a long evolutionary history." To relegate history to such a low status misses the point that more and more biologists (particularly paleobiologists) are coming to accept: To be considered an adaptation, a trait must have a history demonstrating that it was shaped by selection (Brandon, 1990; Burian, 1992; O'Brien and Holland, 1992; Sober, 1984; West-Eberhard, 1992). However, we fully agree with Bettinger and Richerson (1996:224) that "functional responses frequently contain important clues about evolutionary history that are worth paying attention to." This is where behavioral archaeology (e.g., Schiffer, 1996) and human behavioral ecology (e.g., Bird and O'Connell, 2006) have made important contributions. That using adaptationism—the study of adaptations and their functions—as an explanation must be done with a high degree of caution has been noted by both evolutionary biologists (e.g., Gould, 1996, 1997; Gould and Lewontin, 1979) and evolutionary archaeologists (e.g., O'Brien and Holland, 1992, 1995b).

But again, understanding adaptive function is not the same as explaining where a particular feature came from or *why* it arose when and where it did. At the risk of being redundant, we believe that historical understanding must precede many questions concerning functional or adaptational understanding. That is why we have devoted considerable space in this chapter to seriation and heritable continuity. From an evolutionary perspective, to "*explain* means to identify a mechanism that causes evolution and to demonstrate the consequences of its operation" (Bell, 1997:1). The mechanisms are selection and drift (transmission), and the causes precede the effects of the working of the mechanisms. Selection and transmission are historical mechanisms; they operate every moment, at some times more strongly or more rapidly than at others, creating the varying tempo of evolutionary change over time. So what is history other than the passage of time? Robert O'Hara (1988:144) provides a useful discussion:

> [G]enerally speaking a *chronicle* is a description of a series of events, arranged in chronological order but *not* accompanied by any causal statements, explanations, or interpretations. A chronicle says simply that *A* happened, and then *B* happened, and then *C* happened. A *history*, in contrast to a chronicle, contains statements about causal connections, explanations, or interpretations. It does not say simply that *A* happened before *B* and that *B* happened before *C*, but rather that *B* happened *because* of *A*, and *C* happened *because* of *B*.... *Phylogeny* is the *evolutionary chronicle:* the branched sequence of character change in organisms through time.... [H]istory, as distinct from chronicle, contains a class of statements called *narrative sentences*, and narrative sentences, which are essential to historical writing, will never appear in [chronicles]. A narrative sentence describes *an event*, taking place at a particular time, with reference to *another event* taking place at a *later* time.... Just as narrative sentences distinguish history from chronicle, *evolutionary narrative sentences* distinguish evolutionary history from evolutionary chronicle.

O'Hara makes two critical points: first, false or inaccurate chronicle cannot result in accurate history; second, narrative sentences provide the explanations of why chronicles look the way they do. Culture historians recognized these distinctions decades ago (Lyman and O'Brien, 1997; Lyman et al., 1997), but they could not escape the same problem that plagues evolutionary biology today (O'Hara, 1988)—conflating the explanation of *states* and the explanation of *events* of change. The former comprises essentialist, or typological, thinking; the latter comprises materialist, or population, thinking and distinguishes Darwinian evolution as not only a different theory of change but a different *kind* of theory (Lewontin, 1974). Archaeologists often fail to recognize this and attempt to explain the difference in culture states—culture types—in anthropological terms as opposed to explaining change in Darwin's materialist terms.

We underscore the importance to evolutionary studies of showing that a particular phenotypic trait has a positive fitness value (Lyman and O'Brien, 1998; O'Brien and Holland, 1992). In archaeology, this requires that the mechanical properties of artifacts be measured (O'Brien and Holland, 1995b; O'Brien et al., 1994) in a manner similar to that in which one determines the panting dog is regulating its body temperature. Does a particular kind of pottery work better within the particular time–space position it occupies than does some other kind of pottery? If so, why? How does that particular *state* of pottery work in that context? But this is only the first question that must be answered. Additionally, what is the selective environment in which it is found, and what were the selective environments that led to its appearance? What was the history that led to the establishment of that kind of pottery? These are questions about the history of change in pottery. The second set of questions is what makes evolutionary archaeology evolutionary. Answering the questions regarding pottery state requires the use of immanent properties and processes, or an essentialist ontology; answering the questions regarding pottery *change* requires the use of configurational properties and processes, or a materialist ontology.

As we detail elsewhere (Lyman and O'Brien, 1998), potential objection to such a position is found in Bettinger and Richerson's (1996:226) statement that "given time's ravages, few archaeologists will ever be privileged to participate in constructing a 'how actually' explanation." We agree, though the stories constructed under evolutionary archaeology are theoretically informed and thus are testable rather than inductively generated inferences. We also point out that paleobiologists are faced with the same problem, but they do not throw up their hands and focus on modern organisms as analogs to long-dead ones. Brandon (1990) remarks that when a "how possibly" explanation accounts for numerous observations and provides an empirically and logically coherent explanation, it attains the status of a "how actually" explanation yet remains testable in light of new evidence. Additionally, "no one can fairly describe [such a 'how possibly' explanation] as merely an imaginative bit of story telling" (Brandon, 1990:183).

It does not strike us as storytelling to find in Darwinism answers as to why humans behaved as they did at particular times and in particular places. As we see it, there are only two reasons *not* to find answers there: either evolutionism itself is bogus or evolutionary processes no longer affect humans. We do not believe either reason is valid. But having said that, neither do we believe that humans are automatons who wander aimlessly through life waiting to be selected against. We often hear such a position ascribed to humans. Alternatively, we have heard the remark that we view humans as fitness-maximizing individuals who carefully select the options that allow them to be the most reproductively successful. Neither position is correct. Rather, we have consistently made the statement (e.g., O'Brien, 1996b) that there is nothing in evolutionary theory that states that organisms must always act in accordance with some maximizing strategy. As Richard Dawkins (1990:188–189) puts it, "Individuals do not consciously strive to maximize anything; they behave *as if* maximizing something. . .. [I]ndividuals may strive for something, but it will be a morsel of food, an attractive female, or a desirable territory." As Darwin himself figured out, no such thing as a perfectly adapted organism has existed or will ever exist. All he ever had in mind when he adopted Herbert Spencer's phrase "survival of the fittest" was for "the *tendency* of organisms that are better engineered to be reproductively successful" (Burian, 1983:299; emphasis added). In other words, "If *a* is better adapted than *b* in environment *E*, then (probably) *a* will have greater reproductive success than *b* in E" (Brandon, 1990:11).

Our job as archaeologists is to figure out *why a* is better adapted than *b* at a particular time and in a particular place. This requires a thorough understanding of the social and physical environment and of the selective pressures created by that environment that impinge on the success of *a* and *b*. Since neither *a* nor *b* sprang from nothingness, we need to understand their origins by tracing ancestral lineages and documenting changes that took place within those lineages that eventually led to the origin of *a* and *b*. Importantly, *a* and *b* are what we have referred to as ideational units; as such, they are devices used to measure change in ever-evolving lines. In other words, they are chunks of a continuum that *for the moment we are calling* a *and* b. They thus are not real in an empirical sense. Given our upbringing as anthropologists, it is difficult *not* to impart a reality to units, but such is impossible if, as materialism maintains, things are always in the process of becoming something else. This perspective is not science-speak or hand-waving; it is the heart of Darwinian evolutionism. The historical-period archaeological record, itself simply a convenient chunk of the temporal continuum, offers an excellent laboratory in which to expand the domain of the materialist perspective—that is, to rewrite Darwinian evolutionism in archaeological terms.

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