PART I

LITHIC TECHNOLOGICAL SYSTEMS AND EVOLUTIONARY THEORY

ONE

INTERPRETING LITHIC TECHNOLOGY UNDER THE EVOLUTIONARY TENT

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An underlying theme of this volume is that lithic technological analysis is not well integrated with a theoretical approach, and that evolutionary theory has great potential to fill this void. This is not to say that evolutionary concepts and models have not been used by archaeologists who have been working with lithic technological data. In fact a number of recent volumes have been published recently that are dedicated to the application of specific evolutionary concepts to lithic data. Surovell's (2009) book, *Toward a Behavioral Ecology of Lithic Technology*, is a good example. The edited volume by Michael O'Brien (2008), *Cultural Transmission and Archaeology*, draws on many lithic data case studies. A number of highly regarded and well cited journal articles that have applied specific evolutionary approaches to lithic technology (Beck et al. 2002; Bettinger and Eerkens 1999; Brantingham 2003; Mesoudi and O'Brien 2008; O'Brien et al. 2001; and others). This volume attempts to bring together several different evolutionary perspectives and lithic technology. We invited research contributions from a number of scholars who have been standing on different sides of a theoretical fence at one time or another, but have all embraced Darwinian evolutionary approaches and in this case use lithic technology in that effort.

The chapters included in this collection use lithic artifacts or artifact characteristics as an empirical proxy for past human land-use strategies and/or past human behaviors that apply an evolutionary theoretical foundation to help interpret those data. Even though all of the chapters in this volume emphasize evolutionary approaches and lithic technological systems, the amount of theoretical diversity within the volume is quite striking. The chapters cover a range of topics beneath a broad evolutionary umbrella including but not limited to human behavioral ecology (HBE), cultural transmission, phylogenetic analysis, risk management, macroevolution, dual inheritance theory, cladistics, central place foraging, costly signaling, selection, drift and various applications of evolutionary ecology. Some of these evolutionary approaches have not always completely agreed with one another. However, we believe that within this group of studies there is a strong common ground for multiple approaches to Darwinian thinking. In some chapters we see an intentional blending of multiple evolutionary approaches towards the study of lithic technology. In other chapters we intentionally point out areas that we believe represent like-minded thinking from different evolutionary models, even if authors may not have intentionally made such linkages.

This assemblage of chapters is structured in a way that segregates the volume contributions into three very broad thematic topics: phylogenetic evolution, HBE, and cultural transmission. However, many of the chapters in this volume could have been placed into more than one of these themes and we hope authors and readers are comfortable with our distribution. The fact that so many of the chapters could be included in multiple sections again points to our underlying impression that there is increasingly more common ground rising under the evolutionary umbrella in archaeology. It became evident to us that a number of crosscutting issues and data sets joined chapters from different themes. Four of the chapters (Beck and Jones; Kuhn and Miller; Shott; and VanPool et al.) explored evolutionary applications with North American Paleoindian projectile technology. Four chapters (Bettinger et al.; Kuhn and Miller; Stevens; Goodale et al.) examined retouch intensity in some form or another. Two of the chapters used experimental replication of artifacts to assess evolutionary models (Clarkson et al.; Goodale et al.). Four chapters focused on lithic raw material provenance in some form (Beck and Jones; Bettinger et al.; Ferris; Garvey). Of course, all chapters use evolutionary approaches along with some aspect of lithic technology.

We also hope this volume will inspire lithic researchers to apply their data, whether generated experimentally, collected from region surveys, or excavated from detailed stratigraphy, to more problem oriented approaches to analysis and interpretation.

We feel that the context of an archaeological study (particularly lithic study) is extremely important for understanding the kinds of activities that have occurred at a particular location or within a particular region. However, the value of that specific context can often be measured only by the extent to which it is abstracted to more generalized interpretations. In some lithic studies, strict emphasis on context provides little more than a detailed description of artifacts and their associations with one another and their environment. In other studies the lack of context and emphasis on abstract associations of data result in little more than untested hypotheses and speculations about what could or might have happened in past times on sites and within regions. We believe this volume emphasizes both ends of this spectrum and hope our examples show how lithic technological data can be tied to evolutionary theory to build stronger interpretations of past human activities.

CULTURE HISTORY, LITHIC DATA, AND PHYLOGENETIC EVOLUTION

If we acknowledge that evolution is defined simply as descent with modification (Lyman and O'Brien 1998), and that evolutionary approaches deal with historical phenomenon (Boyd and Richarson 1992; Jones et al. 1995; Lipo et al. 2006), then cultural-historical studies associated with lithic assemblages provide a common heritage for the various components of evolutionary thought in archaeology and lithic studies. Archaeologists have been arranging artifact types and assemblages into chronologies since before the use of radiocarbon dating (Krieger 1944; McKern 1939; Ritchie 1944; Witthoft 1949) and the practice continues today (Beck and Jones 2010; Ramenofsky 2009; Sellet et al. 2009). The structuring of lithic types and assemblages into historical sequences based on similarities of form and compositions, respectively, is a form of phylogenetic analysis not substantially different from what takes place in paleoecology. Early chronological studies of stone tool assemblages were explicit about the relationships between different types over time. There was an attempt to show that similarity of form represented lineal descent with modification. This is evident in Jesse Jennings' discussion of the Plano big game hunting tradition. He notes (1968:123), "If typological evidence is to be accepted, one can see a continent-wide dispersal of Big Game Hunters by, or earlier than 10,000 B.P.…In all areas, however, the tradition of the lanceolate blade or point, fluted or unfluted, first coexists with, and finally becomes part of, the next widespread and long-lived stage called the Archaic." That similarity of artifact form over time and space represents common ancestry is an evolutionary notion. As noted by Neiman (1995:31), "Culture history was grounded in the interpretation of the record in terms of homologous similarity."

Cultural chronologies of this kind were swept into the evolutionary literature in archaeology under the wing of the selectionist movement (also identified as evolutionary archaeology) that can be equated roughly with the work of Dunnell (1978, 1980, 1982) and his followers (Jones et al. 1995; Leonard and Jones 1987; Lyman and O'Brien 1998; O'Brien and Holland 1990, 1992; O'Brien and Lyman 2000; O'Brien et al. 1998). They define evolutionary archaeology as change in the composition of a population over time. "In evolutionary archaeology, the population is artifacts, which are viewed as phenotypic features, and it is the differential representation of variation at all scales among artifacts for which it seeks explanations" (Lyman and O'Brien 1998:616). Evolutionary archaeology involves "(1) measuring variation – that is, dividing it into discrete sets of empirical units...; (2) tracking variation through time and across space to produce a historical narrative about lineages or particular variants; and (3) explaining the differential persistence of individual variants comprising lineages in particular time-space contexts" (O'Brien et al. 1998:487). The selectionist paradigm takes the work of culture historical archaeologists and applies heritable continuity to the temporal sequence of artifacts. They, like paleobiologists they emulate, attempt to distinguish between analogous and homologous characteristics to assess degree of relatedness.

Some of the early research in this area dealing with lithic technology can be seen in the scraper study by Meltzer (1981). He attempted to separate aspects of stylistic variability from functional variability with the underlying notion that stylistic variability is viewed as nonselective or homologous (see Dunnell 1978:199). His study recognized scraper characteristics on stone tools for times and places around the world that had little possibility of heritable linkages. In doing so, he was able to establish those characteristics as functional attributes of the tools. "So far as I can tell, given the variables I selected, the sample size, and the particular time/space coordinates of data, there is no stylistic component in the morphology of the tools examined" (Meltzer 1981:326). The separation of style and function in materials is a fundamental distinction for the selectionist approach in archaeology. "Those units that are functional will be sorted by natural selection; those that are stylistic will be sorted by the vagaries of transmission" (O'Brien et al. 2003:576).

The integration of stone tool analysis within the evolutionary framework of selectionism increased in frequency with the adoption of systematic measures of phylogenetic analysis known as cladistics. Put rather simply, cladistics is a form of phylogenetic mapping that uses derived characteristics to construct phylogenies (Mayr 1982). Such analysis is often displayed in the form of a branching tree or cladogram. In a cladogram taxa are organized into groups or clusters based on shared derived characters. Any taxon in the population that does not share a derived character is graphed alone as an out group. In this way the cladogram shows the historical relationship of taxa and identifies the attributes or characters that link the various taxa (Buchannan and Collard 2008).

Foley used cladistics on stone tool assemblages to establish relatedness among early hominids (Foley 1987; Foley and Lahr 2003). Lyman and O'Brien (2000) applied clade-diversity approaches to understanding projectile point variation from Gatecliff Shelter in Nevada. Their analysis showed that projectile point diversity at the site may have resulted from an increase in the number of weapon delivery systems. Others using different kinds of lithic analysis suggest the same results (Beck 1995; Hughes 1998). This type of analysis was applied to Paleoindian projectile technology from the southeastern United States to establish relationships among Paleoindian technologies and later Archaic technologies (Darwent and O'Brien 2006; O'Brien et al. 2001). The Paleoindian example was expanded to explore human peopling of North America using cladistics (Buchanan and Collard 2007, 2008; Buchanan and Hamilton 2009). Others use cladistic approaches to assess phylogenetic relationships between bow and arrow technology and dart technology (Lyman et al. 2008, 2009).

There have been many critics of the selectionist position with regard to using artifacts as phylogenetic markers in the same way that paleontologists use fossil bones to reconstruct phylogenetic trees of ancient members of the animal kingdom (e.g. Bamforth 2002; Boone and Smith 1998; Fitzhugh 2001; Gabora 2006; Shennan 2002), and there has been ample reply to such criticism (O'Brien and Lyman 2002; O'Brien et al. 2003). Though exploring differences and similarities between various ideological camps under the evolutionary umbrella is outside the scope of this book, we do think there has been an increasing amount of common ground between camps. For instance, Bamforth (2002) argued that variation in material culture (artifacts) may be conditioned by a number of different agencies, such as culture and human behavior. He suggested that not all variation in human artifacts over time may be representing evolutionary trends in the same way that paleontologists see evolutionary trends in ancient fossils. We feel that some archaeologists who use phylogenetic analysis of artifacts also embrace this position or have come to embrace it.

Chapter 2 by Lyman explores graphic representation of artifact variation over time to help illuminate evolutionary processes. He demonstrates several important characteristics of graph styles. For instance, he graphs projectile point data to show relative abundance of types (richness) over time (displayed by strata) is a good reflection of the Darwinian variational model of evolution. That model shows changes in frequencies of types over time and not changes in types. When variation in attributes of point types is displayed over time we can see how formal variation of the population is being altered or incorporated into the types. Indeed, graphic styles show important and distinct aspects of artifact variation. However, our "take away" point here is Lyman's recognition of different processes associated with different aspects of lithic artifacts. He emphasizes that graphed patterns and their inferred processes depend on the classificatory units used in the analysis. He notes, "…those units of measurement, that are graphed, whether types of points, length of points measured in centimeters or millimeters, or neck width measured in millimeters or tenths of millimeters. Not just knowing the identity of the graphed units, but understanding what those units actually are, would seem to be a critical step in the production of graphs that are correctly perceived and subject to a minimum of misinterpretation (or misperception)." In our opinion, this is what Bamforth (2002:448) was advocating for with regard to variation in artifact form in stating, "…I have argued here that archaeology's essentially universal reliance on aggregate data sets that represent the activities of human groups whose familial and reproductive relations are unknown currently precludes us from making such a contribution. It may be possible to develop modes of analysis that allow us to surmount this problem, but we have certainly not yet accomplished this." We think Lyman's study goes a long way towards understanding and developing such modes of analysis. As a result we see some common ground here.

Another aspect of the Lyman chapter we think is critical here especially with regard to lithic studies and phylogenetic analysis is the recognition of what we call "context of variation." Lyman correctly notes, "A graphed temporal sequence of archaeological data does not necessarily imply evolution, regardless of pattern or process." This is echoed in Chapter 3 by Shott, which recognizes that projectile points change as a result of multiple processes (use, functional requirements, human situational needs). These sources of morphological variation need to be understood before practitioners of phylogenetic lithic analysis graph or even select artifact attributes for phylogenetic study. "Cladistic analysis may plot the sequence of change, but only detailed contextual study can explain it" (Shott 2008:150). We could not agree more with Shott (and by extension Lyman) on this issue. If archaeologists are interested in characterizing evolutionary trends such as descent with modification in artifact forms it is critical that we select the appropriate attributes to show phylogenetic relationships. It may not be appropriate simply to use whatever attributes are available.

Not all attributes or types produced from attributes represent lineal decent. It is important to understand some of the production, use, maintenance and reuse processes that influence the morphological variability found in stone tools before plugging tool attribute variability into clustering algorithms. For instance, phylogenetic projectile point typologies are meant to show character states that are the result of shared ancestry derived from the ancestral state for the type. This is why we can effectively use projectile point typologies to describe cultural-historical sequences. However, if the projectile point typologies are built or assessed by morphological characteristics that do not vary by descent and are not derived from an ancestral state, there is a good chance we will be barking up the wrong phylogenetic tree. This is relatively easy to visualize with morphological characters associated with phenomena we understand well. If we were interested in describing the phylogenetic history of Alaskan Dall sheep (*Ovis dalli dalli*) based on skeletal remains we probably would not measure horn curl length, knowing that (in male sheep) it correlates positively with the age of the individual animal and is directly related to the life history of the individual organism. We know this through observations of contemporary Dall sheep and through studies charting the growth of horn curl and age at time of death. Foot structure and overall body size have more to do with historical lineages of the species than horn curl length. In the same way, we know that some types of projectile points have blades that are altered and changed throughout the period of time they are used by ancient humans. Figure 13.1 in Chapter 13 by Goodale et al. shows variation in blade shape reflected in stages of projectile point production and use, taken from Al Goodyear's (1974) study of Dalton Points from the Brand Site. This was among the first studies to demonstrate how blade shape and size on projectile points were reduced from use and resharpening. Others have more recently demonstrated such morphological changes on a variety of projectile point styles using both experimental resharpening studies and analysis of allometric characteristics from excavated collections (Ahler and Geib 2000; Andrefsky 2006; Bement 2002; Kuhn and Miller this volume; Shott and Ballenger 2007; Truncher 1990). If projectile point blade elements change size and shape during their use-life it is not reasonable to use this characteristic of projectile points to chart decent. Such measurements are akin to charting Dall sheep lineages based on horn curl length without knowing that horn curl length changes during the lives of individual sheep. Projectile points are not the only stone tools that undergo changes during their use lives. Stone scrapers, knives, and blades have been shown to change morphology as a result of use and resharpening (Goodale et al. 2010; Hiscock and Attenbrow 2003; Hiscock and Clarkson 2007; Clarkson 2002). As Lyman (Chapter 2 and preceding text) notes, it is important to understand the units we are measuring. It is little wonder that Shott (Chapter 3) when referring to projectile point characteristics used in phylogenetic analysis says, "The phylogenetic method used, common in cladistic studies, produced parsimonious cladograms that matched none of the outcomes predicted by any hypothesis, even the one favored."

Chapter 3 by Shott has been mentioned several times in this section. His contribution emphasizes details that are worth considering in phylogentic analysis of lithic artifacts. However, he does more than identify problem areas. He suggests that archaeology needs to embrace a new theoretical perspective and suggests another evolutionary approach used in the biological sciences, morphometrics. Shott describes how morphometrics can overcome many of the analytical problems associated with other phylogentic strategies when dealing with lithic technology. He also eloquently advocates for an archaeological theory that focuses on form and pattern of material culture: one that explains variance and change, and allows for an explanation of mode, rate and causes of change in our materials. We feel Shott's ideas are perfectly aligned with the challenges of lithic technology and fit well under the umbrella of evolutionary thought.

HUMAN BEHAVIORAL ECOLOGY, TOOL USE-LIFE, AND RAW MATERIAL PROVENANCE

Roughly simultaneous with the selectionist genre of evolutionary approaches in lithic technological studies was the adoption of evolutionary ecology or behavioral ecology. Evolutionary ecology attempts to explain cultural and behavioral change as forms of phenotypic adaptation to varying social and ecological conditions (Boone and Smith 1998:141). Evolutionary ecologists assume that natural selection has designed organisms to respond to local conditions in ways that increase their fitness (Winterhalder and Smith 1992). Some archaeologists separate evolutionary ecology and behavioral ecology, where "Behavioral ecology is that subset of evolutionary ecology concerned with accounting for the evolution and adaptive character of behavior" (Fitzhugh 2001:129). In either case, phenotypic variability (including behavior) is constrained by natural selection to seek fitness propagating solutions. Models of behavior (fitness maximizing behavior) are then developed in local ecological contexts and are tested against the archaeological record (Boone 1992; O'Connell 1995).

The lithic technological literature is full of such evolutionary ecological approaches dealing with risk (Bousman 2005; Clarkson 2008; Fitzhugh 2001; Shott 1996; Torrence 1983), production strategies (Andrefsky 1994; Brantingham et al. 2000; Jeske 1989; Clarkson 2008), optimization (Bamforth 1986; Bleed 1986; Goodale et al. 2008; Kelly 1988; Tomka 2001), and residential mobility (Brantingham 2006; Lurie 1989; Parry and Kelly 1987; Shott 1986). Much of the early and contemporary evolutionary ecology research dealing with lithic technology used fairly informal modeling that stresses the association of two or more variables. For instance, many studies emphasize lithic raw material transport costs as an independent parameter for or against a dependent variable such as stone tool technology (Bamforth and Becker 2000; Kuhn 2004). Other studies emphasize the relationship between technology and relative residential sedentism (Kelly and Todd 1988; Wallace and Shea 2006). Such simplistic modeling has been criticized as "nonevolutionary" on the grounds that it does not reference evolutionary forces to explain change (Abbott et al. 1996). However simplistic the modeling, such studies attempt to show causal relationships between two or more factors and they tend to place their studies within a historical context to explain change or stasis over time. Explanations of phenomena do not need to be posed in evolutionary contexts to be related to the processes of evolution. Bettinger and Richarson provide a good example of just such a case (1996:224):

> Thus the question posed to a physiologist, "Why is this dog panting"? Is more appropriately and directly answered by saying "To regulate its body