Chapter 1
Introduction

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Introduction

Evolutionary archaeology has developed from a marginal discussion to a mainstream focus in modern archaeology. Archaeologists have become widely aware that the rigorous procedures developed in the guise of evolutionary research can provide significant insight into a host of phenomena including technological change, migration, subsistence adaptation, demography, sociality, and cognition on long and short scales (Lycett 2015). This handbook is designed as a guide to current research trends, insights, and contributions of evolutionary research in archaeology. The theoretical focus in all chapters is Darwinian evolution process inclusive of perspectives broadly derived from the modern evolutionary synthesis (Huxley 1942) and the emerging extended evolutionary synthesis (Laland et al. 2015). Contributions to the book are not about neoevolution and other social science paradigms more influenced by the writing of Spencer (1857; e.g. Harris (1979); White (1959)). Given the focus on archaeology, the book also excludes specific coverage of evolutionary psychology though issues of cultural transmission and cognitive archaeology at times take us into psychological realms. Finally, this is not specifically a book about paleoanthropology though the models of evolutionary archaeology, human ecology, and evolutionary cognitive archaeology offer a wide range of contributions to our understanding of human bio-cultural evolution.

Evolutionary research in archaeology is now a vast endeavor driven by scholars throughout the globe integrating theoretical concepts spanning evolutionary biology to the various cultural sciences (Mesoudi 2011; Mesoudi et al. 2006). The diversity of evolutionary research in archaeology thus poses a significant challenge for explicating its contributions within a single book. I accomplish this by drawing organizational concepts from the work of Niles Eldredge (1985), who, in his book, *Unfinished Synthesis*, argued that evolutionary process can be understood within dual genealogical and ecological frameworks, both hierarchically structured and implicating evolutionary and ecological process on multiple scales. Entities within the genealogical or evolutionary hierarchy span genes to species to monophyletic taxa implicating processes of evolution acting across time measured on scales of single to thousands of generations or, put differently, as microevolution and macroevolution. It is, thus, within the genealogical hierarchy that we monitor evolutionary change through time. However, Eldredge argues that the process of evolution cannot unfold without activity in the adjoining ecological hierarchy as it is here, with its organisms, avatars, and ecosystems, that energy is exchanged,

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reproduction accomplished, and the process of natural selection actually played out. Thus, the effects of economic, social, and reproductive decision-making among living entities in their ecological surroundings are essential to understanding the wider evolutionary process.

Cultural evolution can also be understood within evolutionary and ecological frameworks. Evolutionary anthropologists established the cultural evolution can be understood to act as an inheritance system operating in parallel to biological inheritance (Boyd and Richerson 1985). This dual inheritance framework permits us to recognize a cultural microevolutionary process with a wide array of potential impacts on the development of cultural concepts and their subsequent evolution over shorter and longer time spans. In the shorter term, cultural inheritance is recognized as a complex process of transmission by imitation, teaching, and experimentation regarding cultural characters that vary with the accumulation of errors, modifications, and innovations. Over longer or macroevolutionary spans, cultural evolution can be understood as a product of accumulated microevolution (O'Brien and Lyman 2000), a result punctuated change on higher integrated scales (Prentiss et al. 2009), or the effect of more complex neutral and nearly neutral processes (Kandler and Crema, this volume; Kandler and Shennan 2013; Laue and Wright, this volume). Boyd and Richerson (1992a, b) recognize that cultural inheritance affects ecological (and reproductive) decision-making. Simultaneously, ecological/reproductive decisions have long- and short-term impacts on the persistence of human populations and their associated cultural traditions (Richerson and Boyd 2005). Consequently it is highly appropriate that we study human ecology within evolutionary frameworks. Finally, given the central importance of human cognition to short- and long-term cultural evolutionary process (Abramiuk 2012), evolutionary cognitive research remains a critical concern to an integrated evolutionary approach to archaeology.

The *Handbook of Evolutionary Research in Archaeology* is thus organized around four major themes: cultural microevolution, cultural macroevolution, human ecology, and evolutionary cognitive archaeology. In the following, Chap. 1 introduces each theme and provides a short history of research and a review of associated critical theoretical and methodological milestones. I close with a short review of book contents by subject matter and author.

Research Themes

Cultural Microevolution

Our understanding of evolutionary process on any scale depends upon our knowledge of microevolutionary process as it is here that change occurs and variants persist on an intergenerational basis. The most widely influential model of microevolution derives from the Darwinian synthesis of the mid-twentieth century in which Darwin's (1859) naturalism was combined with genetics (Huxley 1942). Synthetic Darwinism embodied a number of distinct conclusions regarding the structure of the evolutionary process. These included an emphasis on population thinking such that change was reflected in changes in character frequencies. Given this assumption, species were not "real" in an empirical sense (Brooks 2011). Evolutionary process was understood to be an undirected process (thus, non-Lamarckian) that combined exclusively genetic inheritance with sorting mechanisms consisting of natural selection and drift. Put differently, inheritance was viewed as logically independent or "blind" to the effects of selection or drift processes. Evolution was thus assumed to be a gradual process by which organisms with high fitness would outcompete those with lower fitness within an ecological context. This could be visualized as exclusive occupancy of optimal fitness space held as long as not outcompeted by another variant (Brooks 2011).

Anthropologists have been interested in cultural evolution since the era of the social Darwinists (Morgan 1877; Spencer 1857; Tylor 1871). However, it was not until the 1960s that anthropologists and evolutionary biologists took their first forays into serious consideration of cultural evolution from a Darwinian standpoint. An important early paper was Campbell's (1965) "Variation and Selective Retention in Sociocultural Systems." Campbell made four critical arguments that (1) sociocultural evolution is a process of descent with modification and can thus be examined from a Darwinian perspective; (2) evolution is a genetic and cultural process; (3) natural selection is the ultimate force in cultural and biological evolution; and (4) natural selection has direct impacts on cultural variants. As noted by Richerson and Boyd (2000), these arguments were highly influential and shortly led to a number of important papers. Collectively these contributions suggested that it would be possible to use formal models from evolutionary biology to explore nuances of cultural evolutionary process, particularly cultural transmission (Cavalli-Sforza and Feldman 1973, 1981; Ruyle 1973), and if so, then scholars would also be able to model culture as a fitness-enhancing system (Durham 1976). Durham (1976) introduced the concept of cultural selection, suggesting that if cultural variants offered benefits to biological fitness, then selective retention of those traits might be best understood within the synthetic Darwinian framework. Durham (1976, p. 115) called this process "coevolution" and pointed to cultural evolution as a logically separate but complimentary process to biological evolution.

Lumsden and Wilson (1981) took gene-culture coevolution a step further in their explication of its linkages to sociobiological process. Adherents to sociobiology had argued that behavior could be explained as optimal choices for enhancing fitness in particular settings (Krebs and Davies 1981; Wilson 1975). Critiques of this position focused on the nature of cultural behavior as not inherited biologically and thus inappropriate for sociobiological modeling. But Alexander (1979) and Irons (1979) argued that even cultural behavior could be viewed as phenotypic plasticity and thus still fitness enhancing and subject to effects of selection. Yet, this argument still suffered from its inability to adequately explain the diversity of culture using fitness optimality arguments. Lumsden and Wilson (1981, pp. 343–344) argued that while traditional sociobiology could not adequately account for transitional relationships between genes and cultures, coevolution could make that jump via what they called epigenesis or the rules for development of behavior as proscribed by "gene ensembles inherited by single organisms." Persistence of cultural variants within this framework was thus substantially dependent upon genetic fitness resulting from behavior stimulated by acceptance of those variants.

Boyd and Richerson (1985) note that a wide variety of scholars made similar arguments regarding relationships between genes and culture during this period (e.g., Alexander 1979; Baldwin and Baldwin 1981; Boehm 1978; Harris 1979; Plotkin and Odling-Smee 1981) that ultimately amounted to four substantially sociobiological hypotheses: (1) the "pure environment" hypothesis asserts that different behaviors among different groups is the result of optimal decision-making by individuals as structured by the inherited genetic traits and not culture (cf. Alexander 1979); (2) the environment plus culture hypothesis states that inherited cultural variants can have fitness-enhancing effects along with optimal behavior as explicated under the pure environment hypothesis (cf. Durham 1978, 1979); (3) the pure genes hypothesis holds at its ultimate extreme that cultural differences between human populations are best explained by genetic differentiation (cf. Lumsden and Wilson 1981); and (4) the genes plus culture hypothesis asserts that while cultural inheritance is an important force, its impact is generally short term such that decisions to accept or reject particular cultural variants are still most strongly impacted by population genetics (cf. Lumsden and Wilson 1981). Boyd and Richerson (1985, pp. 170–171) point out that these hypotheses are important in that they provide a biologically oriented standard by which other models of cultural evolution must be compared. However, they argue that there is good reason to believe that none are correct given that the impacts of human decision-making outside of culturally inherited tools to solve complex problems are probably quite minimal and there are many examples of cultural traditions persisting despite environmental change.

Boyd and Richerson's (1985) and Richerson and Boyd's (2005) highly influential dual inheritance theory was a critical outcome of the sociobiology and gene-culture coevolution discussions in the late 1970s and early 1980s. Dual inheritance theory was developed as set of formal models specifying culture as information that was acquired through either imitation or teaching/learning.

Boyd and Richerson sought to overcome challenges of the sociobiological models as well as contra-sociobiological perspectives of other anthropologists, for example, Sahlins (1976) who asserted that genetics and adaptation to environmental contexts could be ignored in theorizing culture and culture change. The outcome was recognition of culture as an inheritance system that included explicit mechanisms by which diversity was introduced over time leading to the possibility of divergent cultural traditions. Boyd and Richerson developed explicit models that included guided variation or the effects of learning from a teacher and bias mechanisms that specified the means by which individuals might preferentially favor one cultural variant over another. The latter included direct bias or the results of evaluations of options, frequency-dependent bias or the effects of chooses that which is most common or rare within a social network, and, finally, indirect biases, those that derive from modeling on an index trait (e.g., prestige) that leads to acceptance of additional traits without question. Boyd and Richerson's work firmly established the study of cultural transmission in the social and biological sciences leading to a wide variety of new studies in and out of archaeology (e.g., Bettinger and Eerkens 1999; Eerkens and Lipo 2007; Kandler and Crema, this volume; McElreath et al. 2003; O'Brien 2008; Richerson et al. 2001; Soltis et al. 1995; Stark et al. 2008; Walsh et al. Chaps. 2 and 3, this volume). Theories of cultural transmission were also an important antecedent to the so-called cultural virus theory, which borrowed equally from Dawkins' (1976) concept of the selfish gene imagining cultural entities ("memes") engaging much like genes in strategies to self-replicate (Blackmore 1999; Cullen 1996). Despite the importance of cultural transmission theory to early evolutionary anthropologists, it was curiously unimportant in early evolutionary archaeology.

During the 1970s and through the 1980s, Robert Dunnell published a series of papers promoting what eventually became known as evolutionary archaeology. Dunnell (1980) offered a number of critiques of archaeological (and by extension, anthropological) theory focusing in particular on problems of essentialism and uses of "common sense" in anthropological interpretation. Dunnell's fundamental concern was that in pursuit of the goals of processual archaeology that involved interpretation of sites in order to reconstruct the functioning of cultural systems, scholars effectively reified the present thus biasing any hope of understanding change. Further, they introduced explanatory bias clouded by ethnocentric assumptions by relying implicitly on so-called common sense arguments derived from Western culture. To Dunnell, this left archaeologists in the position of seeking explanations for change between invalid cultural constructions without reference to defensible theoretical concepts. Interestingly, the post-processual theorists of the 1980s posed some of the same critiques but answered them with a push to move away from science toward Marxian-inspired interpretivist archaeology (Hodder 1985; Shanks and Tilley 1987). Dunnell took the opposite tact promoting an empirically based archaeology that relied heavily on the synthetic evolutionary model. Dunnell's (1980, 1982, 1989) conception of an evolutionary archaeology aligned archaeology with paleontology in the sense that archaeologists cannot direct monitor cultural change at the level of information as proposed, for example, by Boyd and Richerson just as paleontologists could not study evolution as change in gene frequencies. Rather, archaeologists were faced with variation in material culture (artifacts and features), which evidently changed over time but not in the same way as biological species. Indeed, this issue had been a long-standing concern to archaeologists effectively preventing culture history era scholars from adopting synthetic Darwinism at much earlier dates (e.g., Brew 1946; Willey 1966). The study of artifacts with a particular focus on classification became a central concern to early evolutionary archaeology (e.g., Dunnell 1989, 1995; Ramenofsky and Steffen 1998), and this along with a concern for change over extremely long time spans helps to explain its limited engagement with cultural transmission theory (Cochrane 2009).

To create a truly Darwinian scientific archaeology, Dunnell argued that artifacts represent the hard parts of the human phenotype much like fossils and that change was not qualitative but quantitative as characters were added and replaced (Dunnell 1989). If artifacts reflected the evolution of the human phenotype, then it positioned archaeology as another evolutionary science (Goodale et al. this volume). Next, Dunnell needed a way to understand the evolutionary process from a material cultural standpoint. Drawing from the basic tenets of the synthetic model, Dunnell (1989) and colleagues (e.g., Rindos 1989) made the critical argument that, despite the well-recognized fact that cultural transmission is rather Lamarckian in structure (e.g., Boyd and Richerson 1985), when viewed in the long term, cultural variation is still undirected or blind to future developments. This view permitted early evolutionary archaeologists to thus avoid issues of cultural transmission process and to focus on sorting mechanisms of cultural variation (however acquired). Early papers emphasized the importance of natural selection as the dominant force in material cultural evolution (O'Brien and Holland 1990). Fitness was a thorny problem given the challenges of explaining artifact change with a biological model but was resolved as potential for replicative success (Leonard and Jones 1987) or, later, acquisitive fitness (Chatters 2009). Although Dunnell (1980) had initially recognized the possibility of complex macroevolutionary processes in cultural lineages, evolutionary archaeology in effect hardened around a somewhat narrow interpretation of the synthetic model that generally assumed a process of microevolutionary gradualism as the primary pattern and process of cultural evolution (O'Brien and Lyman 2000).

While natural selection was the subject of such attention that 1990s evolutionary archaeology also came to be known as "selectionism," evolutionary archaeologists did not focus exclusively on selection-driven evolutionary trends. Extending back to some of Dunnell's early writing (e.g., 1978), scholars also recognized the importance of drift processes, expected to be associated with artifact style, for example. It was generally assumed that in the absence of adaptive forces, cultural entities would vary due to rates of innovation and "cultural drift" (Shennan 2002). In an important early paper, Neiman (1995) demonstrated that neutral innovation and cultural drift would create patterns in the frequencies of ceramic types resembling what archaeologists call "battleship curves." The issue of neutrality in the cultural evolutionary process remains important as indicated by the frequency of recent papers concerned with the topic (e.g., Acerbi and Bentley 2014; Brantingham and Perreault 2010; Crema et al. 2014; Kandler and Shennan 2013). Advanced quantitative techniques are now being applied to test hypotheses about cultural transmission and neutrality in the archaeological record (Kandler and Crema, this volume). Important outcomes to date from this research suggest that tests of neutrality and transmission process using archaeological data should be designed to recognize the effects of equifinality as in some cases multiple transmission histories may give rise to common patterns.

Cultural Macroevolution

Macroevolution developed as the study of evolution at the species level, which for organic evolution means primary data come from fossil record (Eldredge 1989; Stanley 1998). This contrasts with neontology with its focus on extant organisms. Simpson (1944) made use of the term macroevolution in his overview of paleontological contributions in reference to evolutionary trends, patterns, and rates, drawing from Goldschmidt (1940), to make a distinction between changes within species and that above the level of species. However Simpson's use of the term macroevolution was apparently not in recognition of macroevolution process as distinct from that of microevolution. Rather, to Simpson the term was a practical necessity given different sources of data where microevolution focused on genetic changes across limited numbers of generations and macroevolution emphasizing evolution on scales of species, genera, families, and orders (Stanley 1998). Macroevolution as a distinct area of study faced two major challenges. First, it is hard to do given necessary reliance on fossils. An overarching bias against evolutionary research using fossils had been set in motion by Darwin himself (1859) who sought to defend his position that species were in constant and very gradual state of change by noting that the spotty fossil record of the mid-nineteenth century and its implications for a punctuated process could not possibly be valid for anything other than a marker of the fact that evolution had occurred and that it indeed had significant time depth. A century later, assumptions of an insufficient fossil record still relegated paleontology to the study of geological time and explication of the history of animal and plant life (Gould 1995). Then, the development of evolutionary genetics (Dobzhansky 1937; Wright 1931) strongly reinforced the assumption that evolutionary process played out on microevolutionary scales. Thus, the second challenge for macroevolution was the assumption that there was no such thing as macroevolutionary process, only microevolution stretched out to long time scales (Eldredge 1999). Yet even Darwin had titled his epic tome "On the Origin of *Species*..." (Italics mine) implying that such biological entities might be real and that they could evolve in a process as described by Darwin and, later, the scholars of evolutionary genetics. One potential pathway out of this paradox was the study of speciation (e.g., Mayr 1942; Lewis 1962) with its implication that species were stable entities and that the bulk of evolution occurred during their emergence (Stanley 1998). A "hardened" synthetic evolutionary biology was ultimately not generally receptive to species as real entities (Eldredge 1995), and it eventually fell back to paleontologists (at least to a substantial degree) to make the case. Thus, the publication of Eldredge and Gould's (1972; Gould and Eldredge 1977) arguments for a process of punctuated equilibria acting on species and higher scales ushered in a substantial debate in evolutionary biology that in part resulted in the establishment of the field of paleobiology and its primary focus on macroevolutionary process (Gould 1995). Discussions in paleobiology regarding punctuated equilibria (Gould 2002), multi-level selection (Eldredge 1985; Stanley 1998), and heterochrony (Gould 1977) would help set the stage for today's considerations of the extended evolutionary synthesis, though recognizing that primary contributions are also coming from wider evolutionary biology (Laland et al. 2015).

While the term macroevolution was rarely used, earliest writings in evolutionary archaeology invoked macroevolutionary issues. Dunnell (1980) noted that the pattern of evolution regarding cultural entities could be gradualist or punctuated depending upon scale. Inter-individual genetic change would necessarily be gradual, while change on the scale of species would appear punctuated. Applied to culture Dunnell (1980) pointed to findings of culture history archaeologists that archaeological phases seemed to reflect punctuated change and periods of stasis. However, he also cautioned that such inferences could also be by-products of applied analytical methods. Implicit within Dunnell's argument was an apparent assumption that culture could be measured on different scales with selection favoring traits inherited on both individual and group scales. In the latter case, the implication was that some cultural codes were too complex for any single individual to carry (Dunnell 1980, 1996). If this is the case, then we can only presume that Dunnell was referring to integrated cultural entities more complex than simple rules for making artifacts. It also implied that the cultural evolution could be a hierarchical process with the possibility of change on one scale overriding that of another much as described by Eldredge (1985) in his hierarchical model.

By 1989 however, Dunnell seemed to have little interest in pursuit of evolution on more complex scales beyond artifacts as markers of the human phenotype (Dunnell 1989). Dunnell's positions were substantially reinforced in O'Brien and Lyman's (2000) lengthy review of method and theory in evolutionary archaeology. While still generally avoiding mention of macroevolution by name, these scholars were clearly concerned with macroevolutionary issues as exemplified by their detailed consideration of relationships between archaeology and paleobiology. Ultimately however, their position remained entrenched in the fundamental tenets of the synthetic evolutionary model emphasizing undirected variation and gradual change in the composition of populations over time as impacted by selection and drift. While their focus remained on artifacts, the authors did, however, note the importance for evolutionary archaeology of studying change on all scales. Thus, as exemplified by the work of other scholars (e.g., Braund 1987; Jones et al. 1995; Leonard and Jones 1987; Neff 1992), evolutionary archaeology retained the possibility of inclusiveness in evolutionary analysis within a framework best defined as organismic macroevolution (Prentiss et al. 2009; c.f. Eldredge 1989).

Taxic macroevolution developed within paleobiology as the study of evolutionary forces operating on evolutionary entities at scales above the organism, for example, species and genera (Eldredge

1989; Gould 2002; Jablonski 1999; Stanley 1998). Central to taxic macroevolution was the concept of species selection in which selective forces acted at the level of species as evolutionary individuals. While debated during the 1970s through 1990s (reviewed in Gould 2002), concepts of multi-scalar evolution would eventually become essential to the extended Darwinian synthesis (Brooks 2011; Laland et al. 2015; Müller 2017). This kind of thinking was highly influential on a group of archaeologists during the 1990s seeking a way to move beyond the artifact-centered approach of the evolutionary archaeologists. Prior to this time, scholars had proposed cultural macroevolutionary models (Diener 1974; Diener et al. 1980; Marks and Staski 1988). However, these had generally suffered from poor integration of cultural microevolutionary and macroevolutionary thought. This was particularly evident in Marks and Staski's culture as species approach (see also Pagel and Mace 2004), critiqued for ignoring the cultural evolutionary process on lower scales (e.g., inter-individual cultural transmission) (Boyd et al. 1997; Prentiss et al. 2009).

Rosenberg (1994) provided the first model that could best be linked to taxic macroevolution in recognizing evolutionary process on scales of integrated cultures, termed *baupläne* by Rosenberg. The *bauplan* concept was useful to Rosenberg as it was originally developed in morphometrics to describe a structural design (Seilacher 1970), not a specific evolving entity. Thus, we might envision the "rodent *bauplan*" while recognizing that it was not the *bauplan* specifically that was evolving in contrast to say a particular species of mouse or rat. Regardless, to Rosenberg it was those structural elements within a culture that could be inherited and, thus, evolve in a punctuated manner through periodic crises that could trigger the breakdown and recrystallization of cultural structures. These cultural crises acted something like species selection as, for example, in Vrba's (1985) turnover pulse hypothesis that relied upon periodic ecological crises to eliminate some species and favor others. Thus, Rosenberg's vision of cultural macroevolution relied heavily on the assumption that while lower scale evolution was continuously present, it was the higher scale forces that had the most lasting impacts. Spencer (1990, 1997, 2009; Spender and Redmond 2001) developed a model that recognized selection-driven trends (e.g., McShea 1994) from lower levels leading to newly emergent forms of higher-level integration. For example, decisions made between persons or factions promoting new forms of social organization could be rewarded socially and biologically, thus feeding a growth process leading to new forms of organization. Spencer (1997, 2009) provides the example of the emergent Monte Alban chiefdom "extrapolating" its sociopolitical strategy onto the wider region and thus giving rise to a state-like organization. Spencer's approach was equally influenced by action theory as exemplified by the so-called Michigan school of social evolution (e.g., Marcus 2008; Marcus and Flannery 1996) that recognized a critical role for individual self-interested actors and factions as essential to the emergence of new social strategies. While "intent" was excluded as epiphenomena to evolutionary archaeologists (O'Brien and Lyman 2000), it retained a role to action theorists even when enveloped within a Darwinian-influenced framework.

Prentiss and Chatters (2003), Chatters (2009), Prentiss (2009), and Chatters and Prentiss (2005) offered a third approach to cultural macroevolution that recognized what they termed resource management strategies (RMS) or the integrated logic of human economic organization as evolutionary entities. Recognizing that an entire RMS with its potentially many parts, spanning technology to hunting and gathering tactics and seasonal scheduling, could not be easily transmitted between persons, they suggested that the structural logic of such a complex entity could be transmitted and thus subject to evolutionary forces. Borrowing from Mayr's (1942) model for speciation via reproductive isolation, they argued that local groups socially or physically isolated from dominant regional strategies, while operating under productive resource conditions, offered the best opportunities for rapid evolutionary change. Their model left open the possibility that isolated groups could drift into new forms of organization, for example, by scheduling mishaps and consequent organizational shifts versus simple selection-driven changes as resource structure and demographic conditions changed. Finally, they proposed that regional ecological change could have severe impacts on the survival and further evolution of RMS such that during environmental transitions entire strategies could be driven extinct during short-lived periods resembling Vrba's (1985) turnover pulses. Prentiss and Chatters' arguments regarding the evolution of hunter-gatherer and horticulturalist economic organization are similar to those of Barton et al. (2007), Bettinger and Baumhoff (1982), and Foley and Lahr (2011).

The first decades of evolutionary archaeology were generally long on rhetorical argument and short on empirical tests. A fundamental question lingered and that was whether culture could actually evolve via descent with modification in a branching fashion similar to biological lineages. Evolution by branching is central to a Darwinian understanding of the evolutionary process and is best demonstrated by phylogenetic study designed to determine evolutionary relationships between taxa typically defined as clades (Straffon 2016). Moore (1994) had published a scathing critique of cladistic thought in archaeology and anthropology favoring a model based on the concept of ethnogenesis suggesting that culture change was metaphorically more akin to a braided stream due to blending and borrowing of cultural traits. Moore's argument was influential to those outside of the evolutionary archaeology community who sometimes reified his position with similar statements (e.g., Sassaman 2011). None of these scholars, however, marshaled data to demonstrate whether or not the critique was accurate. Evolutionary archaeology held a long-standing interest in defining artifact lineages and seeking selectionist explanations for particular trends (O'Brien and Lyman 2000). Indeed, it could be argued that this endeavor is essential to creating archaeological histories regardless of explanatory apparatus. Thus, culture historians relied intensively on seriations to not only place artifacts in time space sequences but also to define ancestor descendent relationships (Lyman et al. 1997).

Anthropologists and archaeologists developed an increasingly serious interest in defining phylogenies during the 1980s and 1990s while focusing on two problems: defining lines of inheritance to earliest ancestors to develop an understanding of geographic expansion and cultural change and distributional studies focused on explanation of adaptive diversity (O'Brien and Lyman 2003). Examples of these studies include Kirch and Green's (1987) research into Polynesia adaptations and dispersals; Renfrew's (1987, 1992, 2000) studies of culture, language, and DNA distributions; and various studies into African population movements and cultural adaptations (e.g., Holden and Mace 1997, 1999; Mace and Pagel 1994). Of particular significance for evolutionary archaeology was for some an exploration of phylogenetic modeling using cladistics (Straffon, this volume). Cladistics was developed in biology as a formal means of defining ancestral relationships under the assumption that evolutionary lines eventually split with descendants retaining some ancestral traits while also acquiring new or "derived" traits (Hennig 1966). In theory the most recent descendants within a given phylogeny would also have the greatest frequency of derived traits (Mayr 1969), and thus, all things equal, the "trees" generated by cladistics should represent some underlying historical pattern that could be explained using evolutionary theory (O'Brien and Lyman 2003). But phylogenies generated by cladistics or phenetic techniques that replicate cladistic outcomes (e.g., neighbor joining and NeighborNet networks) are complicated by the possibility that not all relationships between taxa developed from simple branching. In some cases, results are clouded by borrowing and blending effects that are identified as reticulations as might be typical of ethnogenesis per Moore (1994) and earlier concerns by Kroeber (1948). Fortunately, there are quantitative techniques that permit assessment of the degree to which cladistic outcomes are impacted by reticulations, and this provides the opportunity to test the hypothesis that cultural evolution occurs via descent with modification.

A wide range of phylogenetic studies directly addressed the problem of vertical versus oblique and horizontal inheritance initially demonstrating that the issue was one of quantitative variability. Descent with modification was recognizable along with the variable effects of blending in multiple artifact lineages including projectile points (O'Brien et al. 2001), weavings (Tehrani and Collard 2009), skateboards (Prentiss et al. 2011), basketry (Jordan and Shennan 2009), pottery (Cochrane and Lipo 2010), and Lower Paleolithic hand axes (Lycett 2007). Mace and Holden (2005) argued that the phylogenetic approach could be expanded to study the evolution of a wider range of phenomena including complex cultural adaptations. Consequently, scholars demonstrated descent with modification had also occurred in complex technological traditions including ritual features (Cochrane 2015), house architecture (Jordan 2015; Jordan and O'Neill 2010), Neolithic plant economies (Coward et al. 2008), and hunter-gatherer resource management strategies (Prentiss et al. 2014a, b, 2015). An outcome of the latter studies was confirmation of the cultural macroevolutionary contention that higher-scale entities can be measured and shown to evolve via descent with modification. Bayesian phylogenetic analysis is now increasing our ability to directly address macroevolutionary questions regarding cultural branching on higher scales along with variation in rates of evolution (Gjesfjeld and Jordan, this volume).

Cladistic analysis has been very effective at demonstrating the pattern of evolution with multiple data sets reflecting on phenomena of multiple scales. However, explanation remains a matter requiring explicit attention to theoretical concerns. A number of cultural evolutionary scholars have promoted the use of fitness landscapes to envision shifts between adaptive strategies whether optimal means of projectile point manufacture (Mesoudi and O'Brien 2008a, b) or wider adaptive strategies (Bettinger 2015). The fitness landscape concept was originated by geneticist Sewell Wright (1932) who used simple drawings to depict a hypothetical topographic landscape to depict a range of theoretical fitness possibilities (Z axis) for genetic combinations (X and Y axes). Higher "peaks" on the landscape meant higher potential fitness, while low peaks and troughs in between reflected lower fitness options. Evolution was envisioned as a process by which characters shifted between peaks due to the effects of genetic drift and natural selection. While Wright's ideas have been extensively discussed and debated (e.g., Arnold et al. 2001; Boyd and Richerson 1992a; Calcott 2008; Gavrilets 2003; Kaplan 2008; Kauffman and Levin 1987; Pigliucci 2008), they remain important to scholars in evolutionary biology, paleobiology, and evolutionary archaeology. Evolutionary archaeologists have used fitness landscapes as metaphors for microevolutionary process in reference to projectile point manufacture (Mesoudi and O'Brien 2008a, b) and macroevolutionary process regarding stasis (Prentiss 2009; Prentiss and Lenert 2009) and rapid change (Bettinger 2009; Chatters 2009; Kuhn 2006; Spencer 2009). Challenges remain however, as archaeologists have generally relied upon fitness landscape concepts that are little changed from Wright's original models, whereas much is changing in evolutionary biology. Future research will be necessary to develop a more sophisticated approach for cultural evolution drawing from more complex landscape metaphors as associated with nearly neutral models and dynamic, three-dimensional, and holey fitness landscapes (e.g., Kauffman and Weinberger 1989; Gavrilets 2004; Gravner et al. 2007). Such models may offer significant potential for tackling challenging cultural macroevolutionary and paleoanthropological challenges including extremely long-lived technologies in the Paleolithic (e.g., hand axes, Mousterian tool complexes, Upper Paleolithic blade production systems) and major cultural transitions such as the origins of agriculture (Laue and Wright, this volume).

Human Ecology

Anthropologists and archaeologists have had a long-standing interest in human ecological relationships. This has led to a variety of productive research ventures and alternative theoretical perspectives, not all of which were in line with Darwinian thinking. Neoevolution (Sahlins 1960; Service 1962; White 1959) and cultural ecology (Steward 1955) were significant theoretical advances over simple environmental determinism and historical particularism of the late nineteenth and early twentieth centuries. Each directed scholars toward consideration of cultural adaptations within environmental contexts. Yet each suffered significant flaws. As argued by Smith (1991; Smith and Winterhalder 1992), neoevolutionism's primary flaw was typological essentialism, the requirement that a tremendous array of variation be collapsed into "types" such as "bands" and "chiefdoms." Neoevolution, with its theoretical base in Spencer's (1857) brand of evolutionary thinking (Dunnell 1980), was very influential on archaeological theorizing during the 1960s and later as, for example, is evident in the writing of early processual archaeologists (e.g., Binford 1962, 1968). Debates over the use of neoevolutionary terminology continue in anthropological archaeology (e.g., Pauketat 2007). Cultural ecology led to a wide range of studies focused on systemic relationships between local environments and aspects of culture (e.g., Lee 1979; Rappaport 1968). The primary problem with cultural ecology was its reliance on functionalist explanations involving circular logic such that outcome (e.g., benefits to a population) would explain origin. Typically on weak theoretical grounds, such explanations were also not well validated empirically (Smith 1991). Piddocke's (1965) work on the Kwakiutl potlatch is a particularly good example of the functionalist approach. Harris' (1979) cultural materialism was a theoretical descendent of cultural ecology and neoevolution and suffered from the same challenges, in particular, insufficient capacity to define and integrate critical concepts (compare to explanatory structure of synthetic Darwinism) and inability to generate adequate testable propositions, thus leading to nothing much better than "loose plausibility arguments" and "an extreme polemical tone in anthropological theorizing" (Smith 1991, p. 7).

Problems with neoevolution and cultural ecology inevitably led to a strong theoretical response both in sociocultural anthropology and archaeology. Despite the array of important and insightful studies generated within the cultural ecology framework, many sociocultural anthropologists left the fold during the 1970s to focus on non-ecological issues associated with belief systems, symbolism, and Marxian criticism (e.g., Sahlins 1976). A similar trend was initiated in the 1980s in archaeology leading to the so-called post-processual rebellion against Lewis Binford and the processualists (e.g., Hodder 1985). A chief criticism of the latter scholars was that cultural ecology and neoevolutionism left little place for individual agency given their focus on systemic relationships. Their solution was to relinquish interest in ecology in favor of culture-centered understandings. However, as seen with evolutionary archaeology, there was really no need to drop evolution or ecology when Darwinism offered a powerful framework that recognized and indeed relied upon concepts of individual agency as a core element in the structure of explanation. Evolutionary biology was meanwhile already substantially down the road in developing a Darwinian ecological approach to economic, reproductive, and social behavior.

While much ecological research prior to the 1960s had been substantially descriptive, a few mathematically inclined ecologists explored models concerned with competition, predation, and population dynamics (Winterhalder and Smith 1992). This set the stage for the first recognized studies in evolutionary ecology by David Lack (e.g., 1954) and Robert MacArthur (e.g., 1958, 1960). Critically, these scholars wed natural selection thinking from the Darwinian synthesis with the interests of ecologists in thinking about predation strategies, population regulation, community structure, and competitive relationships (Winterhalder and Smith 1992). This was in many ways revolutionary as it opened doors to study of many topics that had long challenged ecologists and simultaneously led to new subfields including island biogeography (MacArthur and Wilson 1967), foraging theory (MacArthur and Pianka 1966), and reproductive ecology (Orians 1969). By the 1970s, the field of evolutionary ecology was formalized by the appearance of multiple textbooks (e.g., Emlen 1973; Pianka 1974; Roughgarden 1979Winterhalder and Smith 1992). In the late 1970s, an initially small group of anthropological scholars recognized the advantages of evolutionary ecology for addressing questions of variability in human behavior in its ecological context (e.g., Smith and Winterhalder 1992; Winterhalder and Smith 1981). Evolutionary ecology offered a comprehensive approach to understanding diversity while avoiding problems of environmental determinism, normative types, functionalism, and culture exclusiveness inherent in other approaches. It permitted linkage to the well-developed tenets of synthetic Darwinism, and it required formal hypothesis testing (Richerson 1977).

Evolutionary ecology (EE) is a diverse field with many subareas. The variant most widely in use by anthropologists and archaeologists is human behavioral ecology (HBE) given a focus on human decision-making and adaptive behavior. Within HBE, anthropological scholars pursue in particular foraging theory, reproductive ecology, and socioecology. While details of individual models vary, all have certain aspects in common. First, models in EE are explicitly formulated within a synthetic Darwinian framework assuming that behavior is part of the human phenotype. Natural selection is assumed to act on phenotypes thus favoring the preservation of certain phenotypes and their associated genotypes. As noted by Kelly (1995), this raises two positions on the evolutionary process in reference to adaptive behavior. The "strong sociobiological thesis" recognizes a strong link between behavior and genetic variation, thus arguing that if behavior is genetically controlled and permits significant reproductive success, then that behavior will become more common. This view immediately encounters the well-debated problem that variability in human behavior is not determined by genetics. This then takes us to the "weak sociobiological thesis" that human behavior results from decision-making that could impact reproductive success measured as inclusive fitness (Kelly 1995). As recognized by cultural microevolutionary scholars (e.g., Boyd and Richerson 1985), this does not mean that natural selection does not affect persistence of cultural characters and their associated human behaviors. Ultimately, HBE proponents favor the weak thesis and assume that behavior comes about via a complex relationship between individual learning and cultural and genetic inheritance, the critical factor being that, however inherited, behavior has impacts on fitness. This naturally leads to the second common characteristic of models in EE, the assumption of methodological individualism (Smith and Winterhalder 1992). Synthetic Darwinism recognizes the effects of selection on variation in phenotypes within population expressed over an intergenerational basic. This requires that analysts be concerned with variability whether expressed with genetic, cultural, or behavioral data. Hypotheses within HBE are then constructed around adaptive decision-making by individuals whether associated with food getting, land use, population regulation, or social cooperation (Cannon and Broughton 2010; Kelly 1995). Third, EE and HBE hypotheses are therefore structured as formal models incorporating optimization assumptions associated with some currency, calories, for example, as a proxy for reproductive fitness in foraging theory (Kelly 1995; but see Bamforth 2002). Optimality has come under criticism as unrealistic for cultural bearing species (Joseph 2000) and as another example of "Panglossian" storytelling (Gould and Lewontin 1979). However, EE/HBE proponents respond that optimality assumptions are simply hypotheses that when tested provide insight as to actual behavioral decision-making that might permit refinement and further research (Cannon and Broughton 2010; see also Gremillion, this volume; Nagaoka, this volume). Finally, in developing optimality models, EE/HBE scholars often rely on assumptions of rationality and universal environmental knowledge by individual actors. This has generated substantial discussion (Cannon and Broughton 2010). As with optimization, rationality has been critiqued as inappropriate given complexities of cultural and cultural inheritance, and yet empirical testing has repeatedly supported the fact that people often do act in economically rational ways (Winterhalder and Smith 2000). Several responses have been proposed to concerns over knowledge assumptions. The first is that cultural inheritance provides "rules of thumb" that often act as proxies for universal knowledge (Boyd and Richerson 1992b). Second, not all models derived from HBE assume universal knowledge as associated with colonization scenarios (Kelly 1999). Third, as noted by Cannon and Broughton (2010), economists have increasingly adjusted their cost-benefit models (the logic of which typically influences those of HBE) to reflect knowledge derived from previous experience.

Evolutionary ecology has been enthusiastically integrated into archaeological research agendas (Bird and O'Connell 2006; Codding and Bird 2015) focusing on a variety of questions that include hominin evolution (e.g., O'Connell et al. 1999), hunter-gatherer subsistence and mobility behavior (e.g., Grayson and Delpech 1998; Kelly 1999; Nagaoka 2005; Stiner et al. 1999), forager-farmer transitions (Kennett and Winterhalder 2006 [and papers therein]), food production (e.g., Barlow 2002; Gremillion 1996), technological decision-making (e.g., Beck et al. 2002; Borrazzo 2012; Clarkson et al. 2015; Goodale et al. 2008; Goodale and Andrefsky 2015 [and papers therein], Kuhn 1994; Messineo and Barros 2015; Surovell 2009), and socioecology (e.g., Bettinger 2015; Eerkens 2013; Hildebrandt and McGuire 2002; Zeanah 2004). Archaeologists interested in using models from evolutionary ecology for explanation of diachronic process have needed to come to terms with the challenge of working with effectively "space-like" models for "time-like" process (e.g., Leonard 1998). Archaeologists are not able to monitor the decision-making of the individual actor and typically cope with measuring decision-making resulting from many events. This does not preclude archaeology from the use of such models given that the record could reflect the cumulative impact many decision-making events. Simple models can thus be very useful for understanding persistent behavioral phenomena. However, this raises an additional concern regarding the appropriate currency used in model construction. Simple models may indeed offer powerful explanations, but they may also be wrong given the possibility of inappropriate assumptions. Debates over Middle Holocene hunting behavior in California illustrate this issue very effectively. The expanded role for mid to large game in hunter-gatherer subsistence economies has been explained as costly signaling by men (Hildebrandt and McGuire 2002) implicating social prestige as a currency. In contrast, a counter hypothesis suggests that cooler and wetter conditions (and thus, better forage production and more game) made hunting a calorically less costly option thus leading to increased frequency of hunting decisions and successful outcomes (Broughton and Bayham 2003; see also Winterhalder 2004). Within the theoretical and methodological framework of evolutionary ecology, resolution of such debates does not depend entirely upon rhetorical flourish or theoretical logic but empirical testing.

An important constraint on human behavior comes with the relationship between resource productivity and demography. The models of Boserup (1965) and Malthus (1976) have been equally influential in EE/HBE theorizing and research. Boserup's (1965) position regarding population pressure and intensification was influential on thinking about subsistence intensification among, for example, hunter-gatherers (e.g., Broughton 1994; Janetski 1997; Morgan 2015). Malthusian models are increasingly important for understanding subsistence, technology, reproduction, and social decision-making (Lee 1993; Puleston et al. 2014; Winterhalder et al. 2015; Wood 1998). Theoretical models offer explicit predictions for optimal decisions and potential outcomes in Malthusian population cycles defined by Puleston et al. (2014) as copial, transitional, and Malthusian. Limited archaeological research has focused on testing these predictions with some success (e.g., Prentiss et al. 2014a, b).

Archaeological applications of EE/HBE logic in explanations for major subsistence and settlement change, in particular, the forager-farmer transition, have recently been challenged by proponents of niche construction theory (NCT) a component of the extended evolutionary synthesis (Smith 2015; Zeder 2016, 2017). Niche construction theory asserts that organisms create changes in their environments that alter ecological interactions and consequently affect evolutionary process. A major implication is that through niche alteration and/or engineering, a coevolutionary process is initiated between the organisms inhabiting a constructed niche (Odling-Smee et al. 1996; Kuijt and Prentiss 2009; Laland and O'Brien 2010; Zeder 2017). When applied to the origins of agriculture, it predicts in that human niche constructing activities could have created contexts favoring increased local biomass and thus a wider resource base that in turn would favor rapidly expanding landscape alteration by human groups and rapid change in the nature and scale of human cooperative activities (Zeder 2016, 2017). This is in substantial contrast with models drawn from human behavioral ecology, which predict domestication as an incidental by-product of expanding diet breadth in the context of demographic packing or climate-induced ecological change reducing access to highest-ranked resources and associated with social changes that include increased inter-group competitive behavior (Zeder 2016). This has led to substantial debate (Gremillion et al. 2014; Zeder 2016), but given that precepts drawn from HBE may be useful for predicting and understanding incidences of niche construction, it is likely that aspects of each will prove not incompatible (Mohlenhoff and Codding 2017).

Evolutionary Cognitive Archaeology

Archaeologists have long been interested in the evolution of human cognition, and this interest has played a significant role in the development of approaches to measuring variation in human behavior. Over the past 150 or so years, the sophistication with which archaeologists have come to approach human behavior, material culture, and human cognition has undergone radical change. Today, the recently developed field of evolutionary cognitive archaeology (ECA) has become aligned with the related fields of paleoneurology, primatology, and evolutionary psychology. However, getting to today's level of discourse and ongoing research has taken considerable time beginning with early concerns about the meaning of artifact typology and progressing through initial theories of the mind as related to artifact manufacture and finally to recent debates concerning the extended mind and its implications for the meaning artifacts as related to the evolution of cognition.

Debates over the uses of archaeological typology exemplify early concerns regarding the manufacture and meaning of artifacts. While nineteenth-century typologies were often designed to show human progress (Daniel 2013), some early archaeological scholars explored concepts that would later be considered in cognitive archaeology, for example, the lithic reduction systems of Holmes (1894). The debate between Ford (1954) and Spaulding (1960) over the nature of archaeological typology exemplifies concerns over our ability as archaeologists to measure human intent and thought processes. Ford favored artifact types as measures of human organization, whereas Spaulding felt that typologies could be reflections of decisions made by their creators and thus indicators of thought processes as, for example, mental templates. The idea that artifacts could reflect mental images or templates strongly influenced the research and writing of Bordes (1968), who eventually debated Binford (1973) regarding the meaning of Mousterian artifact variation. Curiously, despite their differences of opinion regarding the ultimate cause of differences at the assemblage scale, Binford favoring functional variation and Bordes arguing for ethnic distinctions, neither questioned the underlying tenets of the typology as reflecting mental templates. Simultaneous to these discussions, archaeologists had also introduced the "generative concept" emphasizing the mental rule book underlying the development of certain material items (e.g., Breuil 1952; Leroi-Gourhan 1965, 1972). The concept of *chaîne opératoire* or operational sequence was developed to explicate the organization of toolmaking, in effect providing insight into the syntax of artifact manufacture. *Chaîne opératoire* has been widely used within various areas of archaeological research from lithic technology (Geneste 1985) to evolutionary archaeology (Jordan 2015). Abramiuk (this volume) notes that *chaîne opératoire* was foundational to the development of evolutionary cognitive archaeology as it has provided a means by which archaeologists could begin to explore the logic behind decision-making at specific stages of manufacture but also the structural logic behind the production system overall.

By the 1970s, archaeologists interested in cognition had begun to recognize that their research could be enhanced by reference to a cognition research well outside of archaeology. Wynn (1979) explored the manufacture of Acheulian stone tools in light of Piaget's development model and thus demonstrated that archaeological understanding of major classes of tools could be significantly enhanced by formal use of cognitive theory. This in turn had important impacts on how the ECA developed during the 1980s and 1990s. This approach to understanding artifacts in light of their evolved cognitive capabilities would be termed the internalist approach by Garofoli (this volume) and the conditional approach by Abramiuk (2012). Abramiuk (this volume) explains that using this approach, cognitive capabilities can be defined within a framework that links actions within cognitive capabilities as defined by conditioning arguments. Garofoli (this volume) notes that this approach recognizes that artifacts develop from computational mechanisms in the human brain, thus the "internalist" label. The conditional or internalist approach received wide attention during the 1990s with the publication of significant books including works by Renfrew and Zubrow (1994), Donald (1991), and Mithen (1996). These works, especially Renfrew and Zubrow, sought to expand our understanding of how people thought and consequently how that impacted human technology. The works by Donald and Mithen expanded cognitive archaeology explicitly into evolutionary discussions proposing hypotheses for human bio-cultural evolution.

Donald (1991) set the stage for the theoretical expansion of ECA by making the case that the mind might be understood as exiting beyond our physical selves. Thus, to him, stages of cognitive evolution were also cultural stages. In just over a decade, central discussions in ECA began to focus on the extended mind (DeMarrais et al. 2004) with its focus on the extension of cognition into a variety of material media. The reaction against the older “internalist” approach drew from new thinking that rejected the idea that material objects were merely by-products of operationalized codes in our minds while omitting the opportunity for the mind to also engage in intentional construction of its cultural surroundings (Garofoli, this volume). Two branches developed from this line of thinking known as material engagement theory (MET) (Malafouris 2013) and the related, radical enactive cognitive archaeology (RECA) (Garofoli 2018). As noted by Abramiuk (this volume), MET depends upon an ontological assumption that the mind constitutes a whole simultaneously inclusive of the body, the physical world, and actions undertaken therein. RECA takes these perspectives one further step in linking cognitive acts to coupling of an agent with the surrounding world and thus permitting the material world a role in imagination and the scaffolding of new representations (Garofoli 2015, 2018, this volume). Thus, there is the fuel for an emerging debate between proponents of internalist/conditional approaches to ECA and that of MET/RECA. Abramiuk (this volume) argues that both can be criticized with the conditional approach focusing too strongly on abstract qualities over ecological conditions associated with evolutionary process and MET suffering from challenges to theoretical validity, epistemological rigor, and methodological difficulty (in defining data for formal tests). Abramiuk and Garofoli are optimistic that a young ECA will resolve some of these challenges and continue to offer significant contributions to evolutionary research in archaeology particularly given theoretical linkages to concepts associated with the extended evolutionary synthesis including plasticity and exaptation. The potential for significant contributions is well illustrated by the debates over the evolution of “art” from the Paleolithic (Straffon, this volume).

Organization of the Handbook

Evolutionary research in archaeology has a great history and a grand future. This handbook is designed to introduce the reader to major research directions and contributions within the four major themes. In doing so, it provides opportunities for a range of scholars, many early to mid-career, to address the state of the art in the field and, in so doing, define future directions. The handbook is divided into four sections associated with the previously discussed logical divisions to scholarly endeavors in the field. The microevolution section begins with an introduction to the basic concepts underlying the bio-cultural evolutionary process (Walsh et al. Chap. 2) and continues with a focus on innovation and cultural transmission (Walsh et al. Chap. 3), selection (Goodale, this volume) and neutral models (Kandler and Crema). Macroevolution chapters outline major metaphors, models, debates, and future directions (Prentiss and Laue), landscapes and nearly neutral models (Laue and Wright), phylogenetics (Straffon, Chap. 8; Gjesfjeld and Jordan), and macroevolution and social change (Spencer). The human ecology section includes chapters exploring basic concepts (Prentiss), key tenets of optimal foraging theory (Nagaoka, Gremillion), socioecology with special reference to signaling theory (Quinn), ecological demographic theory (Puleston and Winterhalder), and niche construction theory (Riede). Evolutionary cognitive archaeology chapters cover introductory concepts (Abramiuk), radical enactive cognitive archaeology (Garofilo), and ECA’s contributions to the study of art (Straffon, Chap. 20).

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