The Origins and Evolution of Culture

This article outlines a deductive theory that creates a new way to think about the origins and evolution of culture. It is Darwinian in the sense that it posits that novel concepts and behavior, like novel genes, appear randomly and are subject to selection on the basis of specific criteria that are established by the properties of living things. The theory permits us to hypothesize properties of the genome that generate culture and to infer the conditions under which selection would favor the origins of culture. Theoretical deductions lead to the conclusion that the organisms that create culture actively participate in the creation of descendants who exhibit increasing cultural abilities and who generate increases in productivity and more reliable flows of resources. Culture is not something that has evolved solely and relatively recently in the hominin line of evolution. Fossil evidence suggests that culture may have existed at least 50 million years ago, and may have originated more than 200 million years ago.

In his book Innovation (1953), Homer Barnett describes a model of human thinking processes that suggests that the genes that create human brains and thus dictate how we think do not dictate which perceptions will be related to which memory traces, or in which way. We thus think "intelligently" and do not change our behavior merely because we sense material stimuli with particular physical qualities. On the contrary, we construct conceptual models of reality by inference because the genes that control the processes by which concepts form do not control the conceptual outcome of those processes. We thus possess a built-in mechanism—the very process by which people experience material stimuli—which continually generates new and unexpected ways to look at and act in the world.

People are subject to the constraints that bear on all living things. Life may be usefully defined as an open energy system regulated by nucleic acids. By definition, all forms of life require regular inputs of energy and nutrients. Resource is a cover term that encompasses all energy and nutrients and all pathways by which they can be acquired. It follows that selection must favor any property that improves or optimizes resource access, that selection will concentrate innovations that do so, and that selection will build relatively advantageous means of acquiring resources and will eliminate innovations and interfere with the process of resource acquisition.

These propositions are the core of a deductive theory that creates a new way to think about the origins and evolution of culture.1 Previous attempts to conceptualize cultural evolution in Darwinian terms do not tell us clearly and specifically either how genes are related to culture or how genetic change may lead to the origins of culture. They do not tell us clearly how human modes of thought and behavior may be different from or similar to nonhuman modes of thought and behavior. They do not account for the significant trends in hominin biological and cultural evolution. They do not account for obvious properties of human thought and behavior such as our individual variability, our tendency to misconstrue material reality, or our propensity to be self-contradictory.

Previous attempts to conceptualize cultural evolution in Darwinian terms do not answer these fundamental questions because they make untenable assumptions, one of

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which is profoundly wrong.² Dawkins (1976), Cavalli-Sforza and Feldman (1981), Lumsden and Wilson (1981), Boyd and Richerson (1985), and Rindos (1985, 1986), to identify only some of the contributors to this literature, assume that culture is an “inheritance” system; memes, cultigens, or cultural elements, traits, complexes, or symbols are presumed to be heritable. The error here is a simple one: they confuse an idea for a thing. This error has profound implications. It means that conceptualizations built on the error totally misconstrue the issues because they cannot conceptualize the creative properties of human thought and behavior that generate cultural evolution. It also means that, because this error is the keystone for their conceptual structures, those structures crumble entirely once we remove it.

Biologists occasionally also ensnare themselves in another error: they assume, following Adam Smith’s image of organisms that competitively pursue their individual interests, that organisms seek to maximize the number of their genes in the succeeding generation (e.g., William 1966), and, thus, that purposive, intentional behavior is a fundamental driving force of evolution. This is an essentially non-Darwinian view that leads to explanations that are ad hoc or true by definition, and to the logical fallacy of affirming the consequent (see Sober’s thorough discussion [1984]). In The Origin of Species (1859) [1966], Darwin, by contrast, argued that Nature simply exists—as a physical system that operates in terms of discernible principles, and without regard to the intentions, purposes, or rationality of the organisms subject to these principles. In Darwin’s view, the direction of biological or cultural evolution and social change is decided by material events and circumstances completely independently of intentions or of purposeful, rational thought or action. The driving force of evolution is an interaction among environmental parameters, innovations, and selective criteria which are dictated by the properties of living things.

Resource Change and the Origins of Culture

Living things exist only through relationships with environments. Whether the organism is a bacterium, a plant, a fish, or a person, for instance, it must be able to “know” food or danger when it finds them, and it must “know” what to do when it encounters either. Genes construct mechanisms that permit living things to keep track of changes in the world in which they live. We know these mechanisms as “senses.” Environments make themselves known to organisms and organisms track changes in those environments through sound, odor, taste, form, light-spectrum absorption, and other forms of sensation. Senses identify the physical properties of material stimuli and, among some organisms, relay that information along cell pathways to a coordinating center, the central nervous system.

Genes also construct mechanisms that permit living things to change their biological or behavioral state in the presence of significant environmental changes. Because resources change over time, selection will favor organisms that can change their behavior accordingly. Genetically encoded information can determine which properties of physical stimuli, among a vast range of detectable properties, an organism can identify. For example, we do not have the genetic capability, as do some birds, fish, and at least one mollusk, to “sense” the earth’s magnetic field. Our genes do not allow us to “see” ultraviolet light. Genetically encoded information also can instruct an organism to change in specific ways in the presence of stimuli with specific physical properties. This behavioral change mechanism, which we may legitimately call “instinct,” is the simplest one to construct, and plausibly characterized the earliest forms of living things on this planet. It yields a fixed and limited behavioral repertoire and phenotypic plasticity. Some organisms (e.g., bacteria, insects, plants) appear to respond to environmental stimuli almost solely by these means, and perhaps all organisms respond to some environmental cues in this manner.

The timing and predictability of resource change influences the properties of organisms that selection will favor, however. If significant resource change only occurs from one
generation to another, for instance, no selective disadvantage would accrue to organisms that change their behavior mechanically, solely on the basis of genetically encoded information. These would be organisms that used such information to identify resources and resource changes solely on the basis of the physical properties of sensory inputs, and that responded to changes in those cues by "instinct."

For organisms that mediate environmental relationships by instinct, the average duration between the birth of one generation and the birth of its succeeding generation would be short relative to the time span within which significant resource changes took place. Selective disadvantages would only accrue to such organisms if significant resource changes occurred within the course of a single generation and, thus, occurred more rapidly than genetic change.

If generational times lengthen relative to significant resource changes, selection will favor organisms sensitive to discontinuities between perceptions of resources and experience of resources (stored as memory), which respond to those discontinuities by behavioral change and modification. Thus, selection will favor organisms that have memories, can perceive their environments, and could engage in what we might call "simple learning." Simple learning of this kind appears to characterize fish, amphibians, and reptiles. Organisms such as these that utilize memory can be said to possess a conscious awareness of and, thus, a perception of material stimuli because the salient properties of any set of stimuli will be contingent, at least partly, on their prior experience.

This is not to say that genes cease to influence behavior in important ways. For instance, genes must dictate that experience will be stored in a particular form as memory traces. Furthermore, genes continue to determine which physical properties an organism can identify. But genes no longer instruct the organism to change in specific ways solely in the presence of stimuli with specific physical properties. Appropriate behavioral changes must be selected from among a behavioral repertoire on the basis of relationships that are created between specific perceptions and specific memory traces. The existence of perceptions, thus, marks an important change in the manner in which organisms track changes in their environments.

Nonetheless, if intragenerational resource changes occur in predictable ways, genetic change could track them and no selective disadvantage would accrue to organisms that responded to discontinuities between perceptions and memory mechanically, solely on the basis of genetically encoded instructions invoked by specific physical properties of sensory stimuli. Thus, selection for simple learning continues to select for behavioral changes and modifications that are elicited mechanically by the physical properties of environmental things.

However, suppose that significant resource changes occur intragenerationally either very rapidly or randomly. By "random" I do not mean that all possible resource changes are equally likely. "Random" intragenerational resource changes are those that organisms cannot predict because they are determined by a large number of variables, each of which has small effects and can interact in many different combinations to effect resource change at any point in time and space. Organisms subject to very rapid or random intragenerational resource changes would have a very limited potential to change their behavior in adaptive ways if their central nervous system identified discontinuities between percepts and memory of resources solely on the basis of physical cues in sensory inputs.

It follows that selection will favor organisms that can combine perceptions with experience (stored as memory) in ways that are not restricted by experiential cues. This means that selection will favor genes that govern the processes by which perceptions of physical stimuli may be integrated with memory traces of prior experience, but selection will not favor genes that dictate the outcome of that integrative process. Organisms that use this third behavioral change mechanism not only perceive material stimuli but must also conceptualize those stimuli by organizing perceptions and memory traces into mental constructs.
Selection will favor organisms that change both their behavior and their concepts in ways that optimize or improve their access to resources. Hence, selection will favor organisms that generate conceptual and behavioral innovations in the presence of resource changes. Since resource changes cannot be predicted, selection must favor organisms that generate conceptual and behavioral innovations continually. Selection will also favor organisms that match conceptual innovations with corresponding behavioral innovations, whichever occurs first.

It does not follow that the innovations that emerge will optimize or improve resource access in a new structure of resources. Similarly, it does not follow that individuals will correctly identify and choose to utilize those innovations that optimize or improve resource access. On the contrary, resource access is optimized or improved by behavioral and conceptual response diversity. Behavioral and conceptual response diversity is constrained if organisms can change their behavior only by reference to genetically identified experiential cues. It follows, somewhat paradoxically, that selection will favor (1) individuals who cannot invariably generate innovations that optimize resource access, and (2) individuals who cannot invariably identify and correctly choose the innovations that optimize resource access.

However, it does follow that selection will favor those innovations and those decisions that do optimize or improve resource access. It also follows that selection will favor those individuals who can rectify their mistakes most rapidly. Hence, selection will concentrate conceptual and behavioral innovations that improve or optimize resource access.

In short, selection will favor organisms that have genes that control (indeed, that would dictate) the process of concept formation but that do not control the conceptual outcome of this process. These organisms possess the behavioral change mechanism we commonly call “intelligence” (Jerison 1973; Sternberg 1985); forms of life that use this behavioral change mechanism are “intelligent.”

Anthropologists define culture, variously, as systems of mental constructs or symbols, as systems of behavior, or, more generally, as systems of beliefs and behavior. The process of intelligence generates culture, however one wishes to define the term, because selection concentrates conceptual and behavioral innovations that improve or optimize resource access. Hence, when significant intragenerational resource changes occur very rapidly or randomly, selection will favor intelligence and will create organisms that generate culture as a necessary by-product of the means (intelligence) that they use to adjust their behavior to changes in sensory experience.

Genes, Concepts, and Behavior

Mental constructs, as Barnett (1953) shows, are coded bundles of information we call ideas or symbols that are more than the sum of their parts because they integrate information from a variety of senses. They are very much like genes, for concepts function only as whole units, and they exhibit distinctive epiphenomenal properties because they consist of distinctive configurations of parts. Whereas genes are constructed of sequential chemical bases, concepts are constructed from perceptions and memory traces. Unlike genes, however, each part of any concept is itself a concept, and concepts are organized hierarchically. But concepts, like genes, acquire their wholeness and unity only because their components are bound together by relationships of specific kinds. Because concepts cannot exist in isolation, a specific concept must be integrated with other concepts, at least partially, and all concepts must evoke others. Consequently, all concepts function as symbols.

Like genes, the substitution of one or more parts for at least one other part creates a qualitatively different phenomenon. New ideas, like new genes, consist of novel configurations of parts. Moreover, and like genes, the effect of the substitution is contingent on the prototype. This means that changes in concepts must exhibit continuity with previous concepts and that the changes that take place could not have come into being in the ab-
sence of specific cultural prototypes constructed with reference to specific prior material experience. Conceptual innovation, like mutation, is not random in the strict sense that all possible new ideas are equally probable. Conceptual innovation, like mutation, is random only insofar as it is unexpected—we cannot predict which perception or memory trace will substitute for which prototype memory trace, or when it will do so.

Concepts cannot be created unless genes construct neural circuitry that allows information from one sense to be related to information from several or all senses. The hierarchical structuring of ideas plausibly constitutes a genetically controlled technical solution to the problem of packaging information into a minimal physical space in the brain. Moreover, genes appear to determine how many concepts can constitute a given hierarchical level, and genes plausibly determine how rapidly an organism can create relationships among concepts. Among humans, for instance, we commonly find that particular hierarchical levels in short-term memory tend to consist of no more than seven parts and, if information is organized in more than seven units, it tends to be difficult to comprehend (Miller 1956). But there appears to be no restriction on the number of hierarchies into which people can organize a concept. Other organisms may experience sharper restrictions on the number of concepts that can constitute a given hierarchical level, on the number of hierarchical levels that can be created, on the speed with which concepts can be organized, or on the sensory inputs that may be perceived, stored as memory traces, and subsequently integrated as concepts.

However, genes do not determine which perceptual element will be related to which memory traces or in which way. Genes determine only that such linkages will be formed and that concepts will be stored as memory traces, consistent with a small number of packaging constraints.

This conclusion has two primary implications: (1) once a concept has been created as a memory trace it becomes a basis for making perceptions; and (2) any percept or concept, at any time, may be linked with any other concept.

Because any percept may be related to any other concept, or to many others, organisms that mediate their environmental relationships with concepts (1) can reflect on their past experience and can use their past experience to project an image of possible futures; (2) can, therefore, act purposefully to bring about future goals; and (3) can, therefore, change both their ideas and their behavior even if material experience does not change. But they can only interpret the physical properties of particular sensory stimuli by inference (i.e., by speculating, having hunches, making guesses, and formulating hypotheses); hence, they regularly misconstrue prior experience, immediate reality, and the future. Because organisms that rely on intelligence can “know” pertinent domains of their environment only by inference, (1) concepts are arbitrary, ephemeral entities, that cannot be matched perfectly with behavior; (2) “learning” is a creative act; and (3) consequently, the concepts used by any one person change over time and no two people can ever hold identical sets of concepts.

Because “learning” is a creative act, organisms that construct ideas have a built-in mechanism (the process of intelligence) that continually generates conceptual innovation and behavioral change. Consequently, the locus of “culture” is the individual, not the group.

An individual’s culture necessarily reflects his or her interaction with material experience, especially interaction with other people. But culture is not an emergent phenomenon, unlike social phenomena like reciprocity, equality, or competition, which emerge only from the interaction of two or more people. By contrast, culture is created by individual intelligences on the basis of individually unique life history trajectories. Cultural “sharing” and cultural “differences” reflect similarities and differences in the interaction people experience with material stimuli as they trace their unique paths through life. Conceptual and behavioral variability arises as a necessary by-product of “intelligent” processing of sensory experience. Regularities in cultural change can be manifested either as “stability” or as “change.” Both arise because the conceptual and behavioral inno-
vations of specific individuals are subject to selection of varying intensities on the basis of specific criteria—the definitional requirement that living things require regular inputs of energy and nutrients.

**Cultural Dynamics Generate Directional Evolution**

We have long inferred increases in intelligence from increases in relative cranial capacity in the fossil record and from cultural evolution over the Paleolithic—the appearance of the first stone tools, the Acheulian industries whose consistent form implies that they were constructed by reference to a clear prototype concept of form, the evidence of burials and ritual in the Middle Paleolithic which suggest the concept of the supernatural, and the immense proliferation of productive techniques and art forms of the Upper Paleolithic which are mute testimony to profound changes in conceptual abilities. The recurrent increases in intelligence revealed by the archeological record can be deduced from the premise that selection favors biological and behavioral properties that optimize or improve resource access. So can recurrent changes in technology that improve the reliability of resource flows and raise productivity.

Our recent evolutionary history is best conceived as a feedback process driven by cultural dynamics. Organisms with a low level of cultural ability generated a limited number of simple conceptual and behavioral innovations that controlled only limited behavioral domains. Selection brought together some of these innovations as new, relatively advantageous means by which those organisms could gain access to resources. These behavioral changes created selective pressure for increasing cultural abilities because selection favored the organisms that could change their ideas and their behavior in ways that improved or optimized resource access. Organisms that could not effectively utilize these new modes of behavior were selectively eliminated from our line of ancestry (see Wallace 1970:68–69).

Wallace correctly emphasizes (1970:72) that “culture” does not exert selective pressure. Selective pressure exists only as a relationship between the organism and its environment. Intelligent forms of life have a dialectical relationship with their material environment. They use ideas to guide their behavior, but what they do is not mechanically dictated by what they think. What they do becomes part of the environment that they perceive and, by becoming part of it, changes it. What they perceive thus changes over time at least partly because of their own activities. The brains of intelligent forms of life take these perceptions and integrate them with prototype memory traces in ways that generate new and unexpected ways of looking at and acting in the world. This interplay between what one thinks and how one acts, and a world that changes simply because one acts—what we have called “cultural dynamics”—thus regularly generates new and unexpected ways of thinking and acting.

The interaction among ideas, behavior, and material experience that constitutes “cultural dynamics” exerts selective pressures for increasing levels of “intelligence” because selection consistently favors organisms that can create the conceptual and behavioral innovations that selection can then use to build new and relatively advantageous modes of behavior. Organisms with increased intelligence generated further conceptual and behavioral innovations. Selection for conceptual and behavioral innovations that optimize or improve resource access brought together some of these innovations into new, relatively advantageous means they could use to gain access to resources.

The creation of the first stone tools, for example, would have made it easier to shape digging-sticks with which to extract roots; to cut branches with which to build shelters; to kill, carve up, and dismember game; and to protect oneself and one’s food from competitors. The later use of fire made it possible to harden wood in ways that created more efficient digging-sticks and lances, to occupy colder regions, to cook food, and to protect oneself and one’s food from competitors. The ability to cook food profoundly transformed both the reliability and the quality of the nutritional base of our ancestors, and opened
up a vast new range of vegetable foods which, uncooked, had been indigestible or even poisonous. The ability to harden wood and improved stone tool design extended the carrying capacity of regional environments in their own ways because they made more efficient use of existing resources and made it possible to efficiently exploit new sources of food. These behavioral changes created further selective pressure for increasing cultural abilities because selection favored the organisms that could change their ideas and their behavior in ways that improved or optimized resource access. Organisms that could not effectively use these new modes of behavior that were modeled on conceptual innovations were selectively eliminated from our line of ancestry.

Organisms subject to very rapid or random intragenerational resource change may become extinct. This appears to have been the fate of the australopithecines, who disappear from the fossil record somewhere between 1 and 2 million years ago. However, if a species does not become extinct, it will experience random mutations. Even random mutation at low rates must yield genetic changes that increase intelligence. Thus, selection for biological and behavioral properties that optimize or improve resource access must generate recurrent increases in intelligence—recurrent increases in (1) the number of behavioral realms controlled by concepts, (2) the sensory inputs that can be integrated into concepts, (3) the number of ways in which ideas can be related to one another and in the number of hierarchical levels into which concepts can be organized, and (4) the speed with which new concepts can be created.

Intrahistorical resource change may be random or may occur very rapidly due to environmental factors. Brian Hayden (1975) points out that resource stocks are subject to recurrent fluctuations due, for example, to climatic factors and ecological interdependencies among nonhuman species. Resource access is made more reliable, and thus is improved, when resource fluctuations are reduced. Increases in productivity yield more reliable resource flows directly because they reduce the costs that people incur when they seek and use resources. Increases in productivity yield more reliable resource flows indirectly because they increase the amount of time that people can devote to the task of devising new, relatively advantageous means to seek and use resources. Hence, selection will favor conceptual and behavioral innovations that raise productivity and make resource flows more reliable.

Selection does not guarantee that productivity will rise or that resource flows will become more reliable, of course. On the contrary, short-term mistakes will pervade all activities that are carried out under the guidance of cultural constructs. Extinctions can never be ruled out entirely. Moreover, specific cultural changes can be expected to change the environment, and some of these may exacerbate existing resource fluctuations or create new resource fluctuations. One effect of cultural evolution may be to create a deteriorating environment. Nonetheless, selection for conceptual and behavioral innovations that improve or optimize access to resources would mean that the cultural and behavioral changes that comprise the historical record should, in retrospect, exhibit directional change toward increasing levels of productivity and more reliable resource flows (see Hayden 1981).

Even if resource stocks do not fluctuate, however, conceptual change will lead to significant changes in behavior because novel concepts regularly, albeit randomly (unexpectedly) organize the material world in unforeseen ways independently of changes in the immediately perceived physical properties of sensory experience. Cultural evolution will proceed independently of resource fluctuations because selection will favor the conceptual and behavioral changes that optimize or improve access to resources. Cultural evolution speeds up as concepts come to control ever-larger proportions of an organism’s behavior, as the sensory inputs that can be integrated into concepts increase in numbers, as the number of ways in which perceptions and concepts can be organized grow, and as the speed of the process increases. The behavior of such an organism also comes to display “random” changes, from the perspective of those with whom it lives, its predators or its
prey. The evolution of intelligence thus becomes the primary historical reason intragenerational resource change becomes increasingly rapid and increasingly random. Such intelligence-generated resource change plausibly established the conditions under which selection favored the evolution of language as we know it.

Thus, our ancestors actively participated in the creation of descendants who exhibit directional increases in cultural ability because selection for behavior that optimizes or improves resource access generates directional increases in productivity and more reliable flows of resources (Hayden 1981). Organisms that did not have the conceptual ability to take advantage of new, relatively advantageous modes of behavior did not contribute to the pool of genes that comprises our species today. Our ancestors are the organisms which, by mutation, did have this conceptual ability.

Cultural Dynamics and the Evolution of Mammals

The evolution of intelligence and culture is commonly associated solely with human evolution (e.g., Lovejoy 1981; McHenry 1982). We may have underplayed the significance of findings that we are not the only concept-forming species (e.g., Griffin 1984). Although instinct, simple learning, and intelligence are not mutually exclusive, they appear to have emerged at different times in the fossil record. About 50 million years ago, the fossil record displays brains that exhibit fissures and a flexured rather than a linear organization (Jerison 1973:283). Jerison interprets these morphological changes as a solution to the packaging problem of how to fit into a minimal space a brain that was growing larger than that required solely to carry out minimal cell functioning. He points out that this change in the fossil record reflects change in the central nervous system that had been under way during the evolution of mammal-like reptiles some 250 million years earlier, and suggests that the animals that exhibited this change were “intelligent.” I concur. “Intelligence,” as I have been using the word, is the ability to construct conceptual models of reality (Jerison 1973:17) and to use those models “for purposes of adaptations to and shaping and selection of real-world environments” (Sternberg 1985:1111). These organisms created “culture.” Thus, organisms were using culture at least 50 million years ago and culture may have first appeared more than 200 million years ago.

Mammals, the earliest of which were small, nocturnal insectivores, constitute an outgrowth of “mammal-like” reptiles that as a group became extinct some 190 million years ago. Mammals are distinguished from reptiles in many ways, of course. Core elements of the mammalian complex include the following: a palate that is hard rather than soft and does not collapse into the nasal cavity when food is in the mouth; teeth differentiated by shape into incisors, canines, premolars, and molars; high metabolic rates that maintain relatively constant internal temperatures, bodies insulated with hair, and physiological mechanisms that permit fine-tuning of adjustments to cold, heat, and altitude; and a relatively long period of gestation, infants dependent on their parents for their survival, and mothers that feed their offspring breast milk.

We tend to think of the evolutionary emergence of differentiated dentition, a hard palate, high metabolic rates, lengthened periods of gestation and infant-dependency, and breastfeeding mothers as creating the conditions under which “culture” could eventually evolve. In a sense, that is probably correct. Differentiated dentition made the extraction of nutrients more efficient and made it possible to evolve specific forms and numbers of teeth that would optimize resource access for diets with particular compositions. The hard palate made it possible for organisms to eat and to breathe simultaneously. High metabolic rates presuppose a relatively high level of energy and nutrient intake and uninterrupted flow of oxygen. High metabolic rate and a constant internal temperature, bodies insulated with hair, and physiological mechanisms that permit fine-tuning of environmental adjustments made it possible for organisms to extend the range of habitats they could utilize. Lengthened periods of gestation and infant-dependency, and breastfeeding mothers create circumstances in which infants can take advantage of learning and
can come to exploit even more widely diversified niches. Growth in the brain associated with increased cultural ability requires increased levels of energy both during gestation and after birth.

Tom Kemp, in his book Mammal-like Reptiles and the Origin of Mammals, points out that “the essence of mammalian biology is the very high degree of complexity and internal integration of the various structures and functional processes” (1982:313). Kemp thus argues three points. First, the evolution of a particular mammalian characteristic could not proceed far without equivalent evolution in other mammalian characteristics. Random mutation, even at relatively fast rates, cannot be expected to bring about rapid evolutionary change in such complex, integrated systems. Thus, mammalian evolution should proceed slowly. Second, Kemp argues that “mammaness” should not be correlated with particular niches because it is highly flexible and can be adjusted to virtually any kind of terrestrial niche. Third, Kemp points out that mammalian biology cannot be usefully conceptualized as an “all-or-nothing adaptation.” Even incipient mammalian characteristics have selective value. More fully developed mammalian systems possess greater selective value. Mammalian radiations can occur at any point of mammalian development, and selection should favor directional change toward increasingly sophisticated mammalian systems. Thus, mammalian evolution not only should proceed slowly, but should also proceed progressively. He concludes by pointing out that “these three predicted features of the evolution of the mammals are those actually demonstrated by the fossil record” (1982:313).

Kemp’s observations help us better understand why the transition between reptiles and mammals exhibits a slow but consistent change in the direction of increased “mammaness.” But they beg the central question: How and under what circumstances was mammalian evolution initiated? Why should selection have favored the traits by which mammals came to be distinguished from other vertebrates? The evolution of intelligence and culture, which selection favors when intragenerational resource change is very rapid or random, creates appropriate conditions.

We might anticipate that selection will favor differentiated dentition simply because this change increases eating efficiency. Selection will favor hard palates and there will be more intense selection for differentiated dentition, however, only when selection favors high metabolic rates and constant internal temperatures, insulation by hair, and physiological mechanisms for fine-tuning environmental adjustments. Selection will favor these traits when organisms find it advantageous to extend the range of habitats they utilize, but only if they have the behavioral flexibility to effectively exploit new habitats. The emergence of intelligent organisms entails the creation of new behavioral possibilities, even if concepts could be organized only minimally and formed only slowly, and if they controlled only one or two realms of behavior. Because “intelligent” animals possess a mechanism that gives rise to behavioral flexibility that genes deny animals without a cultural ability, they will have a competitive advantage over animals without “intelligence.”

In fact, it appears that differentiated dentition was the first of these mammalian traits to appear in the fossil record. Moreover, the brain appears to have enlarged before the appearance of a complete secondary palate (Kemp 1982:298–305), as we would expect if the selective advantage of other core mammalian traits was contingent on a cultural ability.

Culture may have first appeared among the mammal-like reptiles and their mammalian descendants as an adaptation to nocturnal environments because the reptilian visual sense would not have provided the information necessary to effectively gain access to resources (see Jerison 1973:173–175, 200–224). Organisms that began to seek food at night would have been subject to intragenerational resource changes that would have been random from the perspective of a reptilian brain that relied extensively on visual cues. Selection would have favored a change in the manner in which sound and smell were processed.
Selection would not have favored genes that dictated that specific sounds or smells were to be related to specific memory traces. On the contrary, resource access would be optimized by the development of improved capabilities for hearing and smelling and, thus, selection would have favored genes that made it possible to discriminate among sounds and smells more finely. Jerison (1973) points out that information about smells and sounds is of limited value, however, if it does not also contain information on relative time and distance and so make it possible to precisely locate food and track changes in its position. Thus, selection would favor genes that created an information-control center and a process by which the information available in sounds and smells could be related to memory traces of visual stimuli. The existence of such an integrating center would make it possible to construct a mental map of the landscape with both space and time coordinates.

The changes do not, of course, generate concepts with the complexity and dimensions we are used to. As Jerison points out, however,

even in such simple perceptual worlds one may have a code referring to when as well as where a stimulus occurred relative to other stimuli. It was at least such an advance that was implied in the use of hearing and smell as accurate distance senses. These can add up to a time sense. [1973:275]

Robert Martin (1981) suggests that growth in the brain can only occur when resource fluctuations are dampened and flows of energy and nutrients, consequently, are available more reliably and in greater quantity. However, resources are available in greater quantity and with greater reliability to organisms that can generate conceptual and behavioral innovations from which selection can build new, relatively advantageous means of gaining access to resources. Intelligent organisms that create culture thus actively contribute to the creation of the more stable resource base necessary for further growth in the brain and more sophisticated cultural systems.

Indeed, we can expect that the ability of a species to significantly dampen resource fluctuations stemming from climatic sources or ecological interdependencies among other species will be a direct function of its cultural ability. As that ability increases, the selective forces favoring increased levels of conceptual ability will gradually shift from external sources such as climate to intraspecific competition created by differential cultural abilities. Selection cannot favor lengthened periods of gestation and infant dependency, and of breastfeeding, traits that appear to evolve as an interrelated complex, unless those traits contribute to the formation of new, relatively advantageous means of obtaining access to resources. In the absence of a cultural ability, those traits possess no selective value. Thus, the ability to generate such conceptual and behavioral innovations also creates the circumstances in which selection would favor lengthened periods of gestation and infant-dependency, and of breastfeeding.

Among living mammals, the cultural systems that intelligence automatically generates vary in complexity and sophistication by many orders of magnitude. This is so, I suggest, because intelligence, like "mammalness," is not an all-or-nothing adaptation. Even limited intelligence possesses selective value. Greater intelligence confers greater selective value. Selection favors directional change toward increasingly sophisticated intelligence because intelligent beings generate conceptual and behavioral innovations that selection bring together as relatively advantageous means for resource access. Individuals who were unable to utilize these means were selectively eliminated from the line of ancestry of contemporary mammals.

Trends in intelligence are historical phenomena, however. These trends necessarily will reflect the historically specific selective pressures and genetic, conceptual, and behavioral innovations that were experienced by given lines of evolution. Differences in these historically specific events necessarily yield differently constructed brains with species-specific ideational construction and packaging constraints. The similarities and differences between human culture and the cultures of other intelligent organisms reflect these historically specific events, and should be describable by reference to the following
parameters: (1) the behavioral realms controlled by concepts, (2) the number of ways in which percepts and memory traces can be organized and the number of hierarchical levels into which concepts can be organized, (3) the speed with which new relationships can be formed, and (4) the sensory inputs that can be integrated into concepts. Among people, virtually all behavioral realms appear to be controlled by concepts, and there appear to be no limits to the number of ways in which percepts and memory traces can be organized or the number of hierarchical levels into which an idea can be organized. Any perception or any memory trace thus may be related to any other at any time, and regularly are. The culture of another intelligent organism may control different (and, perhaps, fewer) behavioral realms, and we can expect that it will be built from other sets of sensory information that are organized in different ways, at different rates, and into a different number of hierarchical levels.

However, the ability to create even simple concepts entails the ability to build cultural environments. Organisms build these environments by being able to integrate information from several or all of their senses in ways not restricted by environmental cues. The emergence of fissured brains by 50 million years ago reflects the evolutionary building of integrated neural circuits through which diverse sensory information could be used to create increasingly complex mental images. As we have seen, cultural environments contain their own selective pressures. The first appearance of culture, however rudimentary, thus may explain why mammals evolved in the first place.

Conclusions

Organisms do not necessarily perceive material stimuli, and those that perceive do not necessarily organize perceptions and memory traces into mental constructs. But to say that organisms create ideas is not to say that genes cease to influence behavior in important ways. Concepts are coded bundles of information that are more than the sum of their parts because they integrate information from a variety of senses. Thus, concepts cannot be created unless genes construct neural circuitry that allows information from one sense to be related to information from several or from all senses. Moreover, genes dictate that experience will be stored in a particular form as memory, and that organizations of percepts and memory traces will be constructed within specific constraints of time and complexity.

Although genes control the processes by which concepts form, they do not control the conceptual outcome of those processes. Intelligent forms of life have a built-in mechanism which continuously generates random conceptual innovation and behavioral change. This mechanism exists because their genes do not dictate which perceptions and memory traces will be integrated, when they will be integrated, or exactly how they will be integrated.

We cannot now identify the neural architecture and biochemical processes that distinguish intelligence from instinct and simple learning. When we do, we shall surely find that the distinctions that exist are far more subtle than the simple ones hypothesized in this article. But we do know that our brains construct ideas from sensory information because of our genes, not in spite of them. This means that something about the way our brains work, including the mistakes they generate, provided our ancestors with important selective advantages. This also means that the way our brains work not only reflects evolutionary change but also evolutionary continuity with other forms of life.

Selection favors the genes for intelligence and the cultural systems that intelligence automatically generates, when the resource changes that take place within the lifetime of an organism occur randomly or very rapidly. Once some degree of intelligence exists, random mutation can be expected to alter genes in ways that increase intelligence. Selection will consistently favor the organisms that create new ideas that improve resource access. Thus, forms of life that are intelligent participate in a process that inevitably, even if over very long periods of time, leads to the evolution of more intelligent forms of life.
Moreover, once some degree of intelligence exists, thinking processes automatically organize perceptions and memory traces in ways that lead to new and unexpected ways of looking at the world. Selection will consistently favor those that improve or optimize resource access. Intelligent forms of life think in ways that lead to improvements in resource access. New and relatively better means to access resources create more intensive selective pressures for life forms with greater intelligence. Intelligent forms of life thus actively participate in their own biological and cultural evolution.

As Barnett shows (e.g., 1953), over the life of an individual the brain automatically generates the systems of understanding and meaning that anthropologists call "culture." These systems of ideas must be integrated and must change in ways that maintain an internal coherence not because the world possesses an inherent order and coherence but because new ideas can only be created by combining perceptions with elements of prototype memory traces. Because they are integrated, ideas also must be symbolic because any one idea must evoke another, or others. But ideas constitute inferences about material stimuli—which is to say that they are guesses, hypotheses, and products of our imagination.

This conclusion explains humanity's most fundamental dilemma and underlines what may be our greatest irony: that "intelligence" and the tendency to misconstrue reality are two dimensions of the same phenomenon. Human brains operate in ways that generate an extraordinary range of ideas and potential behavior, but these are wrong-headed in one sense or another. Many ways to think about and act in the world are not very useful, and some constitute fundamental mistakes. It follows that we must engage in an unceasing, interactive relationship with environmental parameters that creates the most distinctive characteristic of human life: its tendency to regularly change in new and unanticipated ways.

Cultural elements (ideas, behaviors, or both, according to one's definition) exist only ephemerally, because the process of intelligence continually re-forms, re-creates, or modifies each as a function of this interaction. Cultural systems are unique to each individual because no two people take precisely the same path through life. Cultural systems can be shared by two or more people only to the extent that those people experience intersecting sets of material stimuli and selective pressures. Because people must create their understanding of a changing world only from prototype memory traces that have been built up over the course of a unique life history, learning is a creative and highly personal act.

It follows that the systems of concepts and behavior we commonly call "culture" cannot constitute an "inheritance system," for there is nothing about culture that can be passed from one person to another, except metaphorically. Objects may be passed from one person to another, of course. But their meaning and the uses to which they may be put will reflect the distinctive life history and selective pressures to which the user is heir and subject. Behavior may be "copied" or "imitated" and ideas may be "adopted," but both the behavior that is "copied" or "imitated" and the ideas that may be "adopted" are invariably reinterpreted and modified in ways that also reflect each learner's distinctive life history and the selective pressures to which he or she is subject.

Men and women thus do not, indeed, cannot think and act in ways that are fixed by socialization or cultural convention. Their childhood and adult experiences provide cultural prototypes that they use to construct and negotiate cultural worlds and social relationships, in particular social interactions, subject to selective constraints. Some conceptual and behavioral innovations create new resources or resource access channels and so change the costs attached to both. These may be as simple as basketry innovations that reduce seed loss in gathering or more efficient settlement site placement, which may have been steps in the origins of agriculture in Mesoamerica (MacNeish 1978). Technical innovations in energy utilization, transportation, information processing and dissemination, agriculture, construction, and manufacturing (see, e.g., Braudel 1979; Barnett 1961) radically changed the cost structure of resource access and thus constitute the core
of the contemporary world social revolution. Selection eliminates innovations that increase the costs of resource access and concentrates conceptual and behavioral innovations that improve or optimize resource access. Consequently, human beliefs and behavior change whenever conceptual and behavioral innovations or changes in ecological or demographic parameters change the cost structure of resource access.

Notes

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1This theory has distinct, testable implications for the nature and direction of social change as well. For example, it follows that the cost structure of resource access creates the properties of social relationships and that new social forms are created independently of antecedent social forms. Implications of this theory explain phenomena as diverse as fiscal corruption (Handwerker 1987) and the modern fertility transition (Handwerker 1989).

2My disagreements with other views of the origins or evolution of culture and its relationship to genes and genetic change are profound and extensive. This short article is not the place to write a polemic, however. Readers may note that the concept of “idea” outlined here is very similar to Dawkins’s concept of a “meme” (1976). Note also the dynamic properties of “ideas” and the means by which they are generated, which contrast with the properties of “memes” which, despite Dawkins’s references to “mutation,” are static.

3We shall also be able to better assess the apparent conceptual abilities of some birds and the possibility that at least some of the dinosaurs may have evolved a form of intelligence.

4This includes, of course, those genetic instructions with which we are born, which are vividly apparent to observant parents and in twin studies, but which we have not yet fathomed.

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