CHAPTER 16

The Structure of Evolutionary Explanations

"It is the desire for explanations which are both systematic and controllable by factual evidence that generates science; and it is the organization and classification of knowledge on the basis of explanatory principles that is the distinctive goal of the sciences" [Nagel, 1979, p.4].

"If any problem in the philosophy of science justifiably can be claimed the most central or important, it is that of the nature and structure of scientific theories, including the diverse roles theories play in the scientific enterprise" [Suppe, 1977, p. 3]

Introduction. This book addresses both the evidence and the explanation of human origins and evolution. Evidence forms the basis of science, but the goal of science goes beyond collecting facts to exploring the significance of the evidence. What do the hard-won hominin fossils mean? What can they tell us about our ancient ancestors' behavior? Can they support predictions about future evolution? How can the distinctive changes in hominin size and shape through the millenia be explained? *What does it mean to explain something?*

There is no precise definition of scientific explanation or what structure it should have [Hempel, 1965b]. Explanation can take different forms, depending on what is being explained and because there is always more than one way to explain it. However, it is clear that the *goal* of explanation is to increase comprehension by reducing a situation to elements that are so logical or so familiar that we accept them as understood. The evidence is not enough; we want to understand its significance.

Explanation may be accomplished in various ways, but there are some general rules. Scientific explanations share a basic two-part form: There is (1) something that needs to be explained (called the *explanandum*, plural *explananda*), and (2) there are statements that provide the explanation (the *explanans*). The explanation should reduce the number of unexplained items by at least one, otherwise no progress has been made. Some regularities can be explained by showing they are manifestations of another, more comprehensive regularity. That is, a deeper understanding of the matter is achieved if it can be shown to be an outcome of more fundamental processes. Explanations are not true or false;

rather they are accepted or rejected according to whether they are more or less adequate than other possible explanations [Suppe, 1977].

Biological explanations require elements that are not necessary in explanations of the inanimate world. Living organisms are enormously more complex than non-living entities such as atoms, molecules and rocks. Life involves phenomena not found in physics and chemistry so we cannot expect to explain them with purely physical laws. They are not just *ordered*, like the periodic table of the elements or atoms in a crystal, they are *organized*: their multitudinous parts have *functions* which act to sustain the organized structure and to reproduce it. Living organisms obey the laws of nature, but they also are subject to biological laws or concepts, such as genetic inheritance, reproduction, the succession of generations, natural selection, sexual selection, competition, adaptation, and reproductive success.

It is a commonsense notion that to explain something is to identify its cause [Salmon, 1990]. This also applies to scientific explanation. One seeks to identify causes: factors that by their own direct effects produce change. Scientific evolutionary biology is founded on the Darwinian causal process—natural selection of inherited variations. This accounts for the origin of species and the emergence of evolutionary adaptations [Beckner, 1959; Goudge, 1961; Sober, 1984; Rosenberg and McShea, 2007]. Natural selection of inherited variations that enhance reproductive success is the causal concept that underlies evolutionary theory. Therefore, in specific cases of evolutionary change (such as the transition to bipedal locomotion, canine diminution, throwing prowess and the like), we seek to identify the factors that yielded more food or mating opportunities to those whose genes were preferentially copied. We ask, in other words, "where was the reproductive advantage?" This represents the search for *ultimate* causes in biology [Mayr, 1961].

Hypotheses and theories. Hypotheses and theories are both forms of explanation, but despite the frequent tendency to use these terms interchangeably, in strict scientific practice they are very different.

The *hypothesis* stands as the lowest tier in the hierarchy of scientific explanation. Simple hypotheses are *ad hoc* explanations of individual events without any wider application. Their scope is a single object of interest. They are tentative explanations of a singular item of experience, based upon causes that seem plausible or at least possible. *Theory-based* hypotheses are another matter. They are predictions of the form "*if* the theory is true, *then* the following outcome should occur," but a hypothesis unattached to a theory is only a speculative guess.

The *theory* resides on the highest level of scientific explanation. In biology, the overriding theory is the modern Darwinian theory of evolution. Subsidiary Darwinian theories pertain to particular aspects of biology; they are all special cases of the general theory of evolution. I shall now describe the classical structure of a theory and present the bipedal weapons proposal in that format later in this chapter. Science welcomes other explanatory schemes with different structures [Kuhn, 1962]. However, some are more convincing and useful than others.

Theories come in different sizes, bounded by the range and detail of evidence which they can explain. Depth, scope, specificity of application and the parsimony of explanatory principles are the measures of a theory's success. Darwin's theory clarified all of biology, explaining it by the principle of natural selection through differential reproduction. It is the quintessential theory.

Scenarios. Somewhere between an unsupported hypothesis and a scientific theory lies an informal explanatory structure referred to as a "scenario". Some writers employ the term in the cinematic sense to mean the summary of a story. Others apply it to evolutionary accounts that lack the structure or scope of a theory but are more elaborate than hypotheses. One variety is the "historical narrative" which Mayr [2004], believed could provide a "quite plausible" story of human evolution. It had the form of a scenario in which past events are accounted for by their consequences: one stage might have led to the next stage, which could have been followed by another, and so on. This format was used by Kingdon [2003] to explain hominin bipedalism. Here are some examples of scenarios which seek to account for more than one hominin trait by describing a sequence of events that might have led to their emergence.

Man the Hunter. Dart [1925, 1949a, b, 1953, Dart and Craig, 1959] created a scenario involving the use of weapons and used it to explain upright stance, diminution of the canine teeth, hunting and fighting prowess of later hominins, and modern human skill at aimed throwing. It was part of Darwin's vision, but devoid of Darwin's emphasis on intellectual powers and social qualities [1871, p. 157]. Male hunting prowess subsequently was said to explain a wide variety of human social attributes [Washburn and Lancaster, 1968; Laughlin, 1968]. Our intellect, interest, emotions, division of labor between genders and basic social life were all ascribed to an adaptation to hunting. Males hunted, females gathered vegetable food and the results were shared with each other, forming the basis for the human family.

Woman the gatherer. This scenario shifted emphasis to the female gender. Gathering and sharing by females was the foundation of human society. Food sharing and the family developed from the bonds between a mother and her children. Females nourished themselves and their young; they were the providers and the inventors. Gathering, carrying and sharing food spawned bipedal locomotion. Females chose to copulate with more sociable, less disruptive, food-sharing males—in other words, with males more like themselves. This resulted in the diminution of male canine teeth. Females may have chosen to mate with males having smaller canine teeth because they appeared to be more sociable [Linton, 1971; Tanner and Zihlman, 1976; G. Isaac, 1978; J. Lancaster, 1978; Zihlman, 1978, 1981; Fedigan, 1986].

Man the provisioner. Lovejoy reversed genders again. Males were the providers. They brought plant food to females as part of a food-for-sex exchange based on pair-bonded monog-amy with dedicated sexual privileges. Food provisioning led to a gradual shift from a female-centric group to a "bifocal" one. Continually receptive females with no visible signs of ovulation ("ovulatory crypsis") enter this scenario. These innovations would require "copulatory vigilance" in both sexes to ensure fertilization. Monogamous copulation would increase pair-bonding and serve as a social display asserting that bond. Canine diminution resulted from this cooperative behavior. Bipedal locomotion emerged from males carrying provisions to their mates [Lovejoy, 1981, 1993, Parker, 1987].

The cooking scenario. Wrangham [2001, 2009] proposed that the control of fire and its subsequent use in cooking were defining events in human evolution, forming the basis of the transition from *Australopithecus* to *Homo* (Chapter 7). The benefits of cooked food resulted in smaller digestive tracts, and large body size. Shoulder, arm and trunk adaptations that enabled hominins to climb well disappeared, leading to dedicated bipedal locomotion when hominins controlled fire and slept on the ground.

Man the thrower. A scenario with expanded scope that avoids social assumptions, is simple in its explanation, and more overtly involves natural selection, was presented by Kirschmann [1999], who refers to it as a "model." Throwing rocks from a bipedal stance as a defensive measure by early hominin males plays an important role in his proposal, which extends its explanatory range to include the central nervous system (Chapter 15). Several features of hominin fossils and modern humans (including bipedal locomotion) are attributed to an adaptation to throwing. Hominins collected rocks for throwing and carried them when they crossed open country. This required upright walking, a behavior that was facilitated by physical adaptations to the improved use of projectiles, such as upright orientation of the body. The longer, stronger legs of *H. erectus* not only improved bipedal gait, they also served as a counterweight that permitted the use of a windup in throwing. The transition to bipedality rests upon the multiple advantages of walking upright for the use of throwing weapons against predators [Kirschmann, 1999; 1.4, 3.6] (Chapter 14). Diminution in size of hominin canine teeth resulted from the loss of their function in fighting which can be traced to the intensive use of rocks as weapons. The weapon characteristic had been transferred from the teeth to the hands [Kirschmann, 1999] (Chapter 11).

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