**Draft of Chapter in:** "Two-thousand years of stasis": How psychological essentialism impedes evolutionary understanding. In K.R. Rosengren, S. Brem, E.M. Evans, & G. Sinartra (Eds). *Evolution challenges: Integrating research and practice in teaching and learning about evolution* (pp. 3-21). New York: Oxford University Press.

# "Two-thousand years of stasis":

# How psychological essentialism impedes evolutionary understanding

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Acknowledgements. Preparation of this chapter was supported by NSF grant BCS-0817128 and NICHD grant R01 HD36043 to Gelman.

*Introduction*

In 1965, David L. Hull published a paper in the *British Journal for the Philosophy of Science* entitled, "The effect of essentialism on taxonomy: Two thousand years of stasis". His argument, in brief, was that the concept of "species", so central to biological understanding, is misunderstood by taxonomists because of an ingrained essentialist assumption regarding definitions (passed down from Aristotle; hence the reference to 2,000 years). Hull's paper is important for noting that a core philosophical assumption can have serious, persistent consequences as scientists struggle to explain and understand the biological world (see also Ghiselin, 1969). It is particularly striking that this sort of conceptual bias can be seen in scientists, who are most committed to viewing the world objectively and to discovering new phenomena. Entrenched essentialist assumptions may have even more persistent effects for the ordinary person, who does not necessarily have such a commitment to objectivity and scientific truth.

In the spirit of Hull's analysis, we suggest that psychological essentialism poses a set of obstacles to a full grasp of evolutionary theory for ordinary (non-expert) adults engaging in everyday thought. This analysis differs from Hull's in at least three respects: whereas Hull focused on the species concept per se, we will examine evolutionary thought writ large; whereas he dissected the beliefs of professional taxonomists, we will focus on lay understandings, particularly those of young children; and whereas he concerned himself with logical assumptions regarding what constitutes a definition, we will examine ontological beliefs about the structure of the world. This work draws on both philosophical

analyses (e.g., Sober, 1980; Ghiselin, 1969; Okasha, 2002) and psychological data (e.g., Shtulman & Schulz, 2008; Shtulman, this volume; Medin, 1989).

Some of the obstacles impede *acceptance* of evolutionary theory; others impede *understanding* evolutionary theory. By "acceptance" we refer to endorsing evolutionary theory as "afford[ing] the best current scientific account of the relevant phenomena based on the available empirical evidence" (Smith & Siegel, 2004, p. 553). By "understanding", we mean recognizing the key principles and their implications (e.g., the distribution of traits within a population shifts over generations, rather than transforming within a generation). It is important to keep both acceptance and understanding in mind, because they are separable problems, as we are defining them: acceptance per se does not entail understanding, and understanding per se does not entail acceptance (but see Smith & Siegel, 2004; Southerland, Sinatra, & Matthews, 2001, for alternate conceptions). We provide two hypothetical individuals to illustrate how the two factors differ. One person may believe that evolutionary theory provides the best account for explaining biological variability (i.e., demonstrating acceptance), yet misunderstand the nature of this variability, believing it to involve superficial characteristics yet leaving the underlying genetic code unchanged (i.e., demonstrating lack of understanding). Another person may understand evolutionary claims regarding variability, including that it entails genetic as well as morphological features (i.e., demonstrating understanding), yet reject evolutionary explanations for such variability, instead endorsing a theistic account (i.e., demonstrating lack of acceptance). Table 1 provides some key aspects of acceptance and understanding that relate to essentialism.

The plan for the chapter is as follows. First we briefly review what we mean by psychological essentialism, and some of the key findings that illustrate that this is a widespread folk theory about biological categories. Next we discuss five assumptions embedded in essentialism that are inconsistent with evolutionary theory. Where relevant, we discuss evidence for these problems; where no evidence is available, we point out these as directions for future research. The chapter concludes with a summary, speculations about education, and some open questions.

*Psychological Essentialism*

Essentialism is a concept with a very long history, extending back at least to the Ancient Greek philosophers. It has been used in different ways by different scholars, thereby leading to some confusion in the literature. Mayr (1982, p. 44) noted: "Many celebrated controversies in the history of science were caused almost entirely because the opponents referred to very different concepts by the same term." As sketched out in Table 2, there are at least 12 versions of essentialism, depending on whether one is focused on the nature of reality or instead how people represent reality, and depending on one's ontological commitments (e.g., concerning how words are defined, or the nature of causal laws, or idealizations that transcends reality). (See Gelman, 2003, for discussion.)

In addition to being of great interest to philosophers concerned with the nature of reality, essentialism has captured the interest of psychologists, because there is abundant evidence that everyday lay theories about the biological world incorporate essentialist biases (Medin, 1989; Gelman, 2003; Keil & Richardson, 1999). We use the construct "psychological essentialism" to refer to a two-fold set of intuitive beliefs: that certain

categories are real rather than human constructions (i.e., these categories are thought to be natural, discovered, information-rich, carving nature at its joints), and that these natural categories possess an underlying causal force (the "essence") that is responsible for category members being the way they are and sharing so many properties. This version of psychological essentialism is representational and causal, and is represented in Table 2 by Xs. John Locke (1671/1959, Book III, p. 26) expressed this latter belief succinctly, as follows: "[Essence is] the very being of anything, whereby it is what it is. And thus the real internal, but generally . . . unknown constitution of things, whereon their discoverable qualities depend, may be called their essence."

According to psychological essentialism, people typically don't have knowledge of what an essence is – only *that* it exists. Medin (1989) thus characterizes the essence as a conceptual "placeholder", one that may later be filled in with more detailed information. In modern day, among those with certain educational backgrounds, the essence may be interpreted roughly as "genes" or "DNA" (Jayaratne et al., 2009), though we suspect that this construal often involves assimilating a biological construct to a folk concept, yielding a variety of misunderstandings along the way. In other words, for the lay adult, the folk concept of essence may not be *replaced* with a scientific notion of genes; rather, scientific terms ("genes", "DNA") may at times be little more than fancy words designating a more primitive essence placeholder.

Within this broad framework, psychological essentialism has several components or core beliefs (Gelman, Heyman, & Legare, 2007; Haslam, Rothschild, & Ernst, 1998). One core belief is that certain categories (including biological categories) are inferentially rich,

such that category members share deep similarities, even in the face of superficial dissimilarities (Gelman & Markman, 1986). Category members are thought to share an underlying reality, including internal or invisible shared properties (Ahn et al., 2000; Gopnik & Sobel, 2000; Legare, Gelman, & Wellman, in press). Relatedly, boundaries between categories are thought to be sharp and impenetrable (Keil, 1989; Rhodes & Gelman, 2009a). Another core belief is that categories are immutable (Keil, 1989; Gelman & Wellman, 1991; Gottfried, Gelman, & Schultz, 1999; Johnson, 1990; Rosengren, Gelman, Kalish, & McCormick, 1991). Category members are thought to have innate potential to develop along predestined pathways (Gelman & Wellman, 1991; Taylor, 1996; Hirschfeld & Gelman, 1997; Taylor, Rhodes, & Gelman, 2009). These beliefs have been documented most consistently in middle-class U.S. samples, including Christian Fundamentalists (Evans, 2001), but are also supported by cross-cultural evidence from a variety of contexts, including India (Mahalingam, 2003), Brazil (Diesendruck, 2001; Sousa, Atran, & Medin, 2002); the Vezo in Madagascar (Astuti, Solomon, & Carey, 2004); the Yucatec Mayans of Mexico (Atran et al., 2001); the Yoruba in Nigeria (Walker, 1999); the Torguud of Mongolia (Gil-White, 2001); and the Menominee (U.S.) (Waxman, Medin, & Ross, 2007).

Children's essentialist biases are particularly informative, for demonstrating that essentialism is a very fundamental component of human cognition. By examining the beliefs of children, we can determine what conceptual biases are present even before an individual has exposure to formal schooling, biological instruction, or exposure to Western philosophical tradition. Indeed, much of the evidence cited above comes from research with young children. Thus, by preschool age, children assume that certain categories—

including biological categories—display inferential richness, sharp boundaries, immutability, and innate potential (Gelman, 2003).

Although evidence for essentialism is extensive and converging from multiple tasks, cultural contexts, and age groups, it is not without controversy. Some have noted that essences do not always drive judgments of categorization (for example, judgments of whether a substance is water do not seem to be governed by the proportion of H2O in that substance; Malt, 1994). Others have proposed that children's use of category labels to draw underlying inferences may reflect simpler associative learning mechanisms rather than an appeal to underlying causal properties (e.g., Sloutsky, 2003). A third critique is that children may only have the first component mentioned earlier (an assumption that categories are real), without appealing to an invisible essence (Strevens, 2000).[1] Regardless of these debates, evidence for essentialism appears across many tasks. We turn next to ways in which essentialism may stand in the way of evolutionary understanding.

*Five ways in which essentialism poses obstacles to evolutionary understanding*

There are five interrelated though distinct essentialist assumptions that we argue impede individuals' understanding and acceptance of evolutionary theory. For each, we will set forth the psychological assumption, show how it conflicts with an aspect of evolutionary theory, and discuss the implications for acceptance and/or understanding of evolution. A schematic of the major points can be found in Table 2.

*Assumption of stability and immutability*

An implicit assumption of essentialism is that categories are stable and immutable, maintaining sameness in the face of outward, apparent change. The stability assumption does not deny that individual organisms can change; rather, it deems such variation to be superficial, with the underlying essence untouched. A scrawny, bald, gray chick can transform to a magnificent swan, but it has not changed type, only appearance. Even though individuals undergo striking perceptual changes, this need not lead to changes in category membership.

In some respects, the stability assumption is sensible and consistent with scientific practice. Keil's (1989) finding that children assume that a raccoon cannot be changed into a skunk, even though it has been surgically altered to look and smell like a skunk, displays in children an apt grasp of the importance of non-obvious features and the deep distinctions between different kinds of animals. Likewise, preschool children's belief that offspring will resemble birth parents rather than adoptive parents (Gelman & Wellman, 1991) reflects an accurate understanding that many morphological and behavioral features are relatively stable across generations. Likewise, biological features cannot be modified easily or at will. This appreciation that categories cannot be understood wholly in terms of outward appearance is a deep insight, and one achieved at a surprisingly early age (Jaswal & Markman, 2007; Graham, Kilbreath, & Welder, 2004). For these reasons, some scholars have argued that essentialism is a basically accurate framework for thinking about the biological world (Pinker, 1994; Bloom, 2000; Kornblith, 1993).

Nonetheless, an overly strong commitment to category stability is incompatible with evolutionary theory. Natural selection clearly rests on the idea that species can change

over generations. The eminent biologist Ernst Mayr (1982, 1988, 1991) has particularly emphasized this essentialist obstacle to evolutionary theory, and proposed that an assumption of unchanging species was one of the major barriers to even coming up with the idea of evolution in the first place: "The ability to make the switch from essentialist thinking to population thinking is what made the theory of evolution through natural selection possible" (Mayr, 1988, p. 15). Likewise, Michael Ghiselin (1969, p. 52) noted that essentialism "almost forces one to ignore everything dynamic or transitory… The Darwinian revolution thus depended upon the collapse of the Western intellectual tradition" (e.g., Plato, Aristotle) from which those essentialist ideas emerged.

When children reject evolution, they make reference to category stability. For example, in one study, Dutch third- and fifth-graders (mean ages 9;4 and 12;3) were questioned extensively about species origins and modifiability (Samarapungavan & Wiers, 1997). Fewer than 10% of the children consistently acknowledged that species could undergo change, whereas roughly half consistently made reference to essentialism, at times mentioning stability and immutability explicitly. For example, when asked, "How did peacocks get their long, colorful tails?," one child replied: "… It just is that way. Peacocks always had long tails just like giraffes always had long necks." Likewise, when asked whether brown bears would develop white fur after living in the North Pole, another child answered, "No, brown bears will always be brown bears. They cannot become another bear." Children ages 5-7 years also reject the idea that one animal can be the descendent of a completely different kind of animal (Evans, 2000, 2008).

Children's rejection of species change can be seen not only in their projections about the future, but also in how they reason about the past. For example, below ages 8-9 children have great difficulty accepting the notion that there was a very first member of any species (e.g., a very first tiger) (Evans, Mull, & Poling, 2002). When directly asked, "Have there always been Xs here on this world?", preschool and early-elementary-school children typically say "yes". It would appear that young children think of species as constants in the world, and the notion that these constants are shifting into or out of existence is highly counterintuitive.

Eventually, of course, many adults do come to accept that species can undergo change, in evolutionary time. Interestingly, however, even for those who endorse evolutionary accounts, species change may be misunderstood in ways that again reflect an overly rigid assumption of category stability. Specifically, an essentialist bias may encourage viewing evolutionary change as constrained, teleological, pre-ordained, or progressing toward an ideal. We will discuss this issue in the section entitled "Platonic notion of ideal essence."

*Boundary intensification*

Related to category stability is the essentialist belief that category boundaries are relatively strict and impermeable; to quote Dennett, "Essences were definitive, and as such they were timeless, unchanging, and all-or-nothing. *A thing couldn't be rather silver or quasi-gold or a semi-mammal*" (1995, p. 36; emphases added). Likewise, the distinction between species is treated as categorical rather than a matter of degree.

Evidence for boundary intensification can be found in adults' judgments of animal category membership, whereby atypical members of a category are judged nonetheless to fully belong in the category (Diesendruck & Gelman, 1999; Estes, 2003, 2004). This is in contrast to artifact categories, where membership is viewed as graded (i.e., an atypical object can be a partial member of an artifact category). Five-year-old children show a similar pattern, reporting that category membership is absolute for animal categories (penguins are fully birds) but not for artifact categories (earmuffs are sort-of clothing) (Rhodes & Gelman, 2009a). In other words, although both penguins and earmuffs are somewhat atypical instances of their respective categories, they are treated quite differently with respect to category membership, with penguins (but not earmuffs) considered in absolute terms (fully members of the category birds). An important control task demonstrates that the atypical members of both animal and artifact categories were judged as equivalently unusual members of their respective categories (i.e., both penguins and earmuffs are sort-of good examples of the categories bird and clothing, respectively).

Boundary intensification is also found in children's judgments about category objectivity (Rhodes & Gelman, 2009b). By age 5, children view the boundaries of animal categories as reflecting objective structure in the world, and reject the possibility that people could choose to categorize animals in an unconventional manner. For example, in an experimental task, Rhodes and Gelman (2009b) found that children judge it as "wrong" for a community to consider a pig and a cow to be the same kind of animal, although they are willing to accept that a community could consider a hammer and a screwdriver to be the same kind of thing. Thus, participants in this study reported that there is one right way

to categorize animals, and appeared to view animal categories as objectively defined categories (reflections of a strict natural structure in the world) with sharp and permanent boundaries.

We suggest that essentialism involves intensifying boundaries rather than treating boundaries as wholly inviolable, as some have suggested (e.g., Kalish, 1995). In other words, the claim is not absolute, but rather one of degree. Even one committed to an essentialist perspective will note and accept that boundaries are sometimes breeched: species interbreed, substances can be laced with impurities, and biological processes can go awry. A labradoodle is neither 100% Labrador nor 100% poodle, but a mixture.

The implications of boundary intensification for evolutionary concepts are similar to those of category stability: a rejection of evolution itself, due to difficulty understanding the possibility of intermediate categories that cross strict boundaries. If an animal cannot be a semi-X, then how can one understand the evolutionary change from X to Y?

The essentialist definition of a species is rooted in Aristotelian logic: the boundaries themselves are the focus of the definition. In contrast, evolution reveals that species are characterized in probabilistic terms (whether the focus is on interbreeding populations or shared characters). It is the population itself that is the focus, and this population can be understood in terms of feature distributions and statistical likelihoods of reproductive success in a particular environment. For the evolutionary biologist, categories cannot be understood in terms of discrete boundary conditions, but rather in terms of ever-shifting populations, with porous boundaries. The characterization of a species is probabilistic, not

rule-governed. This point is tightly linked to the issue of how essentialists vs. evolutionists consider variability, a point to which we turn next.

*Underestimating variability or treating variability as "noise"*

Most U.S. adults agree with the following statement: "Two people from the same race will always be more genetically similar to each other than two people from different races" (Jayaratne, 2001). Yet this statement reveals a serious misunderstanding of how categories of living things are structured. Variability is the rule, not the exception – for race as well as for biological species (Hey, 2001; see Darwin's study of the beaks of finches for a classic example). The degree of genetic variability within people of a given race is just as high as the degree of genetic variability across races (Cosmides, Tooby, & Kurzban, 2003; Templeton, 1998). By focusing on species categories as coherent entities, an essentialist perspective underestimates within-category variability, at the same time that it exaggerates between-category distance (see boundary intensification, above).

There is abundant evidence that children view categories as more homogeneous and less varied than adults. One mechanism by which this is occurs is the tendency to represent categories in terms of prototype structure (Rosch, 1978). In early development, the prototype is more salient than the atypical exemplars (Bjorklund & Thompson, 1983), and during acquisition, atypical exemplars are acquired more slowly. This results in children's categories being literally more homogeneous: for example, a preschool child's "bird" category might exclude dodos and quail. Even after such exemplars are learned, they tend not to be called to mind in most contexts. For example, if asked to come up with a sentence including the word "birds", most people will generate a sentence for which only

typical birds are relevant (e.g., "There were 20 birds sitting on the telephone wire outside my window this morning" works fine when one substitutes a typical bird such as "sparrow", but not when one substitutes an atypical bird such as "duck"; Rosch, 1978).

Direct evidence that children overlook variability to a greater extent than adults do comes from a recent study examining the effect of priming within-category variability on category-based induction (Rhodes & Brickman, in press). College students and six-year-olds were randomly assigned to one of three conditions: 1) a variability condition, in which they were primed to focus on the variability within an animal category (e.g., to notice that some birds fly and some don't, that some have big beaks and some have small beaks). 2) A similarity condition, in which they were primed to focus on the similarities within categories (e.g., that all birds have feathers), and 3) a control condition where they did not receive a prime. Following these primes, participants were asked to select samples to examine to find out if a property holds for an entire category (e.g., to find out if all birds have hollow bones, would you examine two robins or would you examine a robin and a penguin?) Adults reliably chose diverse samples in all conditions, indicating that they generally attend to within-category variability and appreciate the value of sampling across this variability before generalizing to a category. Children, however, did not reliably choose diverse samples in either the control or similarity condition, suggesting that children generally overlook within-category variability and tend to focus instead on the similarities within categories (see also Rhodes, Gelman, & Brickman, 2008; Rhodes, Brickman, & Gelman, 2008), In the variability condition, however, children showed the adult-like pattern of reliably selecting diverse sets. Thus, although children appear not to focus on

variability spontaneously, educational programs may be able to assist them in overcoming this obstacle to understanding evolution.

Language also reflects a tendency to reject variability. All languages permit expressing generalizations that ignore variation: "Dogs are 4-legged" (even though some have only 3 legs); "Birds lay eggs" (even though male birds and baby birds do not); "Sharks attack humans" (even though most sharks never come near a human). These expressions are known as "generic noun phrases" (aka "generics"), and are acquired by about 2-1/2 years of age (Carlson & Pelletier, 1995; Gelman, 2009; Leslie, 2007). In English, generic noun phrases further permit one to treat a category as if it were an individual, thus implying no variation whatsoever: "The horse is a 4-legged animal." As Ghiselin (1969, p. 53) notes, "biology has ceased to think in terms of abstract classes or idealized forms such as 'the horse' and has turned to considering the interactions between 'this horse' and 'that horse.' We owe this shift in emphasis largely to Darwin." It is an open question whether generic language actually encourages speakers to ignore within-category variability. At the very least, this linguistic expression demonstrates a capacity to overlook within-category variability and the ease with which we form generalizations that paper over such variation.

The implications of ignoring variation for evolutionary understanding are two-fold. First, because variability is required for natural selection to take place, an appreciation for within-species variability is a prerequisite to entertaining the basic mechanism of evolution. Thus, a rejection of variability can be an obstacle to acceptance of evolution. And second, even when one acknowledges variation, an essentialist perspective leads one to consider such variability to be superficial, with the underlying essence untouched and

unchanged. Thus, birds are recognized to vary (from hummingbird to ostrich, from eagle to sparrow), yet nonetheless are assumed to share a common, unchanging essence. This can lead to what might be called "pseudo-variability": acceptance of outward variability, but assumption that internal features aren't variable. For example, someone might appreciate that dogs are outwardly very different from one another, but nonetheless assume that dog DNA is unvarying. An otherwise brilliant paper by Kamp and Partee (1995, p. 175) reveals an essentialist misconstrual of species: "… the vast majority of natural kind terms are sharp in the strict sense of being determinately true or false of everything that is found in the real world. For instance, to belong to a particular biological species an individual must have the DNA of that species; and almost without exception this is a property which an individual organism either definitely has or else definitely lacks." In contrast, Sober (1980, p. 380) notes: "… no genotypic characteristic can be postulated as a species essence; the genetic variability found in sexual populations is prodigious…" (See also Wilson, 1999.)

Appreciation of within-category variability correlates with evolutionary understanding. (Shtulman, 2006; Shtulman & Schulz, 2008; Shtulman, this volume). Two basic theories that adults express are the Darwinian "variational" account, in which the distribution of traits within a population shifts over generations, and the intuitive "transformational" account, in which the entire species gradually changes over generations. Shtulman and Schulz found that adults' understanding of evolution correlated with their acceptance of within-species variation. They conclude (p. 1049): "Overall, it is argued that psychological essentialism, although a useful bias for drawing species-wide inductions,

leads individuals to devalue within-species variation and, consequently, to fail to understand natural selection."

The transformational explanations also reflect a focus on the individual rather than the population as the locus of change, since change is instantiated in every organism in the species rather than being a property of the group as a whole. For example, it is easier to think about each individual moth undergoing change, than to think about the distribution of moths undergoing change. We turn to this issue next.

*Treating causes as inhering in individuals*

A key essentialist principle is that causes inhere in the individual: there is some inner substance, part, or quality within each individual organism that causes it to have the features and behaviors it has. It is this essence that all category members are presumed to share. By preschool age, children have some appreciation that hidden, internal parts or "energy" can affect the outward movement, behavior, or function of an individual animal or artifact (Gottfried & Gelman, 2005; Sobel et al., 2007). For example, when viewing a novel, shapeless and faceless aquatic creature (sea-slug), children are much more likely to ascribe blood and muscles to the animal if it is shown to have the capacity to move than if it is not shown moving (Gelman & Nyhof, reported in Gelman, 2003). It would appear that children view blood and muscles as required for the animal movement. In other words, these features are not simply associated with certain outward forms, but instead are understood as having causal force. This assumption of internal causal features is useful in many respects, given that many causes are hidden, non-obvious, or intervening (including batteries, brains, and the mechanism inside a piano).

The problem with this view for evolution is that, without a further understanding of population-level forces, it rests at the wrong level of analysis. As noted in the previous section, evolutionary change takes place at the level of the population, not the individual organism (see also Ghiselin, 1969). When the individual is the sole unit of analysis, rather than the population, one is led to think that change is a matter of individual processes (such as effort or need) rather than population pressures (natural selection). Furthermore, one is led to downplay the importance of environmental influence (Griffiths, Machery, & Linquist, 2009). One also is led to misconstrue the timeframe (a lifetime rather than many generations), thereby leading some changes to seem implausible. The philosopher Elliot Sober (1980, p. 355) is eloquent on these issues:

> "The essentialist requires that a *species* be defined in terms of the characteristics of the *organisms* which belong to it. We might call this kind of definition a *constituent definition*; wholes are to be defined in terms of their parts, sets are to be defined in terms of their members, and so on. … Constituent definitions are *reductionistic*…"

Sober then contrasts the typologist, who searches for invariance possessed by each individual organism, with the populationist, who searches for invariance within the population. Somewhat paradoxically, when the population is the unit of analysis, it is assumed that each individual organism is unique, and when the individual is the unit of analysis, it is assumed that individuals are reflections of a category essence and therefore deeply alike (Mayr, 1982, pp. 45-47).

Evidence that people tend to focus on individuals versus populations for understanding evolution comes from the work of Shtulman and Schulz (2008; cited earlier,

and see Chapter xx), in which children and many adults believe that adaptive features will spread through a species uniformly (Bishop & Anderson, 1990). Similarly, adults often judge that if an individual organism needs a feature to survive, then it will develop that feature and even pass it down to offspring, thus displaying a Lamarckian sort of view (Ware & Gelman, 2010; Bishop & Anderson, 1990; Evans et al., 2009; see Bowler, 2009, for historical examples). For many, evolutionary change is understood as goal-driven change within each individual, and thus links not only to essentialism (i.e., causal properties are within the individual) but also to teleology (i.e., purpose is a driving force to explain the structure of the world; see Kelemen, 2004; Chapter xx). It is currently unclear whether this conceptual difficulty is due to an inadequate knowledge base, a distortion of accurate evolutionary teaching, or a synthetic construction (Vosniadou & Brewer, 1994).

*Platonic notion of ideal essence*

To this point we have focused on "causal essentialism", namely the idea that the essence of a category is that which causes members to be alike and have the features they do. However, there is also the idea (deriving from Plato) that essences are an ideal that can never be fully instantiated in the real world (Ghiselin, 1969). On this view, there might be an "ideal" human, the epitome of humans. It is this notion that seems to encourage the idea of evolution as progressive, of species always improving (orthogenesis). This widespread misconception can be seen in classic depictions of evolution as ever-upward (e.g., with animals getting progressively taller and more upright). Similarly, Aristotle endorsed a "Natural State Model", according to which each species has a particular natural tendency,

though external forces can deflect individuals away from their natural states (Sober, 1980). This view, too, is consistent with idea of programmed, directed evolution.

To date there has been relatively little research examining the extent to which people represent categories in terms of ideals, though the available evidence is suggestive. We know from experimental studies that people can think of certain categories in terms of ideals; for example, weapons that are closer to the ideal weapon (in terms of capacity to inflict harm efficiently) are judged to be more typical than weapons that are more distant from the ideal, even controlling for featural similarity (Barsalou, 1985; Lynch et al., 2000). Also, ideals seem to be an important component of how and when people refer to categories using generic language (Prasada & Dillingham, 2009). For example, when we say "Dogs are 4-legged", we are implicitly endorsing the idea that dogs should be 4-legged (Prasada, 2000). Intuitively, it would seem that a range of concepts might have this structure (e.g., a prototypical rich person is Bill Gates; a prototypical good person is Mother Theresa – these are extremes, not averages), though more research is needed.

### *Conclusions and open questions*

In this chapter we have argued that essentialism is a widespread, highly accessible mode of thought that poses a profound obstacle to grasping the Darwinian theory of evolution. More precisely, there are at least five distinct components of essentialism that impede evolutionary understanding from childhood onward: (1) Species are stable and immutable, and so can't change. (2) Species have sharp boundaries, and so there are no intermediate categories. (3) Species members are homogeneous, and so variation either

doesn't exist, or exists only with respect to superficial features. (4) Causes inhere in individuals, so change must take place within the individual. (5) Species have ideal forms, and so evolutionary change progresses in the direction of that ideal.

The problems engendered by essentialism are of two sorts: acceptance and understanding. The problems of acceptance are more basic, in the sense that they do not permit a discussion of evolution even to get off the ground. If one absolutely rejects that species can change, or that members of a species are variable, then the foundational tenets of evolutionary theory would seem incomprehensible. In contrast, the problems of understanding are superficially consistent with evolution, yet lead to a distortion of what it means. The problems of understanding are arguably more difficult to address, as they are less likely to be examined or challenged. One may happily go about life thinking that one accepts and understands evolutionary theory—and unless taking an evolutionary biology class, may never reflect upon one's misconceptions.

One open question is whether the reasoning biases discussed in this chapter extend beyond children, novice adults, or historical discussions to affect how more biologically informed individuals reason about evolution in contemporary times. On the one hand, expertise may provide just the knowledge base one needs to reject essentialism when reasoning about biological categories. In support of this possibility, Novick and Catley (2007) has obtained striking differences in biological reasoning among experts versus novices in the realm of biology. However, in the realm of physical reasoning, McCloskey (1983) found that even undergraduates who have studied college-level physics are susceptible to some of the more subtle reasoning biases that are displayed by more naïve

participants. It would thus be interesting to determine whether the difficulties with essentialism may extend to experts as well.

To this point we have highlighted the incompatibility of essentialism and evolution. Yet some scholars have argued that essentialism is basically rooted in biological reality. For example, Bloom (2000, p. 153) states: "Essentialism is an adaptive way of looking at the world; it is adaptive because it is true." He goes on to say that essentialism is true in the sense that superficial properties (such as outward morphology) are caused by deeper, underlying properties (such as genetic structure). We believe that the seeming contradiction is due to differing accounts of "essentialism". If by "essentialism" one means that there are discoverable classifications in nature that are non-arbitrary and deeply revealing of non-obvious properties, then this view is compatible with the position of many biologists and philosophers (see Griffiths, 1999; Kornblith, 1993; Kripke, 1972; Putnam, 1975; but also Dupre, 1993). However, if by "essentialism" one means that there is a single, inherent essence that is constant across all category members, with all the additional implications sketched out above, then, as we have argued, it poses problems for evolutionary understanding (but see Devitt, 2008, for argument).

Altogether, the results discussed in this chapter suggest that psychological essentialism may be a *cause* of lay people's difficulties with evolutionary theory (both acceptance and understanding), although further evidence is required to demonstrate a causal link. One approach would be to experimentally manipulate the degree to which people endorse each of the essentialist principles discussed earlier, and then examine evolutionary concepts. For example, it would be interesting to teach children about

gradual category change and test to see whether this leads to increased evolutionary acceptance. The study by Rhodes and Brickman reported earlier, in which children who are instructed to focus on category variability showed greater appreciation of diversity-based reasoning, gives us reason to be optimistic. Nonetheless, such interventions are unlikely to provide a broad-based or long-term solution to the problem of rejection of evolutionary theory. For one thing, essentialist assumptions may be deeply entrenched and not readily modified by instruction. Furthermore, essentialism is not the only cause of rejection of evolution. There is ample evidence to suggest that religious teachings, teleological biases, and difficulty considering complex processes and deep time are also powerful obstacles (see other chapters in the present volume).

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Table 1. Components of essentialism and implications for the acceptance and understanding of evolution.

| ESSENTIALIST COMPONENT | BELIEFS THAT POSE OBSTACLES TO ACCEPTANCE | BELIEFS THAT POSE OBSTACLES TO UNDERSTANDING |
|---|---|---|
| Stability, immutability | Species can't change | |
| Boundary intensification | There are no intermediate categories | Species are absolute, not probabilistic |
| Within-category homogeneity | Rejection of variability | Variability is only superficial |
| Causes inhere in individuals | | Failure to understand change as population based |
| Existence of category ideal | | Evolution is progressive |

Table 2. Varieties of essentialism. Note: Xs indicate the cells that are the focus of the present paper (psychological essentialism).

| | Sortal | Causal | Ideal |
|---|---|---|---|
| Metaphysical | • | • | • |
| Representational | | | |
| Psychological | • | X | • |
| Nominal | • | X | • |
| Cultural | • | X | • |

## Notes

[1] Although we won't have the space to engage with these issues here, interested readers are directed to the following critiques of essentialism: Sloutsky (2003), Sloutsky, Kloos, & Fisher (2007), Landau, Smith, & Jones (1998); Strevens (2000); Malt (1994), Sloman, Lombrozo, & Malt (2007), Braisby, Franks, & Hampton (1996). For defense of essentialism, see Ahn et al. (2001), Gelman (2003), Gelman & Medin (1993), Gelman & Waxman (2007), Gelman & Kalish (2006), Jaswal & Markman (2007).