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**Title:** **The Native Mind : Biological Categorization and Reasoning in Development and Across Cultures**

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**Abstract:** This article describes cross-cultural and developmental research on folk biology: that is, the how people conceptualize living kinds. The combination of a conceptual module for biology : cross-cultural comparison brings a new perspective to theories of categorization and reason the standpoint of cognitive psychology, the authors find that results gathered from standard populations in industrialized societies often fail to generalize to humanity at large. For example similarity-driven typicality and diversity effects either are not found or pattern differently when moves beyond undergraduates. From the perspective of folk biology, standard populations r misleading results because they represent examples of especially impoverished experience nature. Certain phenomena are robust across populations, consistent with notions of a core

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## The Native Mind : Biological Categorization and Reasoning in Development and Across Cultures

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<a href="#">Ranked taxonomy</a>	This research was supported by National Science Foundation (NSF) Grants SBR 9319 9422587, SBR 9707761, and SBR 9983260; NSF/Environmental Protection Agency Grant 9981762; National Institutes of Health Grant MH55079; Russell Sage Foundation Grant 02; and CNRS Contract No. 92 C 0758, Ministère de la Recherche et Technologie.
<a href="#">Biological essentialism</a>	
<a href="#">Biology as a Module of Mind</a>	
<a href="#">Resistance to inhibition and hyperactivity</a>	This work is the summary of a combined effort by a number of long-term research collaborators: Norbert Ross, Elizabeth Lynch, Edilberto Ucan Ek', Valentina Vapnarsky, John Coley, and Ximena Lois. Other important contributors and collaborators include Jeremy Bailenson, Baran, Serge Blok, Russell Burnett, Doug Cox, Paul Estin, Brett Hayes, Lawrence Hirschfeld, Alejandro López, Brad Love, Bobbi Low, Richard Nisbett, Connie Pankratz, Elizabeth F. Hillarie Schwartz, Michael Shum, Brian Smith, Edward Smith, Paolo Sousa, Gert Storm, Christopher Timura, Sandra Waxman, and Phil Wolff. Lance Rips, Susan Gelman, Lawrence Hirschfeld, and Dan Sperber provided constructive comments on a draft. We are deeply grateful to our research partners and participants in Guatemala, Mexico, Brazil, Wisconsin, Illinois, Michigan and especially to the Maya and Menominee communities that took us in.
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<a href="#">A Final Methodological Point</a>	<b>Correspondence concerning this article should be addressed to:</b> Douglas L. Medin, Department of Psychology, Northwestern University, 2029 Sheridan Road, Swift Hall 11 Evanston, IL, 60208-2710. Electronic mail may be sent to: <a href="mailto:medin@northwestern.edu">medin@northwestern.edu</a>
<a href="#">Summary</a>	
<a href="#">Study Populations and Related Methodology</a>	To get along in the world, people need to be able to understand and predict the general properties and behaviors of physical objects and substances (physics), the more specific properties of plants and animals (biology), and the particular properties of their fellow humans (psychology). This article describes an ongoing program of research in the domain of naive or folk biology, including aspects of its interfacing with folk psychology. The topics range from simple categorization to complex inductive inferences. The contexts vary from the rain forest of Guatemala to the most technologically developed urban settings. The study populations extend from the standard undergraduate research pool to Itza' Maya elders in Guatemala who have no formal education, on the one hand, and to doctors of botany, and other; they also range from middle-class children living near major U.S. universities to Maya children of rural Mexico.
<a href="#">Mesoamerica</a>	
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<a href="#">Rural majority culture: Children</a>	
<a href="#">Urban children</a>	
<a href="#">Relation of Folk Biology to Folk Psychology</a>	In this article, we argue that the combination of cross-cultural research with conceptual biological cognition as a privileged, domain-specific competence provides a new perspective on a range of fundamental issues in cognition. This includes (a) a need to revise current models of categorization and reasoning, which have been developed on a narrow empirical base, and speaking; (b) an analysis of the relative contributions of universal versus culturally specific processes to people's conceptions of biological kinds; and (c) a shift in appraisal of the so-called "standard populations" from constituting a norm to seeing them as reflecting the cognitive consequences of diminished contact with nature.
<a href="#">Method</a>	
<a href="#">Results</a>	
<a href="#">Childhood Conceptions of Species Essences</a>	
<a href="#">Summary</a>	
<a href="#">The Essence of the Basic Level</a>	This article can be read from two closely related perspectives. From the point of view of mainstream cognitive psychology, we find that results gathered from standard populations often do not fail to generalize to humanity at large. In the area of categorization, similar driven typicality effects and basic level phenomena either are not found or play out differently when one moves beyond undergraduate participants. In research on category-based reasoning we find again that undergraduates are the "odd group out," a result with corresponding implications for models of induction. In developmental studies, we find both culture and experience affect the status of results that had been treated, at least implicitly, as universal.
<a href="#">Devolution and Expertise</a>	
<a href="#">Typicality</a>	
<a href="#">Use of Categories in Inductive Reasoning</a>	Interwoven in our research program is the notion that specialized cognitive modules face and structure cognition. We argue that this framework is useful but that in the case of naive biology, using standard populations may produce misleading results because such populations represent examples of especially impoverished experience with respect to nature. Nonetheless, the very fact of limited input makes results with these populations of considerable interest. They show which aspects of biological cognition are especially resilient. The pattern of universally culturally variable results illuminates researchers' understanding of biology as a domain.
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With respect to methodology, our research constitutes a distinctive point of view with re cultural psychology. In this article, we provide a description of several conceptual issue have provided a framework for our research. This framework serves as a guide to a nu methodological challenges that inevitably arise in cultural research. In a companion arti contrast our view of culture and cultural models with a number of competing concepor illustrate its efficacy in studies of cultural differences in mental models and environment decision making ([Atran, Medin, & Ross, 2004a](#)).

## [Biology as a Core Cognitive Domain](#)

At the level of theory, we attempt to describe the scope and limits of folk biology as a functionally autonomous domain of human cognition by concentrating on cross-cultural regularities (including systematic differences) in structure and development. In this sect outline our approach to core modules in general and introduce our conjectures about th structure of the folk-biology system.

We hypothesize a folk-biological system (FBS) of the human mind that discriminates ar categorizes parts of the flux of human experience as “biological” and develops complex to infer and interpret this structured, core cognitive domain. In a general sense, there is different about the FBS—in terms of innateness, evolution, or universality—than the vis system (VS) or any other evolved cognitive system (cf. [Chomsky, 2000](#)). The FBS is nc less) “autonomous” from the surrounding social environment, or from other mental syst than the VS is detachable from surrounding light and object patterning or from other ph systems (including linguistic and other cognitive systems of meaning; [Mayr, 1982](#)). The does not exist, and cannot develop, in isolation, but only as subsystems of even more i

and interdependent structures. Thus, claims about the biological “autonomy” or “modularity” of the FBS refer only to specifiable level of systemic functioning within a system hierarchy.

How the FBS combines with local environmental conditions and cultural history to produce people's actions on the environment is the subject of a companion article ([Atran et al., 2004a](#)). In this article, however, we restrict our focus acquiring knowledge of folk biology.

How the FBS interfaces with folk-*psychological* ([Carey, 1995](#)) and folk-mechanical ([Au, Romo, & DeWitt, 1999](#)) sy a subject of current controversy in developmental and cognitive psychology. We have little to say about the interfac between folk biology and folk mechanics. To be sure, there is a substantial body of information on perceptual trigge conditions for attributions of agency (e.g., [Bloom & Veres, 1999](#); [Csibra, Gergely, Bíró, Koós, & Brockbank, 1999](#); [Simmel, 1944](#); [Premack, 1990](#)); however, there is only sparse and scattered work on how groups of animals and pl assigned causal properties (by perceptual analyzers or otherwise) that distinguish them (e.g., as group essences) f objects on the basis of perceptual cues and mechanical indicators of boundary and movement. In contrast, ever sir [Carey's \(1985\)](#) pioneering studies, the relation between folk biology and folk psychology has come under intense experimental scrutiny ([Gelman & Wellman, 1991](#); [Inagaki & Hatano, 1993](#); [Keil, 1989](#)).

Our present knowledge of evolutionary mechanisms and history is generally too poor to generate causal explanatic cognition. Often, evolutionary accounts are mere consistency arguments—“just-so stories”—that lack evidentiary st for ruling out indefinitely many contrary evolutionary scenarios ([Atran, 2002](#)). There have been more constrained evolutionary accounts of higher order cognitive functions specific enough to motivate competing theories and inform research (e.g., [Cosmides & Tooby, 1992](#); [Pinker & Bloom, 1990](#)). So far, however, these accounts arguably do little than retrodict findings generated independently of any evolutionary considerations (e.g., [Hauser, Chomsky, & Fitch Sperber, Cara, & Giotto, 1995](#)).<sup>1</sup> At the same time, we hope to illustrate how an evolutionary perspective can be u: even necessary—to progress in the field. A factor motivating our experiments, and our interpretation of them, is evc plausibility. We do not claim that evolutionary arguments have explanatory value, only heuristic value.

Humans and their ancestors undoubtedly depended for their survival on intimate interaction with plants and animal: likely required anticipatory knowledge of at least some plant and animal species. This makes it likely (but not neces that adaptations for special dealings with plants and animals evolved and, further, that they evolved in a manner so independent of adaptations for dealings with other people. For example, identification and categorization is differen humans, on the one hand, and for animals and plants, on the other. There are cognitive mechanisms primarily dedi

tracking humans as individuals, such as facial recognition (e.g., [Carey & Diamond, 1977](#); [Diamond & Carey, 1986](#)), and semantic structures of pronominalization and proper naming ([Arnold, Eisenband, Brown-Schmidt, & Trueswell, 2001](#); [Balogh, Swinney, & Tighe, 1998](#)), social game strategies ([Axelrod, 1985](#); [Nowak & Sigmund, 1998](#)), and so forth. For animals and plants, the default recognition strategies likely are focused at the collective, species level (individualized pets may involve anthropomorphic extensions of person-identification strategies). From an evolutionary vantage, it would matter which member of a plant or animal species a person could eat or be eaten by, but it would matter greatly in particular a person could mate, fight, or cooperate with ([Eldredge, 1986](#)). People's beliefs about personal identity even survive changes in kinship or species identity ([Blok, Newman, Behr, & Rips, 2001](#); [Blok, Newman, & Rips, 2001](#)). One implication of this analysis for folk-biological cognition is that results focused at the level of individuals do not necessarily carry over to studies at the level of species, and vice versa.

## Structural Principles of Folk Biology

### Ranked taxonomy

In every human society, it appears, people tend to think about plants and animals in the same special ways. These ways of thinking, which can be described as *folk biology*, are basically different from the ways humans ordinarily think about other things in the world, such as stones, tools, or even people:

*From the most remote period in the history of the world, organic beings have been found to resemble each other in descending degrees, so that they can be classed into groups under groups. This classification is not arbitrary like the grouping of stars in constellations. (Darwin, 1859, p. 431)*

The structure of these hierarchically organized groups, such as *white oak-oak-tree* or *mountain robin-robin-bird*, is identical to that of *folk-biological taxonomy*. These nonoverlapping taxonomic structures can often be interpreted in terms of species (related species descended from a common ancestor by splitting off from a lineage).<sup>2</sup>

The human taxonomic system for organizing species appears to be found in all cultures ([Atran, 1990](#); [Berlin, Breedlove, & Raven, 1973, 1974](#)). It includes the conceptual realization that say, apple trees and robins belong to the same fundamental level of (folk) biological reality and that this level of reality differs from the subordinate level that includes wildflowers and trees and mountain robins as well as from the superordinate level that includes trees and birds. This taxonomic framework also supports indefinitely many systematic and graded inferences with respect to the distribution of known or unknown properties among species ([Atran, 1998](#)). Biological ranks are second-order classes of groups (e.g., species, family, kingdom) whose elements are first-order groups (e.g., lion, feline, animal). Folk-biological ranks vary little across cultures as a function of theories or belief systems ([Malt, 1995](#)). Ranks are intended to represent fundamentally different levels of biological reality, not convenience ([Berlin, 1992](#)).

### Biological essentialism

There is also growing cross-cultural evidence of a common-sense assumption that each species has an underlying nature, or internal essence, that is uniquely responsible for the typical appearance, behavior, and ecological preferences of the kind ([Atran, 1998](#); [Atran, Estin, Coley, & Medin, 1997](#); [Atran et al., 2001](#); [Gelman, 2003](#); [Gelman & Wellman, 1991](#); [Sousa, Atran, & Medin, 2002](#)). We suggest that this notion of biological essence may be universal. People in diverse cultures consider it responsible for the organism's identity as a complex entity governed by dynamic internal processes that are lawful even when hidden. This essence maintains the organism's integrity from birth even as it causes the organism to grow, change form, and transmit the same causal cycle across generations. Thus, a tadpole and frog are conceptually the same animal although they look and behave very differently and live in different places. For these reasons, biological essentialism is more specialized than mere nominal essentialism, which applies to all objects (e.g., desk, gold) and qualities (e.g., red, liquid; [Atran, 1998](#); [Rips, 1995](#)).

Western philosophers, like Aristotle and Locke, attempted to translate the common-sense notion of essence into scientific metaphysical reality, but evolutionary biologists reject the notion of essence as such (e.g., [Mayr, 1982](#)). Nevertheless, biologists have traditionally interpreted conservation of identity under change as being because organisms have genes that are separate from phenotypes. Although science does not abide metaphysical essentialism, there is a wide variety of evidence supporting the notion of *psychological* essentialism ([Ahn et al., 2001](#)); that is, even when people do not have specific beliefs about essences, they may nonetheless have a commitment to the idea that there is an underlying nature (i.e., they have an "essence placeholder"; [Medin & Ortony, 1989](#)). This hidden, causal essence is presumably responsible for

emerging and manifest properties of the kind. That biological science can overturn **psychological** essentialism in its construction in no way implies that **psychological** essentialism can be dismissed from everyday thought any more physical science's rejection of constant intervals of space and time implies alterations in our ordinary use of absolute and time ([Atran, 1987](#)).

The idea of an essence placeholder allows that people may come up with different mechanisms for conveying or manifesting causal essence. This process operates under "soft constraints" in the sense that some mechanisms may be more plausible or natural choices than others. For example, beating of the heart and circulation of blood give prima facie mechanistic evidence for causal activity. In addition, loss of blood and stopping of the heart are often signs of loss of life. Thus, blood may be privileged candidates for the locus of essence, as it has been throughout the history of European society ([Atran, 1990](#)). Even contemporary Americans who undergo heart transplants show evidence of believing that at least some aspects of essence have been transmitted from the donor to the recipient ([Sylvia & Novak, 1997](#)). In different cultural settings, other plausible candidates (e.g., milk as conveyor of essence through nursing) may have priority ([Stoler, 1997](#)). Willingness to allow transformations of essential kindhood (e.g., through blood transfusions or organ transplants) may depend on cultural context ([Mahalingam, 1998](#); [Walker, 1992](#)).

For the moment, we defer addressing the question of whether hierarchical taxonomies and the presumptions of essence are specific to biology (see [Hirschfeld, 1995](#), and [Atran, 1995](#), for one round of arguments). Different kinds of categories conform more or less well to a hierarchy (many social categories do not), and people may, at least in a weak sense, essentialize all categories (see [Rips, 1995](#)). But a system of rank is not simply a hierarchy, and it is less clear that there is anything corresponding to a cross-culturally stable sense of essences for nonbiological kinds (for an attempt to rank artifacts, see [C. Brown, Kolar, Torrey, Troung-Quang, & Volkman, 1976](#); for opposing arguments, see [Atran, 1987](#); findings contrary to attributions of essences to artifacts, see [Sloman & Malt, 2003](#)). None of our central claims hinge on whether patterns of categorization and reasoning are confined solely to naive biology, and it is possible that strategies and presumptions that originate in naive biology are generalized beyond it (either ontogenetically or in evolution).

## Biology as a Module of Mind

Different cognitive scientists have offered alternative, and sometimes conflicting, notions of modules; so, we take a few paragraphs to say what we mean by modules. We consider that there are roughly two classes of evolved cognitive modules: perceptual modules and conceptual modules. A *perceptual module* has automatic and exclusive access to a specific set of sensory inputs, its own proprietary database, and may not draw on information produced by other conceptual modules. A perceptual module is usually associated with a constrained neural architecture and fast processing that is not accessible to conscious awareness. Examples may be modules for facial recognition, color perception, identification of object boundaries, and morphosyntax ([Fodor, 1983](#)).

A *conceptual module* works on a privileged, rather than strictly proprietary, database that is provided by other parts of the nervous system (e.g., sensory receptors or other modules) and that pertains to some specific cognitive domain ([Atran, 1990](#), p. 285). Examples include folk mechanics, folk biology, and folk psychology.<sup>3</sup> The argument for conceptual modules, as in the case of folk biology—involves converging evidence from a number of venues: functional design ([Atran, 1990](#); [Pinker, 1997](#)), ethology ([D. Brown & Boysen, 2000](#); [Cerella, 1979](#); [Herrnstein, 1984](#)), universality ([Atran, 1990](#); [Berlman, 1974](#); [C. Brown, 1984](#)), precocity of acquisition ([Dougherty, 1979](#); [Hatano & Inagaki, 1999](#); [Stross, 1973](#)), independence from perceptual experience ([Atran et al., 1997](#); [Gelman & Wellman, 1991](#); [Sousa et al., 2002](#)), selective cerebral impairment ([Caramazza, 2002](#); [Farah & Rabinowitz, 2003](#); [Sartori & Job, 1988](#)), resistance to inhibition (hyperactivity), and cultural transmission. None of these criteria may be necessary, but presence of all or some is compelling, if not conclusive. Here, we consider only the latter two principles because they are rarely a part of discussions of modules (for a full discussion of principles, see [Atran, 2001](#)).<sup>4</sup>

## Resistance to inhibition and hyperactivity

One characteristic of an evolved cognitive disposition is evident difficulty in inhibiting its operation ([Hauser, 2000](#)). Such beliefs in essences. Such beliefs greatly help people explore the world by prodding them to look for regularities and explanations of variation in terms of underlying patterns. This strategy may help bring order to ordinary circumstances including those relevant to human survival. But in other circumstances, such as wanting to know what is correct or true about the cosmos at large, such intuitively ingrained concepts and beliefs may hinder more than help.

Because intuitive notions come to people so naturally, they may be difficult to unlearn and transcend. Even student

philosophers of biology often find it difficult to abandon common-sense notions of species as classes, essences, or kinds in favor of the concept of species as a logical individual—a genealogical branch whose endpoints are somewhat arbitrarily defined in the phyletic tree and whose status does not differ in principle from that of other smaller (variety larger (genus) branches ([Ghiselin, 1981](#)). Similarly, racism—the projection of essences onto social groups—seems cognitively facile and culturally universal tendency ([Hirschfeld, 1996](#)). Although science teaches that race is biologically incoherent, racial or ethnic essentialism is as notoriously difficult to suppress as it is easy to incite ([Gil-White, 2001](#)).

## Cultural transmission

Human cultures favor a rapid selection and stable distribution of those ideas that (a) readily help to solve relevant recurrent environmental problems, (b) are easily memorized and processed by the human brain, and (c) facilitate the retention and understanding of ideas that are more variable (e.g., religion) or difficult to learn (e.g., science) but are useful or important. Folk-biological taxonomy aids humans in orienting themselves and surviving in the natural world noted earlier, its structure and content tends to be fairly stable within cultures (high interinformant agreement, substantial historical continuity) and structurally comparable across cultures ([Berlin et al., 1973](#)). Over time and in different cultural settings, taxonomic structure and content may become deeper or shallower (as with industrialized populations). Nevertheless, its organizational principles remain robust.

The sort of cultural information that is most susceptible to modular processing is the sort of information most readily acquired by children, most easily transmitted from individual to individual, most apt to survive within a culture over time (provided adequate input and cultural support), and most likely to recur independently in different cultures and at different times. Critically, it is also the most disposed to cultural elaboration and makes cultural variation comprehensible. We suggest that folk biology meets these criteria.

## Summary

We believe that there are strong constraints on how people organize their local knowledge of biological kinds. These evolutionary constraints form a “learning landscape” that shapes the way inferences are generalized from particular instances or experiences. It produces consensus even though specific inputs vary widely in richness and content. To many different people observing many different exemplars of *dog* under varying conditions of exposure to those exemplars may nonetheless generate more or less the same concept of “dog.”

To say an evolved biological structure is “innate” is not to say that every important aspect of its phenotypic expression is “genetically determined.” Biologically poised structures “canalize” development but do not determine it—like mountain channels scattered rain into the same mountain-valley river basin ([Waddington, 1959](#)). Cultural artifacts can—purposefully or inadvertently—further channel developments in various directions, like dams or water gates placed at different locations.

Our burden of proof is to show that the above analogy forms a meaningful pattern in the domain of naive biology rather than a mishmash of vague ideas and speculations. As a guideline and overview, we provide a summary of our central theoretical and empirical claims, along with our assessment of the corresponding state of evidence, in [Table 1](#). We return to this in the General Discussion.

Table 1  
*Empirical and Theoretical Claims and the Status of Evidence Bearing on Them*

Claim	Status of evidence
Essentialism is a universal bias.	This generalization holds over several populations but needs further case studies.
The essence and inductive privilege are at the rank of species (e.g., robin), not life-form (e.g., bird).	This claim is supported across variation in culture and expertise but needs further case studies.
The basis for typicality ratings and typicality effects in reasoning is knowledge dependent, and undergraduates are often the “odd group out.”	Itza' Maya, bird experts, fish experts, and tree experts differ from undergraduates.
Standard populations (e.g., undergraduates) may use impoverished default categorization and reasoning strategies (e.g., abstract similarity judgments) relative to those used by most of humanity (e.g., content-rich strategies).	This claim is strongly supported in the domain of folk biology. It needs to be tested in other domains.
Children's folk biology is distinct from folk psychology and not anthropocentric.	There is evidence supporting this claim in Maya, Menominee, and rural majority-culture populations.
Folk biology represents an innate module, with coherent variation as a function of culture and expertise.	The domain specificity framework is useful, but the results have been only partially predicted in advance.

### *Empirical and Theoretical Claims and the Status of Evidence Bearing on Them*

## Cross-Cultural Comparison

Our claims concerning folk biology rely heavily on comparative research, typically within- and across-cultures. One begin to conduct this type of research without making a series of methodological and conceptual commitments. On that comparative research has not been popular is that it is not always clear how to do it successfully. When one cc two groups and finds clear differences, interpretative problems quickly emerge. Which of the many ways in which th groups differ are crucial? For example, [López, Atran, Coley, Medin, and Smith, \(1997\)](#) found that U.S. undergradu: Itza' Maya of Guatemala showed different patterns of responding on a category-based inductive reasoning task inv mammals. Although this undermines the universality of the particular reasoning phenomenon, the two groups differ myriad ways (e.g., age, education, literacy, livelihood, language, cosmology, and so on). Which of these differences matters? Practically speaking, it may be impossible to disentangle these various factors. Suppose one could contrc education, literacy, and the like in comparing Itza' Maya and undergraduates. How does one decide which variable: represent culture and therefore should not be controlled and which variables do not and should be controlled. The I Maya practice agroforestry and also hunt and collect plants in the forest. Should these factors be controlled or are t of Maya culture?

Now suppose that one controls for every variable one can think of and still finds differences. In this case, it seems t is more or less forced to reify or essentialize culture. That is, the only explanation of the cultural difference involves appealing to some abstract notion of “culture.” In short, it seems we may be caught between two equally undesirab possibilities: One is to end up with a notion of culture that solely has recourse to circular explanations of differences (Itza' are different because they are Itza"). The other is to conclude that cultural comparisons just represent confour experiments and that the notion of culture is not needed once proper experimental control is achieved.

Another problem associated with comparative research is the issue of sampling. If one wants to know how the Itza' categorize and reason, he or she had better take a random sample of Itza', else his or her results may not generaliz Itza' population as a whole. But the sample used by [López et al. \(1997\)](#) was anything but random—it consisted of It elders who speak Itza' Maya. That fact alone makes the sample unusual and unrepresentative because Itza' Maya dying language; the “typical” Itza' speaks mainly Spanish. How can one justify nonrandom sampling? In what follow describe our methodological strategy for cultural comparisons.

## Triangulation as a Research Strategy

There is no theoretically neutral way to define culture (see, [Atran et al., 2004a](#)). We have just suggested that the ic

culture is whatever is left when all potentially confounding variables are controlled is self-defeating. Granted, it is under control for variables that are clearly irrelevant to culture. But one must bear in mind that decisions about what is irrelevant are necessarily theory based and commit one to a particular notion of culture.

Because (cultural) groups cannot be found that represent orthogonal combinations of variables, it may be in principle impossible to disentangle the various sources of variation among groups. The general idea of triangulation is to use observations from a third group to get at least modest leverage for understanding initial group differences. The third group should resemble one group in some potentially important ways and the second group in other ways. If the third group performs like one group and different from the other group, then the variables shared by the third group and the group it mimics become candidates for critical variables.

To illustrate this strategy, consider the study by [López et al. \(1997\)](#). In that study, Itza' Maya elders and University of Michigan undergraduates were compared on categorization and reasoning involving local mammals (local to Petén Guatemala, and Michigan, respectively). The participants were told of a new disease that was known to affect *coyotes* and another new disease that was known to affect *coyotes* and *cows*. Then, they were asked which disease was more likely to affect all mammals. University of Michigan undergraduates overwhelmingly said the disease that affects *coyotes* is more likely to affect all mammals. They justified their answers by appealing to the dissimilarity of the two premises: *diversity*. That is, they said that if some disease affects such different mammals as *coyotes* and *cows*, it is likely to affect all mammals. This reasoning strategy seems straightforward and [Osherson, Smith, Wilkie, López, and Shafir's \(1990\)](#) for category-based reasoning predicts that people will prefer more diverse premises in drawing inductions to a category. What is surprising is that the Itza' Maya do not show a diversity effect. In some cases, they are reliably below chance in picking the more diverse premises on these kinds of tests.

Why don't the Itza' use a diversity-based reasoning strategy? Obviously, there are any number of hypotheses one can conjure up. Perhaps the question wasn't asked quite the same way in Itza' Maya (back translation is no guarantee of equivalence), perhaps formal education is a prerequisite for this form of abstract thought, or perhaps the Itza' have a different conceptualization of disease. It just isn't clear.

Here is where our triangulation strategy proved to be effective. In this case, the third group was U.S. tree experts who were asked to reason about novel tree diseases. U.S. tree experts resemble Michigan undergraduates in many respects (language, formal education, etc.) and resemble Itza' with respect to having considerable domain knowledge. A typical diversity probe might be as follows: "White pine and weeping willows get one new disease and river birch and paper birch get another. Which is more likely to affect all trees?" Using these kinds of probes, [Proffitt, Coley, and Medin \(2000\)](#) found that parks workers, like the Itza', showed reliably below chance diversity responding. Below, we describe what strategies Itza' and parks workers share. For now, we simply note that the triangulation strategy pinpoints domain knowledge as a variable in diversity responding (though as we show below, not the whole story).

At first glance, it might appear that the triangulation strategy is just a  $2 \times 2$  design with one cell missing. But a  $2 \times 2$  design presumes what the triangulation strategy is intended to discover, namely, which factors are crucial to group differences. The logic of triangulation implies compression of any number of possible  $2 \times 2$  designs that together entail a host of possible explanations for group differences. Instead of  $2^N$  controlled designs, each of which allows inference to a single factor, a carefully chosen third group deliberately confounds a number of variables. By carefully choosing a third group, C, that resembles the first group, A, in a number of ways and the second group, B, in a number of other ways, one can assess the relative importance of the set of culturally confounded variables by which C differs from A versus those by which C differs from B.

## Purposive Sampling

Cultures are not static but relentlessly develop, dissolve, merge, and mutate. Nonetheless, it seems sensible to look for sharp contrasts by means of selecting subpopulations that have retained more traditional knowledge. These considerations lead one to use sampling techniques most likely to reveal cultural differences rather than focusing on estimating population parameters. Consider again [López et al.'s \(1997\)](#) studies with the Itza' Maya. Younger Itza' might have notions of boundaries that differ from those of Itza' elders, differences that reflect assimilation to western culture. Thus, a random sample might tend to hide rather than reveal cultural differences. Instead of randomly selecting participants, López et al. restricted their sample to Itza'-speaking Maya as the best representatives of Itza' culture. It's not that there was some pure Itza' culture in the past that nowadays is being degraded—cultural change is a constant. Itza' cultural life is a rich blend of ideas and habits stemming from different inputs, including a great deal of Spanish influence. A random sample is only appropriate when one wants to make claims about population parameters, something that we believe is rarely relevant in cultural comparison.

## A Final Methodological Point

The streets of unfortunate cross-cultural comparisons are strewn with studies that began with methodologies developed in the United States and then rigidly applied to other populations of interest. It is very important to be sensitive to the possibility of cultural misunderstandings arising from task instructions and interpretation. This threat can be substantially reduced through careful pretesting informed by ethnographic, ethnohistorical, ethnobotanical, and ethnolinguistic preparation.

For example, broad cross-cultural agreement in biological categorization should not conceal the fact that different experimental procedures may yield different patterns of taxonomic or ecological sorting. Thus, in pretests with Itza' Maya, [Lopez et al. \(2001\)](#) asked them to sort things most "similar" (*b'ay*) or "alike" (*je-b'ix*) to replicate as closely as possible instructions given to American participants (e.g., [Boster & Johnson, 1989](#)). Initial results were discouraging: Consensus across participants was low, and participants seemed to justify sorts by often idiosyncratic and conflicting notions of use (e.g., "horses and cows are more similar to one another than to tapirs because tapirs don't carry loads"; "tapirs and cows are more similar to one another than to horses because horses are not eaten at festivals"). But ethnohistory indicates that the expression of a deep taxonomic reasoning endures over time ([Bartlett, 1940](#); [Trager, 1939](#)). Thus, 16th-century Itza' Maya taxonomically assigned the horse (a perissodactyl) by identifying it as a kind of tapir (the only native perissodactyl; [Landa, 1566/1985](#)). Itza' Maya still use the same name to the horse (*tzimin*) and tapir (*tzimin~che'* [forest horse]), although they are maximally distant by functional criteria: The former is terrestrial, domestic, and inedible; the latter is aquatic, wild, and edible. Interviews reveal that Itza' Maya consider the tapir and horse to be "companions by nature" (*et'~ok* [go together]). This proved the key to asking Itza' Maya items that "go together by nature," which yielded taxonomies resembling those found in cultures the world over ([López, 1997](#)). By contrast, there was no significant difference in the performance of American students asked to sort items by similarity versus going together by nature.

Similar sorts of analyses and pretesting accompanied preparation of all of our instructions. One advantage of tailoring instructions to a variety of nonstandard populations is that usually they can be further applied to other populations with greater ease and confidence than if they had been simply translated from instructions given to undergraduates or other groups affiliated with large research universities and urban environments in the United States. Moreover, we have found that the instructions so pretested usually can be successfully reapplied to standard populations.

## Summary

We have spent considerable time in describing our framework for comparative research in folk biology, in part because of contrast with previous approaches to cultural comparison. The stage is now set to begin a systematic **review** of empirical results in relation to theories. In each study set, our findings contrast sharply with previous generalizations.

## Study Populations and Related Methodology

In the next several paragraphs, we describe the main study populations in our research. The reader less interested in specific characteristics of the populations may wish to skip ahead to the next section.

### Mesoamerica

#### Itza' Maya

A good deal of our work concerns native Itza' Maya in the municipality of San Jose in Guatemala's Department of El Quiché. Men are primarily occupied with practicing agriculture and horticulture, hunting game and fish, and extracting nontimber forest products for sale. Women mainly attend to household gardening and maintenance. The climate is semitropical, with quasi rain forest predominating (tropical dry forest-subtropical humid forest).

#### Yukatek Maya

We have also worked with children and adults from Yukatek-speaking rural villages in southcentral Quintana Roo, Mexico. Like the Itza', they practice agriculture, hunting, and extracting forest products, though their forests are more degraded than those of the Itza'. Yukatek were chosen because of their close linguistic and cultural connection with the Itza' and because of their proximity to the Itza'.

there are thousands of Yukatek-speaking children but no more children who speak Itza' as a first language.

## North American Populations

It has also been helpful to collect data from a number of U.S. populations. When we began to study folk biology with standard undergraduate populations, it soon became clear that the typical college student knows very little about plants and animals. Consequently, we sought out a variety of other U.S. populations. There is also evidence that urban and suburban children may have relatively impoverished experience with nature (compare [Stross, 1973](#), on Maya children's knowledge and naming of plants, with [Dougherty, 1978](#), on Berkeley children), and therefore, our developmental studies also included several different groups.

## Undergraduates

This group hardly needs description. They consist of students taking introduction to psychology at major research universities in the Midwest.

## Biology “experts.”

This category includes diverse groups with distinct kinds of expertise: bird-watchers, fishermen, parks maintenance workers, landscape architects, and professional taxonomists. They typically had at least 20 years experience in their occupation.

## Menominee: Adults

The Menominee (“Wild Rice People”) are the oldest continuous residents of Wisconsin. There are 4,000–5,000 Menominees living on tribal lands in and around three small communities. Over 60% of Menominee adults have at least a high school education, and 15% have had some college. As in the past, the reservation is heavily forested. Hunting and fishing are important activities for most men and for many women.

## Menominee: Children

The Menominee children attended an elementary school on the Menominee reservation. Although they tend to know Menominee words, especially those for clan animals, they are basically monolingual English speakers.

## Rural majority culture: Adults

Adjacent to the Menominee reservation is Shawano County, which consists of farmland, small forest plots (typically 10–20 acres), and numerous lakes and rivers. Hunting, fishing, water recreation in the summer, and snowmobiling in the winter are popular activities. Our adult participants came from in and around the community of Shawano.

## Rural majority culture: Children

The majority-culture children attended an elementary school in Shawano. About 20% of the children lived on farms. In the case of the Menominee children, it is not uncommon for preschool children to be introduced to fishing.

## Urban children

The urban children attended an elementary school in Boston, Massachusetts. The school is located in East Boston and serves a middle-class community.

## [Relation of Folk Biology to Folk Psychology](#)

In her influential 1985 book, [Susan Carey, 1985](#) proposed that young children's understanding of living things is initially embedded in a folk **psychological**, rather than folk biological, explanatory framework and that human beings act as a prototype. Her data suggested that children did not develop an independent model of biology in which humans were one animal among many (at least with respect to bodily parts and their functions) until they were 10–12 years old. In line with this view, children have to undergo a fundamental conceptual change to achieve an autonomous biology.

A strong form of evidence for this theory comes from an inductive inference task in which children are told that some property is true of one biological kind (e.g., “Humans have a little green thing inside them called an omentum.”), then asked whether that property is true of other biological kinds (e.g., “Do you think that dogs also have an omentum?”). Major findings bolster the claim that children's conceptions of the biological world are anthropocentric. First, children readily project properties from humans to other living kinds rather than they project properties from other living kinds to another or to humans. The other two findings are consequences of this difference in induction potential. The second concerns asymmetries in projection: Inferences from humans to mammals are stronger than from mammals to humans. Third, 4-year-old children violate projections according to similarity: Inferences from humans to bugs are stronger than from bees to bugs. Together, these findings suggest that humans are the preferred base for young children's inferences about the biological world.

[Carey's \(1985\)](#) claims have not gone unchallenged, and her book has served to stimulate a large body of research on children's biology. The current consensus appears to be that even young children do have distinct biological theories ([Carey, 1999](#); [Gelman, 2003](#); and [Inagaki & Hatano, 2001](#), for extensive reviews), though these theories may differ systematically from the science that they must learn in school. Nonetheless, Carey's induction task continues to be of great interest. There is work suggesting that the relative prominence of **psychological** versus biological construals of biological kinds is sensitive to contextual factors ([Guntheil, Vera, & Keil, 1998](#)). Our work suggests that there is an important cultural and experiential dimension that merits attention. Specifically, our evidence suggests that the anthropocentrism observed in Carey in young children does not reflect a failure to distinguish biology from psychology. Instead, we believe that humans serve as prototypes because human beings were the only biological entity that young urban children knew very well.

Research on children's biology has been conducted almost exclusively with individuals from North American, urban, technologically advanced populations. In the majority of the studies that go beyond this sample (e.g., [Inagaki & Hatano, 2002](#), and [Hatano & Inagaki, in press](#), in Japan), the focus is still on urban, majority-culture children from technologically advanced societies. Thus, it is not clear which aspects of children's naive biology are likely universal and which depend critically on cultural conceptions and conditions of learning. Human-centered reasoning patterns might reflect lack of knowledge about nonhuman living things rather than a radically different construal of the biological world.

## Method

To evaluate the role of cultural milieu and conditions of learning in children's inductive reasoning, we have studied four populations of children—urban Boston children, rural Wisconsin majority-culture children, Menominee children, and Maya children of varying ages (4 to 11)—and adults ([Atran et al., 2001](#); [Ross, Medin, Coley, & Atran, 2003](#)). All tests were administered in the United States; Yukatek Maya was used for the Maya children and adults.

Detailed color drawings of objects were used to represent base and target categories. Four bases were used in Mexico: human (man, woman), dog, peccary, and bee. Targets were divided into two sets. Each set included a representative of the category: human (man, woman), mammal (deer, coatimundi), bird (eagle, chachalaca), reptile (boa, turtle), invertebrate (worm), plant (cane, tree (kanan, gumbo-limbo), stuff (stone, mud), artifact (bicycle, pencil), and sun (in both sets). The U.S. populations used human, wolf, bee, goldenrod, and water as bases and a corresponding set of mammals, birds, reptiles, invertebrates, plants, stuff, and artifacts as targets.

As in [Carey's \(1999\)](#) studies, participants were shown a picture of one of the bases and taught a new property about it. Thus, the experimenter might show the dog picture and say “Now, there's this stuff called andro. Andro is found inside some things. One thing that has andro inside is dogs. Now, I'm going to show you some pictures of other things, and I want you to tell me if you think they have andro inside like dogs do.” Participants were then shown each of the targets and asked “Does it have andro inside it, like the [base]?” Properties were unfamiliar internal substances of the form “has X inside.” A different property was used for each base.

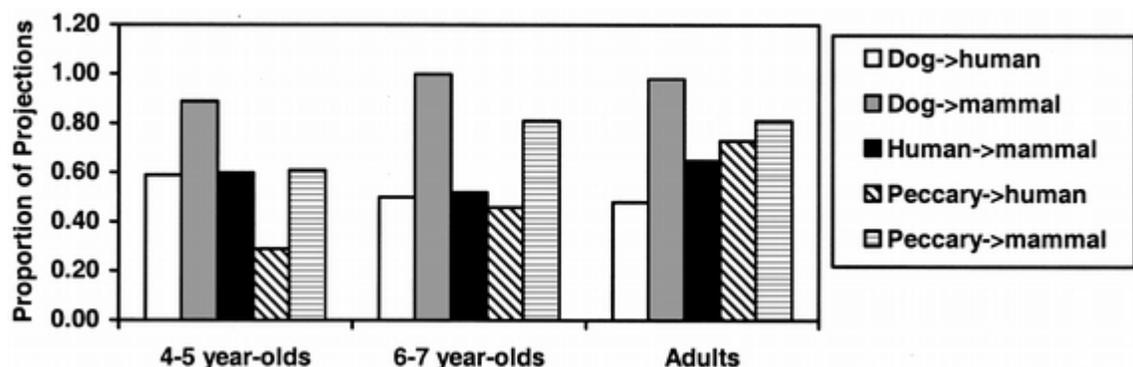
## Results

The pattern of responding varied substantially across groups. The young urban U.S. children (5–6-year-olds) generalize from all bases in a broad, undifferentiated manner, and the only clear trend was greater generalization from a human target than to other targets. Older urban children (9–10-year-olds) generalized in terms of biological affinity, showing a strong asymmetry in reasoning between humans and other animals. Although these data do not replicate (Carey, 1985) findings that young children readily generalize from humans but not other bases (there were some procedural differences between our studies and hers), they agree in the outcome that young urban children did not generalize on the basis of biological affinity.

The young, rural majority-culture children revealed a different pattern; they showed the mature pattern of generalization in terms of biological affinity. It is interesting to note that both they and older rural children showed asymmetries in reasoning between humans and animals and often justified a failure to extend a property from an animal to humans on the grounds that “people are not animals.” This observation strongly suggests that the asymmetry does not derive from humans being conceptualized as the “prototypic” animal. Instead, seeing humans as animals may be something of a developmental achievement, as suggested by K. Johnson, Mervis, and Boster (1992; see also the sorting task in Carey, 1985, indicating that young children may deny that people are animals). Finally, older rural children gave some evidence of reasoning in terms of ecological relations, as when they justified generalizing from bees to bears because a bee might sting a bear because a bear might acquire the property by eating the bee's honey.

Menominee children demonstrated yet a third pattern. First, even the youngest Menominee often provided justifications for their answers by referring to ecological relations, including those involving people (e.g., “people eat honey”). In addition, children of all ages generalized in terms of taxonomic relatedness and showed no reliable human-animal asymmetry. The Menominee origin myth has people coming from the bear, and even the youngest children are familiar with the animist clan system. In short, there is cultural support for a symmetrical relation between humans and other animals.

Findings from our studies of inductive projection among Yukatek Maya also do not replicate Carey's (1985) results for urban American children (see Figure 1) and are not consistent with the claim that folk biology is anthropocentric in childhood. Here we present data from younger children (4–5-year-olds). First, for Yukatek Maya, like Menominee children, (a) projections from humans are no stronger than projections from other living kinds, (b) there is no overall human-animal asymmetry, and (c) young children do not violate their own perceptions of similarity out of preference for humans as an inductive base.

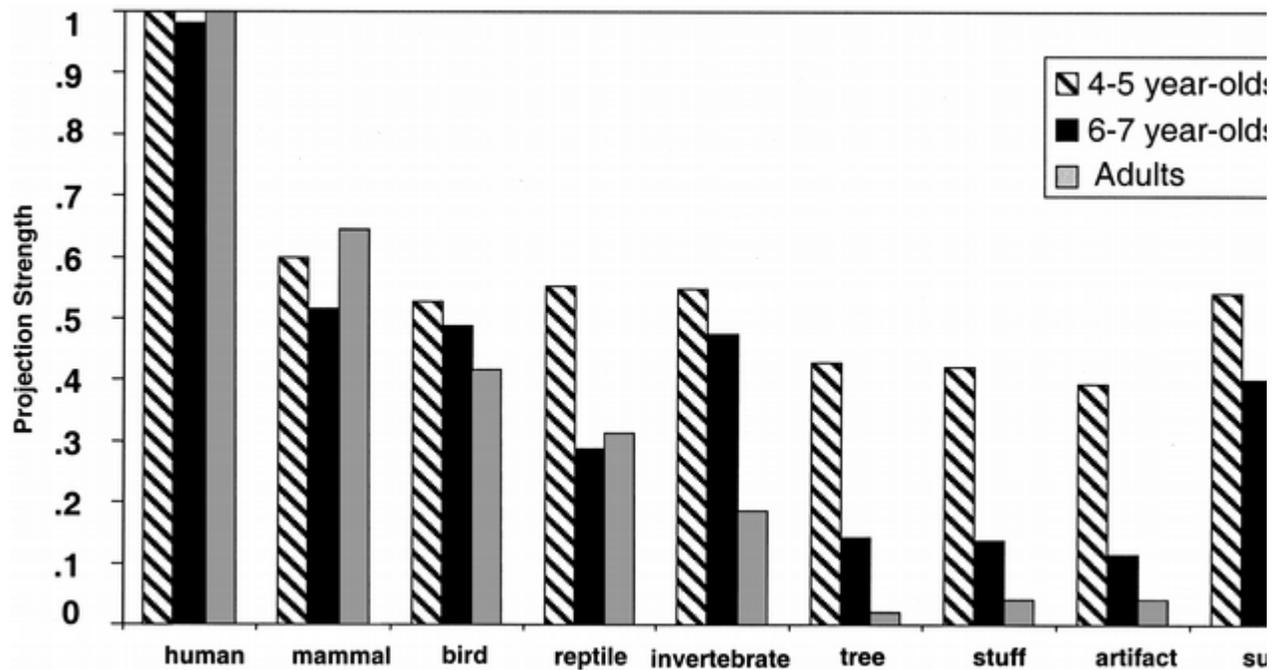


*Yukatek Maya participants' willingness to project unknown biological properties. From “Evolution of Knowledge: A Tale of Two Biologies,” by S. Atran, D. Medin, and N. Ross, 2004, *Journal of the Royal Anthropological Institute*, 10, p. 409. Copyright 2004 by Blackwell. Adapted with permission.*

There are, however, asymmetry effects for the youngest Yukatek girls with respect to a wild versus domestic animal (human → mammal → peccary → human) and for the youngest children overall in regard to inferences involving invertebrates. That such asymmetries are not generalized across the youngest age group suggests that they are the result of familiarity rather than anthropocentric bias as such. Younger girls are less familiar with wild animals than are younger boys, and young children on the whole are less familiar with invertebrates than they are with humans or mammals. Less familiarity with invertebrates may favor them less as sources of induction. The fact that dogs are a better base for induction than are peccaries is consistent with this observation. Apparently, the more properties a child knows about some kind

more likely they are to generalize some new property to other living kinds.

Young Yukatek Maya children (especially the girls) generalized in a fairly undifferentiated way from humans (see [Figure 1](#)). It is not clear how to interpret this pattern of results. One possibility is that these children lack a clear grasp of how life fits into the tree of life (the girls show the same pattern with the peccary, an animal with which they are unfamiliar). A possibility is that humans, being the primary focus of ecological interactions (e.g., eating the meat of peccaries, a primary mechanism of property transmission), provide a plausible inductive base for thematic relationships that may have little correlation with taxonomic distance.



*Yukatek Maya projections or properties from human base.*

On the whole, Yukatek Maya children look much like Menominee children but with some intriguing gender differences. These gender differences may reflect the strong sexual division of activity that is institutionalized early in the first year. In the *jeetz-meeek'* ceremony, Maya girls are introduced by the women to household utensils, whereas Maya boys are introduced by the men to agricultural and hunting tools. Later in life, Maya women will spend their time almost wholly in the vicinity of the house and house garden, in close interaction with domestic animals. By contrast, Maya men spend days, weeks, and even months in the forest away from home. For Maya women, dogs are household animals, whereas for men, dogs are hunting animals. Maya boys also venture out into the forest with their fathers at an early age and so become familiar with wild animals, such as the peccary, before girls do. These findings suggest that induction patterns may be influenced by relative familiarity with animals and by the culturally specific character of the functional and ecological relationships between humans and other natural categories of elements.

Overall, it appears that lack of intimate contact with plants and animals is responsible for the anthropocentric bias characteristic of urban American children. Consistent with this view, [Inagaki \(1990\)](#) presented evidence that experience influences children's biological reasoning. She found that kindergartners actively involved in raising goldfish were more likely than their counterparts who did not raise goldfish to reason about a novel aquatic animal (a frog) by analogy to goldfish rather than by analogy to humans.

The observation that young (Native American) children often engage in ecological reasoning seriously complicates the interpretation of the induction task. Consequently, the induction task may have limited utility, unless it is supplemented by additional converging evidence. What is clear is that anthropocentrism and human-animal asymmetries in reasoning are the exception, not the rule. We turn now to data that bear more directly on the precocious and perhaps universal development of the idea of species essences.

## Childhood Conceptions of Species Essences

Given the framework outlined at the beginning of this article, we would expect that essentialism would be among the most robust features in children's (and adult's) reasoning. Young of a species have the potential to develop certain adult characteristics before those characteristics appear. The origins of these characteristics can be explained in two broad different ways: nature and nurture. Some characteristics seem likely to develop from birth because they are essential to the species to which the individual belongs, such as a squirrel's ability to jump from tree to tree and hide acorns. Other characteristics are determined by the environment in which the individual is reared, such as a squirrel's fear or lack of fear of human beings.<sup>5</sup>

[Gelman and Wellman \(1991\)](#) argued that young children predict category-typical characteristics of individual animals on the basis of the innate potential of the animal (i.e., the species of its birth parent) rather than on the basis of the environment in which it was raised (i.e., the species of its adoptive parent). Using an adoption study, they showed that 4-year-old children judge that a baby cow raised by pigs will have the category-typical characteristics of cows (moos, straight tail) rather than pigs (oinks, curly tail). They interpret the results as showing that preschoolers believe that the innate potential or essence of a species determines how an individual will develop, even in contrary environments.

[Gelman and Wellman's \(1991\)](#) study has been criticized as inconclusive with regard to children's assumptions about the innate potential for two reasons. First, because the experimenters told the child that the baby and mother were of the same species, the study does not address the question of how the children identify to which species the baby belongs in a particular place ([S. Johnson & Solomon, 1997](#)). Given this explicit verbal identification, one cannot rule out that the children's performance owes to an essentialist bias that is a general property of language; that is, children might expect that an animal would continue to have the properties of the labeled species, even in the absence of reasoning about the environment in which it is raised ([Gelman & Hirschfeld, 1999](#)).<sup>6</sup>

Second, [Gelman and Wellman's \(1991\)](#) study explored only known facts about species and their associated properties. It did not examine whether children use the concept of biological parentage as an inferential framework for interpreting or explaining hitherto unknown facts. It may be that a child has learned from experience, and as a matter of fact, that a cow because it was born to a cow. Still, the child may not know that having certain kinds of parents causes a cow to have certain traits ([Carey, 1995](#)).

We have been studying several culturally distinct populations to test the extent to which children's assumptions about species potential govern projection of both known and unknown properties. In one study (for details, see [Atran et al., 2002](#)), Yukatek Maya children and adults were presented with a forced-choice task involving an adoption scenario. They were asked whether an adult animal adopted at birth would resemble its adoptive parent (e.g., cow) or birth parent (e.g., pig), on four different individual traits: known behaviors (e.g., moo vs. oink), known physical features (e.g., straight vs. curly tail), unknown behaviors (e.g., looks for chachalacas vs. looks for pigeons), and unknown physical features (e.g., heart shape vs. flatter vs. rounder when it is sleeping). Known traits were context-free, category-typical features that the children readily associate with species, whereas unknown traits were chosen to minimize any possibility of factual or prelearned associations of traits with categories. Each unknown trait within a set was attributed to the birth parent for half the participants and to the adoptive parent for the other half. This assured that projection patterns of the unknown traits were based on prior associations.

Stories were accompanied by sketches of each parent. Sketches were designed to unambiguously represent a particular species of animal with minimum detail. In addition, sketches of known physical features (e.g., a sketch of a curly or straight tail), unknown physical features (e.g., flat vs. round heart), and relevant aspects of unknown behavioral contexts (e.g., closed vs. open eyes when afraid, stops in front of mahogany vs. cedar trees) were shown to participants. These sketches in no way indicated the species to which the traits belonged.

The story was followed by two comprehension questions. First, "Who gave birth to the baby?" And second, "Who did the baby grow up with?" Children then were presented with the experimental probes. For example, they might be told "The baby was all grown up and mooed and the pig oinked. When the baby is all grown up will it moo like a cow or oink like a pig?" The probes were preceded by a bias control in which the participant was asked "When the baby was growing up did it eat with animals that looked like X or animals that looked like Y?" (Notice that this last probe involves an inference and is not simply a memory check.)

Overall, results showed systematic and robust preference for attributions from the birth parent. This preference was observed for all Yukatek age groups and for known and unknown behavior and physical properties. The trend was

somewhat stronger in older children and adults and slightly stronger for known than for unknown properties. The low bias on the bias control probe for all groups indicates that the method of the current experiment did not bias participant responses toward the birth parent.

In work with U.S. urban and rural majority-culture children, with Menominee children, and with three groups of urban children in Brazil, it was also found that young children show a strong pattern of inferencing in terms of birth parent: (Sousa et al., 2002). The developmental trajectory of this pattern varies across populations, sometimes weakening in children and other times strengthening (see Table 2). In addition, judgments about whether biological manipulations, such as, for example, a blood transfusion (where the baby's blood is replaced by blood from the adoptive parent) change kindhood also varies across culture and development. Few Brazilian or Yukatek adults judge that a blood transfusion changes kindhood (4% and 12%, respectively). Brazilian children, however, tend to say that the transfusion changes kindhood (71% for 4–5-year-olds and 70% for 6–7-year-olds), but Yukatek children generally do not (44% for 4–5-year-olds and 21% for 6–7-year-olds). Overall, the data are consistent with a universal initial assumption of an underlying essentialist bias in biological kinds that may be somewhat modified by the cultural landscape.<sup>7</sup> These findings, together with Gelman & Wellman's (1991) earlier results, raise the possibility such an essentialist bias in children may be universal.

**Table 2**  
*Percentage Birth Parent Choice for Brazilian Children*

Age group	Known behavior	Known trait	Unknown behavior	Unknown trait	Blood	Control
4-year-olds	87***	87***	78**	83**	33	13***
5-year-olds	92***	96***	78**	87***	25*	0***
6-year-olds	71*	87***	71*	75*	26*	4***
7-year-olds	83**	83**	79**	83**	35	0***
Adults	100***	100***	83**	87***	96***	0***

*Note.* From "Essentialism and Folkbiology: Further Evidence From Brazil," by P. Sousa, S. Atran, and D. Medin, 2002, *Journal of Cognition and Culture*, 2, p. 208. Copyright 2002 by Brill Academic Publishers. Adapted with permission.

\*  $p < .05$ . \*\*  $p < .01$ . \*\*\*  $p < .001$ .

### *Percentage Birth Parent Choice for Brazilian Children*

There are two types of objections to our claims that we briefly consider. One is simply an empirical issue: Is this pattern of results truly universal? Bloch, Solomon, and Carey (2001) reported that 7–13-year-old Zafimaniry children from a village in Madagascar reasoning about an adoption scenario show a bias toward adoptive parents, an apparent counterexample to our claims. We have several reservations about this study. First, the features attributed to adoptive birth parents were not counterbalanced and tended to be much more negative for the adoptive parent. Participants have the belief that negative properties are more powerful and dominate positive qualities (e.g., as in the historical "drop rule" in southern states; see also Stoler, 1995). Second, the children in Bloch et al.'s study were several years older than they were in our studies. Hirschfeld (1996) has found that for racial categories, fifth and sixth graders show strong social effects not apparent in second graders. We find greatest agreement (and a birth bias) in the youngest children across various populations. The ideal test case for our hypothesis is a culture in which the adults are not essentialists about ethnicity (see Astuti, 1995, but also Gil-White, 2001, for cautions concerning claims about adult conceptions). Here we would still expect that young children would be essentialists even if adults were not (though adults may be essentialist about animals other than humans). Finally, as we noted earlier, on evolutionary grounds, there is reason to expect that reasoning about animal and plant species may be different from reasoning about people. Indeed, in follow-up studies of the Vevo of Madagascar, Astuti (1995) and Carey (2003) found a reliable birth bias for the youngest children they tested (7-year-olds) when animals rather than humans were used in the adoption scenario.

There are other data from related tasks that suggest that young children are heavily influenced by superficial or surface properties in judging kindhood that seem to undermine a precocious essentialist bias. Keil (1989) presented children with scenarios in which an operation was performed by doctors that changed the surface characteristics of one animal to make it look like those of another. For example, a raccoon was described as having its fur dyed black, having a white stripe bleached down the center of its back, and undergoing surgery to have a sack of smelly stuff placed inside it. Then children were asked whether, after the operation, the animal was a skunk or raccoon. The judgments of kindergarten children were not affected by this scenario, and fewer than 50% said that the operation did not affect kind identity (see also Simons &

[1995](#), for related work).

We have two general responses to these sorts of transformation studies. One is that the pragmatics of the experim situation may have either confused young children or invited them to answer in “pretend mode.” [Walker \(1999\)](#) repl [Keil's \(1989\)](#) results among urban and rural Yoruban children of western Nigeria, which attests to their robustness. the details of her findings suggest that pragmatics may be in play. Young rural children (5–6 years old), who have r more contact with plants and animals than young urban children, were reliably more likely than urban children to ju the transformation changed kind identity. These young rural children may be much less familiar with interviewing cc with adults and more influenced by demand characteristics. Across development, there was a crossover interaction older rural children and adults being less likely than urban participants to judge that identity was changed. The urba children showed very little change in judgments between ages 5–6 and 11–12. This pattern leaves us agnostic abo basis for children's judgments.

The other response is to concede that children may not have detailed expectations or knowledge about novel situa such as authority figures (doctors) performing operations. When more familiar transformations are used such as co changes that alter appearances, children are considerably less likely to judge that identity has changed ([Keil, 1989](#)), is other research demonstrating that young children are not bound by surface appearances (see [Gelman, 2003](#), ch. a nice overview). For example, [Rosengren, Gelman, Kalish, and McCormick \(1991\)](#) reported that children as young expect animals to undergo changes (e.g., via growth) over time without affecting identity and that they know that gr unidirectional and specific to living kinds (see also [Hicking & Gelman, 1995](#); [Inagaki & Hatano, 1996, 2002](#)). They a that 5-year-olds even understood that animals can undergo metamorphosis without changing identity. In short, you children's notions about biological identity are not constrained by surface appearances.

Another objection to our data is that we may be guilty of overinterpreting the results in the sense that projection on of species membership should not be equated with projection on the basis of some essence (see [Rips, 2001](#), for an amplification of this criticism). An alternative view is that children are using ideas about causal relations but that the have no notion of “essence” whatsoever ([Stevens, 2000](#)). Although this distinction may be subtle, it has been disc length elsewhere (see the [Ahn et al., 2001](#), commentary), and we confine ourselves to a few remarks in the contex summarizing this section.

## Summary

The combination of developmental and cross-cultural studies confirms universal aspects of children's folk-biologica cognition, suggests that biology is a conceptual domain distinct from psychology, and indicates that anthropocentri young children is the exception, not the rule. These same sorts of comparative studies reveal components of biolo cognition that vary systematically as a function of cultural milieu and input conditions (intimacy of contact with natur the one hand, the fact that young Native American children often reason in terms of ecological relations poses a ch for interpreting patterns of projection on the induction task. On the other hand, the prominence of ecological reason points to a component of children's biology that has scarcely been studied, in part because this pattern has scarcel evident in developmental studies with standard populations. Finally, we note that the attribution of essences to spee groupings has implications for the organization and structure of taxonomies and the basic level.

Our claim is that from a quite early age children have intuitions that the mechanisms underlying essential causes ar biological. The essential causal relations are those involving, for example, birth, biological relatedness, and internal structure. Just how detailed these notions are and how they are modified by experience and cultural milieu awaits f comparative study

## The Essence of the Basic Level

Ever since the pioneering work of Berlin and his colleagues ([Berlin, 1992](#); [Berlin et al., 1974](#)), ethnobiological evide been accumulating that human societies everywhere have similar folk-biological structures (see also [Atran, 1990](#); [1984](#); [Hays, 1983](#); [Hunn, 1977](#)). Striking cross-cultural similarities suggest a small number of organizing principles universally define systems of folk-biological classification. Most FBSs have between three and six ranks. Taxa of th rank are mutually exclusive and tend to display similar linguistic, biological, and **psychological** characteristics.

The most general rank is the folk kingdom. Examples are *plant* and *animal*. Such taxa are not always explicitly nar represent the most fundamental divisions of the biological world. These divisions correspond to the notion of “ontol

category" in philosophy ([Donnellan, 1971](#)) and psychology ([Keil, 1979](#)). From an early age, it appears, humans can but conceive of any object they see in the world as either being or not being an animal ([Inagaki & Hatano, 1993](#)), and is evidence for an early distinction between plants and nonliving things ([Hatano & Inagaki, 1999](#)). Conceiving of an a plant or animal seems to carry with it certain presumptions that are not applied to objects thought of as belonging ontological categories, like the category of substance or the category of artifact ([Keil, 1989](#)).

The next rank down is that of life-form. Most life-form taxa are named by lexically unanalyzable names (primary lex and have further named subdivisions. Examples are *tree* and *bird*. Biologically, members of a single life-form are di Psychologically, members of a life-form share a small number of perceptual diagnostics, such as stem habit, skin c and so forth ([C. Brown, 1984](#)). Life-form taxa may represent general adaptations to broad sets of ecological conditi as the competition of single-stem plants for sunlight giving rise to trees ([Atran, 1985](#); [Hunn, 1982](#)). Classification ac to life-form may occur relatively early in childhood. For example, familiar kinds of quadrupes (e.g., dog and horse)   classed apart from sea versus air animals ([Mandler, Bauer, & McDonough, 1991](#)).

The core of any folk taxonomy is the generic-species level (also called *folk generic*; [Berlin, 1992](#); see [Atran, 1990](#), historical development of biological categories). Like life-form taxa, generic-species taxa are usually named by prim lexemes, like *oak* and *robin*. Sometimes generic species are labeled as binomial compounds, such as *hummingbird* other occasions, they may be optionally labeled as binomial composites, such as *oak tree*. In both cases, the binom makes apparent the hierarchical relation between the generic species and the life-form.

Generic species constitute the overwhelming majority of taxa in any FBS. They often correspond to scientific gener species, at least for the most phenomenally salient organisms, such as larger vertebrates and flowering plants ([Atr Berlin, 1992](#)). Generic species are also typically the categories most easily recognized, most commonly named, an perhaps most easily learned by children ([Stross, 1973](#)). Ethnobiologists who otherwise differ in their views of folk ta tend to agree that one level best captures discontinuities in nature and provides the fundamental constituents in all of folk-biological categorization, reasoning, and use ([Bulmer, 1974](#); [Ellen, 1993](#); [Hunn, 1982](#)). On evolutionary grou would expect that innate potential is vested at the generic-species level: For the most part, generic species are gen geographically, and reproductively isolated ([Mayr, 1982](#), calls these *nondimensional species*). Hence, we would ex presumptions of essence to be at the generic-species level, where innate potential is.

Given these observations, results of **psychological** studies of privilege or basicness are striking and puzzling. In a celebrated set of experiments, [Rosch, Mervis, Grey, Johnson, and Boyes-Braem \(1976\)](#) set out to test the validity c notion of a psychologically privileged taxonomic level. Using a broad array of converging measures, they found sup the view that there is a "basic level" in category hierarchies of "naturally occurring objects," such as "taxonomies" of as well as living kinds (cf. [C. Brown et al., 1976](#)). For artifact and living kind hierarchies, the basic level is the most : level in which (a) many common features are listed for categories, (b) consistent motor programs are used for the ii with or manipulation of category exemplars, and (c) category members have similar enough shapes so that it is pos recognize an average shape for objects of the category. The basic level is also preferred in adult naming, first learn children at the level at which entities can be categorized most rapidly.

Thus, work by both [Berlin \(1992\)](#) and [Rosch et al. \(1976\)](#) indicates a privileged level in category hierarchies. Morec claim that this privileged take on naturally occurring objects is directly tied to objective discontinuities in the real wo the basic level that Rosch et al. had hypothesized for living kinds, which they initially presumed would accord with E folk-generic rank, did not prove to be privileged. For example, instead of *maple* and *trout*, Rosch et al. found that *tr fish* operated as basic-level categories for American college students. Thus, Rosch et al.'s basic level for living kinc generally corresponds to Berlin's life-form level, which is superordinate to the generic-species level.

How can we reconcile the discrepancy between [Berlin's \(1992\)](#) observations and data from [Rosch et al. \(1976\)](#) con privileged levels? In one attempt to do so, [Dougherty \(1978\)](#) argued that the basic level is a variable phenomenon t as a function of general cultural significance and individual familiarity and expertise (cf. [K. Johnson & Mervis, 1997](#); [& Taylor, 1991](#)). Thus, most folk in industrial societies often have little distinctive familiarity with, knowledge of, and various species of trees, fish, birds, and so forth. As familiarity with the biological world decreases, there is a gradu attrition of folk-biological knowledge up the hierarchy, with the basic level devolving from the generic-species to the levels. A related (but alternative) view of the Berlin-Rosch et al. discrepancy is that it is sensitive to how privilege is measured. Specifically, some measures of privilege may be driven more by experience than others (see also [Barsc 1991](#)).

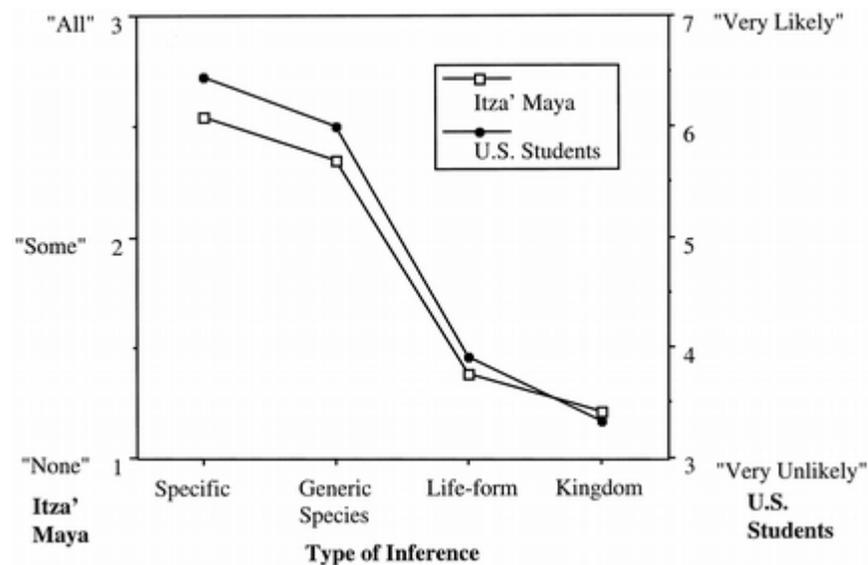
In brief, discrepancies in findings for different populations suggest that the basic level is knowledge dependent. The

evidence that biological experts have a more specific basic level than novices, but this describes results from a novice perspective. We offer a reframing. Experts and people from small-scale societies have “normal” basic-level categories corresponding to a default inference-recognition strategy whose recognition component degenerates with lack of expertise but whose inference component remains intact.

There is reason to prefer our framing. Our studies focus on inductive inference. One might expect novice, expert, and small-scale groups to privilege their respective basic levels for induction (e.g., *tree* for U.S. students, *oak* for experts and however, our studies indicate that both industrialized and small-scale populations prefer the same folk-taxonomic ranks for induction (Atran et al., 1997; Coley, Medin, & Atran, 1997).

Inductive inference allows people to extend knowledge beyond their immediate experience and beyond the information given and is a crucial part of category formation and use (Rips, 1975; Smith & Medin, 1981). Use of inductive inference as a tool is also motivated by the experiments in the last section suggesting that generic species are characterized by a presumption of essence that directs the search for underlying causal principles and theories (cf. Medin, 1989). Inductive inference must be a mainstay of any such search for underlying causal principles, and its focus should be at the generic species rank.

Examining inferences from a given rank to the adjacent higher order rank, Coley et al. (1997) found a sharp decline in the strength of inferences to taxa ranked higher than generic species, whereas strengths of inferences to taxa ranked lower than generic species were nearly equal and similarly strong (see Figure 3). Although all ranks may not be relevant in all cultures—or not relevant in the same ways—some categorization processes may be relatively immune to cultural differences. Thus, people from traditional versus high-technology cultures may differ in terms of the level at which ranks readily come to mind, the level at which taxa are most easily imaged, or the level at which their biological knowledge is complete. Nevertheless, they may presume that the same rank is privileged for biological reasoning, namely, the rank of generic species.



*Inductive inferences for Itza' Maya and U.S. students compared. From “Does Rank Have Privilege? Inductive Inferences in Folkbiological Taxonomies,” by J. Coley, D. Medin, and S. Atran, 1997, Cognition, 64, pp. 85 and 91. Copyright 1997 by Elsevier. Adapted with permission.*

On the basis of extensive fieldwork, Atran et al. (1997) chose a set of Itza' folk-biological categories of the kingdom (L), generic-species (G), folk-specific (S), and folk-varietal (V) ranks. The authors selected three plant life-forms (*che'* [tree], *ak'* [vine], *pok~che'* [herb/bush]) and three animal life-forms (*b'a'al~che' kuxi'mal* [“walking animal,” i.e., mammal], *ch'iich'* [birds including bats], *käy* [fish]). Three generic-species taxa were chosen from each life-form; each generic species had a subordinate folk-specific; and each folk-specific had a salient varietal. The properties chosen for animals were diseases related to the heart (*pusik'al*), blood (*k'ik'el*), and liver (*tamen*). For plants, the properties chosen were diseases related to the roots (*motz*), sap (*itz*), and leaf (*le*). Properties were chosen according to Itza' beliefs:

essential, underlying aspects of life's functioning. Properties used for inferences had the form "is susceptible to a disease [X]." For each question, "X" was replaced with a phonologically appropriate nonsense name (e.g., "eta") to minimize the task's repetitiveness. All participants responded to a list of questions in which they were told that all members of a category had a property (the premise) and were asked whether all, few, or no members of a higher level category (conclusion category) also possessed that property.

In one set of experiments, the premise category was at one of four levels: life-form (e.g., L = tree, mammal), generic (G = oak, dog), folk specific (S = white oak, poodle), or varietal (V = swamp white oak, toy poodle). The conclusion was drawn from a higher level category. Thus, there were 10 possible combinations of premise and conclusion category levels: L → K, G → K, G → L, S → K, S → L, S → G, V → K, V → L, V → G, and V → S. For example, a folk specific to life-form (S → L) question might be "If all white oaks are susceptible to the disease called eta, are all other trees susceptible?" If a participant answered "no," then the follow-up question would be "Are some or a few other trees susceptible, or no trees?"

[Atran et al. \(1997\)](#) totaled the proportion of "all" responses for each kind of question (e.g., the proportion of times participants agreed that if white oaks had a property, all oaks would have it). A response of "all" was counted as 3, "few" as 2, and "none" as 1. A higher score reflected more confidence in the strength of an inference. Examining inferences from a given rank to the adjacent higher order rank (i.e., V → S, S → G, G → L, L → K), the authors found a sharp decrease in the strength of inferences to taxa ranked higher than generic species, whereas V → S and S → G inferences were nearly as strong and similarly strong. For "all" responses, the overall Itza' and Michigan patterns were very similar. For example, given a premise of folk specific (white oak, poodle) and a conclusion category of generic-species rank (oak, dog), most participants indicated that all members of the generic species would possess a property that the folk specific has. A comparable number of participants also indicated that a property possessed by a folk varietal (swamp white oak, toy poodle) would also be found with the generic species (oak, dog) as with the folk specific (white oak, poodle). In contrast, few participants indicated that properties found in a folk varietal, folk specific, or generic species would be found among all members of the superordinate life-form (tree, mammal) or folk-kingdom (plant, animal) categories or that properties found in a life-form would generalize to the folk kingdom.

Nevertheless, in the combined response scores ("all" + "few"), there was evidence of increased inductive strength for higher order taxa among Americans versus Itza'. In other words, both Americans and Itza' showed the largest break between inferences to generic species versus life-forms; however, only American students also showed a consistent pattern of inferences to life-form taxa higher than to taxa at the level of the folk kingdom: G → K versus G → L, S → K versus S → L, V → K versus V → L. For the Americans, the preferred level of perceptual identification (life-form) appeared to have a secondary effect on inference, whereas for Itza' the life-form level seems to carry no inductive privilege. Although Itza' students cannot perceptually identify most bird or tree species, they can readily form (and draw) an abstract image or "tree." Itza' consent only to draw particular kinds of birds or trees.

These results indicate that both the inexperienced Americans and the Itza' elders prefer taxa of the generic-species rank when making biological inferences. In related work with U.S. botanical experts, [Schwartz and Medin \(2000\)](#) also found clear evidence of privilege at the generic-species level. If inferential potential were a simple function of perceptual similarity, American nonexperts should prefer life-forms for induction (as with [Rosch et al., 1976](#)). The findings suggest that categorical organization and reasoning processes in folk biology owe to conceptual assumptions (about the causal locus of biologically essential attributes at the generic-species level) and not exclusively to general, similarity-based (e.g., perceptual) heuristics. To be sure, language may signal expectation that little or poorly known generic species are biologically informative than better known life-forms for Americans (e.g., via common use of binomials, such as *oak* vs. *oak*). But our experiments still show reliable results in the absence of clear linguistic cues (e.g., *oak-white oak-swamp oak* vs. *dog-poodle-toy poodle*).

Undergraduates' lack of close contact with biological kinds may be precisely what allows us to tease apart the components of perceptual processes and abstract expectations to the privileged level in induction. There is now considerable evidence for perceptual learning (e.g., for recent work, see [Goldstone, 1994](#); [Schyns, Goldstone, & Thibaut, 1998](#)) in general as evidence that the basic level on perceptual tasks becomes more specific with expertise (e.g., [K. Johnson & Merzenich & Taylor, 1991](#)). Expertise is almost always a relative term and one could equally cast these results into a different frame: so-called "expert" performance on perceptual tests could be the default outcome of normal development, an undergraduate performance on perceptual tests (favoring the more abstract life-form level) could be the result of a delay in undergoing "normal" perceptual development with respect to biological kinds. If this were true, then we would expect Itza' to perform like experts on perceptual tests, and only for cases of impoverished input would we expect a discrepancy between

abstract expectations and perceptual processes. Arguably, there is an evolutionary design to a cognitive division of between domain-general perceptual heuristics and (domain-specific) learning and inference mechanisms, the one flexible adaptation to variable conditions of experience and the other invariably steering people to those enduring a biological reality that are both causally recurrent and relevant to the emergence of human life and cognition.

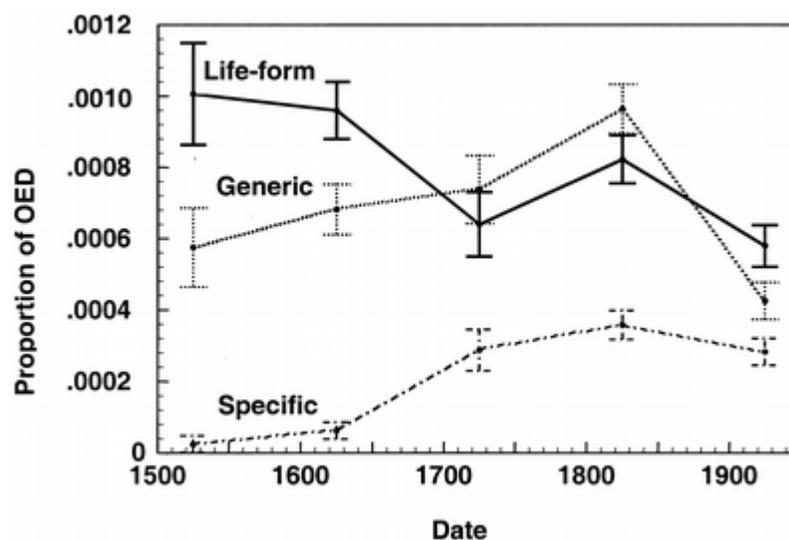
In summary, we consistently found a decisive break in inductive strength just above the rank of generic species. Nevertheless, we also found secondary evidence that supports the downgrading of American folk-biological knowledge versus the upgrading of Maya knowledge, relative to the generic-species level. Specifically, we find Americans have faith in inductions to superordinate life-form taxa than do the Itza', and Itza' differentiate among subordinate taxa more than do students. This observation, coupled with some suggestive data on the decreasing salience of biological kinds in societies, raises further issues concerning the relativity of expertise.

## Devolution and Expertise

So far, we have found it natural to treat undergraduates as the reference population and to categorize groups that know more than they do as “experts.” Of course, by this standard, practically everyone with more contact with nature would be considered an expert. Our alternative perspective is suggested when one takes the knowledge of the typical member of a nonindustrialized society as the standard. With this reference point, undergraduate knowledge would be considered below average or “devolved.”

A survey conducted at Northwestern University offers some index of what undergraduates know about one domain in biology, namely trees (Coley, Medin, Proffitt, Lynch, & Atran, 1999). Students were provided with the names of 80 trees and asked to circle the trees they had ever heard of before, regardless of whether they knew anything about them. More than 90% said that they had heard of birch, cedar, hickory, maple, pine, and spruce. But fewer than half indicated any familiarity with alder, buckeye, hackberry, hawthorn, honey locust, linden, sweet gum, and tulip tree, all of which are common in the campus area (and in the case of the buckeye is accompanied by the fact that the Ohio State Buckeyes are a fellow school!). Although it would take time travel to firmly establish that Northwestern students know less than their counterparts of the 19th century, there is indirect evidence that favors the devolution hypothesis.

Wolff, Medin, and Pankratz, (1999) examined a large sample of written material from the 16th through the 20th century contained in the online *Oxford English Dictionary* (OED Online, 2004). Of interest was the relative frequency and specificity of the use of tree terms. Wolff et al. found a precipitous decline in the use of tree terms after but not before the 19th century (see Figure 4). The number of sources mentioning trees declined by 45%, and the number of quotes fell 40%. Furthermore, the specificity of quotes declined between the 19th and 20th centuries. Although the use of the life-form term, *tree*, declined 26%, the use of generic-species terms (e.g., *oak*, *maple*, *pine*) fell by 50%. More detailed analyses showed that the declines were present regardless of whether the tree term was or was not the topic of the sentence. Finally, Wolff et al. found similar declines for other life-form terms, such as *bird* or *grass*, but only increases for nonbiological superordinate terms such as *furniture* and *clothes*.



*Proportion of quotations in the Oxford English Dictionary (OED; [OED Online, 2004](#)) for different levels of specificity, along with associated 95% confidence intervals. Note that before ca. 1700 generic terms (e.g., oak, bear) referred mostly to monogeneric European species, whereas a 1700 generic terms often referred to polytypic species built around a European type. From "Evolution and Devolution of Folkbiological Knowledge," by [P. Wolff, D. Medin, and C. Pan, 1999](#), *Cognition*, 73, p. 198. Copyright 1999 by Elsevier. Adapted with permission.*

This evidence of diminished cultural support for biological kinds is consistent with our suggestion that undergrad urban, middle-class children are anything but a standard population when it comes to the domain of biology. In this section, we found that the standard population's (in this case, children's) patterns of inductive projection across life-kingsdoms, and ontological domains (e.g., humans, animals, plants, artifacts) depend on familiarity with the categori question and perhaps cultural construals of the role of humans in nature and do not readily generalize to other popi and cultural settings. In this section, we found that inductive projections within the domains of animals and plants sl evidence of universal patterns of reasoning that were not previously apparent in standard populations (in this case, students) and that seem relatively independent from cultural familiarity. In the next two sections, we show further ev that undergraduates are nonstandard with respect to folk-biological thought. We first examine typicality effects and to the use of categories in reasoning.

### Typicality

Next to the notion of a basic level, perhaps the most important notion in the psychology of categorization is that of t effects. The idea is that some instances of a category may be better examples of a category than others. For exam common intuition is that robins are better examples of bird than are chickens. Furthermore, the consensus has bee basis of typicality effects is similarity relationships—robins are better birds because they are more similar to other b are chickens (see [Rosch & Mervis, 1975](#), and [Smith, Shoben, & Rips, 1974](#), for empirical and theoretical treatment: typicality). Once again, however, these observations rest on a narrow empirical base with respect to study populati

Work on typicality judgments among Itza' shows that inductively useful notions of typicality may be driven more by considerations of idealness than central tendency ([Atran, 1999](#)). In each case for which we have direct Itza' ratings "truest" or "most representative" living kind categories are large, perceptually striking, culturally important, and ecol prominent. For example, the three most highly rated mammals are the jaguar (also called "The Lord of the Forest"), mountain lion (the jaguar's principal rival), and the tapir (also called "The Beast of All Seven Edible Kinds of Flesh") three most highly related snakes are the large and deadly fer-de-lance (also called "The True Snake") and its comp the large and venomous tropical rattlesnake and the smaller but deadly coral. The three most representative birds : large, morphologically striking, and highly edible Galliformes (wild fowl): ocellated turkey, crested guan, and great c

One might wonder if somehow the instructions were different or whether typicality has a different meaning in the Itz language. Further observations undermine this possibility. [Lynch, Coley, and Medin \(2000\)](#) found that U.S. tree exp based their typicality judgments on ideals (e.g., height, absence of undesirable characteristics) and that central ten was uncorrelated with judgments. Lynch et al. used instructions that followed verbatim those by [Rosch and Mervis](#) their original studies showing central-tendency based typicality effects.<sup>8</sup> The best predictor of undergraduate typica ratings was word frequency. In other studies with birders (bird-watchers) and fishing experts (majority-culture and Menominee fishermen in Wisconsin), we also find that typicality is organized in terms of ideals and that central tenc uncorrelated with judgments ([Bailenson, Shum, Atran, Medin, & Coley, 2002](#); [Burnett, Medin, Ross, & Blok, in pres Ross, Atran, Burnett, & Blok, 2002](#)). The exact ideals vary somewhat with cultural group. For example, Menominee fishermen rate the culturally important sturgeon as a better example of fish than do majority-culture fishermen. Man Menominee think of the sturgeon as sacred, and the tribe continues to have a sturgeon ceremony each spring. In e centuries, the sturgeon was one of the first species to migrate upriver to spawn in the spring and was a major sour food.

No doubt similarity structures and similarity-based typicality are important determinants in natural categorization. O findings suggest that for American undergraduates, these may be dominant factors. But for our relative experts (U: experts and Itza'), who have substantial knowledge, goals, and activities about the items they classify and reason v information other than that derived from perceptual clustering and similarity judgment is relevant to understanding r biodiversity. Behavior and ecology, for example, appear to be crucial to the deeper and broader understanding of n scientists and bird-watchers seek.

In summary, we consistently find that among people knowledgeable about a domain, typicality judgments are based on base rates. Only undergraduates appear to rely on central tendency or word frequency. Of course, one might play down the significance of these findings by suggesting that they only hold for direct judgments of typicality. As we show in the next section, however, these effects also extend to how categories are used in reasoning.

## Use of Categories in Inductive Reasoning

Categorization tasks are of independent theoretical interest and self-contained, but they are also designed to provide an inferential framework for category-based reasoning. In this section, we focus on models for use of categories in inductive reasoning in general and biological inference in particular. The empirical phenomena of interest are typicality and diversity effects in reasoning. We briefly mentioned diversity effects in illustrating our triangulation strategy, and now we return to them. To set the stage for our discussion, we briefly review one of the most influential models of induction, the similarity coverage model (SCM) of [Osherson et al. \(1990\)](#).

An important function of taxonomic classification is enabling generalizations between categories. [Osherson et al. \(1990\)](#) identified a set of phenomena that characterize category-based inferences in undergraduates and formalized a model that predicts the strength of those inferences. [Sloman \(1993\)](#) has presented an alternative model, but for our purposes, we use the same predictions. Both models rely on the notion of similarity and similarity relations as a guide to induction. Rather than talking about inductive “inferences,” Osherson et al. discussed inductive “arguments,” in which facts used to generate an inference play the role of premises, and the inference itself plays the role of conclusion. Thus, inferring that all birds have ulnar arteries from the fact that jays and flamingos do amounts to the following argument: Jays have ulnar arteries, flamingos have ulnar arteries; therefore all birds have ulnar arteries. This argument is strong to the extent that belief in the premises leads to belief in the conclusion. For all SCM phenomena, the properties (e.g., “have ulnar arteries”) are “blank.” They are designed such that they do not favor one category over another at the same rank or level. For example, “has ulnar arteries” should be a priori equally likely to be true of jays and flamingos.

The SCM predicts that the strength of an argument from a premise to a conclusion will vary with the similarity of the premise to the conclusion category. For example, an inference from cows to horses should be stronger than an inference from squirrels to horses because cows are more similar to horses than squirrels are. The SCM also predicts that typical members of a category will have greater inductive strength than atypical examples for the conclusions about the entire category. For example, an inference going from bears to all mammals should be stronger than an inference going from mice to all mammals because bears are more representative of the category than are mice. In the terms of the SCM, *bears* provides better “coverage” of the category than does *mice* because bears have greater average similarity to other category members than do mice.

Diversity also relies on the notion of coverage. Consider the following argument: “Cows and horses get one disease and squirrels get another disease. Which disease is more likely to affect all mammals?” [López et al. \(1997\)](#) found that in arguments like these, undergraduates strongly preferred the argument having the more diverse premises (in this case, cows and squirrels rather than cows and horses). From the perspective of the SCM, the argument with the more diverse premises is stronger because it provides better coverage. Cows and horses each likely have greater average similarity to members of the mammal category, but this coverage is redundant—the mammals to which cows are highly similar are the same to which horses are very similar. Conversely, the mammals to which squirrels are similar are different from the ones to which cows are similar. The SCM relies on a measure of maximal average similarity and thus is sensitive to the presence of redundancy. Hence, the SCM predicts that diverse arguments will have greater inductive strength.

To develop predictions associated with the SCM, [López et al. \(1997\)](#) used a sorting task in which participants were asked to sort local mammals into groups, to “put the animals that go together by nature into as many groups as you want.” Subsequent sorting into sub- and superordinate categories created a hierarchical taxonomy for each participant; the taxonomies were then combined to create a group taxonomic hierarchy. The rationale for eliciting such taxonomic hierarchies was to be able to indirectly but “automatically” compute measures of similarity, typicality, and category centrality from a single cognitive structure, without having to directly elicit separate measures (e.g., through independent ratings).

To justify combining individual sorts into an aggregate cultural taxonomy, [López et al. \(1997\)](#) first applied the [Romney, Weller, and Batchelder \(1986\)](#) cultural consensus model to the participant by a participant agreement matrix for both the Itza' and undergraduate sample. Both groups showed a strong consensus. With these results in hand, distance in the consensual group taxonomy provides a key measure of similarity that was then used to study category-based inference.

Similarity predicts that the stronger inference should be the one in which the premise is closest to the conclusion, with “closeness” measured as the number of nodes in the taxonomic tree (produced by cluster analyses) that one has to go through to reach the conclusion category from the premise category. Like similarity, the metric for typicality is also based on the taxonomy itself, as the lowest average tree distance. Thus, the typicality of a taxonomic item (e.g., a generic species) is the average taxonomic distance of that item to all other items in the inclusive category (e.g., life-form). Finally, diversity is based on the average lowest tree distance between either of the premise categories and the members of the conclusion category.

[López et al. \(1997\)](#) used the SCM to investigate inductive reasoning about mammals among U.S. college students and Maya speakers. Although reliable similarity and typicality effects were found in both groups, the groups differed in the extent of their use of diversity. As we noted earlier, U.S. undergraduates demonstrated powerful diversity effect whereas the Itza' were reliably below chance in the selection of arguments with more diverse premises both for mammals and for palms.

Although the source of this striking finding was not obvious (see [Atran, 1998](#), and [Coley et al., 1999](#), for more discussion of possible explanations), two candidates are cultural influence and relative expertise. Perhaps diversity is a novice strategy used in situations in which more specific knowledge is not available. Alternatively, perhaps it is a result of the emphasis on taxonomic classification in modern western society. Our work among U.S. tree experts suggests that neither answer will explain the finding. [Proffitt et al. \(2000\)](#) found that groups of U.S. tree experts differ in their use of diversity-based reasoning: Taxonomists and landscapers show reliable diversity-based reasoning (albeit nowhere as high as [López, 1997](#), undergraduates), whereas maintenance workers show below chance diversity, responding much like the Itza' suggests that neither relative expertise nor cultural influence alone determines whether diversity is seen as a viable inductive heuristic.

Why do many experts and Itza' not show diversity? Consider, first, the Itza'. Itza' justifications revealed that disease functioned as blank predicates for the diversity items but instead served as triggers for ecologically based inductions. In some cases, ecological considerations led participants to conclude that the argument with more diverse premises was actually weaker. For example, one Itza' favored the argument *rat, pocket mouse-mammal* over *tapir, squirrel-mammal*. She thought that tapirs and squirrels are less likely to pass on the disease because they require an ecological agent (a bat biting them) to get the disease in the first place, whereas rats and pocket mice are close enough “companions” that they do not need an ecological agent (a bat biting them) to get the disease. Ecological considerations also led to diversity-based inductions in a few cases. Thus, another Itza' reasoned, to the contrary, that rats and pocket mice live only where there is corn, sleep above ground, and do not travel in parts of the forest where other animals may catch their disease.

U.S. tree experts also frequently used content-based reasoning involving disease mechanisms and ecological diversity, which often led them to choose the less diverse premises ([Proffitt et al., 2000](#)). They did this both for predicates involving disease and for those involving enzymes. Apparently the experts thought that ecological factors influence the presence of enzymes (but see [Shafto & Coley, 2003](#), for evidence that experts distinguish between different types of predicates when inferring). It is interesting to note that the tree experts did not show typicality effects. Their justifications for typicality probes often appealed to “family size,” in which *family* refers not to scientific families but to generic species. This is a finding of privilege at the generic-species level noted earlier. To further test the generality of these findings on typicality diversity, we tested Itza' on yet other kinds and properties (e.g., “has little things inside”), and we also tested other U.S. expert groups. Let's look at one of these lines of research in further detail.

## Triangulating With Birds

[Bailenson et al. \(2002\)](#) studied three populations on categorizing and reasoning about birds: Itza' Maya of Guatemala, bird experts (bird-watchers), and U.S. novices recruited through ads placed on campus. The stimulus materials were pictures of Chicago-area birds and pictures of lowland Guatemala birds. The idea was to see if the experts responded differently to local versus exotic species. Itza' can be thought of as novices with respect to U.S. birds, but they have extensive experience with birds that they may bring to bear with novel bird species. Each set consisted of full-color illustrations of 104 bird species laminated onto index cards. The structure of the scientific taxonomy representing the bird set was designed to correspond maximally with that representing the Tikal bird set ([Bailenson et al., 2002](#)). One difference was in the number of passerines (songbirds) in the two sets. Although passerines are the numerically dominant group both in Chicago and Guatemala, they are somewhat more prevalent in Chicago.

All participants were told that the researchers were interested in how they organized their knowledge about birds. First, they were shown all 104 bird cards one at a time and asked to name them “as specifically as possible.” Next, all 104 cards

placed in front of the participant, who was asked to “put together the birds that go together by nature into as many groups as you'd like.” The experimenters asked the participant to explain their basis for each category. The same procedure used by [López et al. \(1997\)](#) to create higher and lower level partitionings was then followed. The result was a hierarchy taxonomy of birds for each participant.

## Correspondence to Scientific Taxonomy

To compare performance from each group to science, we used the scientific taxonomy to derive a pair-wise bird-by-bird taxonomic distance matrix by calculating the distance between all possible pairs of birds in the taxonomy. We used a classical evolutionary taxonomy because it represents a reasonable compromise between similarity-based phenetic, numerical, taxonomy and theory-based cladistic, or phylogenetic, taxonomy (see [López et al., 1997](#), for further discussion). We then compared the average matrix from each group with the science matrix. The mean correlations for each of the groups on the U.S. birds were .38, .60, and .45 for novices, U.S. experts, and Itza' experts, respectively. Note that Itza' agreed more with science than did novice sorts. The mean correlations for each of the groups on the Guatemalan birds were .34, .70, and .61 for novices, U.S. experts, and Itza', respectively. Again, Itza' sorts corresponded more closely to science than did novice sorts.

Novice correlations with science are reliable but quite low, in no case accounting for more than 16% of the variance. We take this as evidence that the structure of nature is not nearly so transparent as previous researchers have suggested ([Boster, Berlin, & O'Neill, 1986](#)) or at least that the structure of nature is not transparent in pictures of birds. It may be that novices have had so little by way of meaningful interactions with birds that they have failed to learn which aspects, or dimensions are most relevant to organizing and classifying birds (see our earlier comments on perceptual learning).

There is some support for this interpretation. [K. Johnson and Mervis \(1997\)](#) tested bird experts, fish experts, and novices on a triads task in which participants were asked to pick out the two animals that were “most like the same kinds of thing.” Some triads pitted overall morphological similarity against taxonomic membership. Not only were bird experts more likely to make the taxonomic choice for birds and fish experts to make the taxonomic choice for fish, but these two types of experts were also substantially more likely than novices to pick the taxonomic choice for the domain in which they lacked expertise. These findings support the idea that some combination of perceptual learning and what they referred to as “intuitive theories” (e.g., understandings of the functional significance for the animal of different features) leads experts to organize biological kinds in a manner closer to scientific taxonomy.

[Bailenson et al.'s \(2002\)](#) results are consistent with this general interpretation in that the bird-watchers and Itza' were able to use information not reflected in the novice sorts. In short, expertise appears to involve more than a passive reception of world structure—it includes learning to attend to the features and relationships that are most informative, which does not necessarily correspond with overall similarity (cf. [Boster & D'Andrade, 1989](#)).

## Category-Based Induction

We used the data from the sorting study to develop typicality and diversity probes to see how participants use bird categories and salient examples of birds in reasoning. On the basis of previous work, we decided against using idiosyncratic properties for the Itza' and U.S. induction probes. Half of the probes involved disease, and this was constant across groups. For the other half, we used “enzyme” for U.S. participants and “little things inside” for Maya participants. We piloted these terms with both groups and found that U.S. adult participants were confused by “little things inside” but not “enzyme” or “protein,” or “disease X,” whereas Maya participants were confused by “enzyme” and “protein” but not by “little things inside” or “disease X.” As in the sorting study, we used probes involving both U.S. birds and birds of the Tikal region of Guatemala.

For both kinds of probes, we presented two pairs of birds and then asked about the property in question (disease, enzyme, or little things inside). For example, for the typicality trials, we displayed both birds in each pair and said,

*Let's assume that we discovered two new diseases. All we know about these diseases is that Disease A is found in these types of birds and Disease B is found in these. Which disease do you think is more likely to be found in all birds?*

For the diversity trials, we placed one pair of birds on the left-hand side and one pair of birds on the right-hand side and asked the same question.

## Typicality Results

There were no differences as a function of property; so, we collapsed across this variable. Only the undergraduates (novices) showed any indication of a typicality effect (means for undergraduates, U.S. bird experts, and Itza' were .7 and .50, respectively, where chance would be .50). A look at the justifications for choices confirms this pattern. The striking difference is that novices use typicality as a reason for the choice more than half of the time, whereas experts and Itza' never mention typicality. Both Itza' and U.S. experts tended to use range or other ecological factors as justifications.

## The Passerine Effect in Reasoning

To gain further insight into the basis for reasoning performance, we also analyzed the responses to the probes not in terms of typicality but also in terms of whether one of the birds in a pair was or was not a passerine. The U.S. experts and novices chose the passerine over the nonpasserine (66% and 86%, respectively) more than did the Itza' (40%). In contrast, Itza' experts tended to avoid passerines in their choices, whereas the U.S. participants tended to choose them. As shown below, this difference probably derives from the salient role of nonpasserines in Itza' Maya folk biology.

## Diversity

Again, there were no differences as a function of property; so, we collapsed across this variable. Across conditions, experts chose the more diverse pair on 58% of the trials, the novices chose the more diverse pair on 58%, and the Itza' chose the more diverse pair on 45%. None of these percentages differed reliably from each other or from chance (50%). In terms of justifications, novices tended to use either typicality or diversity as a justification and, at least initially, found typicality more compelling. It is interesting to note that they appeared to show something of a learning effect in that diversity justifications increased from 17% to 43% from the first to the second half of probes. It was as if once they hit on this strategy, they thought it was a good one and tended to continue using it. The diversity pattern for the U.S. experts was largely driven by 2 people who gave diversity justifications almost exclusively. The other U.S. experts and Itza' predominantly responded in terms of ecological-causal relations. (U.S. and Itza' experts showed no changes in pattern of justifications between the first and second half of probes).

The results on diversity probes again reveal a passerine effect. Regression analyses revealed that U.S. population of probe pairs involving the greater number of passerines, whereas Itza' showed a marginally reliable tendency to avoid them. The justifications suggest that the U.S. nonexperts chose passerines because they considered them to be more typical birds. U.S. experts tended to pick small songbirds as generalizing to the population of all birds, but they never gave this as a justification. Instead they tended to appeal to geographic range, relative population size, and evolutionary age. The negative passerine effect for the Itza' suggests that the idealness of the birds may be driving their results more than coverage. As we noted earlier for the Itza', passerines are not considered "true birds" to the same extent as other birds in the environment. They also have more ecological knowledge about nonpasserines. In short, for both the Itza' and U.S. experts, the basis for responding is not idealness per se, and their justifications did not directly appeal to either idea of typicality. Given the prominent role of the larger game birds in the behavioral ecology of Guatemala and the more immediate goals of Itza' in monitoring their ecology, the information provided by nonpasserines would be more relevant to environmental understanding and management than information provided by songbirds. Itza' appear to monitor those species in their ecosystem (e.g., game birds as opposed to passerines) that provide the most relevant information about the interaction of human needs with the needs of the forest. For the novices, whose interest in and interaction with the behavioral ecology is of a much reduced and altogether different order, correlated perceptual information may be more relevant by default.

## Summary of Bird Studies

Our triangulation strategy again proved to be useful. For a number of important phenomena, U.S. experts and Itza' together and contrasted with U.S. novices. The expert groups sorted in closer correspondence with scientific taxonomy than did novices. This difference is particularly striking for Itza' on U.S. birds because they were unfamiliar with western scientific taxonomy, and the birds used. U.S. novices had prior exposure to the birds and to western science, but they corresponded less well with scientific taxonomy than did those of the Itza'. The data suggest that expertise confers an ability to abstract important relationships in nature and, as a consequence, may lead to greater correspondence with scientific taxonomy. In that regard, our results are well-anticipated by the findings mentioned earlier by [K. Johnson and Mervin](#) who showed that bird and fish experts were better able than novices to apprehend relational features tied to functional ecology.

The category-based induction findings also reinforce the view that the novices are the “odd group out.” Novices rely heavily on familiarity or typicality as the basis of their choices on both the typicality and diversity trials. Neither the U.S. experts ever gave typicality as a justification for either type of probe. Instead, they used knowledge about the novices apparently did not possess. For example, both the Itza' and U.S. experts frequently (more than a third of the time) mentioned the geographical range of birds, an explanation that the novices rarely produced. This is a striking qualitative difference.

We found patterns of expertise in natural categorization and reasoning that selectively transcend cultural boundaries. Both Maya speakers and U.S. experts use causal and ecological reasoning more than do U.S. novices, and the Maya and U.S. experts are better at discriminating one another's natural environment than the novices are at discriminating their own. One implication is that rich interaction with the environment and relative expertise is the evolutionarily determined default condition for the operation of folk biology. This has serious implications given the fact that U.S. undergraduates comprise the one participant pool in the literature that is consistently and overwhelmingly relied on for making *psychological* generalizations—not only with respect to folk biology but also with respect to virtually every aspect of human cognition. In further follow-up work with Menominee and majority-culture fishing experts in rural Wisconsin, we have found that ecological-causal reasoning dominates and that neither typicality nor diversity effects are observed in either group.

An outstanding issue concerns the more general role that standard or default patterns of reasoning play in cognition in everyday life. What knowledge conditions are required to enable someone to “override” reliance on similarity-based typicality and diversity? Would experts “fall back” on central tendency and coverage if denied access to a rich knowledge base (e.g., in a novel domain)? The answer to these and other related questions await further studies.

## General Discussion

### Implications for Theories of Categorization and Reasoning

#### Categorization

Two of the most robust and significant findings in the psychology of concepts are basic level phenomena and typicality effects. Our work suggests important modifications in each of these.

#### Basic level and essentialism

A serious conceptual problem is that both ethnobiology and cognitive psychology have argued for one especially salient level of categorization but have disagreed about which specific level is privileged in biological taxonomies. The study by [Rosch et al. \(1976\)](#), using measures of knowledge, naming preferences, and perceptual tests, found converging evidence for the life-form level as the most relevant. Ethnobiology favors the generic-species rank as privileged.

Our studies provide a way of reconciling this divergence. Our developmental studies and related work by other researchers suggests that young children have a naive biology distinct from psychology. Furthermore, the data are consistent with the idea that biological essentialism may be universal and linked to an evolutionarily adaptive appreciation of generic species. For contemporary peoples in small-scale societies who continue to live intimately with nature, the level of generic species is the most relevant, as it likely was also for our hominid ancestors. When we used an induction task in which performance can be based on knowledge and/or expectation, we found convergence across cultures and expertise on the generic-species level as privileged for biological inference. The fact that biological experts also privilege the generic-species level on perceptual tests suggests that the divergence in question has little to do with how psychologists versus ethnobiologists measure the basic level. Rather, the apparent salience of the life-form level for undergraduates on feature listing and perceptual tests appears to be a peculiarity of the devolved state of undergraduate biological knowledge in particular: that of industrialized populations in general (for a German example, see [Zubin & Köpcke, 1986](#)).

Why should the generic-species level be privileged for biological inference in the face of uncertainty? The answer is because that is where the action was and often still is in human dealings with biological kinds. It would also be sensible for the perceptual system to be tuned to this same level of biological reality, and we suspect that this is the default for human beings who depend directly on nature for survival (i.e., without the intermediary of supermarkets and shops). Perceptual learning may be necessary to achieve this consonance (e.g., [Goldstone, 1998](#); [K. Johnson & Mervis, 1999](#); [Schyns & Rodet, 1997](#)), experience that undergraduates may lack. More generally, people may have a perceptual

heuristic that allows them to rapidly and economically navigate their everyday world. This heuristic may be important influenced by cultural support ([Wolff et al., 1999](#)). There is increasing evidence from studies with infants that words invitations to form basic level concepts ([Waxman, 1999](#); [Waxman & Markow, 1995](#)), which in our society tend to form the life-form level (except for familiar pets and domestic animals; hence, bird, fish, and dog are basic).

## Typicality

The standard assumption has been that goodness of example, or typicality, is driven by similarity relations. A good of a category is one that looks like its fellow category members and unlike members of contrasting categories (e.g., [Mervis, 1975](#); [Smith et al., 1974](#); [Smith & Medin, 1981](#)). As we noted, the SCM assumes that goodness of example extend to category-based induction.

Once again, however, results based on the standard undergraduate population proved to be atypical in the case of biological kinds. First, when the stimuli being judged are names of trees, undergraduates even fail to show similarity typicality. Instead, word frequency or familiarity is the best predictor ([Lynch et al., 2000](#)). Apparently, undergraduate know too little about trees to even have a basis for computing similarities. More to the point, populations with domain familiarity whether professional taxonomists or Itza' farmers, consistently organize categories in terms of ideals, such as the taxonomist's American elm or the Maya's wild turkey.

We believe that people who have serious commerce in a domain rarely approach it in a content-neutral manner, but rather recording the regularities associated with the category. We saw that the Itza', for example, bias their observations of biological kinds toward those that are most perceptually and ecologically salient (e.g., large game birds, predators, poisonous snakes). Parks workers worry about susceptibility to disease and other maintenance problems with local trees and their typicality ratings reflect this concern. Majority-culture fishermen attend to game fish, and Menominee fishermen expand that focus to include sacred, culturally important fish. In brief, the ways people deal with the world affect the way they cognize it.

## Category-based inference

Much the same story of abstract reasoning strategies in novices and more content-laden strategies in more knowledgeable groups can be told for typicality effects in reasoning, in which responses to probes may be better predicted from knowledge of ideals than from computed central tendency. It is important to emphasize that the use of ideals in reasoning is indirect rather than direct. That is, idealness per se plays no role in the rationale for responses. Instead, it is the implicit organization of knowledge around goals that both creates category ideals and drives category-based inference. For example, the Itza' Maya find passerines less relevant than game birds and raptors for understanding the forest (the forest being the primary focus of their understanding of the biological world). Consequently, they have much more knowledge about large birds, knowledge that is recruited on reasoning tasks.

Although previous induction models have implicitly assumed that diversity-based responding is universal, it clearly is not. When we probed Itza', bird-watchers, tree experts, and fishermen in areas in which they had knowledge, we hardly observed diversity responses (and sometimes found below chance diversity). Obviously, observations such as these require a reformulation of inference theories (for a possible alternative based on "relevance theory," see [Medin, Coley, Stoerger, & Hayes, 2003](#)).

Itza' noncompliance with diversity-based reasoning apparently results neither from a failure to understand the principle of diversity nor from any problems of "computational load." As with the most evident divergences between American and Itza' performance on similarity and typicality tasks, divergence from diversity apparently results from real-world concerns: the absence of a theory—or at least the presumption of a theory—of causal unity underlying disparate species, there is a compelling reason to consider a property discovered in two distant species as biologically intrinsic or essential to be a property of the species (see also [Proffitt et al., 2000](#)). This does not mean that Itza' do not understand a diversity principle. In fact, in a series of experiments designed to assess risk-diversification strategies (e.g., sampling productivity from one forest plot or several) Itza' consistently showed an appreciation of the diversity principle in these other settings ([López et al., 1997](#)). This suggests that although diversity may be a universal reasoning heuristic, it is not a universally relevant aspect of folk-biological taxonomic knowledge as we also found in U.S. populations having more direct interest in the natural world.

We have provided evidence for structural and functional autonomy of folk biology in human cognition. First, our cross-cultural experiments on children's inductions from human to animals and vice versa indicated that humans are not t

prototype that organizes the domain of animals. Second, young children from diverse cultures, who were tested on inheritance and adoption tasks, showed evidence for understanding the concept of innate potential of species. Third, induction experiments with regard to the basic level indicated that folk-biological taxonomies are universally anchored at the generic-species level, in which inductive potential is greatest. Fourth, our category-based induction experiments show that people from diverse societies build topologically similar biological taxonomies that guide inferences about the distribution of biological and ecological properties. Just how the taxonomies are used may vary across groups. For undergraduates, the taxonomy is a stand-in for ideas about the likely distribution of biologically related properties (e.g., diseases). For the Itza' (and other knowledgeable groups), the taxonomy constrains the likely operational range of ecological agents and causes.

These universal tendencies are most salient outside the center of industrialized societies but nonetheless discernible everywhere. Our observations provide a cautionary tale: At least in the case of folk biology, standard populations are nonstandard and vice versa. Trying to understand the structure of folk biology by focusing exclusively on relatively uneducated college students may be akin to an attempt to understand the structure of language by concentrating on feral children. That is to say, we may be able to understand a great deal (e.g., about which aspects of biological cognition are least dependent on input conditions and direct experience), but only if we recognize this population as being at a distance from commerce with nature.

## Conclusion

The fundamental structure of folk-biological taxonomy appears to be universal. It is centered on essence-based generic species that are further organized into groups under groups, with these subordinate and superordinate groups, in turn ranked into a few absolute levels. Nevertheless, differences in experience and expertise can affect how this structure is used to understand nature. For example, we have seen that folk taxonomy can guide category-based inferences about similarity relationships, as with undergraduates, as well as causally based inferences about ecological relationships: Itza' Maya and various types of U.S. experts. We have also seen that taxonomic levels can play different roles in focus of attention and recognition. Although the generic species is privileged for induction by all of our populations, uneducated undergraduates and other urbanized groups act as if the life-form level were basic or privileged when trying to recognize (or generate properties of) living kinds. Maya and other small-scale populations prefer the generic species or even more subordinate levels for tracking local biodiversity. Finally, the conceptual contents of taxa can be influenced by experiential goals. This is particularly so at subordinate levels below the generic species, where folk-specific and folk-varietal taxa are often organized into perceptual contrast sets that also mark utilitarian cultural distinctions (e.g., *sugar maple*, *silver red maple*; *toy poodle*, *hunting poodle*). The effects of experience and interests may also be apparent at (nonranked) intermediate levels between generic species and life-form: for example, in the intermediate Itza' category that includes game birds (often, but not always, closely related phylogenetically) and the category that includes arboreal mammals (squirrels, monkeys, raccoons, etc.). In short, cognitive universality does not preclude cultural diversity. Indeed, we believe that it makes such diversity both possible and understandable.

We have outlined a framework in which cultural and ecological inputs combine with innate propensities to determine biological cognition. Although we have not specified the mechanisms underlying this innate potential and their development with experience, we have provided a functional analysis and a set of candidate universal principles. Against the backdrop of such principles, we see patterned variation as a function of ecological and social contexts.

We are all born with native minds, though some develop in a manner better attuned to their natural surroundings than others. The full expression of the folk-biology module requires environmental triggering conditions and cultural support that may be lacking for certain groups in industrialized societies, including the usual participants in most cognitive and developmental psychology experiments. From a theoretical perspective, the chief interest in studying these groups is not to establish a baseline for generalizations about folk-biological knowledge but to explore the cognitive consequences of a limited input.

## Footnotes

<sup>1</sup> This excludes—perhaps artificially—lower order cognitions related to sex, kinship, and violence.

<sup>2</sup> Phylogenetic comparisons of humans with other primates show some evidence for rudimentary forms of biological conceptualization of species differences. For example, vervet monkeys have distinct alarm calls for different predator species or groups of species: snake, leopard and cheetah, hawk, eagle, and so forth (Hauser, 2000). Chimpanzees

even have rudimentary hierarchical groupings of biological groups within groups (D. Brown & Boysen, 2000). Only however, appear to have a concept of (folk) species as such, as well as taxonomic rankings of relations between sp

<sup>3</sup> For Fodor (2000), the primary criterion for modularity is “encapsulation,” that is, exclusive access to a proprietary Encapsulation is supposedly true only of perceptual modules, such as language or facial recognition. In ordinary circumstances, internal principles of grammar, phonetic rules, and lexical structures provide a database for rapidly processing linguistic input with little or no influence from other cognitive systems. Similarly, folk-biological taxonomy provide a privileged database for nearly automatic recognition of plant and animal exemplars in terms of the (folk) s which they uniquely belong. Of course, almost by definition any conceptual system has some functional autonomy ; therefore encapsulated. Virtually any game (e.g., chess) or routine activity (e.g., car driving) relies on a restricted d; that gives it privileged access to a certain range of input. This would seem to trivialize the notion of modularity and any descriptive or explanatory force. Indeed, according to Fodor (2000), the best case that can be made for the computational theory of mind (i.e., the view that all conceptual processes are Turing-like computations over syntact representational structures) is in terms of conceptual modularity; however, because conceptual modularity “is pretty mistaken” (p. 23), then so very likely is the claim that the computational theory of mind has very much to tell us abo the mind configures the world. For Sperber (2001), Fodor's pessimism is unwarranted because it ignores the fact th privileged access to an input set depends on the competition for mental resources. Evolutionary task demands gen favor certain naturally selected modular structures for processing certain types of naturally recurrent and statistically relevant input (all other things being equal). In principle, then, an explanatory account of modularity in terms of evol task demands and related developmental considerations of modularity is preferable to a purely descriptive account of encapsulation, mandatoriness, and the like.

<sup>4</sup> Paul Griffiths (in press) argued that because the items on any such symptomatic list don't necessarily co-occur in given case and can't unequivocally demonstrate innateness, then notions of innateness are inherently confused an be discarded. The same could be said against modularity. But the list represents only a family of evidential heuristic does not pretend to be a causal analysis of innateness or modularity.

<sup>5</sup> Still other characteristics may be explained in terms of individual, random variation; however, our use of paired ca typical characteristics minimizes this eventuality.

<sup>6</sup> In another study, however, Gelman and Wellman (1991) asked children to reason about plants without identifying species membership. For example, they described a seed that came from an apple and was planted in a field a cor without identifying the seed as “an apple seed.” The results were largely the same as with the animals and support nature-over-nurture bias (cf. Gelman, 2003, and Hicking & Gelman, 1995).

<sup>7</sup> For example, in Brazil, several of the 6–7-year-old children based their responding on an explicit analogy with the movie, *Tarzan*, which was widely shown at the time of the study. They evinced a significant but weaker birth bias th year-olds, consistent with Tarzan's mixed human-ape behavioral characteristics.

<sup>8</sup> Barsalou (1985) argued that idealness rather than central tendency predicts typicality in goal-derived categories ( foods not to eat on a diet, things to take from one's home during a fire, camping equipment), although central tende supposedly predicts typicality in taxonomic categories (e.g., furniture, vehicles), including folk-biological categories birds).

<sup>9</sup> At the time this study was conducted, we thought that we were observing central-tendency based typicality effect: realized later that typicality in this sense was confounded with typicality based on ideals. Subsequent studies (to be described shortly) suggest that idealness is the key factor.

## References

1. Ahn, W.-K., Kalish, C., Gelman, S., Medin, D., Luhmann, C. & Atran, S. (2001). Why essences are essential in th psychology of concepts. *Cognition*, 82, 59-69. et al.
2. Arnold, J., Eisenband, J., Brown-Schmidt, S. & Trueswell, J. (2000). The rapid use of gender information: Eviden time course of pronoun resolution from eyetracking. *Cognition*, 76, B13-B26.

3. Astuti, R. (1995). "The Vezo are not a kind of people": Identity, difference, and "ethnicity" among a fishing people western Madagascar. *American Ethnologist*, 22, 464-482.
4. **Atran**, S. (1985). The nature of folk-botanical life forms. *American Anthropologist*, 87, 298-315.
5. **Atran**, S. (1987). Ordinary constraints on the semantics of living kinds. *Mind and Language*, 2, 27-63.
6. **Atran**, S. (1990). Cognitive foundations of natural history. Cambridge, England: Cambridge University Press.
7. **Atran**, S. (1995). Classifying nature across cultures. In E. Smith & D. Osherson (Eds.), *An invitation to cognitive Thinking* (Vol. 3, pp. 131-174). Cambridge, MA: MIT Press.
8. **Atran**, S. (1998). Folkbiology and the anthropology of science: Cognitive universals and cultural particulars. *Beh and Brain Sciences*, 21, 547-609.
9. **Atran**, S. (1999). Itzaj Maya folk-biological taxonomy. In D. Medin & S. **Atran** (Eds.), *Folk biology* (pp. 119-203). Cambridge MA: MIT Press.
10. **Atran**, S. (2001). The case for modularity: Sin or salvation? *Evolution and Cognition*, 7, 46-55.
11. **Atran**, S. (2002). Modest adaptationism: Muddling through cognition and language. *Behavioral and Brain Scier* 504-506.
12. **Atran**, S., Estin, P., Coley, J. & Medin, D. (1997). Generic species and basic levels: Essence and appearance i biology. *Journal of Ethnobiology*, 17, 22-45.
13. **Atran**, S., Medin, D., Lynch, E., Vapnarsky, V., Ucan Ek', E. & Sousa, P. (2001). Folkbiology doesn't come from folkpsychology: Evidence from Yukatek Maya in cross-cultural perspective. *Journal of Cognition and Culture*, 1, 3-4
14. **Atran**, S., Medin, D. & Ross, N. (2004a). The cultural mind: Ecological decision making and cultural modeling v across populations. Manuscript submitted for publication.
15. **Atran**, S., Medin, D. & Ross, N. (2004b). Evolution and devolution of knowledge: A tale of two biologies. *Journe Royal Anthropological Institute*, 10, 395-420.
16. Au, T. K., Romo, L. F. & DeWitt, J. E. (1999). Considering children's folkbiology in health education. In M. Sieg Peterson (Eds.), *Children's understanding of biology and health* (pp. 209-234). London: Cambridge University Pres
17. Axelrod, R. (1985). The evolution of cooperation. New York: Basic.
18. Bailenson, J., Shum, M., **Atran**, S., Medin, D. & Coley, J. (2002). A bird's eye view: Biological categorization an reasoning within and across cultures. *Cognition*, 84, 1-53.
19. Balogh, J., Swinney, D. & Tigue, Z. (1998, March). Real-time processing of pronouns with contrastive stress. P session presented at the 11th Annual CUNY Conference on Human Sentence Processing, New Brunswick, NJ.
20. Barsalou, L. W. (1985). Ideals, central tendency, and frequency of instantiation as determinants of graded struc categories. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 11, 629-654.
21. Barsalou, L. (1991). Deriving categories to achieve goals. In G. H. Bower (Ed.), *The psychology of learning anc motivation: Advances in research and theory* (Vol. 27, pp. 1-64). San Diego, CA: Academic Press.
22. Bartlett, H. (1940). History of the generic concept in botany. *Bulletin of the Torrey Botanical Club*, 47, 319-362.

23. Berlin, B. (1992). *Ethnobiological classification*. Princeton, NJ: Princeton University.
24. Berlin, B., Breedlove, D. & Raven, P. (1973). General principles of classification and nomenclature in folk biology. *American Anthropologist*, 74, 214-242.
25. Berlin, B., Breedlove, D. & Raven, P. (1974). *Principles of Tzeltal plant classification*. New York: Academic Press.
26. Bloch, M., Solomon, G. & Carey, S. (2001). Zafimaniry: An understanding of what is passed on from parents to children: A cross-cultural investigation. *Journal of Cognition and Culture*, 1, 43-68.
27. Blok, S., Newman, G., Behr, J. & Rips, L. J. (2001). Inferences about personal identity. In *Proceedings of the 2nd Annual Conference of the Cognitive Science Society* (pp. 80–85). Mahwah, NJ: Erlbaum.
28. Blok, S., Newman, G. & Rips, L. J. Individuals and their concepts. in press In W.-K. Ahn, R. L. Goldstone, B. C. B. Markman, & P. Wolff (Eds.), *Categorization inside and outside the lab*. Washington, DC: American Psychological Association.
29. Bloom, P. & Veres, C. (1999). The perceived intentionality of groups. *Cognition*, 71, B1-B9.
30. Boster, J., Berlin, B. & O'Neill, J. (1986). The correspondence of Jivoroan to scientific ornithology. *American Anthropologist*, 88, 569-583.
31. Boster, J. & D'Andrade, R. (1989). Natural and human sources of cross-cultural agreement in ornithological classification. *American Anthropologist*, 91, 132-142.
32. Boster, J. & Johnson, J. (1989). Form or function: A comparison of expert and novice judgments of similarity in folk biology. *American Anthropologist*, 91, 866-889.
33. Brown, C. (1984). *Language and living things: Uniformities in folk classification and naming*. New Brunswick, NJ: Rutgers University Press.
34. Brown, C., Kolar, J., Torrey, B., Truong-Quang, T. & Volkman, P. (1976). Some general principles of biological classification. *American Ethnologist*, 3, 73-85.
35. Brown, D. & Boysen, S. (2000). Spontaneous discrimination of natural stimuli by chimpanzees (*Pan troglodytes*). *Comparative Psychology*, 114, 392-400.
36. Bulmer, R. (1974). Folk biology in the New Guinea Highlands. *Social Science Information*, 13, 9-28.
37. Burnett, R., Medin, D., Ross, N. O. & Block, S. V. Ideal is typical. *Canadian Journal of Psychology* in press
38. Caramazza, A. (2002, June). The organization of conceptual knowledge: The view from neuropsychology. In L. Barsalou (Chair), *Conceptual knowledge: Developmental, biological, functional and computational accounts*. Symposium for the British Academy, London.
39. Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: Bradford Books.
40. Carey, S. (1995). On the origin of causal understanding. In D. Sperber, D. Premack, & A. Premack (Eds.), *Causal cognition* (pp. 268–308). Oxford, England: Clarendon Press.
41. Carey, S. (1999). *The origin of concepts*. Cambridge, MA: MIT Press.
42. Carey, S. (2003, February). The origin of concepts. Paper presented at the Joint Program Lecture Series in Cultural Cognition and Evolution and Human Adaptation, Ann Arbor, MI.

43. Carey, S. & Diamond, R. (1977, January 21). From piecemeal to configurational representation of faces. *Science*, 196, 312-313.
44. Cerella, J. (1979). Visual classes and natural categories in the pigeon. *Journal of Experimental Psychology: Human Perception and Performance*, 5, 68-77.
45. Chomsky, N. (2000). Minimalist inquiries: The framework. In R. Martin, D. Michaels, & J. Uriagereka (Eds.), *Step by step* (pp. 89-155). Cambridge, MA: MIT Press.
46. Coley, J., Medin, D. & **Atran**, S. (1997). Does rank have its privilege? Inductive inferences in folkbiological taxonomy. *Cognition*, 64, 73-112.
47. Coley, J., Medin, D., Proffitt, J., Lynch, E. & **Atran**, S. (1999). Inductive reasoning in folkbiological thought. In D. Medin & S. **Atran** (Eds.), *Folkbiology* (pp. 205-232). Cambridge, MA: MIT Press.
48. Cosmides, L. & Tooby, J. (1992). Cognitive adaptations for social exchange. In J. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 163-228). New York: Oxford University Press.
49. Csibra, G., Gergely, G., Bíró, S., Koós, O. & Brockbank, M. (1999). Goal attribution without agency cues: The power of "pure reason" in infancy. *Cognition*, 72, 237-267.
50. Darwin, C. (1859). *On the origins of species by means of natural selection*. London: Murray.
51. Diamond, R. & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*, 115, 107-117.
52. Donnellan, K. (1971). Necessity and criteria. In J. Rosenberg & C. Travis (Eds.), *Readings in the philosophy of language* (pp. 647-658). Englewood Cliffs, NJ: Prentice-Hall.
53. Dougherty, J. (1978). Salience and relativity in classification. *American Ethnologist*, 5, 66-80.
54. Dougherty, J. (1979). Learning names for plants and plants for names. *Anthropological Linguistics*, 21, 298-315.
55. Eldredge, N. (1986). Information, economics, and evolution. *Annual Review of Ecology and Systematics*, 17, 31-52.
56. Ellen, R. (1993). *The cultural relations of classification*. Cambridge, England: Cambridge University Press.
57. Farah, M. J. & Rabinowitz, C. (2003). Genetic and environmental influences on the organization of semantic memory: Is "living things" an innate category? *Cognitive Neuropsychology*, 20, 401-408.
58. Fodor, J. (1983). *Modularity of mind*. Cambridge, MA: MIT Press.
59. Fodor, J. (2000). *The mind doesn't work that way: The scope and limits of computational psychology*. Cambridge, MA: MIT Press.
60. Gelman, S. (2003). *The essential child: Origins of essentialism in everyday thought*. New York: Oxford University Press.
61. Gelman, S. & Hirschfeld, L. (1999). How biological is essentialism? In D. Medin & S. **Atran** (Eds.), *Folkbiology* (pp. 427-446). Cambridge, MA: MIT Press.
62. Gelman, S. & Wellman, H. (1991). Insides and essences. *Cognition*, 38, 213-244.
63. Ghiselin, M. (1981). Categories, life, and thinking. *Behavioral and Brain Sciences*, 4, 269-313.

64. Gil-White, F. (2001). Are ethnic groups biological "species" to the brain? *Current Anthropology*, 42, 515-554.
65. Goldstone, R. L. (1994). Influences of categorization on perceptual discrimination. *Journal of Experimental Psychology: General*, 123, 178-200.
66. Goldstone, R. L. (1998). Perceptual learning. *Annual Review of Psychology*, 49, 585-612.
67. Griffiths, P. E. Evolutionary psychology: History and current status. in press In S. Sarkar & J. Pfeiffer (Eds.), *The philosophy of science: An encyclopedia*. New York: Routledge.
68. Guntheil, G., Vera, A. & Keil, F. C. (1998). Do houseflies think? Patterns of induction and biological beliefs in development. *Cognition*, 66, 33-39.
69. Hatano, G. & Inagaki, K. (1999). A developmental perspective on informal biology. In D. L. Medin & S. Atran (Eds.), *Evolutionary psychology: A developmental perspective on informal biology* (pp. 321-354). Cambridge, MA: MIT Press.
70. Hatano, G. & Inagaki, K. The formation of culture in mind: A sociocultural approach to cognitive development. in J. Mehler, S. Carey, & L. Bonatti (Eds.), *Cognitive development and conceptual change*. Cambridge, MA: MIT Press.
71. Hauser, M. (2000). *What animals really think*. New York: Henry Holt & Company.
72. Hauser, M., Chomsky, N. & Fitch, W. T. (2002, November 22). The faculty of language. *Science*, 298, 1569-1579.
73. Hays, T. (1983). Ndumba folkbiology and general principles of ethnobotanical classification and nomenclature. *Anthropologist*, 85, 592-611.
74. Heider, F. & Simmel, S. (1944). An experimental study of apparent behavior. *American Journal of Psychology*, 57, 243-259.
75. Herrnstein, R. J. (1984). Objects, categories, and discriminative stimuli. In H. L. Roitblat, T. G. Bever, & H. S. Terrace (Eds.), *Animal cognition* (pp. 233-261). Hillsdale, NJ: Erlbaum.
76. Hicking, A. & Gelman, S. (1995). How does your garden grow? Evidence of an early conception of plants as big kinds. *Child Development*, 66, 856-876.
77. Hirschfeld, L. A. (1995). Do children have a theory of race? *Cognition*, 54, 209-252.
78. Hirschfeld, L. (1996). *Race in the making*. Cambridge, MA: MIT Press.
79. Hunn, E. (1977). *Tzeltal folk zoology*. New York: Academic Press.
80. Hunn, E. (1982). The utilitarian factor in folk biological classification. *American Anthropologist*, 84, 830-847.
81. Inagaki, K. (1990). The effects of raising animals on children's biological knowledge. *British Journal of Developmental Psychology*, 8, 119-129.
82. Inagaki, K. & Hatano, G. (1993). Young children's understanding of the mind-body distinction. *Child Development*, 64, 1534-1549.
83. Inagaki, K. & Hatano, G. (1996). Young children's recognition of commonalities between animals and plants. *Child Development*, 67, 2823-2840.
84. Inagaki, K. & Hatano, G. (2001). Children's understanding of mind-body relationships. In M. Siegal & C. Petersen (Eds.), *Children's understanding of biology and health* (pp. 23-44). Cambridge, England: Cambridge University Press.

85. Inagaki, K. & Hatano, G. (2002). Young children's naive thinking about the biological world. New York: Psychol Press.
86. Johnson, K. & Mervis, C. (1997). Effects of varying levels of expertise on the basic level of categorization. *Journal of Experimental Psychology: General*, 126, 248-277.
87. Johnson, K., Mervis, C. & Boster, J. (1992). Developmental changes within the structure of the mammal domain. *Developmental Psychology*, 28, 74-83.
88. Johnson, S. & Solomon, G. (1997). Why dogs have puppies and cats have kittens: The role of birth in young children's understanding of biological origins. *Child Development*, 68, 404-419.
89. Keil, F. (1979). Semantic and conceptual development. Cambridge, MA: Harvard University Press.
90. Keil, F. (1989). Concepts, kinds, and cognitive development. Cambridge MA: MIT Press.
91. Landa, D. de (1985). Relación de las Cosas de Yucatán [Account of the Yucatán]. In M. R. Dorado (Ed.), *Crónica de América* (No. 7). Madrid, Spain: Historia 16. (Original work published 1566)
92. López, A., Atran, S., Coley, J., Medin, D. & Smith, E. (1997). The tree of life: Universals of folk-biological taxonomy and inductions. *Cognitive Psychology*, 32, 251-295.
93. Lynch, E., Coley, J. & Medin, D. (2000). Tall is typical: Central tendency, ideal dimensions and graded category structure among tree experts and novices. *Memory & Cognition*, 28, 41-50.
94. Mahalingam, R. (1998). Essentialism, power and theories of caste: A developmental study. *Dissertation Abstracts International*, 60, 2B (UMI No. AAM9919309)
95. Malt, B. (1995). Category coherence in cross-cultural perspective. *Cognitive Psychology*, 29, 85-148.
96. Mandler, J., Bauer, P. & McDonough, L. (1991). Separating the sheep from the goats: Differentiating global categories. *Cognitive Psychology*, 23, 263-298.
97. Mayr, E. (1982). The growth of biological thought. Cambridge, MA: Harvard University Press.
98. Medin, D. (1989). Concepts and conceptual structures. *American Psychologist*, 45, 1469-1481.
99. Medin, D., Coley, J., Storms, G. & Hayes, B. (2003). A relevance theory of induction. *Psychonomic Bulletin & Review*, 10, 517-532.
100. Medin, D. & Ortony, A. (1989). **Psychological** essentialism. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 179-195). New York: Cambridge University Press.
101. Medin, D., Ross, N., Atran, S., Burnett, R. & Blok, S. (2002). Categorization and reasoning in relation to cultural expertise. In B. Ross (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 41, pp. 1-30). New York: Academic Press.
102. Nowak, M. & Sigmund, K. (1998, June 11). Evolution of indirect reciprocity by image scoring. *Nature*, 395, 573-577.
103. (2004). Oxford, England: Oxford University Press. *OED Online*. Retrieved from <http://dictionary.oed.com>
104. Osherson, D., Smith, E., Wilkie, O., López, A. & Shafir, E. (1990). Category-based induction. *Psychological Review*, 97, 85-100.

105. Pinker, S. (1997). *How the mind works*. New York: W. W. Norton.
106. Pinker, S. & Bloom, P. (1990). Natural language and natural selection. *Behavioral and Brain Sciences*, 13, 707-727.
107. Premack, D. (1990). The infant's theory of self-propelled objects. *Cognition*, 36, 1-16.
108. Proffitt, J., Coley, J. & Medin, D. (2000). Expertise and category-based induction. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 26, 811-828.
109. Rips, L. (1975). Inductive judgments about natural categories. *Journal of Verbal Learning and Verbal Behavior*, 14, 665-681.
110. Rips, L. (1995). The current status of research on concept combination. *Mind & Language*, 10, 2-104.
111. Rips, L. (2001). Necessity and natural categories. *Psychological Bulletin*, 127, 827-852.
112. Romney, A. K., Weller, S. & Batchelder, W. (1986). Culture as consensus: A theory of culture and informant agreement. *American Anthropologist*, 88, 313-338.
113. Rosch, E. & Mervis, C. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology*, 7, 573-605.
114. Rosch, E., Mervis, C., Grey, W., Johnson, D. & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, 8, 382-439.
115. Rosengren, K. R., Gelman, S. A., Kalish, C. W. & McCormick, M. (1991). As time goes by: Children's understanding of biological growth. *Child Development*, 62, 1302-1320.
116. Ross, N., Medin, D., Coley, J. D. & Atran, S. (2003). Cultural and experiential differences in the development of folkbiological induction. *Cognitive Development*, 18, 25-47.
117. Sartori, G. & Job, R. (1988). The oyster with four legs: A neuro-psychological study on the interaction of semantic and visual information. *Cognitive Neuropsychology*, 5, 105-132.
118. Schwartz, H. & Medin, D. (2000). Expert and novice judgments of inductive inferences within folk-biological taxonomies. Unpublished manuscript, Northwestern University, Evanston, IL.
119. Schyns, P., Goldstone, R. & Thibaut, J. (1998). Development of features in object concepts. *Behavioral and Brain Sciences*, 21, 1-54.
120. Schyns, P. & Rodet, L. (1997). Categorization creates functional features. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 23, 681-696.
121. Shafto, P. & Coley, J. D. (2003). Development of categorization and reasoning in the natural world: Novices to experts. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29, 649.
122. Simons, D. J. & Keil, F. C. (1995). An abstract to concrete shift in the development of biological thought: The i story. *Cognition*, 56, 129-163.
123. Sloman, S. (1993). Feature-based induction. *Cognitive Psychology*, 25, 231-280.
124. Sloman, S. & Malt, B. (2003). Artifacts are not ascribed essences, nor are they treated as belonging to kinds. *Language and Cognitive Processes*, 18, 563-582.

125. Smith, E. & Medin, D. (1981). *Categories and concepts*. Cambridge, MA: Harvard University Press.
126. Smith, E., Shoben, E. & Rips, L. (1974). Structure and process in semantic memory. *Psychological Review*, 241.
127. Sousa, P., **Atran**, S. & Medin, D. (2002). Essentialism and folkbiology: Further evidence from Brazil. *Journal of Cognition and Culture*, 2, 195-223.
128. Sperber, D. (2001, November). In defense of massive modularity. Paper presented at the Innateness and Structure of the Mind Workshop, University of Sheffield, England.
129. Sperber, D., Cara, F. & Girotto, V. (1995). Relevance theory explains the selection task. *Cognition*, 57, 31-95.
130. Stoler, A. (1995). *Race and the education of desire*. Durham, NC: Duke University Press.
131. Strevens, M. (2000). The naive aspect of essentialist theories. *Cognition*, 74, 149-175.
132. Stross, B. (1973). Acquisition of botanical terminology by Tzeltal children. In M. Edmonson (Ed.), *Meaning in natural languages* (pp. 107-141). The Hague, the Netherlands: Mouton.
133. Sylvia, C. & Novak, W. (1997). *A change of heart*. Boston: Little, Brown.
134. Tanaka, J. & Taylor, M. (1991). Object categories and expertise: Is the basic level in the eye of the beholder? *Psychology*, 23, 457-482.
135. Trager, G. (1939). "Cottonwood" = "tree": A southwestern linguistic trait. *International Journal of American Linguistics*, 9, 117-118.
136. Waddington, C. (1959, June 13). Canalisation of development and the inheritance of acquired characteristics. *Journal of Theoretical Biology*, 183, 1654-1655.
137. Walker, S. J. (1992). Supernatural beliefs, natural kinds and conceptual structure. *Memory & Cognition*, 20, 65-75.
138. Walker, S. J. (1999). Culture, domain specificity and conceptual change: Natural kind and artifact concepts. *British Journal of Developmental Psychology*, 17, 203-219.
139. Waxman, S. (1999). The dubbing ceremony revisited: Object naming and categorization in infancy and early childhood. In D. Medin & S. **Atran** (Eds.), *Folkbiology* (pp. 233-284). Cambridge, MA: MIT Press.
140. Waxman, S. & Markow, D. (1995). Words as invitations to form categories: Evidence from 12-month-old infants. *Cognitive Psychology*, 29, 257-302.
141. Wolff, P., Medin, D. & Pankratz, C. (1999). Evolution and devolution of folkbiological knowledge. *Cognition*, 73, 204.
142. Zubin, D. & Köpcke, K.-M. (1986). Gender and folk taxonomy. In C. Craig (Ed.), *Noun classes and categorization* (pp. 139-180). Amsterdam: John Benjamins.

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