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ITZAJ MAYA FOLKBIOLOGICAL TAXONOMY: COGNITIVE UNIVERSALS AND CULTURAL PARTICULARS

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Introduction*

One of the most difficult matters in all of controversy," lamented Bertrand Russell, is to distinguish disputes about words from disputes about facts" (Russell 1958:114). This is so, particularly in the early stages of an interdisciplinary field, such as folkbiology." In other chapters we see psychologists split between those who believe that domain-specific theories" drive folkbiology from early childhood on (Keil et al this volume, Hatano & Inagaki this volume) and those who believe that children initially have no biological theories" to speak of and, therefore, no folkbiology (Au & Romo this volume, Carey 1995). Within this debate, existence of folkbiology depends on existence of intuitive" or folk" theories, since everyone seems to agree that whatever such theories may be they are neither explicit nor scientific. My take is that folkbiological knowledge, even among educated lay Americans or Europeans (or Japanese), need never become theoretical in any meaningful sense (Atran forthcoming). But I also think that Western folk have, and have always had, folkbiologies.

In what follows, I outline a small but crucial part of the folkbiological system of a people unschooled in Western notions of theories: the folkbiological taxonomy of the Itzaj Maya. Such taxonomies are crucial to understanding folkbiology for two reasons: biological taxonomies seem to be culturally universal; and they are well-structured enough to impose constraints on any and all possible theories, thereby rendering biological theories possible, including evolutionary theory (at least historically). Western biological theories emerged by decontextualizing nature: by curiously tearing out water lilies from water so that they could be dried, measured, printed and compared with other

living" forms detached from local ecology and most of the senses. For Itzaj, folkbiological taxonomy appears to hearken to a somewhat different calling in human life and cognition. However one chooses to characterize this system in terms of theory," there seems no denying the fact that if this is not evidence of folkbiology," nothing else is sure to be.

Humans everywhere classify animals and plants into species-like groupings that are as obvious to a modern scientist as to a Maya Indian (Simpson 1961, Diamond & Bishop this volume). Such groupings are primary loci for thinking about biological causes and relations (Mayr 1969). Historically, they tended to provide a transtheoretical basis for scientific biology in that different theories - including evolutionary theory - have sought to account for the apparent constancy of common species" and the organic processes centering on them (Wallace 1889:1). In addition, these privileged groupings have from the most remote period... been classed in groups under groups" (Darwin 1859:431). This taxonomic array provides a natural framework for inference, and an inductive compedium of information, about organic categories and properties (Atran 1990). It is not as conventional or arbitrary in structure and content, nor as variable across cultures, as the assembly of entities into cosmologies, materials or social groups (Berlin 1992).

The universal character of folkbiological taxonomy does not mean that folkbiological categories are culturally irrelevant. On the contrary, insofar as they reflect a cognitively-biased, phenomenal appreciation of the surrounding environment they help to set the constraints on life that make a culture possible. It is little wonder, then, that folkbiological taxonomies tend to be among the most stable, widely-distributed and conservative cognitive structures in any culture. Once set into place, such a structure would likely survive even catastrophic historical upheaval to a clearly recognizable degree. Ancient and contemporary Maya societies would be no exception. Even with the social order and cosmological system sundered, the folkbiological structure would persist

as a cognitive basis for cultural survival under two conditions: first, there must be significant biological continuity in the ecological distribution of species; second, their must be significant linguistic continuity with the dialect that first encoded the knowledge.

Itzaj Maya folkbiology provides evidence for generalizations about the specific taxonomic structure that delimits the universal domain of folkbiology, but also for the influence of local ecology and culture. The Itzaj are the last Maya Indians native to the Peten tropical forest of northern Guatemala, once an epicenter of Classic Maya civilization. The Spanish conquest of the Itzaj in 1697 put a brutal end to the last independent Maya confederacy. Although the Itzaj cosmological system was destroyed, Itzaj folkbiological knowledge - including taxonomic competence as well as practical application - remains strikingly robust (Atran 1993, Atran & Medin 1997). Presently, however, Itzaj forest culture verges on extinction: the language, banned for decades by government authorities with threats of fine and punishment, is dying among the young and the forest is being razed at an awesome rate by loggers, immigrant slash-and-burn farmers and cattle ranchers. We are working with Itzaj to establish a Bio-Reserve.

Principles of Folkbiological Taxonomy

Over a century of ethnobiological research has shown that even within a single culture there may be several different sorts of "special-purpose" folkbiological classifications, which are organized by particular interests for particular uses (e.g., beneficial / noxious, domestic / wild, edible / inedible, etc.). Only in the last decades has intensive empirical and theoretical work revealed a cross-culturally universal "general-purpose" taxonomy (Berlin, Breedlove & Raven 1973) that supports the widest possible range of inductions about living kinds that are relevant to everyday life (Atran in press). This includes indefinitely many inductions about the plausible distributions of initially unfamiliar biologically-related traits over organisms given the discovery of such traits in some organism(s), or the likely correlation of known traits among unfamiliar organisms given the discovery of only some of those traits among the organisms. For example,

learning that one cow is susceptible to "mad cow" disease one might reasonably infer that all cows may be susceptible to the disease but not that all mammals or animals are.

This "default" folkbiological taxonomy, which serves as an inductive compendium of biological information, is composed of a stable hierarchy of inclusive groups of organisms, or taxa. At each level the taxa, which are mutually exclusive, partition the locally perceived biota in a virtually exhaustive manner. Lay taxonomy is composed of a small number of absolutely distinct hierarchical levels, or ranks (Berlin 1992): the levels of folk kingdom (e.g., ANIMAL, PLANT), life form (e.g., BUG, FISH, BIRD, MAMMAL, TREE, HERB/GRASS, BUSH), generic species (e.g., GNAT, SHARK, ROBIN, DOG, OAK, CLOVER, HOLLY) folk specific (POODLE, WHITE OAK) and folk varietal (TOY POODLE; SPOTTED WHITE OAK). Ranking is a cognitive mapping that projects living kind categories onto a structure of absolute levels, that is, fundamentally different levels of reality. Taxa of the same rank tend to display similar linguistic, biological and psychological characteristics. Ranks, not taxa, are apparently universal.[1]

Kingdoms and Life Forms. The most general rank in any folkbiological taxonomy is the folk kingdom,[2] that is, PLANT or ANIMAL. Such taxa are not always explicitly named, and represent the most fundamental divisions of the (nonhuman) biological world. These divisions correspond to the notion of "ontological category" in philosophy (Donnellan 1971) and psychology (Keil 1979). From an early age, it appears, humans cannot help but conceive of any object they see in the world as either being or not being an animal, and there is evidence for an early distinction between plants and nonliving things (Gelman & Wellman 1991, Keil 1994, Hickling & Gelman 1995, Hatano & Inagaki 1996). Conceiving of an object as a plant or animal seems to carry with it certain presumptions that are not applied to objects thought of as belonging to other ontological categories, like the categories of person, substance or artifact.[3]

The next rank down is that of life form.[4] The majority of taxa of lesser rank fall under one or another life form. Most life-form taxa are named by lexically unanalyzable names (primary lexemes), and have further named subdivisions, such as TREE and BIRD. Biologically, members of a single life form are diverse. Psychologically, members of a life form share a small number of perceptual diagnostics, such as stem habit, skin covering and so forth (Brown 1984). Life-form taxa may represent general adaptations to broad sets of ecological conditions, such as the competition of single-stem plants for sunlight and tetrapod adaptation to life in the air (Hunn 1982, Atran 1990). Classification by life form may occur relatively early in childhood. For example, familiar kinds of quadruped (e.g., dog and horse) are classed apart from sea versus air animals (Mandler, Bauer & McDonough 1991; Dougherty 1979 for American plants).

Itzaj kingdoms and life forms provide evidence for this universal cognitive structure in a Maya idiom. There is no common lexical entry for the plant kingdom; however, the numeral classifier teek is used with all and only plants. Plants generally fall under one of four mutually exclusive life-forms: che' (trees), pok~che' (herbs, shrubs = undergrowth), ak' (vines) and su'uk (grasses). Each life-form conforms to a distinct stem habit. Some introduced and cultivated plants are unaffiliated with any of these life-forms, and are simply denoted jun-teek (lit. "one plant," e.g., jun-teek ixi'im = a maize plant). This is also true of many of the phylogenetically isolated plants, such as the cacti. All informants agree that mushrooms (xikin~che', lit. "tree-ear") have no puksik'al and are not plants, but take life away from the trees that host them. Lichens and bryophytes (mosses and liverworts) are not considered to be plants, to have an essence or to live.

In Itzaj, the term for animals (b'a'al~che' = "forest-thing") polysemously refers to: (1) the whole animal kingdom (including invertebrates, birds and fish); (2) a more restrictive grouping of quadrupeds (i.e., b'a'al~che'+k-u-siit' = "jumping animals" or amphibians; b'a'al~che'+k-u-jil-t-ik-u-b'aj = "slithering animals" or reptiles; b'a'al~che'+k-u-xi'-mal = "walking animals" or mammals); (3) typically the mammals

alone. Birds (ch'iich' including sotz' = bats) and fish (käy) exhibit patterns of internal structure that parallel those of the "unnamed" mammal and herpetofauna life forms.[5] Like the named life form, ch'iich', the mammal group forms an inferentially self-contained category over which inductive generalizations can be made about biologically-related properties. To a significant extent, patterns of induction are the same for the Itzaj life forms, b'a'al~che' (sense 3) and ch'iich', as they are for the American folk categories MAMMAL and BIRD (Atran, Estin, Coley & Medin forthcoming). Snakes (kan) also form an inferentially self-contained group (Atran 1994); however, snakes are also consistently and exclusively sorted with the lizards at one (intermediate) level, and with the rest of the herpetofauna at the next (life-form) level.[6]

Like the life form of invertebrates (mejen+b'a'al~che' = "small animall"), herpetofauna seem to form a "residual" life-form category that does not have a conceptually distinctive role in "the economy of nature." This contrasts with the other plant and life-form categories, which seem to have mutually defined ecological roles (see Atran 1990, Berlin 1992): birds and trees in the air (ik') and upper forest tier; mammals and herbs on the ground (lu'um) in the forest understory; vines in the connecting "middle" (tan-chumuk) tiers; grasses in the open lands (chäk'an); fish in the water (ja'). To be sure, the boundaries between these "adaptive zones" are permeable by members of each life form; however, each of these life forms has its respective habitat, or "home" (otoch). Accordingly, because the chicken (aj-kax) has its home exclusively on the ground, and cannot live in the air like other birds, is not a bird, nor is it included under any of the other life forms (although for Tzeltal Maya the chicken is the prototypical bird, Hunn 1977).

For the mejen+b'a'al~che', whose morphologies and ecological proclivities are very distant from humans and other vertebrates, correspondence of folk to modern systematics blurs as one descends the ranks of the scientific ladder, and violations of scientific taxonomy tend to be more pronounced. Still, in this respect as in others, Itzaj

taxonomy differs little from that of any other folkbiological system, such as that which initially gave rise to systematics, including evolutionary systematics. For Linnaeus, a Natural System is rooted in "a natural instinct [that] teaches us to know first objects closest to us, and at length the smallest ones: for example, Man, Quadrupeds, Birds, Fish, Insects, Mites, or first the large Plants, last the smallest mosses" (1751 sec. 153).

Generic Species. The core of any folk taxonomy is rank of generic species, which contains by far the most numerous taxa in any folkbiological system. Most cultures have a set of life forms, but all cultures have a set of generic species. People in all cultures spontaneously partition the ontological categories ANIMAL and PLANT into generic species in a virtually exhaustive manner. "Virtually exhaustive" means that when an organism is encountered that is not readily identifiable as belonging to a named generic species, it is still expected to belong to one. The organism is assimilated to one of the named taxa it resembles (see Berlin's chapter, this volume). This partitioning of ontological categories seems to be part and parcel of the categories themselves: no plant or animal can fail to uniquely belonging to a generic species.

Taxa of the generic-species rank generally fall under some life form, but there may be outliers that are unaffiliated with any major life form taxon.[7] This is often so for plants and animals of particular cultural interest, such as cassowaries for the Kalam of New Guinea (Bulmer 1970) and maize (ixi'im) for Itzaj and other Maya (cf. Berlin, Breedlove & Raven 1974; Barrera Marín, Barrera Vásquez & López Franco 1976). Like life-form taxa, generic-species taxa are usually named by primary lexemes. Examples are OAK and ROBIN in English, or oop (custard-apple tree) and pek' (dog) in Itzaj. Sometimes, generic species are labeled as binomial compounds, such as HUMMINGBIRD or k'u'~che' (god's tree" = tropical cedar). On other occasions, they may be optionally labeled as binomial composites, such as OAK TREE (as opposed to POISON OAK) or ix-k'o'och(+che') = the k'o'och tree" (Cecropia peltata, as opposed

to the k'o'och herb = Ricinus communis). In both cases the binomial makes the hierarchical relation apparent between the generic species and the life form.

The term "generic species" is used here, rather than "folk genera/folk generic" (Berlin 1972) or "folk species/folk specieme" (Bulmer 1970), for three reasons.[8] First, a principled distinction between biological genus and species is not pertinent to local folk around the world. The most phenomenally salient species for humans, including most species of large vertebrates, trees, and phylogenetically isolated groups such as palms and cacti belong to monospecific genera in any given locale. Closely related species of a polytypic genus are often hard to distinguish locally, and no readily perceptible morphological or ecological "gap" can be discerned between them (Diver 1940). Second,"generic species" reflects a more accurate sense of the correspondence between psychologically privileged folkbiological groups and historically privileged scientific groups (Stevens 1994). A distinction between genus and species did not appear until the influx of newly discovered species from the world over compelled European naturalists to mnemonically manage them within a worldwide system of genera built around (mainly European) species types (Atran 1987). Third, "generic species" reflects their dual character. As privileged mnemonic groups, they are akin to genera in being those groups most readily apparent to the naked eye (Cain 1956). As privileged causal groups, they are akin to species in being the principal loci of evolutionary processes responsible for the appearance of biological diversity (Mayr 1969).

The correspondence of the generic species to scientific species or genera is not isomorphic, and varies according to patterns of species distribution within biological families and other factors. Moreover, generic species may on occassion to correspond to locally represented families, orders or higher scientific ranks. In Itzaj, for example, the Itzaj generic-species term for vulture (ch'om) refers to several genera of the family Cathardidae; the term for bat (sotz') denotes several families of the order Chiroptera; and the generic-species terms for many invertebrates, such as that for worm (ix-nok'ol), can

encompass different orders and even phyla. Nevertheless, generic species usually encompass single biological species and usually do not extend beyond biological genera for the larger vertebrates and flowering plants, that is, for those organisms that are phenomenally most salient for human beings. For example, in a comparative study we found that two-thirds of tree genera in both the Chicago area - 40 0f 48 - and a sample portion of the Itzaj area of Peten - 158 of 229 - are monospecific (AHG/APESA 1992; Medin, Lynch, Coley & Atran 1997). Moreover, nearly 300 generic species of Peten trees and other plants, which Itzaj have thus far identified to us as useful to them, correspond to some 350 biological species (Atran in press). A comparative study of mammal classification among Itzaj and undergraduates from rural Michigan reveals a similar pattern. The great majority of mammal taxa in both cultures correspond to scientific species, and most also correspond to monospecific genera: 30 of 40 (75%) basic Michigan mammal terms denote biological species, of which 21 (70%, or 53% of the total) are monospecific genera; 36 of 42 (86%) basic Itzaj mammal terms denote biological species, of which 25 (69%, or 60% of the total) are monospecific genera (López, Atran, Coley, Medin & Smith 1997).

The rank of generic species is the level at which morphological, behavioral and ecological relationships between organisms maximally covary. The majority of Itzaj folkbiological taxa belong to this level. It is this level that Itzaj privilege when they see and talk about biological discontinuities. Generic species represent cuts in nature that Itzaj children first name and form an image of (for Highland Maya, see Stross 1973 for Highland Maya), and which Itzaj adults most frequently use in speech, most easily recall in memory and most readily communicate to others (for Highland Maya, see Berlin et al. 1974; Hunn 1977). It is the rank at which Itzaj, like other folk around the world, are most likely to attribute biological properties: including characteristic patterns of inheritance, growth and physiological function as well as more "hidden" properties, such as hitherto unknown organic processes, organs and diseases (Atran et al forthcoming).

Folkspecifics and Varietals. Generic species may be further divided into folkspecifics. In general, whether or not a generic species is further differentiated depends on cultural importance. Itzaj subdivide 257 useful plant generic species into 279 subordinate taxa. But even useful generic species are more likely to be monotypic than polytypic: Itzaj have no subdivisions for two-thirds of useful trees (95 of 138) and other useful plants (79 of 119); however, Itzaj subdivide the remaining one-third into 217 folkspecifics, 58 varietals and 4 subvarietals (Atran in press).

Folkspecific taxa are usually labeled binomially, with secondary lexemes. Such compound names make transparent the hierarchical relation between generic species and subordinate folkspecifics, like WHITE OAK and MOUNTAIN ROBIN. However, folkspecifics that belong to generic species with a long tradition of high cultural salience may be labeled with primary lexemes, like WINESAP (a kind of apple tree) and TABBY (a kind of cat). Foreign organisms suddenly introduced into a local environment are often initially assimilated to generic species as folk specifics. For example, the Lowland Maya originally labeled the Spanish pig "village peccary," just as they termed wheat "Castillian maize." Similarly, the Spanish referred to the indigenous pacas and agoutis as "bastard hares," just as they denoted the Maya breadnut tree "Indian fig" (Beltrán 1742/1859). Over time, as introduced species acquire their own distinctive role in the local environment, they tend to assume generic-species status and, as with most other generic species, are labeled by a single lexeme (e.g., "corn" in American English now refers exclusively to maize). Thus, the original Lowland Maya word for the peccary, k'ek'en, now refers exclusivey to the introduced pig, whereas the native peccary is obligatorily marked in the composite expression k'ek'en(+)che' = forest k'ek'en."

The subordinate ranks of folk specific and varietal corresponds to ranges of perceptible natural variation that humans are most apt to appropriate and manipulate as a function of their cultural interests. Partitioning into subordinate taxa usually occurs as a set of two or more taxa that lexically contrast along some readily perceptible dimension

(color, size, etc.); however, such contrast sets often involve cultural distinctions that language and perception alone do not suffice to explain (Hunn 1982). An example is the Itzaj Maya contrast between RED MAHOGANY (chäk[+]chäk-al~te') and WHITE MAHOGANY (säk[+]chäk-al~te'). RED MAHOGANY actually appears to be no redder than WHITE MAHOGANY. Rather, RED MAHOGANY is preferred for its beauty because it has a deeper, darker woodgrain than WHITE MAHOGANY. But why "red" as opposed to "white," rather than simply "dark" as opposed to "light"?

A majority of Itzaj folkspecifics reflect color contrasts, and the most habitual contrast is between chäk and säk (Atran in press). This, despite the fact that distinctions involving "green," "yellow" or "black" may be no less obvious to the naked eye. One interpretation is that use of contrasting color specifics, which almost invariably involve just the five primary colors, is related to the overriding importance of these colors in Maya cosmology (cf. Bruce 1968 for Lakantun, Barrera Marín et al. 1976 for Yukatek). In this ancient cosmology, the RED EAST is the true direction of rain and good life, whereas the WHITE NORTH is the false direction of cold and deception. This is not to deny that color contrasts generally signal perceptible distinctions among folkspecifics. It merely suggests that color perception alone may underdetermine whether, say, "red" versus "white" is really more apparent for a given case than "black" versus "yellow."

Occasionally, an important folkspecific will be further subdivided into contrasting varietal taxa, such as SHORT-HAIRED TABBY (CAT) versus LONG-HAIRED TABBY (CAT), or ix-chäk[[+]]tzäma'[+](b'u'ul) = the red tzäm'a (bean)" versus ix-säk[[+]]tzäma'(b'u'ul) = "the white tzäma' (bean)." Varietals are usually labeled trinomially, with tertiary lexemes that make transparent their taxonomic relationship with superordinate folkspecifics and generic species. An example is SPOTTED WHITE OAK versus SWAMP WHITE OAK, or ix-kän[[+]]put-il[+]kaj = the yellow village papaya" versus ix-säk[[+]]put-il[+]kaj = the white village papaya."

Intermediate taxa. Intermediate levels also exist between the generic-species and life-form levels. Taxa at these levels usually have no explicit name (e.g., rats + mice but no other rodents), although they sometimes do (e.g., felines, palms). Such taxa - especially unnamed "covert" ones - tend not to be as clearly well-delimited as generic species or life forms, nor does any one intermediate level always constitute a fixed taxonomic rank that partitions the local fauna and flora into a mutually exclusive and virtually exhaustive set of broadly equivalent taxa. Still, there is an evident preference for forming intermediate taxa at a level roughly between the scientific family (e.g., canine, weaver bird) and order (e.g., carnivore, passerine) (Atran 1983, Berlin 1992).

Like folk around the world, Itzaj also have a number of relatively stable intermediate categories, both named and unnamed. Such categories may be nested one within the other. For example, the named category of snakes is embedded in the larger unnamed category of squamates (snakes and lizards). In turn, the squamates are embedded in the (unnamed) life form that includes all herpetofauna. Other examples of named intermediate categories are: ch'uuy (diurnal raptors), aak (turtles), kab' (bees), sinik (ants). A number of intermediates are also polysemously named after protoytpical species: b'alum (jaguars in particular, and large felines in general), juj (iguanas in particular, and lizards in general), ya' (chicle tree in particular and resinous Sapotaceae trees in general), xa’an (guano palm and palms in general). In such cases, the intermediate can generally be disambiguated from its prototypical generic species as uy-et'~ok X ("companions of X") or u-ch'ib'-al X ("lineage of X"), where X is the name of the generic species. Like the named intermediates, unnamed intermediates are usually restricted to locally occurring fragments of biological orders, families or genera. Examples include: Araneida (tarantulas and other spiders), Anura (frogs and toads), Psittacidae (parrots and macaws), Dasypractidae (agoutis and pacas), Meliaceae (mahogany and tropical cedars) and Annona (custard apples).

Lowland Maya Nomenclature and Notation

The systematic qualification of folbiological categories by attributives often indicates binomial folkspecific taxa of cultural importance. Yet, reliance on nomenclature alone can be misleading. To highlight cognitive distinctions between superficially similar expressions, a set of nomenclatural marks are introduced. These notations represent "hidden" cognitive features of folkbiological categorization that are not apparent from spoken linguistic forms. In what follows, all terms that express taxonomic ranking are composite expressions, rather than compounds or descriptive phrases (cf. Conklin 1962). Morpheme breaks are indicated by a hyphen, -".

Composite expressions consist of a qualifier plus a stem. The stem designates a category immediately superordinate to the category in question. For example, the composite mejen+b'a'al~che', which designates the Itzaj life form INVERTEBRATE, consists of the stem for the superordinate kingdom (b'a'al~che' = ANIMAL) plus a qualifier (mejen = small). For the few life forms that are composite expressions, the relationship between stem and qualifier is indicated by a plus sign, "+". By contrast, the expression nojoch b'a'al~che' ("big animal") is a descriptive phrase, rather than a composite. Although nojoch b'a'al~che' could refer to all animals that are not mejen+b'a'al~che' - BIRDS, MAMMALS, FISH and REPTILES - this reference is not systematic, and the distinction between "big animal" and "small animal" does not represent a taxonomic partition of ANIMAL. This is not to deny that mejen b'a'al~che' can also be used descriptively: to denote any "small animal," which may or may not be an INVERTEBRATE depending on the context in which the descriptive phrase is used. The relationship between terms in a descriptive phrase is indicated by a blank space between the terms.

Notice in these examples that the ANIMAL kingdom is denoted by a compounding of two terms: b'a'al = "thing," together with che' = "tree/forest." A compound is formed by uniting two terms whose different meanings may or may not be related, in order to form a single new meaning. The relationship between compounded

terms is indicated by a tilde "~". The expression b'a'al~che' is not a composite because b'a'al is not a kind of che' (i.e., "thing" is not a kind of "tree"). Neither is the expression a descriptive phrase because b'a'al does not qualify che' (i.e., "thing" does not modify "tree"). Another example is k'u'~che' ("god tree"). This compound expression refers exclusively to the generic species, tropical cedar (Cedrela mexicana). For the Maya, tropical cedar was traditionally a sacred tree, and the etymological significance of the compound name is thus apparent on inspection. But few present-day Itzaj are spontaneously aware of the constituent meanings; no more, say, than most Americans automatically think of the compond term "eggplant" as, first of all, describing an eggy plant.

Composite expressions also occur for a few generic species when their names indicate an intermediate category. For example, the tapir, tzimin(+)che' ("forest beast") forms an intermediate category together with horse, tzimin, which is optionally marked by the compositve expression tzimin(+kaj) ("village beast") or tzimin(+kastil) ("Spanish beast"). [9]FTerms that are intermediate composite expressions are indicated by a plus sign in parantheses, "(+)". Optional composite expressions are indicated by enclosing a plus sign with in parentheses together with the stem or qualifier. For example, tzimin(+kaj) has the form STEM(+QUALIFIER), whereas tz'ab'(+kan) ("rattle snake") has the form QUALIFIER(+STEM). In the latter example, tz'aab' ("rattler") can stand alone (in which case the vowel may be elongated).

Most folkspecifics are composite expressions consisting of a generic-species stem plus a qualifier. This relationship is indicated by a plus sign in brackets, "[+]"; for example, ix-ch'uuk[+]ik ("sweet chile"). Varietals are nearly always composites whose superordinate specific is itself a composite. This embedded composite relationship is indicated by a plus sign in double brackets, "[[+]]"; for example, ix-noj[[+]]ch'uuk[+]ik (big sweet chile"). The female gender marker, ix, and the male gender marker, aj, are usually obligatory for folkspecifics and varietals in that they designate an item in a

contrast set. They are also occasionally attached to certain generic species, with ix habitually attached to plants (e.g., ix-xyaat, a small herbaceous palm) and smaller animals (ix-litz', a small lizard) , and aj to larger vertebrates (aj-koj, mountain lion) and a few trees (aj-k'uxu', annota). The prototypical generic species of an intermediate taxon is generally not marked by gender (e.g., b'alum, juj, ya', xa'an,) (for details see Lois, in press).

To see how the notation helps clarify cognitive status, consider some representative folkbiological expressions from Table 1, which represents the intermediate taxon uy-et'ok xa'an.

1. jach xa'an = "true guano." This is descriptive phrase is usually employed to indicate the protypical status of Sabal mauriitiformis among the intermediate category of (usually) taller palms, xa'an. On occasion, however, it can be descriptively used to indicate a specific kind of S. mauriitiformis as the prototypical folkspecific, namely, b'äyäl[+]xa'an (see example 4 below).

2. b'otan(+xa'an) = "botan guano." This is composite expression refers exclusively to the generic species, S. mauriitiformis. Usually, the generic species is simply denoted xa'an; however, use of the composite b'otan(+xa'an) allows the generic species, xa'an, to be disambiguated from the intermediate palm category, xa'an. Most often, b'otan is used without the composite stem, either to refer to the generic species S. mauriitiformis, or to its mature form alone.

3. aj-b'on(+)xa'an = "cabbage-palm guano." This refers exclusively to the generic species Sabal mexicana, the closest taxonomic ally of S. mauriitiformis. A minority of informants consider the composite stem optional, and simply refer to aj-b'on or b'on. But for all other generic species of the intermediate palm category, xa'an, inclusion of the composite stem is always optional: for example, kuum(+xa'an) = Crysophilia staurocauta), tuk'(+xa'an) = Acrocomia mexicana, etc.

4a. b'äyäl[+]xa'an = "basket whist guano." This is the prototypical folkspecific of Sabal mauriitiformis (see also example 5 below).

4b. b'äyäl(+xa'an) = "basket whist guano." Only a few informants extend the limits of the intermediate palm category, xa'an, to palms of the genus Desmoncus. In general, this generic species of climbing palms is simply denoted b'äyäl.

5. b'äyäl(+ak') = "basket whist vine." Most informants consider Desmoncus palms to belong to the life-form category, ak' (VINE), and will optionally include the life-form stem when referring to the generic species. In some contexts (e.g., our experiments with palms), Itzaj use this composite to distinguish basket whist from the protoypical guano folkspecific, b'äyäl[+]xa'an.

6. k'i'ix xa'an = "spiny guano." This descriptive phrase can be used to denote some or all of the armed palms. Although for some informants it can describe a stable intermediate grouping of armed palms, there is no cultural consensus in the use of the phrase. For example, although most informants will agree that it describes the armed "tree-like" palms kuum and tuk' (see example 3 above), few allow that it describes the armed "vine," b'äyäl (see example 4b above).

7a. k'än xa'an = "yellow guano." This can be understood as describing any guano that is withering, guano that appears to shimmer yellow in the sun, etc.

7b. k'än~xa'an = "yellow guano." This composite refers exclusively to nargusta trees (Terminalia amazonia), which are not folktaxonomically related to xa'an.

8. ix-jäl[+]ja'as = u-ch'up-al[+]ja'as = "female plantain." This composite refers to a specific kind of plantain that taxonomically contrasts with the "male plantain," ix-ixik[+]ja'as = u-xib'-al[+]ja'as. Itzaj are well aware that plantains and bananas are propagated without regard to sex from underground buds on the rhizome. Itzaj thus use the sexual analogy to highlight a morphological contrast rather than to describe or type a truly sexual distinction. It is unclear, however, whether stable kinds of plantains should be considered folkspecifics of the generic species, plantain, or folkvarietals of a generic

species that includes both plantains (ja'as) and bananas (gineeyoj). In the latter event, ja'as would refer polysemously to both the intermediate category of plantains and bananas, and to the generic species of plantains alone. In that case, the composite expression for "female plantain" would be ix-jäl[[+]]j'a'as.

9. b'ox~ja'as = "black plantain." This compound expression actually refers to a specific kind of banana (gineeyoj) rather than plantain (ja'as). The terms of the compound expression loosely describe taxonomically relevant properties of the fruit, whose peel and pulp are dark reddish and whose length resembles plantains. Depending on whether the kind is considered a specific or a varietal (see example 8 above), its composite expression would be b'ox~ja'as[+]gineeyoj or b'ox~ja'as[[+]]gineeyoj[+]ja'as.

10a. chäk ja'as = "red plantain." This could describe any plantain or banana whose peel or fruit took on a reddish cast. It can also elliptically refer to the redder (as opposed to yellower) variety of b'ox~ja'as. In the latter case the full composite form would be ix-chäk[[+]]b'ox~ja'as if considered a varietal, or ix-chäk[[[+]]]b'ox~ja'as if considered a subvarietal (see example 9 above).

10b. chäk-al~ja'as = "reddish plantain." This refers exclusively to the red mamey tree (Pouteria mammosa), which has no taxonomic relationship nowadays with plantains and bananas. Historically, however, the native mamey was originally labeled ja'as . It was initially perceived as related to the introduced plantains and bananas in much the way that the tapir and horse were perceived to be related. When the Spanish introduced the horse, a perissodactyl, the Maya classified it as a specific kind tapir, the only native perissodactyl. Over time, the importance of the horse in the Maya vision of "the economy of nature" came to outweigh the tapir's. The original unmarked term for tapir, tzimin, was passed on to the horse, and the tapir acquired the obligatory marking tzimin(+)che' ("forest tzimin"). But an intermediate-level taxonomic link persists for Yukatekan Maya (Itzaj, Lakantun, Mopán, Yukatek), indicating awareness of a significant biological relationship between the tapir and horse. By contrast, these Lowland Maya ultimately

recognized the initial morphological analogy between the native mamey fruit and the introduced plantains and bananas to be biologically superficial and taxonomically insignificant.

In sum, surface expressions of folkbiological nomenclature, while valuable as a starting points in ethnotaxonomic inquiry, can only be indirect guides to the current status of cognitive categories. For further clarity, cultural context may be crucial and historical analysis enlightening. Controlled psychological testing, however, can sometimes be decisive on these and other issues concerning the cognitive nature of folkbiological taxonomy and taxonomy-based reasoning.

Taxonomic Categories and Category-Based Inference

To illustrate the character of Itzaj folkbiological taxonomy, I will summarize some recent experimental findings gathered with colleagues. The experimental strategy was as follows: First we asked individual informants to perform successive sorting tasks of name cards or colored picture cards (or specimens in Itzaj pilot studies) in order to elicit individual taxonomies. Then, we used statistical measures to see whether or not the data justified aggregating the individual taxonomies for each informant group into a single "cultural model" that could confidently retrodict most (of the variance in) informant responses. Finally, we used the aggregated cultural taxonomies to perform various category-based inference tasks with the same or different informants. Our intention was to see whether and how how people reason from their cultural taxonomies to determine the likely distribution of unfamiliar biologically-related properties. At each stage of the sorting and inference tasks we asked informants to justify their responses. Task preparation and interpretation involved researchers from several countries and disciplines.

By and large, the Itzaj males in our studies were traditional farmers and woodsmen, while females tended household. In nearly all studies equal numbers of men and women were represented. There is some evidence of differences in knowledge (e.g.,

men often know more about forest trees and animal habits, women often know more about medicinal herbs that grow around the village); however, with the exception of one inference task concerning bird typicality (discussed below) there were no statistically significant differences between men and women in tasks concerning the structuring of taxonomic categories or category-based inference. The folktaxonomic data presented below are intended to be illustrative rather than exhaustive.

Ranking and Inductive Privilege. The study summarized here uses a standard tool of cognitive psychology - inductive inference - to explore the cognitive validity of folkbiological ranks in general. In particular, the study tests whether or not there is a psychologically privileged rank that maximizes the strength of any potential inference about biologically relevant information. The crucial question is whether and where in the taxonomic hierarchy a breakpoint or sharp change in inductive strength occurs. Similar studies were performed with Lowland Maya and Midwestern Americans (for comparative results see chapter by Coley et al, this volume).

Based on extensive fieldwork and preliminary sortings , we chose Itzaj folkbiological categories of the kingdom (K), life-form (L), generic-species (G), folkspecific (S), and varietal (V) ranks. We selected three plant life forms: che' = tree, ak' = vine, pok~che' = herb/bush. We also selected three animal life forms: b'a'al~che' kuximal = "walking animal," i.e., mammal, ch'iich' = birds including bats, käy = fish. Three generic-species taxa were chosen from each life form such that each generic species had a subordinate folkspecific, and each specific had a salient varietal.

Pretesting showed participants willing to make inferences about hypothetical diseases. The properties chosen for animals were diseases related to the "heart" (puksik'al), "blood" (k'ik'el), and "liver" (tamen). For plants, diseases related to the "roots" (motz), "sap" (itz) and "leaf" (le'). These properties were chosen according to Itzaj beliefs about the essential, underlying aspects of life's functioning. Thus, the Itzaj word puksik'al, in addition to identifying the biological organ "heart" in animals, also

denotes "essence" or "heart" in both animals and plants. The term motz denotes "roots," which is considered the initial locus of the plant puksik'al. The term k'ik'el denotes "blood," conceived as the principal vehicle for conveying life from the puksik'al throughout the body. The term itz denotes "sap," which functions as the plant's k'ik'el. The tamen, or "liver," helps to "center" and regulate the animal's puksik'al. The le', or "leaf," is the final locus of the plant puksik'al. For inferences, properties had the form, "is susceptible to a disease of the <root> called <X>." For each question, "X" was replaced with a phonologically appropriate nonsense name (e.g. "eta") in order to minimize the task's repetitiveness.

Each participant responded to a list of over 50 questions in which he/she was told that all members of a category had a property (the premise), and asked whether "all," "few," or "no" members of a higher-level category (the conclusion category) also possessed that property. The premise category was at one of four levels, either life-form (e.g. L = bird), generic-species (e.g. G = vulture), folkspecific (e.g. S= black vulture), or varietal (e.g. V = red-headed black vulture). The conclusion category was drawn from a higher-level category, either kingdom (e.g. K = animal), life-form (L), generic-species (G), or folkspecific (S). Thus, there were ten 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 folkspecific-to-life form (S->L) question might be, "If all black vultures are susceptible to the blood disease called eta, are all other birds susceptible?" If a participant answers "no," then the follow-up question would be "Are some or a few other birds susceptible to disease eta, or no other birds at all?

Representative findings are given in Figure 1. Responses were scored in two ways. First, we totaled the proportion of "all or virtually all" responses for each kind of question (e.g., the proportion of times respondents agreed that if red oaks had a property, all or virtually all oaks would have the same property). Second, we calculated "response scores" for each item, counting a response of "all or virtually all" as 3, "some or few" as

2, and "none or virtually none" as 1. A higher response score reflected more confidence in the strength of an inference.These scores were analyzed using t-tests with significance levels adjusted to account for multiple comparisons. All results reported are significant beyond chance.

Figure 1 summarizes the results from all Itzaj informants for all life forms and diseases, and shows the proportion of "all" responses (black), "few" responses (checkered), and "none" responses (white). For example, given a premise of folkspecific (S) rank (e.g., red squirrel) and a conclusion category of generic-species (G) rank (e.g., squirrel), 49% of responses indicated that "all" squirrels, and not just "some" or "none," would possess a property that red squirrels have. These results were obtained by totaling the proportion of "all or virtually all" responses for each kind of question (e.g., the proportion of times respondents agreed that if red oaks had a property, all or virtually all oaks would have the same property). Thus, a higher response score represented more confidence in the strength of the inductive inference.

Following the main diagonal of Figure 1 refers to changing the levels of both the premise and conclusion categories while keeping their relative level the same (with the conclusion one level higher than the premise). Induction patterns along the main diagonal indicate a single inductively privileged level. Examining inferences from a given rank to the adjacent higher-order rank (V->S, S->G, G->L, L->K), we find a sharp decline in strength of inferences to taxa ranked higher than generic species, whereas V->S and S->G inferences are nearly equal and similarly strong.[10] Moving horizontally within each graph in Figure 1 corresponds to holding the premise category constant and varying the level of the conclusion.[11] Itzaj show the largest break between inferences to generic species versus life forms. The same pattern for "all" responses is evident for Americans along the main diagonal (Atran et al forthcoming), while in the combined response scores ("all" + "few") there is evidence of increased inductive strength for higher-order taxa among Americans versus Itzaj. Americans also show a consistent pattern of rating

inferences to life-form taxa higher than to folk-kingdom taxa: G->K vs. G->L, S->K vs. S->L, and V->K vs. V->L. This indicates a secondary privileging of life-form taxa for Americans, which arguably owes to attrition of experience at the generic-species level (versus enhancement of experience for Itzaj).[12]

Finally, moving both horizontally and along the diagonal, there is a modest but significant difference between inductions using conclusions at the generic-species versus folkspecific levels: V->G and S->G are modestly weaker than V->S. Most of this difference owes to induction patterns for the Itzaj tree life form. There is evidence that Itzaj confer special privileged status upon trees at the folkspecific level (e.g. savanna nance tree): Figure 2 shows inductive privilege at the folkspecific level for the life form che' (tree). A strong ethic of reciprocity in silviculture still pervades the Itzaj, which involves Maya tending trees in order that the forest tend to the Maya (Atran & Medin in press). Knowledge and expertise concerning trees thus seems to translate into an upgrading of biological interest in tree folkspecifics. In sum, Itzaj patterns of induction across folkbiological ranks reflects the overall privilege of the generic-species as well as the secondary importance of lower-level distinctions, at least for kinds of trees (cf. Ellen this volume).

Itzaj Mammal Taxonomy. What follows is a brief account of findings in regard to all mammals represented in the local environment of the Itzaj. We included bats, although Itzaj do not consider them mammals (because we wanted to compare how Americans and Maya treat bats, see López et al. in press). We asked informants to sort name cards of all local mammal generic species into succesive piles. Pretesting name cards were Maya words in Latin letters and informants were asked to to succesively sort cards according to the degree to which they "go together as companions" (uy-et'~ok) of the same "natural lineage" (u-ch'ib'al). When an informant indicated no further desire to successively groups cards the first piles were restored and the informant was asked to subdivide the piles until he or she no longer wished to do so.

The "taxonomic distance" between any two taxa (cards) was calculated according to where in the sorting sequence they were first grouped together. While a majority of Itzaj informants were functionally illiterate, they had no trouble in manipulating the name cards as mnemonic icons. There were no observed differences in handling of cards between literate and illiterate Itzaj, and no statistically significant differences in results. We chose names cards over pictures or drawings to minimize stimulus effects and to maximize the role of categorical knowledge.

Results indicate that individual Itzaj mammal taxonomies are all more or less competent expressions of a consensual cultural model of the mammal world.[13] To compare the structure and content of the cultural model with a scientific model, we mathematically correlated each group's aggregate taxonomy with a classic evolutionary taxonomy, that is, one based on a combination of morphological and phylogenetic criteria (Atran 1994; López et al. in press). The overall correlation between evolutionary and Itzaj taxonomies was strong ($\underline{r} = .81$). A comparison of higher-order taxa only (i.e, excluding generic species) still shows a robust correlation ($\underline{r} = .51$).[14]

Agreement between higher-order groups and science is maximized at the level of the scientific sub-order (i.e., the level between family and order), both for Itzaj and Michigan subjects, indicating an intermediate-level focus in the folk taxonomies of both cultures. On the whole, taxa formed at this level are still imageable. Consider the mammal sorting of one Itzaj woman in Figure 3, which is fairly representative of the aggregate taxonomy (i.e., her first-factor, or competence, score was > 0.9). For example, taxa formed at level 3 in Figure 3 (the Itzaj counterpart of scientific rankings at the level of the sub-order or below) are not only representable by an abstract image, but are sometimes named as well. At level 3, for example, b'alum includes the large felines (margay, ocelot, jaguar and mountain lion). At level 2, och includes the skunk, oppossum, porcupine and weasel, which are morphologically and behaviorally close (in Figure 3) but scientifically distant (in Figure 4).

Closer comparison suggests cognitive factors at work in folkbiological classification that are mitigated or ignored by science. For example, certain groupings, such as felines + canines, are common to both Itzaj and Michigan students (cf. López et al. in press), although felines and canines are phylogenetically further from one another than either family is to other carnivore families (e.g., mustelids, procyonids, etc.). These groupings of large predators indicate that size and ferocity or remoteness from humans is a salient dimension (cf. Rips et al. 1973). This is a dimension that a corresponding evolutionary classification of the local fauna does not highlight.[15]

An additional non-scientific dimension in Itzaj classification, not present in American folk classification, relates to ecology. For example, Itzaj form a group of arboreal animals, including monkeys as well as tree-dwelling procyonids (kinkajou, cacomistle) and squirrels (a rodent). The ecological nature of this group was independently confirmed: We asked informants to tell us which plants are most important for the forest to live. Then, we aggregated the answers into a cultural model, and for each plant in the aggregate list we asked which animals most interacted with it (without asking directly which animals interact with one another). The same group of arboreal animals emerged as a stable cluster in interactions with plants (Atran & Medin in press).

Itzaj Palm Taxonomy. The biasing roles of size and habit are also apparent in the comparison of Itzaj palm classification with a scientific classification of local palms and their folkbotanical allies, the zingiberales (e.g., bananas and plantains). Sorting results show that Itzaj taxonomy correlates positively and significantly with the scientific taxonomy when the generic-species level is included ($r = .71$). Furthermore, there is a more modest but significant correlation when the folk generic-species level is excluded ($r = .44$). These results indicate that Itzaj roughly tend to agree with science in their classification of palms and folkbotanical allies: scientifically distant or close plants tend to be seen on the whole as distant or close on scientific grounds as well. The correlation with science in the case of palms closely parallels the mammal case.

The overall correlation between Itzaj and scientists (which accounts for slightly over half of the variance) reflects the fact that when scientists and folk carve up the biological world, they tend to make the same basic cuts. The lower correlation involving only superordinate palm groupings suggests that folk discriminate these groupings on the basis of somewhat different criteria than does scientific systematics (see Figures 5 and 6). As with the case of mammals (for both Itzaj and American folk), the chief difference appears to be folk reliance on the dimension of size. For example, Itzaj readily acknowledge a similarlity in leaf and overall morphological aspect between all of the Chamaedorea; however, because ch'ib' tends to be markedly taller than the other Chamaedorea it is classed with other treelets (in Figure 5) rather than with the other Chamaedorea "herbs" (pok~che'). Similarly, although there is some local acknowledgement of an affinity between all of the Hyophorbeae (in Figure 6), the tree-like character of aj-k'än~b'o' places it with coconut trees and royal palms rather than with the herb-like Chamaedorea.

In sum, the evidence points to both marked convergence and divergence between folk and science. But the lack of a perfect correlation does not necessarily mean that, where they diverge, folk present a "wrong" image of biological reality and science a "right" one. Thus, in the folk case, stem and leaf size (and habit) is intimately bound up with an appreciation of the ecological role the taxa play in the local setting. At best, such an appreciation is only of secondary concern to systematics (as a source of information about the genealogical relationships among organisms). Nevertheless, folk appreciation is equally factual. Indeed, the very notion of TREE, although banned from systematics since at least Linneaus (1751, section 209), can hardly be thought to represent a "false" picture of the world. Linnaeus - no less than any contemporary field botanist - would invariably rely on everyday concepts like TREE, VINE or HERB to understand the composition of any local flora. In the local context of Peten, knowing that ch'ib' and aj-k'än~b'o' are not part of the lower undergrowth to which the rest of the hyophorbaceous

Chamaedorea belong is not only Maya common sense, it also reflects what is truly perceived.

Itzaj Snake Taxonomy. There are also evident folk biases in Itzaj classification of snakes = kan. Itzaj group snakes into basically three clusters (Figures 7 and 8): 1) long and thin "vine snakes" = kan-il(+)ak' and "fasting snakes" = aj-suk'in(+)kan, which are thin, mostly inactive snakes that are either nocturnal and arboreal or burrowing), 2) snakes that eat other snakes (e.g., the large boa constrictor, or "oppossum snake" = och(+)kan, and the large "rat snake" = kan(+)ch'o'), and 3) the supposedly lethal snakes, including the fer-de-lance = k'ok'o', the tropical rattlesnake = aj-tz'ab'(+kan), and the coral snakes. But the primary cognitive dimension in the snake classification is venomous versus nonvenomous. Questioning shows that people fear certain snakes. Only some of these are actually poisonous, but all those feared are nevertheless thought to sprout wings and extra heads, and to fly off to the sea with their last victims - a likely cultural survival of the Precolumbian cult of kukul~kan ("feathered serpent"). Interviews suggest that supposed danger is a very strong factor in snake sortings, and supports one interpretation of a multi-dimensional scaling of these sortings (Figure 8).[16]

A first interpretation might be that in some cases the biological target is more determined by culturally specific interests than by readily-perceptible phenotypic gaps in the distribution of local biota. Evidence from biology and social history, however, indicates a more complex story. Humans everywhere, it seems, are emotionally disposed to fear snakes (Seligman 1971) and to socially ritualize this phobia (Marks 1987) in recurrent cross-cultural themes, such as "the cult of the serpent." The fact that people are spontaneously more inclined to exhibit and expresss fear of snakes than fear of much more lethal cultural artifacts - like swords, guns and atom bombs - intimates an evolutionary explanation: naturally selected phobias to resurgent perils in ancestral environments may have provided an extra margin for survival, whereas there would be no direct natural selection of cognitive responses to the more recent dangers of particular

cultural environments. To an extent, then, Itza snake classification seems an exception that proves the rule: folktaxonomies are more or less naturally selected conceptual structures - "habits of mind" - that are biologically "pretuned" to capture relevant and recurrent contents of those natural environments - "habits of the world" - in which hominid evolution occurred.

For snakes, the correlation between Itzaj classification and evolutionary classification is not highly significant, although the correlation between science and the Itzaj herpetofauna as a whole is comparable to the mammal case. Nevertheless, there is a clear morpho-behavioral basis for Itzaj snake classification, which is phenomenally salient in the context of forest life and survival. Thus, Itzaj classification of snakes into deadly versus nondeadly violates evolutionary classification because nonlethal colubrids are often classed with the lethal pitvipers and corals. A closer look at the violations reveals that ostensibly poisonous colubrids are often biological mimics of the venomous snakes. Mimics are species 1) whose ecological range overlaps with a venomous species or group of species, 2) whose mimetic features are restricted to external characteristics, and 3) which are less able to defend themselves than are their models.

For example, Itzaj classify the following colubrid species with the true corals (Micrurus spp.): Lampropeltis triangulum, Oxyrhopus petola, Pliocercus elapoides, Rhinobothryum bovalli, Scaphiodontophis annulatus, Sibon sartori, Tintilla moesta, and Stenorrhina freminvillei (only red specimens of this species, which is highly variable in color). Even expert herpetologists often have trouble distinguishing some of these species from true corals at a glance. Moreover: "It seems clear that potential predators, for whatever reason, may be discouraged by the bright colors displayed by Micrurus... and that other broadly sympatric... harmless snake species derive benefit from being colored similarly" (Campbell & Lamar 1989:379). In this case, then, human cognition of nature's mimics resembles the instincts of other species. Similar considerations apply to mimics of the pitvipers, such as Xenodon rabdocephalus. It resembles the fer-de-lance in size and

skin patterning, and it can it change its shape to look venomous. Juvenile specimens of Senticollis triaspis also resemble the fer-de-lance, although adult specimens generally do not. Here awareness of morphological similarities has obvious precautionary survival value.

The fact that Itzaj classify specimens of mimics with lethal snakes does not always mean that Itzaj think of the mimics as essentially venomous. For example, Itzaj sometimes label specimens of green-colored arboreal colubrids as ya'ax[+]k'ok'o', whose prototype is the relatively rare palm pitviper, Botreichis schlegeli. But Itzaj say it is hard to tell if a given specimen is "really" an exemplar of ya'ax[+]k'ok'o, or an exemplar of some other green snake taxon, such as ya'ax[+]soj~bach ("green dry-bone," a vine snake whose protoytpe is Oxybelis fulgidus) or ya'ax(+)kan ("green snake," a semi-venomous nonlethal colubrid whose prototype is Leptophis ahaetulla). The "true" test of which taxa a given specimen belongs to depends on its "heart" or "essence" (puksik'al); for example, an essential character of ya'ax[+]k'ok'o', as opposed to the other green snake species, is that it kills its victim: "if you feel the gas spread within you, and the blood flows from your pores, and you die within the day, then it's ya'ax[+]k'ok'o'." Unfortunately, only the dead may be sure to know to which taxon a given specimen belongs. Of course, there are also "mistaken" cross-classifications, such as identification of the green-speckled specimens of Drymobius margeriitiferus with any of the three green snake taxa. But here as well initial classificatory identification seems motivated by the survival strategy, "better safe than dead." Still, the principled classification of taxa by essences potentially distinguishes morphologically similar species. This principled basis for classification involves cognitive strategies that go far beyond the evidence at hand and the recognitory instincts of other species.

Itzaj Bird Taxonomy. In an experiment with color drawings of 104 local bird species (plus 2 bat species), we asked Itzaj to pilesort as in name card experiments with mammals, palms and herpetofauna. We used drawings instead of name cards to directly

compare how Itzaj classify their birds with how folk in other cultures classify these same birds. As with mammals, palms and herpetofauna (including snakes), aggregated individual sortings yield a highly consensual taxonomy; that is, a single factor accounted for most of the variance in a principal components analysis, and all individual first-factor scores were positive. Itzaj bird classification is well-correlated with evolutionary taxonomy (r = .75), with over half the variance accounted for. [17]

To make sense of remaining variance, consider higher-order sortings in Figure 9, representing the consensual bird taxonomy. Itzaj, local Spanish and common English names of folktaxa are given in Listing 1, along with scientific orders, families and species to which the taxa belong (Figure 10). Stimuli broadly represent local distributions of higher- and lower order scientific taxa; but there are notable absences. Individual variation in naming mostly revolves around closely related taxa (e.g., names for exemplars of the intermediate parrot taxon, ix-t'ut').

Stimulus effects sometimes lead to misidentification because morphological attributes on picture cards give no evidence of the distinctive calls and behaviors often used to identify birds in nature and locate them in culture. Many Itzaj bird names are onomatopoeic, with constituent sounds also often accorded meaning. For example, Itzaj women tend to consider mournful cooing of the short-billed pigeon (ix-ku'uk~tzu'uyen = squirrel tricked me") as the lament of the bird mother who confided her child to the squirrel trickster. With jaguar approaching, the squirrel offered to hide the mother's child while she escaped, then ate the child. Itzaj men, who venture deeper into the forest, say the bird can also be called ix-k'uk'~suku'un (budding brother") or ix-waxak~tun (bewailing Uaxactun, ancient site of Maya spirits). Itzaj only confound this species with other birds of the intermediate pigeon taxon (ix-tuut/ix-paloomaj) when it is not heard.

Correspondence of distinctive perceptual and behavioral markers with cultural meanings occurs at the life-form, intermediate, generic-species, folkspecific and varietal levels. For example, although bats (aj-sotz') are classed with birds, their dualizing"

behavior with mammals emerges in folktales: they are deceitful creatures who, in legendary battles between life forms for forest supremacy, betray their (bird) kind for their own advantage. The deluder pretends to suckle its young in the company of mammals and desire only fruit,then sneaks at night to suck out the life blood of both mammals and birds. Itzaj believe that while some bats eat fruit, all suck blood. The especially furtive and small vampire bat (aj-sotz'[+]b'ampiiroj = Desmodus rotundus) is the deadliest offender, but larger frugivorous bats (aj-nojoch[+]sotz') also dine on friend and foe.

The intermediate owl group (aj-b'uj) augurs death. Owl generic species distinguish kinds of death augured: the dirge of the barn owl (xooch' = Tyto alba) foretells a foreigner's (tz'ul) demise; the dimunitive appearance of the pygmy owl (ix-nuk = Glaucidium brasilianum) portends widowhood; the horned screech owl (aj-b'uj[+]kaachoj / aj-kukus[+]b'uj = Otus guatemalae) is an omen of a violent end. The generic species of vultures also augurs death and decay; however, only red vultures" (aj-chäk[+]ch'om) as opposed to black vultures" (aj-b'ox[+]ch'om) rule the underworld of fire (k'ak'), with the red king vulture (aj-chäk[+]ch'om[[+]]usil = Sarcoramphus papa) its master (u-yum-il k'ak'). Still, the true overlord of life and death in the forest (jach u-yum-il k'aax) remains the jaguar, or red black b'alum" = (b'alum+)chak(+)ek'el, although pumas (aj-koj) may be more ferocious. In short, cultural meanings reflect upon taxonomy.

The broadest bird division that some informants explicitly provide in justifying higher-order sortings is (I) edible = k-u-jan-b'-äl versus (II) inedible = ma' tan-u-jan-b'-äl. But a more consensual, if covert, division, involves a nuanced mix of habit and habitat:

(IA) "Fish-eating water birds" = ch'iich'-il ja' k-u-jan-t-ik käy: (IA1) Coraciiformes in part (kingfishers = aj-ch'el), (IA2) Ciconiiformes (egrets = aj-säk~b'ok and herons = aj-t'on~k'uum), (IA3) Anseriformes (ducks = kutz'-il~ja') and Charadriiformes (jacanas = ix-ch'iich'-il~nab'). Other swimming birds called kutz'-

il~ja’ but not represented in the sample include Gruiformes (coots, grebes, scamps, teals, etc.). The sandpiper, ix-tu’wi’is (Scolopacidae: Actitis macularia), is a Charadriiforme that visits wetlands but is not represented . Also not represented in (IA)’s sample is the cormorant, mulach’ (Pelecaniformes: Phalacrocoracidae, Phalacrocorax brasilianus).

(IB) "Edible fruit-eating ground birds" = ch'iich'-il lu'um k-u-jan-b'äl k-u-jan-t-ik ich: (IB1) Columbiformes (pigeons, doves = ix-tuut) and (1B2) Galliformes (tinamous, quails, turkeys). One Galliforme, the raucous and gregarious chachalaca = ix-b'ach, is closer folktaxonomically to (1B1) than (1B2). Remaining Galliformes divide as: (1B2a) uy-et'ok ix-mankolol = "companion of the great tinamou" (small Cracidae and Phasiandae), and (IB2b) “companion of the wild turkey” = uy-et’~ok kutz’-il(+)k’aax , or "true birds" = jach ch'iich' (large Phasiandae and Cracidae).

(IC) "Edible fruit-eating tree birds" = ch'iich'-il che' k-u-jan-b'-äl k-u-jan-t-ik ich. These subdivide into those that: (IC1) "eat worms" = k-u-jan-t-ik nok'ol,, Piciformes in part (woodpeckers = aj-cheje’/ kolon~te’), versus (IC2) "are beautiful" = yutzil, or brightly colored, including Piciformes in part (toucans = aj-pichik’, aj-piitoj), Psittaciformes (macaws = aj-mo’ and parrots = ix-t’ut’) and Trogoniformes (trogons = ix-kokochan). The quetzal (ketzal), Guatemala's rare national bird, is a spectacular trogon of the distant cloud forest that stands alone.

(IIA) "Inedible flesh-eating birds" = ch'iich' ma' tan-u-jan-b-äl k-u-jan-t-ik b'äk. These subdivide into those that eat flesh which is: (IIA1) "rotten" = tu’-il, Falconiformes in part (vultures = aj-ch’om), versus (IIA2) obtained by killing” = k-u-kin-s-ik. The latter further subdivides into those that feed: (IIA2a) "by night" = ti ak'ä, Strigiformes (owls = aj-b’uj), versus (IIA2b) "by day" = ti k'in, Falconiformes in part (hawks, falcons, kites = aj-ch’uuy/mujan). The jet-black ani (Cuculiformes in part = aj-chäk~b’uul), with its grooved-bill and fondness for hunting small reptiles and mammals near the forest edge, is marginally attached to (IIA2b), although some informants place it with the blackbird (aj-pich’) in (IIB).

(IIB) "Inedible fruit-eating birds" = ch'iich' ma' tan-u-jan-b'-äl k-u-jan-t-ik ich: Cuculiformes in part (cuckoos), Apodiformes (swifts, hummingbirds), Caprimulgiformes (poorwills, potoos), Coraciformes in part (momots) and Passeriformes (becards, flycatchers, orioles, robins, tanagers, jays, foliage gleaners, grosbeaks, martins, swallows, blackbirds, oropendolas). Subdivisions are: (IIB1) becards (ix-ma'~tuch) and Caprimugliformes (aj-pujuy); (IIB2) ix-wirisu', including most Passeriformes; (IIB3) ix-kusam, including martins, swifts and swallows; (IIB4) cuckoos (aj-käpäk~ch'o'), oropendolas (k'ub'ul) and motmots (aj-b'uk-pik); (IIB5) tz'unu'un, hummingbirds. Also known as birds that eat flower honey" (ch'iich' k-u-jan-t-ik u-kab'-il top'), hummingbirds are harbingers of promiscuity.

Some informants link Caprimugliformes to owls (IIA2b) because both groups are noctural hunters, but occasional sortings (and misidentifications) of potoos with antshrikes (not included in sample) and becards pulls" the group into (IIB). The prototypes of (IIB2) are the queens" (ix-reeynaj[+]wirisu'), which are flycatchers notable for their white head stripe. The category includes otherwise unremarkable passerines, although orioles (ix-tzi'il), robins (ix-k'ok') and tanagers sometimes stand apart (including Tanagra = chichin~b'äkäl, not represented). Other somewhat distinctive passerines not represented in our sample include warblers (ix-pitzi'~oox, Parulidae) and the black-headed Saltator atriceps (ix-tz'apin , Emberezidae). Swifts are confounded with martins and swallows in (IIB3), because of morpho-behavioral similarities, especially tail-feathers and flight. Although Cuculiformes have aspects of both (IIA) and (IIB) because they eat both fruit and small vertebrates, cuckoos (aj-käpäk~ch'o') are attached to (IIB) along with the blue-crowned momot (aj-buk-pik). Momots, unlike some other Coraciformes such as kingfishers (see IA), are akin to squirrel cuckoos in size, eating habit, habitat and elegant tail-feathers (also a feature of oropendolas). The Itzaj name, aj-buk-pik, imitates the motmot's call in the forest understory, whereas the Yukatek name, toj-toj, imitates its call from scattered tree tops (there is little understory left in Yucatan).

Itzaj variation in naming and misidentification is far greatest for Passeriformes, with some families split among local taxa (Corvidae, Thraupidae, Icteridae). Scientists, too, have difficulty distinguishing passerine families, which have come to occupy such a wide variety of ecological niches with little concomitant change in structure.

(IIC) "Inedible blood-sucking birds" = ch'iich' ma' k-u-jan-b'-äl k-uy-u-k'ik', Chiroptera (bats). The bat = aj-sotz' was initially excluded from bird sortings (for reasons of cross-cultural comparison); but subsequent sorting trials revealed this folktaxonomic position.

In sum, Itzaj bird taxa largely preserve scientific species, genera, families and orders. But ecology on a human scale takes on increasing significance as one ascends the life-form taxonomy. Knowledge of which birds can be hunted, and where, is inseparable from knowledge of where and how birds themselves obtain food. Such knowledge, in turn, is intimately linked to awareness of relationships between birds, and the forest fauna and flora that birds depend on. This awareness includes patterns of predation and seed dispersal that keep the forest alive. For Itzaj, to infer how the forest can stay alive is to imagine how they can survive (Atran & Medin in press).

Itzaj Typicality Judgments and Typicality-Based Inference**.** Itzaj Maya and students from rural Michigan both project biological properties from typical taxa to an inclusive taxonomic group better than from less typical taxa: $p < .05$ on all two-tailed t-tests, n = 12-24 Americans (6-12 men + 6-12 women) and 12-16 Itzaj (6-8 men + 6-8 women). The metric for typicality is given by the taxonomy itself, as the lowest average taxonomic distance. In other words, the typicality of an 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). Items that are more typical provide greater coverage of the category than less typical items. Thus, Itzaj choose JAGUAR / MAMMAL or MOUNTAIN LION / MAMMAL over SQUIRREL / MAMMAL or RACCOON / MAMMAL, judging that all mammals are more likely to be susceptible to a disease that jaguars or mountain lions

have than to a disease that squirrels or raccoons have. This is because Maya consider jaguars and mountain lions more typical of mammals than are squirrels and raccoons. In fact, jaguars and mountain lions are not typical for Itzaj just because they are more directly related to other mammals than are squirrels and raccoons; they also more closely represent an ideal standard of the "true animal/mammal" (jach b'a'al~che') against which the appearance and behavior of all other animals may be judged (cf. Barsalou 1985). This is evident from Itzaj justifications as well as from direct ratings of which mammals Itzaj consider to be the "truest."

By contrast, American informants choose the items SQUIRREL / MAMMAL or RACCOON / MAMMAL over BOBCAT / MAMMAL or LYNX / MAMMAL, presumably because they consider squirrels and raccoons are more typical of mammals for Americans than are bobcats and lynxes. Note that typicality in these cases cannot be attributed to frequency of occurrence or encounter. Our American subjects were all raised in rural Michigan, where the frequency of encounter with squirrels, raccoons, bobcats and lynxes is nowadays about as likely as the corresponding Itzaj encounter with squirrels, raccoons, jaguars and mountain lions. Both the Americans and Maya were also more or less familiar with all animals in their respective tasks.

Similarly, birds at the top of Rosch's (1975b) American typicality list (e.g., plain-colored passerines like sparrows) are never considered "true representatives" (jach) of BIRD (ch'iich') for Itzaj, whereas birds at the bottom of Rosch's typicality list are (e.g., galliformes such as turkeys). This is the case despite the fact the frequency of occurrence and encounter with plain-colored passerines is about the same in rural Michigan and central Peten, and always greater than frequency of occurrence and encounter with galliformes. In one study, we asked Midwestern Americans and Itzaj to indicate the "truest" birds among a series of 104 scaled color drawings of the birds of Peten. The Americans invariably placed passeriformes, such as flycatchers and orioles, at the top of their list and galliformes, such as the ocellated turkey, crested guan and great curassow,

at the bottom. Itzaj did just the reverse. When asked which birds were more likely to share a disease with other birds, Americans and Itzaj both strongly preferred their respective "truest" birds. We used "true" rather than "typical" because "typical" correlates closely with "true" for the Americans and because the Itzaj have no term that directly glosses "typical."

In justifying choices, Americans argued that the less remarkable and more frequently encountered passeriformes were more like most other birds than the remarkable galliformes were more like most other birds. By contrast, Itzaj tended to argue that diseases of the galliformes would have greater impact on other living things in the forest, including other birds. This is because of their remarkable size, behavior and value (in the food-chain) to other salient birds (predators), mammals (large carnivores), trees (large nut and fruit trees) and humans.

Comparing direct ratings of "true" with "taxonomic typicality," we found that passeriformes actually had a higher taxonomic-typicality rating (i.e., lower average taxonomic distance) than galliformes for both Itzaj and Americans. This suggests that the concept of typicality inherent in the taxonomy is not the only determinant of typicality-based biological reasoning for Itzaj. Among Itzaj, both "true" and "taxonomically typical" have roles to play where these two notions diverge, as with birds (true" and taxonomically typical" more closely coincide for mammals and palms). For example, we pitted passeriformes against diurnal raptors (Accipitridae + Falconidae). For Itzaj, passeriformes have medium to high taxonomic typicality, whereas the diurnal raptors have the highest taxonomic-typicality ratings. Itzaj considered the diurnal raptors much stronger candidates than passeriformes for biological inference to all birds. But when dirunal raptors are contrasted with galliformes, overall Itzaj choose galliformes as often as diurnal raptors, although galliformes have the lowest taxonomic-typicality ratings.

Surprisingly, 75% of men chose the raptors whereas 75% of the women chose the galliformes, with the sex difference being significant ($p = < .05$ on a two-tailed t-test, $n =$

8 women + 8 men). In their justifications, men tended to claim that because raptors fly over the entire forest and eat other birds (including other raptors) they can better acquire and spread the biologically-related properties (e.g., diseases) of other birds. By contrast, the women inclined to argue that because the galliformes roam over the forest floor and eat all manner of seeds, fruits and insects they can better acquire and spread their properties throughout the forest (including through their excrement) to other birds that either feed on the galliformes themselves or feed on the myriad other things on the forest floor that galliformes are in contact with.

In each case for which we have Itzaj typicality ratings, the "truest" (and often most taxonomically-typical taxa) are large, perceptually striking, culturally important and ecologically prominent: the jaguar and its allies or the tapir for the mammal life form, the ocellated turkey and its allies or the laughing and collared falcons for the bird life form, the fer-de-lance and its allies for the named intermediate category of snakes, the guano palm and its allies for the unnamed intermediate palm category. The dimensions of perceptual, cultural and ecological salience are all seemingly necessary to a determination of typicality, but none alone appears to be sufficient.

Thus, each typical representative can grow large, but is not the necessarily largest of its group (cows are bigger than jaguars and tapirs, certain herons and vultures are taller or more massive than ocellated turkeys or falcons, boa constrictors are longer and more massive than fer-de-lance, corozo palms are more massive than guano palms). Each is otherwise physically striking, but in a different way (the jaguar's luxuriant coat and the tapir's elephant-like snout, the ocellated turkeys iridescent feathering and the falcon's loud call, the fer-de-lance's yellow throat, the young guano's palm-leaf cover of the forest floor and the mature guano's strikingly tall and leafless trunk). Each is culturally important, but in a different way (jaguars and the falcons are predatory lords of the forest, tapirs and ocellated turkeys define the country's bounty, fer-de-lance is the most feared creature of all, guano palms provide materials for all types of shelter).

Each is salient to to the forest's ecological composition and to people's place in it, but in a different way (the jaguar's and tapir's habitats - some 50 km2 - determines the extent of a forest section, the presence of the ocellated turkey and black hawk-eagle indicate where game is abundant, where the fer-de-lance strikes determines where people should fear to tread, where there are guano palms human settlement is possible). Indeed the three dimensions seem to be so bound up with one another that it is difficult, if not impossible, to completely distinguish them for any particular case. In other words, typicality for the Itzaj appears to be an integral part of the human (culturaly-relevant) ecology. Thus, the Itzaj say that wherever the sound of the jaguar is not heard, there is no longer any "true" forest, nor any "true" Maya. Nothing of this sort arises for American judgments of biological typicality and typicality-based biological inference. For example, the wolverine is emblematic in Michigan, but carries no privileged inductive load.

Ecological Context and Causal Reasoning versus Diversity-Based Categorical Inference. Concern with ecology is also likely one reason for Itzaj "failure" to apply the so-called "diversity principle" to biological reasoning with animal (e.g., mammal) and plant (e.g., palm) taxa (Osherson et al. 1990). On this principle, when things are equal (e.g., when taxa are equally typical), then a biological property shared by two taxonomically close taxa (e.g., a wolf and a coyote) is less likely to be shared by a superordinate group of taxa (e.g., mammals) than a property shared by two taxonomically distant taxa (e.g., a wolf and a gopher). The diversity principle corresponds to the fundamental principle of induction in scientific systematics: a property shared by two organisms (or taxa) is likely shared by all organisms falling under the smallest (or lowest ranked) taxon containing the two (Warburton 1967).

Thus, American folk seem to use their biological taxonomies much as scientists do when given unfamiliar information in order to infer what is likely in the face of uncertainty: informed that goats and mice share a hitherto unknown property, they are more likely to project that property to mammals than if informed that goats and sheep do.

By contrast, Itzaj tend to use similarly structured taxonomies to search for causal ecological explanations of why unlikely events should occur. In many cases, ecological considerations lead Itzaj informants to conclude that the arguments with the more diverse premises are actually the weaker. For example, Itzaj generally favored argument (i) over argument (ii), where X and Y are unfamiliar biologically-related properties, such as unknown diseases.

(i) TINAMOU (ix-noom) & QUAIL (ix-kob'an) have X, therefore any BIRD (chiich') has X

(ii) TOUCAN (aj-pittoj), CHACHALACA (ix-b'ach) has Y, therefore any BIRD has Y

One Itzaj man argued that the taxonomic allies, rufescent tinamou and spotted wood quail, eat many things of the same things off the same ground, including disease-bearing insects and worms. They also leave many half-eaten and disease-ridden things behind for other birds to eat. Raptors eating any of the birds that eat what tinamous and quails eat will, in turn, also be susceptible to the disease. Taxonomically more distant toucans and chachalacas eat fresh fruits apart in trees; hence, they are less likely to get and spread a disease. In other words, more (kinds of) birds are apt to have X than Y. In this, as in many other cases, taxonomic distance is inversely related to the likelihood that ecological (causal) chains linking habit (especially eating habit) and habitat can be maintained to spread the property to other members of the life form.

Consider, for example, why one Itzaj woman preferred (iii) to (iv):

(iii) BROWN JAY (ix-p'aap) & ROBIN (ix-k'ok') have Y, therefore any BIRD has Y

(iv) HUMMINGBIRD (tz'unu'un) & KINGFISHER (ch'el) have X, therefore any BIRD has X

She argued that jay and robins both eat fresh as well as rotting things in trees, which can fall to the ground for many other birds to eat. By contrast, kingfishers eat only fish that may fall into water where few other birds venture; and hummingbirds eat only the nectar of flowers that rarely convey disease. As a result, more birds are apt to have Y than X.

For birds (Figure 9) and mammals (Figure 3), when typicality is held constant across premises, Itzaj consider arguments with more similar premises to be stronger than arguments with more diverse premises ($p < .05$).

Notice that, from an epidemiological perspective, Itzaj use of related taxa to generate plausible ecological chains for the spread of a disease across other taxa can be as valid a reasoning strategy as the use of distant taxa to judge widespread intrinsic susceptibility to the disease. A priori, a biologically intrinsic or an ecologically extrinsic stance might be correct. Thus, diseases are clearly biologically-related; but distribution of a hitherto unknown disease among a given animal population could involve epidemiological factors that depend on both inherent biological susceptibility and ecological agency.

For Palms (Figure 5), although similar premises are chosen more frequently than diverse premises, the difference fails to reach significance. Nevertheless, Itzaj preference for causally-based ecological reasoning is evident here as well. For example, one person favored argument (v) over argument (vi), arguing that because the coconut and the royal palm are tall and tree-like, their disease is more able to spread to other palms:

(v) COCONUT (kookoj) & ROYAL PALM (palmareaal) / all PALMS (tulakal uy-et'ok xa'an)

(vi) COCONUT (kookoj) & BASKET WHIST (b'äyäl) / all PALMS

In this case, as in many others, size is indicative of the broader ecological coverage of the forest's canopy. In other cases, ecological considerations again led diversity-based inductions. For example, one informant accepted (vi) as being stronger than (v) by saying: Don't you see that the coconut is a big tree and the basket whist clings to it worse than a vine, isn't that so? It can encounter the coconut, climb it and catch the same disease the other has [and give it to the other palms]." In other words, vine-like basket whists can help spread the disease of tree-like coconuts to all other palms, whereas the tree-like royal palm would presumably contribute little more to the

spread of the disease than would the coconut alone. In this case, as in others, the focus seems to be on broader ecological coverage in terms of the vertical, or storied, relationships between forest species rather than in terms of horizontal relationships of broad spatial coverage.

In the absence of a theory - or at least presumption of a theory - of causal unity underlying disparate species, there is no compelling reason to consider a property discovered in two distant species as biologically intrinsic or essential to both. It may make as much or more sense to consider the counter-intuitive presence of a property in dissimilar species as the likely result of an extrinsic or ecologically "accidental" cause. For Itzaj, taxonomic distance can provide one indication of the extent to which ecological agents are likely to be involved in predicting biological properties that do not conform to surface relationships. This may account for negative diversity on some tasks (López et al. in press). This does not mean that Itzaj fail to grasp or use a diversity principle. In justifications, Itzaj clearly reject a context-free use of the diversity-principle in favor of context-sensitive reasoning about likely causal connections. In tasks designed to assess risk-diversification strategies (e.g., sampling productivity from one forest plot or several), Itzaj consistently showed an appreciation of the diversity principle in these other settings (Atran 1995, López et al in press).

More generally, what "counts" as a biological cause or property may be somewhat different for folk, like the Itzaj, who necessarily live in intimate awareness of their surroundings, and those, like American folk, whose awareness is less intimate and necessary. For Itzaj, awareness of biological causes and properties may directly relate to ecology, whereas for most American folk the ecological ramifications of biological causes and properties may remain obscure. Historically, the West's development of a world-wide scientific systematics explicitly involved disregard of ecological relationships, and of the colors, smells, sounds, tastes and textures that constitute the most intimate channels of Maya recognition and access to the surrounding living world.

For example, the smell of animal excrement so crucial to Maya hunters, or the texture of bark so important to their recognition of trees in the dark forest understory, simply have no place in a generalized and decontextualized scientific classification (Atran 1990).

The Relevance of Taxonomy-Based Inference. The idea that folkbiological taxonomies provide a universal framework for general-purpose inductions, while also supporting context-sensitive causal inferences, leads to speculation about whether or not a single model of taxonomy-based inference can account for all of these phenomena. We have seen from our experimental studies that similarity-based models of taxonomic categorization and category-based induction cannot explain our results. The first study on the relationship between rank and inductive privilege suggests that similarity-based models of taxonomic categorization (e.g., Rosch et al 1976, Hunn 1976) cannot account for the generic-species level being the privileged rank for both Itzaj and Americans. This is because American perceptions and experiences tend to privilege life forms for recognition, recall, and communication, whereas Itzaj perceptions and experiences tend to privilege generic species or folkspecifics (in the case of trees) for daily use. Nevertheless, Americans privilege generic species just as Itzaj do for inductions regarding biologically-relevant properties (Coley et al. this volume). For the most part, this is true regardless of familiarity or experience with generic species.

The bird-inference studies show that even taxonomically-defined criteria of typicality do not suffice to uniformly explain patterns of projection among different categories of the same rank (e.g., mammals versus birds), or among different subpopulations of the same culture (e.g., men versus women). Where taxonomically-defined typicality tends also to coincide with causal ideals, as in the case of Itzaj mammals or palms, then patterns of property projection tend to parallel American patterns. But where ratings of taxonomic typicality and idealness diverge, as in the case of birds, neither may have a clear advantage in determining inference.

The diversity studies show that similarity-based models of taxonomic induction (e.g., Osherson et al 1990, Sloman 1993) cannot account for observed asymmetries in patterns of category-based induction. Thus, whereas both Americans and Itzaj use their respective taxonomies to project biologically-related properties (e.g., disease) in accordance with taxonomically-defined patterns of similarity and typicality, Itzaj do not also project properties in accordance with diversity although Itzaj clearly apply diversity-based reasoning to other tasks. Yet, typicality and diversity presumably reflect the same similarity-based notion of coverage. The fact that certain American groups, such as ecologically-knowledgeable parks maintenance workers, also do not reason in accordance with diversity demonstrates that this phenomenon is not restricted to a single culture or type of culture (e.g., small-scale or traditional" versus industrialized or urban) (Coley et al. this volume).

As an alternative to similarity-based models of taxonomic categorization and category-based inference, which fail to account for our results, we are exploring a relevance-based model of inference. The central idea in a relevance-based model involves an optimizing function between the cognitive costs in mobilizing and making sense of information, and the cognitive benefits in utilizing that information (Sperber & Wilson 1986). On the one hand, certain cognitive benefits, such as correctly anticipating where maximum biological information is to be found in the world, may outweigh the costs of mobilizing information that is somewhat detached from what is most readily perceived or familiar in a local context. This would favor the universal privilege of the generic-species rank in folktaxonomy. On the other hand, certain cognitive benefits, such as understanding the causal connections between biological items that make up the local ecology, and the cognitive costs associated with this understanding, may depend on cultural experience or expertise. This could help to explain how different cultural contexts lead to different predictions of inductive power or argument strength in cases involving typicality and diversity.

To illustrate, consider the Diversity task in terms of its relevance. Suppose that the more taxonomically-related two items are, the more people expect them to share biologically-related properties. This entails that the more taxonomically-distant two items are, the more people do not expect them to share properties. This principle corresponds to the Similarity phenomenon in Osherson et al (1990). Suppose also that people are given a situation where taxonomically distant items share a property, just as taxonomically close items share a property. This corresponds to the experimental set-up in the Diversity task. On the previous principle, an unexpected relationship is being presented as just as true (or likely, plausible etc.) as the expected relationship.The problem, then, is to activate background assumptions and knowledge that could, in fact, make the unexpected relationship true, and do so with the least cognitive effort.

The presence of a superordinate category mobilizes this search for the relevant background information. Take, for example, the case of RAT, POCKET MOUSE/MAMMAL versus TAPIR, SQUIRREL / MAMMAL (in López et al in press). The category MAMMAL frames the problem as: What is it about Mammals in general that makes the (taxonomically more distant, hence relatively) unexpected relationship between TAPIR and SQUIRREL true?" Itzaj seem to mobilize the following background assumptions: Mammals in general have varied and particular ecologically-based causal relationships that govern their interactions, in addition to the host of shared properties and relationships one would expect of closely-related taxa; however, the more unlikely the relationship in terms of (taxonomically) shared expectations, the more likely the relationship can be accounted for only in terms of particular causal relationships."

The most relevant causal relationships - that is, those most easily generated or activated from background knowledge and experience - are then mobilized to render the taxonomically unexpected relationship true, or at least understandable, in the context of these background assumptions and knowledge. In other words, conditions of relevance compel Itzaj to search for information that most readily renders understandable the

proposition: If X were the case, then TAPIR, SQUIRREL / MAMMAL would be true." According to one woman, if bats were to bite and infect tapirs and squirrels, bats could also bite and infect other mammals. Invocation of causal properties to fill in" X plausibly stems from Itzaj being primed by their life circumstances to consider such causal relationships crucial to daily subsistence and long-term survival

Once mobilized to explain these taxonomically-unexpected relationships, causal interpretations would also be mobilized to account for the (taxonomically) expected relationship. This is necessary if the induction problem is to be equally relevant for both arguments: the one involving taxonomically-distant premise categories, and the one involving taxonomically-close premise categories. The induction problem becomes: Which causal relationship is more easily generalized from any of the original items (premise categories) to all other items that fall within the superordinate's range (conclusion category)?" Because rats and pocket mice forego an external agent, such as a bat, to share and spread their disease, other mammals will more likely get it.

On the average, we should find that the more taxonomically-distant and unexpected the relationship, the more particular and idiosyncratic the causal connection, and the less generalizable that causal relationship is to other items. But this need not always be the case. This is because the causal relationships mobilized from background knowledge, although they will tend to be particular to the specific items in question, may create causal contexts with a wider scope than the causal contexts evoked to connect taxonomically-closer items. Thus, we have seen that Itzaj invoke causal scenarios of differing scope for the same arguments, which sometimes leads to contrasting judgments about argument strength.

For Midwesterners, taxonomically-distant items do not engender a causal account. The students do not readily think about causal relationships among living kinds because they do not depend on such knowledgeto sustain their everyday lives. There is

woefully little background knowledge of the living world directly available to them, or in need of ready access.

Like Itzaj, the Americans students assume that taxonomically-close items share more properties more strongly than do taxonomically-distant items. Like Itzaj, they therefore face the problem: What is it about horses and squirrels in particular, or mammals in general, that would make the unexpected relationship between horses and squirrels as true as the expected relationship between rats and mice?" As for the Itzaj, conditions of relevance compel the students to search for information that most readily renders understandable the proposition: If X were the case, then HORSE, SQUIRREL / MAMMAL would be true." Because the students know next to nothing about the ecological, or causal, connections between horses and squirrels in particular - and usually need to care about such connections even less - the students fall back" on the relevant area of taxonomy alone (i.e., the area delimited by the superordinate category highlighted by the task). Their answer to the problem is: Horses and squirrels share properties because they are mammals." Unlike the case for Itzaj, where X is replaced by a variety of causal scenarios, for most of the students X is simply replaced by the (empty) knowledge that the items are mammals, or that they belong to some relatively large subset of mammals.

Once mobilized to explain taxonomically-unexpected relationships, a category-based (rather than causally-based) interpretation will also be acitvated to account for (taxonomically) expected relationships. This is necessary if the induction problem is to be equally relevant for both arguments: one involving taxonomically-distant premise categories (HORSE, SQUIRREL), and the one involving taxonomically-close premise categories (RAT, MOUSE). The induction problem then becomes: Which taxonomic relationship is more easily generalized from any of the original items (premise categories) to all other items that fall within the superordinate's range (conclusion category)?" On the average, we should find that the more taxonomically-distant and

unexpected the relationship, the more generalizable that causally-empty relationship is to other items. This is not the case for all Americans. For example Midwestern parks maintenance workers, who are ecologically knowledgeable and depend for their livelihood on that knowledge, reason on diversity tasks in patterned ways that closely parallel those of the Itzaj.

Conclusion

Itzaj folkbiological taxonomy manifests the culturally universal feature of uniquely assigning every readily perceptible (nonhuman) organism to a species-like group, and further ranking these mutually exclusive generic species" into higher- and lower-order groups. Like folkbiological taxonomies everywhere, it also provides a general inferential framework for category-based inductions. This allows people to readily predict and project the likely distribution of familair or unfamiliar biologically-related properties across living kinds, and thus to extend knowledge in the face of uncertainty. The generic species is the privileged locus for isolating such properties and making predictions.

Itzaj folkbiological taxonomy also exhibits features that are culturally particular, or at least constrained by the requirements of life in a small-scale society. For Itzaj, as opposed to scientists or American university students, ecology matters for categorization and category-based inference. These findings, however, do not uphold the customary distinction in anthropology and in history and philosophy of biology, between "general-purpose" scientific classifications that are designed to maximize inductive potential and "special-purpose" folkbiological classifications (Gilmour & Walters 1964, Bulmer 1970), which are driven chiefly by "functional" (Dupré 1981), "utilitarian" (Hunn 1982) or "social" (Ellen 1993) concerns. On the contrary, like scientific classifications Itzaj folkbiological taxonomies appear to be "general-purpose" systems that maximize inductive potential for indefinitely many inferences and ends. Only, that potential, and the nature of biological causality it realizes, may be conceived differently by a small-

scale society and an industrialized scientific community (as well as folk communities influenced by science).

For scientific systematics, the goal is to maximize inductive potential regardless of human interest. The motivating idea is to understand nature as it is "in itself," independently of the human observer (as far as possible). To adopt this, Itzaj would have to suspend their primary concern with ecological and morpho-behavioral relationships in favor of deeper, hidden properties of greater inductive potential. But the cognitive cost would likely outweigh the benefit (Sperber & Wilson 1986). For this potential, which science strives to realize, is to a significant extent irrelevant, or only indirectly relevant, to local ecological concerns.

For scientific systematics, folkbiology may represent a ladder to be discarded after it has been climbed, or at least set aside while scientists surf the cosmos. But those who lack traditional folk knowledge, or implicit appreciation of it, may be left in the crack between science and common sense. For an increasingly urbanized and formally educated people, who are often unwittingly ruinous of the environment, no amount of cosmically valid scientific reasoning skill may be able to compensate the local loss of ecological awareness.

For the Itzaj, and arguably for other small-scale societies, folkbiological taxonomy works to maximize inductive potential relative to human interests. Here, folkbiological taxonomy provides a well-structured but adaptable framework . It allows people to explore the causal relevance to them - including the ecological relevance - of the natural world, and in indefinitely many and hitherto unforeseen ways. Maximizing the human relevance of the local biological world - its categories and generalizable properties (including those yet undiscovered) - does not mean assigning pre-defined purposes or functional signatures to it. Instead, it implies providing a sound conceptual infrastructure for the widest range of human adaptation to surrounding environmental conditions, within the limits of culturally acceptable behavior and understanding.

Notes

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[1]1. Comparisons between folkbiological systems are often based on analyses of a specious level of folk taxonomy called "terminal contrast." Terminal contrast occurs between named groupings that include no additional named groupings. For example, among folk in Michigan the class of terminal contrast includes: BAT, SQUIRREL, WEASEL, BEAVER, BEAGLE (dog), POODLE (dog), CALICO (cat), SHORT-HAIRED TABBY (cat), LONG-HAIRED TABBY (cat), an so on. There is little systematic relation between terminal folktaxa and corresponding scientific taxa. Thus, BAT includes a variety of different scientific families, genera and species in the order Chiroptera, many of which are locally represented in Michigan. SQUIRREL includes different local genera and species of the family Sciuridae. WEASEL encompasses two local species of the genus Mustela. BEAVER corresponds to the single local species Castor canadensis. BEAGLE and POODLE denote two "varieties" of the species Canis familiaris. CALICO refers to a "variety" of Felis cattus, whereas SHORT-HAIRED TABBY and LONG-HAIRED TABBY are (mongrelized) "races" of the species. Using terminal contrast as the focus of comparison between folkbiology and scientific systematics thus reveals little relationship. In fact, several studies in psychology and anthropology that purport to compare the "taxonomic structure" of folk and scientific biology use terminal contrast as the basis of analysis (Conklin 1962, Lévi-Strauss 1966, Rosch 1975a). This is unfortunate, because terminal contrast is a purely (ethno)linguistic feature that has little direct significance for the structure of living kind taxonomies. As a result, the profound similarities between Linnaean and folkbiological taxonomies have often been ignored.

[2]2. English speakers ambiguously use "animal" to refer to at least three distinct classes of living things: non-human animals, animals including humans, and mammals (prototypical animals). "Beast" seems to pick out non-human animals in English, but is seldom used today. "Plant" is ambiguously used to refer to the plant kingdom, or to members of that kingdom that are not trees.

[3]3. Like other folk who have not been exposed to the Western tradition dating to Aristotle, Itzaj consider humans ontologically distinct from other living kinds (Atran

1985; cf. Kesby 1979, Posey 1981). Itzaj believe that all living kinds (humans, animals and plants) have a heart / essence" (puksik'al) that makes any individual the kind of living thing it is. But only animals and plants are always exclusively individuated in terms of their unique generic-species essence, whereas humans are variously individuated as both individual agents and as social actors in accordance with inferred intentions rather than expected clusters of body parts. Itzaj, like folk everywhere, always identify an individual animal or plant, first and foremost, as a member of the generic species that presumably causes that individual to be. But Itzaj, like most people in the world, individuate humans, or winik, without exclusive recourse to a single superordinate level of superordinate existence, such as the level of species. Depending on context, a person may be Itzaj or Yukatek, Maya or Ladino, man or woman, mother or godmother, neighbor or stranger, hunter and/or farmer or some combination which presumably determines that person's intentional self.

[4]4. Life forms vary across culture. Ancient Hebrew or modern Rangi (Tanzania) include herpetofauna (reptiles and amphibians) with insects, worms and other "creeping crawlers" (Kesby 1979), whereas Itzaj Maya and (until recently) most Western cultures, include herpetofauna with mammals as "quadrupeds." Itzaj place phenomenally isolated mammals like the bat with birds, just as Rofaifo (New Guinea) place phenomenally isolated birds like cassowaries with mammals (Dwyer 1976). Whatever the content of life-form taxa, the life-form level, or rank, universally partitions the living world into broadly equivalent divisions.

[5]. According to Brown (1982:102), Itzaj see mammals as part of an unnamed "residual category" that includes invertebrates save worms. For Mayan languages generally, he claims MAMMAL is a residual life form encompassing creatures left over after encoding BIRD, FISH, and SNAKE. The evidence for the former claim comes from Otto Schumann's (1971) superficial dictionary and the unpublished notes of Pierre Ventur (Brown 1979:382). Evidence for the latter claim comes second-hand, via dictionaries. Overall, our experiments show that patterns of induction among mammals are the same as those for BIRD, FISH, TREE or VINE (Atran et al forthcoming). In sorting tasks, mammals are always isolated from the other animals as an exclusive group, with two exceptions: the bat (sotz') is always classified with the birds, and the otter (pek'-il ja') is always classified with other mammals but occasionally crossed-classified with some water-dwelling reptiles (crocodiles and turtles, but not water snakes). Brown also relies

on linguistic evidence to claim that kan (snakes) is an Itzaj life form. But sorting and inference tasks (see Figure 7 below) clearly indicate that snakes and lizards (uy-et'~ok juj) are taxonomically closer to one another than either of these intermediates is to other intermediates of the herpetofauna life form (b'a'al~che'+k-u-jil-t-ik-u-b'aj), such as turtles (aak) or amphibians (b'a'al~che'+k-u-siit').

[6]6. Mammals and herpetofauna also appear to be embedded under the mutually exclusive category QUADRUPED (i.e., b'a'al~che' sense 2), which can be explicitly rendered as a'-b'a'al~che' yan uy-ok ("animals having feet") or kän-p'eel uy-ok ("four-footed"). More often, kän-p'eel uy-ok refers exclusively to the herpetofauna, much as the old Yukatek terms xaknal or xakatnal might be translated as quadrúpedo but refer only to herps (Beltrán 1742/1859:228). Snakes are thought to have "hidden" feet that "only the dumb can see" (chen ch'uch' k-u-cha'an-t-ik uy-ok kan).

[7]7. In the logical structure of folk taxonomy, outliers may be considered monotypic life forms with only one generic species (for a formalism, see the appendix in Atran 1995).

[8]8. Botanists and ethnobotanists see privileged folkbiological groups as akin to scientific genera (Bartlett 1940, Berlin, 1972, Greene 1983). Plant genera especially are often readily recognized morphologically without technical aids (Linnaeus 1751). Zoologists and ethnozoologists view them as more like scientific species, where reproductive and geographical isolation are more readily identified in terms of behavior (Simpson 1961, Diamond 1966, Bulmer 1970).

[9]9. Contrast this with tzimin~che', the tapir-tree" (Vatairea lundelli), so called because tapirs seek out the bark of its large buttresses for nourishment. Such names reflect ecological relations.

[10]10. For "all" responses, the overall Itzaj and Michigan patterns were nearly identical, indicating that generic species are inductively privileged regardless of whether people are perceptually familiar with them (Itzaj) or not (Americans).

[11]11. Moving vertically within each graph corresponds to changing the premise category while holding the conclusion category constant. This allows us to test The Similarity-

Coverage Model of category-based reasoning (Osherson, Smith, Wilkie, López & Shafir 1990). In this model, the closer the premise category is to the conclusion category, the stronger the induction should be. Our results show only weak evidence for this general reasoning heuristic, which fails entirely to account for the various "jumps" in inductive strength that indicate absolute or relative privilege.

[12]12. Consider the relative cognitive advantages of perceptual ease and familiarity in handling living-kind categories versus an appropriate anticipation of where biologically-relevant properties will likely cluster. For convenience, call the first perceptual privilege, the second inductive privilege. Perceptual privilege facilitates access to, and use of, knowledge of the day-to-day world we usually experience, and is associated with ease of communication, category recognition and recall. Inductive privilege allows us to go beyond the information that experience privileges, and into the realm of reasonable expectations about the causal underpinnings of natural categories.

From an evolutionary standpoint, both forms of cognitive privilege make sense: perceptual privilege adaptively harnesses experience with nature, whereas inductive privilege adaptively harnesses expectation about nature. If such expectation is always focused on the folk-generic level, it is arguably because that level captures aspects of biological reality that are both causally recurrent and especially relevant to the emergence of human life and cognition. In small-scale traditional" societies, as perhaps in ancestral hominid environments, relatively short-term experience with the ambient world of plants and animals, which is intimate and intensive, could privilege the same level of biological awareness that relatively long-term considerations of causal importance and relevance would. For large-scale industrialized societies, a cognitive division of labor could develop to manage the psychological requirements of appreciating and dealing with what we most readily experience versus what is likely to matter most in the run of life.

If so, then at least for the domain of living kinds, we should expect perceptual privilege and inductive privilege to somewhat diverge in focus and target along the lines that our results indicate. But regardless of perceptual experience or familiarity, inductive privilege at the generic-species should generally dominate exploration of the biological world, and inferences in the face of uncertainty. This is because the generic-species level generally corresponds to that cut in nature where the biological properties and causes most relevant to long-term human survival and apprehension of nature tend to maximally cluster and most likely recur.

[13]12. For each subject, we have a square symmetric data matrix, where number of rows and columns is equal to the number of generic species sorted. Subjects' taxonomic distance matrices were correlated with each other, yielding a pairwise subject-by-subject correlation matrix representing the degree to which each subject's taxonomy agreed with each other subject's taxonomy. Principal component factor analyses were then performed on the intersubject correlation matrix for each group of informants to determine whether or not there was a "cultural consensus" in informant responses. A cultural consensus is plausible if the factor analysis results in a single factor solution. If a single dimension underlies patterns of agreement within a domain, then consensus can be assumed for that domain and the dimension can be thought of as reflecting the degree to which each subject shares in the consensual knowledge (Romney, Batchelder & Weller 1986). Consensus is indicated by a strong single factor solution in which: 1) the first latent root (eigenvalue) is large compared to the rest, 2) all scores on the first factor are positive, and 3) the first factor accounts for most of the variance. To the extent some individuals agree more often with the consensus than others, they may be considered more "culturally competent" than others with respect to the domain. Estimation of individual knowledge levels, or competencies, is given by each subject's first factor scores. This represents the degree to which that subject's responses agree with the consensus. In other words, the pattern of correlations among informants should owe entirely to the extent to which each knows the common (culturally relative) "truth." The mean taken from all first-factor scores provides an overall measure of consensus.

[14]14. Including the generic-species level yields a higher correlation because it involves filling in the respective matrices' diagonal cells (e.g., BAT-BAT). For folk matrices, diagonal cells are always 0 because the folk distance between a folktaxon and itself is 0. For the corresponding scientific matrix, diagonal cells are usually 0, but not always so. When the scientific difference between a generic species and itself is not 0, it is because the scientific extension of that folktaxon and itself crosses one or more scientific levels. For example, in Michigan, BAT exemplars extend over several genera of the same family (second level); so, the most conservative estimate of scientific distance between any two BAT exemplars is 2 rather than 0. Likewise, in Peten, BAT exemplars extend over two suborders of the same order (fourth level); so, the estimate of scientific distance between any two BAT exemplars for Itzaj is 4 rather than 0. In many cases where the diagonal is greater than 0, folk - particularly Itzaj - clearly distinguish between all the scientific

species and provide binomial names for them; however, these distinctions do not exist at the generic-species level, but at the subordinate level of folkspecific. In these instances, folk consider the distinction between the scientific species to be finer than the distinction between folkgeneric species.

[15]15. Other factors in the divergence between folk and scientific taxonomies are related both to science's global perspective in classifying local biota and to its reliance on biologically "deep," theoretically-weighted properties of internal anatomy and physiology. Thus, the opossum is the only marsupial in North and Central America. Both Itzaj and Midwesterners relate the opossum to skunks and porcupines because all share readily-perceptible features of morphology and behavior. From a scientific vantage, however, the opossum is taxonomically isolated from all the other locally represented mammals in a subclass of its own. One factor mitigating the ability of Itzaj or Midwesterners to appreciate the opossum as scientists do is the absence of other locally present marsupials to relate the opossum to. As a result, both Michigan students and Itzaj are apparently unaware of the deeper biological significance of the opossum's lack of a placenta.

[16]16. Figure 8 shows only prototypical species of the most frequently cited Itzaj snake taxa. We have yet to determine the full extension of these taxa. Itzaj use other snake categories as well, but our biological inventories of them are too incomplete to allow their inclusion at this time.

[17]17. That Itzaj and scientists discern broadly similar groups in nature does not entail that they are observing what science views as "objectively out there." It could indicate that both perspectives share the same phenomenal bias to see the world in peculiarly human ways. For example, Maya and American folk, as well as scientists, tend to underdifferentiate the large order of passerines as a group relative to the bigger, more distinctively colored or more vocally apparent birds (cf. Boster 1988). Phylogenetically-minded systematists may seek to "correct" this cognitively-motivated historical bias, which places more than half of all living birds in a single order. But given the "classic" ornithological classifications that now exist as a basis for comparisons in psychology and anthropology, any correspondence between scientific and folk classifications in the literature must be interpreted with caution as to what it tells us about "reality."