Evolution and Devolution of Knowledge:
A Tale of Two Biologies

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Anthropological investigations suggest that all human cultures classify animals and plants in similar ways. Nevertheless, despite rapid advances in biological science, our citizenry’s practical knowledge of nature is diminishing. Convenient choice of American and European students as psychology’s preferred study populations obscures this fact. Here we describe historical, cross-cultural and developmental research on how people ordinarily conceptualize nature (naive or folkbiology), concentrating on cognitive consequences associated with knowledge devolution. Our approach integrates three disciplinary perspectives. For cognitive science, we show that results on categorization and reasoning from “standard populations” in industrialized societies fail to generalize to humanity at large. For developmental research, we find that usual populations studied represent impoverished experience with nature. This yields misleading results about how knowledge is acquired and about the ontogenetic relationship between folkbiology and folkpsychology. Understanding the conceptions of biology children bring to the classroom is important for science education. For cultural and environmental studies, we show that groups living in the same habitat can manifest strikingly distinct behaviors, cognitions and social relations relative to it. This has novel implications for environmental decision making and management, including commons problems.

As students come to know more about microbiology and evolution they become less familiar with the plants and animals surrounding them. Below is part of an interview with a university Honors student who expressed surprise that 3 and 4-year olds were asked to give examples of plants:

I: Tell me all the kinds of trees you know.
S: Oak, pine, spruce, cherry…. (Giggle) evergreen, Christmas tree, is that a kind of tree? God, what’s the average here? So what do kids say, big tree, small tree?
I: Tell me some plants.
S: I can’t think of plants that aren’t trees. I know a lot about angiosperms, gymnosperms, gametophytes, sporophytes….but this is biology. It’s not really about plants and trees.

It would be hard to find such relative lack of knowledge about salient local species even among 4-year-old Maya with whom we have worked.

For several years we have been investigating the cognitive consequences of reduced contact with nature – what some refer to as “extinction of experience.” To get along in the world, people need to be able to understand and predict general properties and behaviors of physical objects and substances (physics), more specific properties of plants and animals (biology), and particular properties of their fellow human beings
(psychology). What follows outlines an ongoing program of research in the domain of naïve or folk biology.

**Evolved Universals in Cognition and Culture**

Cultural belief and activity involve a variety of cognitive and affective systems, some with separate evolutionary histories and some with no evolutionary history to speak of. Folkbiology is a domain of human thought and practice that likely has an evolutionary history. In every society, people tend to think about plants and animals in special ways that are distinct from ways humans ordinarily think about other things in the world, such as stones, tools or even people.

All cultures, it appears, partition local biodiversity into taxonomies whose basic level is that of the “generic species,” the common man’s (folk) species. Generic species often correspond to scientific species (e.g., dog, apple tree); however, for phenomenally salient organisms, such as most vertebrates and many flowering plants, a scientific genus frequently has only one locally occurring species (e.g., bear, oak). In addition to this spontaneous division of local flora and fauna into generic species, such groups have, as Darwin noted, "from the remotest period in... history... been classed in groups under groups. This classification is not arbitrary like the grouping of stars in constellations." The structure of these hierarchically-organized groups, such as white oak/oak/tree or mountain robin/robin/bird, is called "folkbiological taxonomy." These nonoverlapping taxonomic structures can often be interpreted in terms of speciation (related species descended from a common ancestor by splitting off from a lineage).

The taxonomic system for organizing readily perceptible (nondimensional) species entails realization that, say, apple trees and robins belong to the same fundamental level of (folk)biological reality, and that this level of reality differs from the subordinate level that includes winesap apple trees and mountain robin as well as from the superordinate level that includes trees and birds. This taxonomic framework also supports indefinitely many systematic and graded inferences regarding the distribution of known or unknown properties among species, although the character of the induction (e.g., morphological, ecological, genetic) varies across societies and historical periods.

Biological ranks are second-order classes of groups (e.g., species, family, kingdom) whose elements are first-order groups (e.g., lion, feline, animal). Folkbiological ranks vary little across cultures as a function of theories or belief systems. Ranks are intended to represent fundamentally different levels of reality, not convenience.

There is growing cross-cultural evidence of a commonsense assumption that each species has an underlying causal nature, or essence, uniquely responsible for the typical appearance, behavior and ecological preferences of the kind. We speculate that this notion of biological essence is universal. People in diverse cultures consider it responsible for the organism's identity as a complex entity governed by dynamic internal processes that are lawful even when hidden. This essence assumedly maintains the organism's integrity even as it causes the organism to grow, change form and reproduce.

For example, a tadpole and frog are conceptualized as the same animal although they look and behave differently, and live in different places. Western philosophers, like Aristotle and Locke, attempted to translate this commonsense notion of essence into metaphysical reality; however, evolutionary biologists reject the notion of essence as such. Nevertheless, biologists have traditionally interpreted this conservation of identity under change as due to the fact that organisms have genotypes separate from phenotypes.
Although science does not abide metaphysical essentialism, there is growing evidence supporting the notion of psychological essentialism. Even when people have no specific ideas about essences they may have an “essence placeholder,” that is, a commitment to the idea that there is an underlying nature. This hidden, causal essence is presumably responsible for manifest properties of the kind. The fact that biological science can overturn psychological essentialism in theory construction in no way implies that psychological essentialism is dismissible from everyday thought, any more than physical science’s rejection of constant intervals of space and time implies alterations in our ordinary use of absolute space and time.

In brief, there are strong constraints – perhaps naturally selected - on how people organize local knowledge of biological kinds. Universal appreciation of generic species may be one such functional evolutionary adaptation: it makes little difference which tiger could eat a person or which apple a person could eat. Moreover, pigeonholing of generic species into a hierarchy of mutually exclusive taxa allows incorporation of new species and biological properties into an inductively coherent system that can be extended to any habitat, so facilitating adaptation to many habitats (a hallmark of Homo sapiens).

These evolutionary constraints form a "learning landscape" that shapes how inferences are generalized from particular instances or experiences. It produces consensus even though specific inputs vary widely in richness and content. Thus, many different people, observing many different exemplars of dog under varying conditions of exposure to those exemplars, may nonetheless generate more or less the same concept of dog. To say an evolved biological structure is naturally selected is not to say that every important aspect of its phenotypic expression is “genetically determined.” Biologically poised structures “canalize” development, but do not determine it – like mountains that channel scattered rain into the same mountain-valley river basin.

**Historical Developments.** As in any native folkbiological inventory, ancient Greek and Roman naturalists contended with only 500 or 600 local species. Because biological genus and species are often extensionally equivalent in any given locale, there was no apparent basis for systematically distinguishing them. For Aristotle and Theophrastus, as for Dioscorides and Pliny, the term _atomon eidos_, or “species,” referred to generic species (e.g., eagle, dog, oak, wheat), whereas the term _megiston genos_, or “genus,” referred to superordinate life forms (bird, quadruped, tree, grass).

Europe's Age of Exploration introduced a multitude of new species. The French naturalist Joseph Tournefort originated the genus concept as the ranked class immediately superordinate to that of the species. This allowed the reduction of species by an order of magnitude to equivalence classes that the mind could easily manage again (from roughly 6000 known species to 600 genera). The place of a new species in the natural order of genera would be initially determined in either of two ways: (1) By empirical intuition, that is, readily visible morphological agreement with a European representative or some other preferred type-species of the genus, or (2) by intellectual intuition, that is, analytic agreement with the generic fructification (fruit and flower) according to the number, topological disposition, geometrical configuration and magnitude of its constituent elements. Within this Cartesian framework, the one criterion would be ultimately commensurate with the other, allowing a mathematical reduction of the new species to its associated type by reason of their common fructification. In this way, the customary
native knowledge of the folk naturalist would be rationally extended to a worldwide scale. Such was the aim of Caroli Linnaeus’s ‘natural system’. Under Locke’s influence, the English naturalist John Ray questioned whether fructification characters encoded the essential order of plant life. Analytic convenience might justify reliance on readily visible and enumerable parts of the fruit and flower as a classificatory strategy, but there was no guarantee such analytic characters could be apodictically arranged into a preset combinatory system. With animals, reduction of visible parts to computable characters proved unwarranted.

The geometrical rate of exploration and discovery further undermined taxonomic priority of the genus. As awareness of new forms increased another order of magnitude, the family concept became the new basis for taxonomy. The family was itself rooted in local groupings that native folk implicitly recognize but seldom name, such as felines, equids, legumes and umbellifers. The ancients called these eide anonyma or genera innominata. The local series of such groupings does not fully partition a local environment, but is riddled with gaps. A strategy emerged for closing the gaps: Looking to other environments to complete local gaps, naturalists sought to discern a worldwide series that would cover the lacunae in any and all environments. This would reduce the ever-increasing number of species and genera to a mnemonically manageable set of basic, family plans that were still perceptually distinguishable. Linnaeus dubbed this strategy “the natural method” for completing “family fragments.”

French Enlightenment naturalists elaborated the natural method, favoring empiricism over rationalism. Adanson introduced classification by “family resemblance” (air de famille) for completing a world-wide family series. A.-L. Jussieu reduced the thousands of genera proposed since Tournefort to exactly 100 families, but acknowledged this number to be more convenience than necessity. Jussieu’s families became the standards of modern plant taxonomy. Extending the « méthode naturelle » to animals, including humans, Buffon first identified family plans as lineages of temporally related species. This idea became crucial to the evolutionary thinking of Lamarck and Darwin. Although Enlightenment taxonomy kept biological science tied to the readily visible world of species, genera and families, it provided a cognitively expedient morphological framework for initial exploration of the causal relations and history of species.

Historically taxonomy is conservative, but it can be revolutionized. Even venerable life forms, like tree, are no longer scientifically valid concepts in systematics because they have no genealogical unity (e.g., legumes are variously trees, vines, bushes). The same might be said of many longstanding taxa. Phylogenetic theorists question the "reality" of zoological life forms, such as bird and reptile, and the whole taxonomic framework that made biology conceivable in the first place. Thus, if birds descended from dinosaurs, and if crocodiles but not turtles are also directly related to dinosaurs, then: crocodiles and birds form a group that excludes turtles; or crocodiles, birds and turtles form separate groups; or all form one group. In any event, the traditional separation of bird and reptile is no longer tenable.

From Linnaeus to the present, biological systematics has used explicit principles and organizing criteria that traditional folk might consider secondary or might not consider at all (e.g., the geometrical composition of a plant’s flower and fruit structure, or the numerical breakdown of an animal’s blood chemistry). Nevertheless, as with
Linnaeus, the modern systematist initially depends implicitly but crucially on a traditional folk appreciation, whether in botany or zoology. As Linnaeus needed the life form tree and its common species to do his work, so Darwin needed the life form bird and its common species. From a cosmic vantage, the title of his great work, *On the Origins of Species*, is ironic and misleading - much as if Copernicus had entitled his attack on the geocentric universe, *On the Origins of Sunrise*. Of course, in order to attain that cosmic understanding, Darwin could no more dispense with thinking about "common species" than Copernicus could avoid thinking about sunrise. In fact, not just species, but all levels of folktaxonomy served as landmarks for Darwin's awareness of evolving biodiversity: from folk specifics (e.g., poodle) and varietals (e.g., toy poodle) whose variation humans had learned to manipulate, to intermediate-level families and life-form classes, such as bird. For example, in the Galapagos Islands, Darwin ranked as distinct species 23 of 26 types of land birds that he assumed had arisen there. He then described the family affinity of these species to those of continental America, as "manifest in every character, in their habits, gestures, and tones of voice. So it is with other animals, and with a large proportion of plants.... Facts such as these, admit of no sort of explanation on the ordinary view of creation."

Use of taxonomic hierarchies in systematics today reveals a similar point. By calculating whether or not taxonomic diversity in one group varies over time as a function of taxonomic diversity in another, evidence can be garnered for or against the evolutionary interdependence of the two groups. Thus, comparisons of the relative numbers of families of insects and flowering plants reveal the surprising fact that insects were just as taxonomically diverse before emergence of flowering plants as after. Consequently, evolutionary effects of plant evolution on the adaptive radiation of insects are probably less profound than previously thought. The heuristic value of (scientifically elaborated) folk-based strategies for cosmic inquiry is compelling, despite scientific awareness that no "true" distinctions exist between various taxonomic levels.

**Devolved Knowledge and Familiarity with Nature.** Despite Western science’s historical take-off from the same universal principles of folkbiology found across cultures, in our globally-mobile society there is marked deterioration in commonsense understanding of the everyday living world. This impairment affects practical ability to interact with the environment on a sustainable basis: people who cannot distinguish one kind of bird or tree from another, cannot respond appropriately to changes in the ecological balance among these living kinds. For example, many recent immigrants to Phoenix cannot distinguish the pruned eucalyptus trees in their landscaped plots, much less surmise that the eucalyptus is not conducive to maintaining biodiversity when competition for water is scarce; and few long-standing residents of Chicago are able to spot a buckthorn, much less comprehend that a fire that weeds out invasive buckthorns is not a calamity or that it would not affect Burr oaks and other native prairie tree species. This lack of understanding becomes less immediately obvious but more critical as ties with nature become less direct and more abstract. By contrast, in small-scale communities a fitter understanding may arise normally through application of universal principles under conditions of sufficient exposure to biological diversity and activity.

Although folktaxonomic structure is roughly the same in diverse cultures and historical periods, our’s reveals systematically shallower knowledge than others. We examined written material in the (online) Oxford English Dictionary for references to terms...
used to describe trees from the 16th-20th centuries. After the 19th century sources mentioning trees declined 45%; number of quotes fell 40%. Specificity of quotes also declined. Use of the life-form term, tree, only fell 26%, whereas use of generic-species terms (e.g., oak) fell 50%. Other life-form terms (bird, grass, etc.) also declined, but use of nonbiological superordinates (furniture, clothes, etc.) increased. Consistent with this trend, we found that in nature walks around Northwestern University, students overwhelmingly identified tree and bird species only at the life-form level (“tree,” “bird”). In contrast, subsistence-based Itza’ Maya overwhelmingly identify plant and animal species at more specific levels. We take this as evidence for our culture’s diminishing support for familiarity with nature.

What happens cognitively when contact with nature diminishes? To find out we only need turn to psychology’s most studied populations, undergraduates and urban children near major universities. Generalizations from these populations about basic cognitive processes do not hold for other groups that attend to their biological surroundings (birders, fishermen, naturalists, rural children and adults, Native-American Menominee and Maya). Our data challenge existing models of conceptual development, graded category structure, category-based induction, and decision-making.

Child Development. Previous work with standard populations suggests that children begin with anthropocentric conceptions of biology and must undergo fundamental conceptual change to see humans as one animal among many. To understand children’s conceptions of biology as opposed to simple factual knowledge, investigators focused on projection of novel properties (e.g., “has a green round thing called an omentum inside”) from one category to others. Young children generalized from humans to animals based on similarity to humans (e.g., to dogs more than to bees), but were reluctant to generalize from animals to other animals, including humans. They even preferred inferences from humans to bugs over inferences from bees to bugs. These results support the claim that children do not distinguish between naïve psychology, where humans are presumed prototypical, and naïve biology, where humans are not.

Our research undermines this claim. Human-centered reasoning patterns may reflect lack of knowledge about nonhuman living things rather than a different construal of the biological world. A human-centered model may be specific to urban, industrialized cultures. We used essentially the same induction task with urban children and replicated previous results. We also probed three culturally-distinct populations who have greater contact with plants and animals: rural Wisconsin majority-culture and Native-American (Menominee) children from a nearby reservation, and (Yukatek) Maya children from rural Mexico. Even for the youngest Yukatek (4-5-year-olds), humans are no better as an inductive base than other animals, and both similarity-based and ecologically-based reasoning strategies are used. Menominee children perform much like Yukatek. Rural majority-culture children also make similarity-based generalizations but the youngest are reluctant to generalize from animals to humans, justifying their response by saying “humans are not animals.” These results indicate that folkbiology and folkpsychology are distinct from the start.

Urban children may generalize from humans because humans are the only animal they know much about. Rural majority-culture children are reluctant to generalize to humans because humans are seen as atypical animals. Perception of humans as atypical is a cultural construal in that Menominee and Yukatek children do not treat humans as
distinct or atypical. Even within our groups experience matters. For example, Yukatek girls show less differentiated generalization from wild than from domestic animals, consistent with girls staying at home and boys regularly venturing into the forest. What developmentalists had deemed universal now seems peculiar to our society’s lack of contact with nature.

Rural majority-culture, urban majority-culture and Native-American children have three culturally-distinct conceptions of nature. This may be critical to understanding children’s learning: "Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information." The fact that science goes from being Menominee children’s best subject in their first four years to their worst subject four years later underlines this issue’s significance (http://data/dpi.state.wi.us/data/graphshell.asp, 2/26/01, Department of Public Institutions, State of Wisconsin).

**Categorization and Reasoning.** Theories of adult cognition may be also misdirected by the effects of impoverished experience with nature. A succinct summary of our studies is that biologically-knowable USA adults respond more like illiterate Maya than USA college students.

One classic finding is that some category members are better examples than others and that goodness-of-example ratings are based on central tendency. The “best” examples of a category are members that are similar to many other category members. However, typicality for knowledgeable adults (landscapers, taxonomists, parks maintenance workers, fishermen, Menominee, Itza’ Maya) is based on positive and negative ideals (e.g. for trees, height, weak limbs) rather than central tendency.

A central function of categorization is to support reasoning in the face of uncertainty. The same notion of typicality based on central-tendency plays an important role in models of category-based induction. The prediction is that inference to a category from a typical example (robin to bird) is stronger than inference from an atypical example (turkey). These models are also used to predict diversity effects. Suppose River Birch and Paper Birch trees get Disease A, and White Pine and Weeping Willow get Disease B. Which disease is more likely to affect all kinds of trees? The models would predict Disease B on grounds that White Pines and Weeping Willows are more different (diverse) than River Birch and Paper Birch.

Such reasoning also underlies scientific sampling strategies, and is useful in generating plausible inductions: a property discovered in two organisms (e.g., turkey, snail) may justify generalization to all organisms in the lowest-ranked taxon containing the original pair (e.g., all animals). Undergraduates show both typicality and diversity effects, seemingly paralleling scientific practice. Closer analysis shows deep underlying differences: biological experts, including systematists, often prefer alternative strategies. When they do use diversity, it is not based on superficial similarities but on causal theories (e.g., evolution). Surface similarities may be misleading: Undergraduates generalize properties from porcupines to opossums because they appear similar, whereas biologists would not so generalize from placental mammals to marsupials. Students’ superficial reliance on scientific modes of biological categorization and reasoning, such as confounding evolutionary diversity with perceptual dissimilarity, cannot make up for corresponding loss of folkbiological commonsense.

Our studies with birders, fishermen, tree experts, Menominee and Maya do not
find typicality effects and they show weak or even negative diversity effects. Most often they use causal/ecological reasoning rather than taxonomic inference. In the above example the modal response was Disease A, because birches are disease-prone and cover a wide geographical range (creating opportunities for spreading the disease to other trees). In short, people with domain-knowledge prefer content-rich strategies to abstract, similarity-based reasoning strategies. Normatively, both ecological and taxonomic reasoning may be appropriate. For example, the anti-cancer drug taxol was first discovered in the Pacific yew, then the discovery was generalized to the European Yew; however, the best source ultimately proved to be a fungus associated with Yews.

Even similarity-based strategies show knowledge effects. To set up category-based reasoning probes for bird tasks, we studied three populations: Itza’, USA bird watchers, and college students. Two picture sets were used: Chicago-area and lowland Guatemala birds. Each set contained 104 species matched for (evolutionary) taxonomic structure. Both birdwatcher and Itza’ correlations between folk-taxonomic sorts and scientific taxonomies were higher than student correlations on each set. Itza’ results are dramatic: despite having no familiarity with science, systematics or USA birds, they have a truer picture of the novices’ world than the novices themselves.

Basic Level and Inductive Privilege. Psychologists claim that covariant features in the environment combine with experience to create “basic-level” categories central to cognition. Basic-level categories like chair and fish contrast with more superordinate (furniture, animal) and more subordinate (e.g., recliner, trout) categories. Anthropologists who have examined taxonomies in small-scale cultures also argue for a single preferred level of classification, the generic-species level. In these cultures, categories like oak and trout are basic, whereas for psychologists’ standard populations, tree and fish are. This contrast suggests that the basic level is knowledge-dependent. There is evidence that biological experts have a more specific basic level than novices; however, this describes results from a novice perspective. We offer a reframing. “Experts” and people from small-scale societies have “normal” basic-level categories, corresponding to a default inference/recognition strategy that degenerates with lack of exposure. There is reason to prefer our framing because all populations appear to privilege the same folk-taxonomic rank for induction.

Inductive inference is an important function of categories but there has been scant attention to relative inductive privilege at different hierarchical levels. One might expect novice, expert, and small-scale groups to privilege their respective basic levels for induction (e.g., tree for college students, oak for experts and Maya). But our studies indicate that all groups privilege the generic-species level for induction.

Examining inferences from a given rank to the adjacent higher-order rank, we find a sharp decline in strength of inferences to taxa ranked higher than generic species, whereas strength of inferences to taxa ranked lower than generic species, are nearly equal and similarly strong. For example, given a premise of folk-specific (white oak, poodle) and a conclusion category of generic-species rank (oak, dog), most respondents indicated that all members of the generic species would possess a property that the folk specific has. A similar number of respondents also indicated that a property possessed by a folk varietal (swamp white oak, toy poodle) would as likely be found with the generic species (oak, dog) as with the folk specific (white oak, poodle). In contrast, few respondents believed that properties found in a folk varietal, folk specific or generic species would be
found among all members of the superordinate life-form (tree, mammal) or folk-kingdom (plant, animal) categories, or that properties found in a life form would generalize to the folk kingdom. Only novices show a discrepancy between the level privileged in perceptual and knowledge-based measures of basicness and the level privileged in induction. There may be a universal – perhaps evolutionarily determined - underlying disposition to privilege the generic-species level (nondimensional biological species) as the principal source of information about the biological world and the best basis for making inductions under uncertainty.7

Culture and Environmental Decision-Making. Differences in ecological knowledge that emerged from our categorization and reasoning studies motivated work on relations between knowledge and resource management. This research focuses on interactions of mental models, cultural values and behaviors, and social networks in environmental decision-making and inter-group conflict. One case study involved three culturally-distinct groups exploiting the same habitat in Guatemala’s Petén rainforest: native lowland Maya (Itza’), immigrant Maya from the neighboring highlands (Q’eqchi’), and immigrant Spanish-speaking Ladinos (mixed European and Amerindian descent). We find that lack of knowledge correlates with unsustainable agro-forestry.46

The Lowland Maya region faces environmental disaster, owing in part to open access to forest resources by non-native actors. Since 1960 massive immigration has razed more than half of Petén’s forest, converting it to agriculture. Habitat destruction does not owe exclusively to population pressure because Pre-Columbian Petén once supported many more people.

Our studies show striking differences in folkecological models of groups exploiting the same habitat. Q’eqchi’ Maya immigrants see plants as passive donors to animals, and animals having no effect on plants. Native Itza’ Maya have a rich, reciprocal model of animal-plant interactions, where animals can help or hurt plants. Immigrant Ladinos display a simpler, non-reciprocal model - animals do not help plants. These differences in models parallel agroforestry practice. Itza’ folkecological models stress reciprocity; their practices respect and preserve the forest. Q’eqchi’ folkecology sees plants as resources to be exploited; their agricultural practices are correspondingly insensitive to forest survival. Ladino folkecology and agroforestry are intermediate. Measurements of behavior patterns (plot sizes, species diversity, tree counts, canopy coverage) and consequences for soils corroborate patterns of reported behavior (as does satellite imagery).

For Itza’, ecological centrality (number of associations in a group's consensual ecological model for a given plant) and combined utility (value of a plant for wood, shelter and cash combined) predicted which plants they protect. For Ladinos, cash value was the only reliable predictor (Ladinos protect plants having cash value). For Q'eqchi', negative correlations indicated that plants most valued for utility were most readily destroyed. Q'eqchi' social networks show that information pertinent to the long-term survival of the forest comes from outside organizations with little long-term experience (e.g., Washington-based NGOs). Social network analysis reveal that, for Ladinos, strong overlap between socially-connected individuals and Ladino experts (who themselves name Itza' as experts) provides channels of reliable but non-institutionalized ties for learning about the forest from Itza'.
Like models of induction, abstract decision models employ a homogeneous notion of the object domain – in this case, of utility – where content biases and protected values simply are annoying. In the area of decision making and the commons, a prevailing view is that behavior is driven by self-interest, mitigated only by institutional constraints. Protected or sacred values are annoying because their “utility” may be hard to measure. Thus, analyses of commons problem may appear to be trapped somewhere between isolated individual interests which lead inevitably to commons destruction and a focus on institutions that has little need for cognitive science. Our results oppose this conception.

Immigrant Q’eqchi’ form the most socially interconnected and institutionally-structured community, but are least likely to preserve the resource base (perhaps because the community is so culturally-hermetic). The Itza’ community is the most socially-atomized and the least institutionalized, but its individuals most clearly act to maintain the common environment. If neither institutionalized learning nor institutional control mechanisms are exclusively responsible for commons maintenance among Itza’, what is?

Our evidence suggests that Itza’ see forest species as a relational entities, like friends or enemies, not as objectively-defined and objectively-valuated entities, like monetary objects of a payoff matrix. Itza’ rank-orderings of forest species from the viewpoint of forest spirits are significant predictors of ecological centrality and human impact. (Spirit preferences may represent a cultural summary of sustained human-species interactions over many generations). Ladin and Q’eqchi’ show no such relations. These results pertain to devolution because they show that sheer contact with nature does not suffice for development of ecological knowledge (and correlated values and practices), and that exclusive concern with economic rationality and institutional constraints do not sufficiently account for cultural differences in commons behavior.

Other studies among groups from the adjacent Chiapas rainforest in Mexico suggest that the patterns of knowledge and behavior among native Lacandon Maya versus Tzeltal and Tzotzil Maya born to families that immigrated into the area resembles that of Itza’ to Q’eqchi’ immigrants. The fact that these descendants of immigrants have lived all their lives in the rainforest indicates that mere personal exposure to the local ecology is not a deciding factor.

Our studies among Lacandon Maya also indicate inter-generational knowledge loss. Formerly, the Lacandones lived in dispersed settlements, moving their houses with the agricultural cycle. This pattern was interrupted when they were pressured to form set villages in the 1970s. Village life has resulted in the young generation losing interest in and knowledge about the rainforest. Older Lacandones show a rich model of ecological interactions, guided by intricate observations and cosmology that younger Lacandones lack. These generational differences are also reflected in agricultural practices (e.g. little crop diversity, focus on cash crops).

We think devolution can unfold in two ways: as generalized loss of knowledge and as skewing by limited goals. We suggested that, relative to native Itza’, Q’eqchi’ immigrants approach the forest with narrow utilitarian objectives. In parallel studies in the USA we find that majority-culture expert fishermen, relative to Menominee experts, show a corresponding influence of restricted interests: their answers are driven by sporting goals (catching big fish) that ignore broader ecological relations involving fish life cycles. The two devolutionary paths may interact in that limited goals can, in the long run, lead to more limited knowledge. Psychology’s standard populations may represent
an extreme case on both counts.

We have provided several lines of evidence indicating that “the extinction of experience” has important cognitive and practical consequences. First, standard views of development reflect devolution rather than universal processes. Second, cognitive theories based on devolved knowledge provide misleading pictures of how people generally understand nature. Third, devolutionary processes lead to anthropocentric views of nature, neglecting cultural values and ecological variables that directly affect a society’s manner and possibility of survival. Our civilization is currently in the midst of a conceptual, technological and ethical revolution with regard to biological knowledge and its uses. There is also an emerging moral consensus to leave the planet in the same or better shape than we found it. But if human beings are increasingly isolated from their natural environments, how will they care for it?

23 Tournefort, J. (1694) Eléments de botanique (Imprimerie Royale, Paris).
27 Adanson, M. (1763) Familles des plantes (Vincent, Paris).
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