CHAPTER 16 "Indigenous Knowledge" and the Understanding of Cultural Cognition: The Contribution of Studies of Environmental Knowledge Systems

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Defining Our Terms of Reference

The term "indigenous knowledge" arose largely in its modern setting as a designation for the technical or empirical knowledge of mainly non-Western peoples, of the kind also described as ethnoscience. As a category it is problematic, and has become ideological through its entanglement in political debates about indigeneity. Applying the adjective "indigenous" to the substantive "knowledge" raises the same complications that we find with the category "indigenous peoples." Indigeneity is an often contested status, and it has been suggested that terms such as "traditional" or "local" might be preferable. But these too have their limitations, as what is traditional is not necessarily indigenous or local, and what is local is not always indigenous or traditional. The designations "folk" or "ethno-" (as in, say, ethnobiological or ethnomedical knowledge) are current in academic work, but have less currency outside the academy.

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Many ethnoscience domains have been the subject of systematic documentation and theorization, both in terms of the encyclopedic information they encode (especially their classificatory apparatus) and also in terms of their underlying explanatory and organizational logics. My main focus here will be on studies of environmental knowledge systems, but because we are not referring to scientific knowledge in the accepted narrow sense (only as a comparator and means of evaluating other bodies of knowledge), we inevitably imply the existence of a dualistic "other." Indeed, there is a danger in seeming to essentialize the features of non-scientific environmental knowledge systems by contrasting them with scientific knowledge; or to conflate the dualism as a whole with the distinction between Western and non-Western. It is difficult to generalize about these features, as in the widest sense they must apply to all those diverse knowledges that lie outside of science as it emerged as an ideal and institutionalized body of global practice. As a category, "indigenous knowledge" also sustains an ambiguity in relation to how we should regard the great literate scholarly traditions of knowledge (such as Ayurveda or early modern European herbalism), which in turn are often distinguished from local oral traditions, but with which they have continuously interacted historically. However, it has become conventional (see, for example, Ellen and Harris 2000) to characterize folk knowledge in particular as rooted in the experience of living in a particular place, and as orally or performatively transmitted. Despite often being seen as static, folk knowledge is actually remarkably fluid, a consequence of a practical and experimental engagement with everyday life. Folk knowledge is more culturally distributed and shared than scientific knowledge, not existing in its totality in any one person or group. However, particular kinds of knowledge may be the domain of specialists or particular sub-groups. Though characteristically embedded in other aspects of culture, and often described as holistic and integrative, it is precisely the difficulty of separating the technical from the social, and the rational from perceived non-rational elements, that has made it easy to ridicule as a kind of pseudo-science. The same interconnections have, by contrast, encouraged activist and spiritual representations of indigenous knowledge as intrinsically mystical, and through this have perpetuated mythologized notions of tribal environmental wisdom (Ellen 1986).

Most accounts of indigenous knowledge are summations of what people know, or qualitative descriptions that are not really relevant to the objectives of this chapter. Those who seek to apply indigenous knowledge to practical problems of development often tend to be more inclusive in their use of the term (e.g., Warren et al. 1995; Sillitoe et al. 2002), applying it to, say, philosophical or medical knowledge. However, it is mainly knowledge of the natural world (ethnobiological knowledge, ethnoecological knowledge, landscape classification, and conceptions of nature in a more general sense, together with some applications of such knowledge) that have made the most obvious contribution to our understanding of cognition, especially concerning the interplay between linguistic, cultural, environmental, social, and evolved factors. It is upon these that I focus here. I will also look at aspects of cultural cognition involved in technology and material culture, spatial orientation and way-finding, insofar as these connect with the preceding themes. It is partly because the greatest impact of indigenous knowledge studies on cognitive anthropology has been through ethnobiology and studies of material technologies, and because a line has to be drawn somewhere, that I shall confine myself to these areas. Cognitively speaking, "indigenous knowledge" is not one single homogeneously identifiable thing, or indeed something that is easily divisible. It might, for example, be seen as a series of overlapping domains, some of which share organizational features, some of which may acquire a certain "systematicity," but often the domain boundaries and systemic features are more heuristic than empirical.

The Beginnings of Anthropological Approaches to the Study of Environmental Cognition

The history of the study of indigenous environmental knowledge systems has revealed a twin-track approach, directed in part by the search for fundamental truths about how people organize sense data about the natural world, and in part by a more pragmatic concern for the empirical content of that knowledge and how it might assist in development contexts. Our concern here, as I have indicated, is with the former.

Anthropologists studying the classification of plants and animals and the distribution of ethnobiological knowledge have made a particular contribution to the development of field methods, and from the earliest days, studies of knowledge systems have been closely associated with the emerging paradigm of cognitive anthropology, largely through the work on ethnoscience in the late 1950s and early 1960s, and its strong association with the American school of ethnosemantics (Sturtevant 1964), the guiding methodology of which entailed the use of formal protocols to yield sufficient data for an ethnographer to successfully replicate native language behavior in a designated context (e.g., Frake 1980). Although the approach failed as a way of reporting ethnographic data more generally, it proved to be a productive paradigm in terms of the studies of ethnobiological knowledge they inspired, and provided elicitation techniques and an analytical language that persists (for example, the received concept of "cognitive domain"). In particular, they enabled a clearer understanding of the relationship between category and word, and demonstrated that the correspondence between the two in category formation, classification, knowledge distribution and transmission, was seldom straightforward. These developments were made possible by mapping folk categories onto their phylogenetic denotata. Such a linguistic approach to folk classification is perhaps best exemplified in the work of Harold Conklin (1954, 1962) and Brent Berlin (Berlin et al. 1974). In other words, biological kinds provided a "natural metric" for cultural comparisons, and a way of linking work in cognitive anthropology and cognitive psychology.

The early influence of linguistics was reflected also in the prominence of the distinctive feature model, emphasizing category boundaries and reflected in the semantic structuralism of Edmund Leach (e.g., 1964) and Mary Douglas (e.g., 1975). The immediate stimulus of this work was Lévi-Strauss (1962:1–33), though ultimately it was inspired by Émile Durkheim and Marcel Mauss (1963[1901–02]) who had prefigured a sociological theory of classification. Since then, debates around the role of metaphor, totemism, animism, and the construction of "nature," have supported the view that the interrelationships between symbolic and mundane classification are often far from clear (e.g., Rosaldo 1972; Ellen 1993; Healey 1993). However, initial approaches in this tradition were generally untested in either field or laboratory settings, and new evidence soon showed that categories are much more fuzzy, and more realistically modeled using notions of polythesis, or in terms of semantic cores and peripheries, which assume the pre-eminence of particular cognitive prototypes.

The more recent work of Berlin (1992), Atran (1990, 1998), Hunn (1977), and Boster (1996) all bear testimony to the fertile synergy between research on ethnobiological knowledge and cognitive studies more generally. With a shift away from the dominance of distinctive features, and an emphasis on core–periphery models and cognitive prototypes, and with a growth in the use of psychological at the expense of linguistic approaches, greater recognition has been given to how we might engage with differences in the world without using language as an intermediary. In recent decades more work has been undertaken on intracultural variation, on degrees of consensus, on knowledge transmission, and on the interactive relationship between cognitive process and learned bodily routines. I shall develop these themes later in this chapter.

Language and Cognition

It has long been known that language gives us our most accessible clues as to how categories and knowledge are organized. Plant binomials, for example, usually indicate the existence of a *kind of* relationship. A shared name is generally the outcome of a process whereby a percept is registered through repeated perceptual events, reinforced over the longer term and transmitted between individuals. As we have seen, it was first assumed that this was through a process of contrasting distinctive features, a model derived from lexicography and logic (Conklin 1962). Thus, birds have wings, feathers, beaks and fly, in contrast to fish, which swim and have fins. However, it was soon noted that the systematic patterns of contrast necessary for this model to work were not always present. For example, category A might be linked to category B through common attribute *a*, but category B linked to category C through common attribute *b*. This connected categories A and C even where they had nothing in common. This process, which we now know more generally as "polythetic classification," has been documented for folk classifications of plants and animals, where it has been described as "chaining" (e.g., Hays 1976; also Ellen 1993:121). As research on ethnobiological classification developed it became apparent that the digital distinctive feature model explained only certain kinds of fairly self-conscious classifying behaviors, and that an analog approach based on the notion of cognitive prototype presented a better way of modeling the cognition of basic and more inclusive categories. In this model, incoming perceptual images from the environment are matched by the brain with pre-existing cultural images of, say, "birdness" or "treeness," where the presence or absence of specific characteristics is not an overriding consideration, only closeness or marginality of overall match (Rosch 1977). Thus in British English classification of birds a robin would configure closely the core prototype, but an ostrich would be marginal, whereas in the famous Kalam example described by Bulmer (1967), the perceptual marginality of the cassowary is reinforced culturally so that it ceases to be a "bird" altogether. In everyday cognitive practice, therefore, we use the notions of both contrasting features and cognitive prototypes, and move freely between the two.

As the Kalam example shows, the difficulties we face in assigning things to categories are simplified by imposing culturally agreed boundaries, or indeed by instituting these by the ways we manipulate the natural world, for example, breeding varieties of plants or animals that emphasize phenotypic difference for aesthetic reasons, marvelously illustrated in Darwin's famous account of the Spitalfields pigeon-fanciers (Feely-Harnik 2007) or in Fukui's (1996) account of Bodi cattle patterns and colors, or Shigeta's (1996) study of Ari ensete selection. Thus, because parts of our experience of the world are complexly continuous it is occasionally necessary to impose boundaries to produce categories at all, and sometimes these are remarkably arbitrary. Consider, for example, what we conceive of as the technically precise area of engineering design, where as Lemonnier (1992) has demonstrated, the scope for cultural arbitrariness over technical necessity is as great, if not greater, than in the making of Anga fiber capes in the New Guinea highlands.

We may conclude that language is a good first guide to thought. Thus, the very sounds we use may identify certain species or groups of animal, as in onomatopeia (e.g., Nuaulu *kukue* [*Cuculus saturates*] and English "cuckoo"), or in the kind of verbal mimesis reported by Berlin (2006) in which there is a plausible correlation between bird morphology and the openness or closure of vowels in cross-language data. We can also infer cognitive process to some extent from the morpho-syntactic structure of names and their meanings. But all this is rather imperfect, and often language evidence may obscure cognitive process, for example, that related to artisanal performance (Dougherty and Keller 1982). Lexicalization and other forms of linguistic encoding are often prompted by the social need to exchange information, and where this necessity does not arise we need not expect language to predict cognition. Rather different is the delay in the erosion of category labels once these have been absorbed into language as morpho-syntactic classifiers (e.g., numerical classifiers), and where apparent linguistic indicators may sometimes be at variance with otherwise cognized groupings (e.g., Grinevald 2000).

Nested Classifications and the Problem of "Taxonomy"

It is now well attested that cognitive domains of environmental phenomena are established at varying degrees of classificatory inclusiveness. Thus, depending on a locally defined situation or the focus of analysis, we might isolate "all living things," "plants," "trees," and "oak," where each appears to be related through a "kind of" relationship. In such cases domain boundaries reflect distinctions that are empirically important for the population who share them. Thus if a population has no concept of "fish" then "fish" cannot be a cognitive domain. However, categories can exist without labels, even at the domain level. Thus, the lexical field, for say plants, may not correspond with the cognitive domain because of the existence of covert categories at various levels of inclusiveness, including the "unique beginner" for the domain (e.g., Taylor 1984).

The internal subdivisions of cognitive domains have often been represented as taxonomies, in the sense of a hierarchical model of contrast and class inclusion, partly because these are so prevalent in literate Euro-American literary scientific culture, most obviously reflected in the tradition emanating from Linnaeus. In the context of cognitive anthropology, Brent Berlin (1972, 1992; and Berlin et al. 1974) has put forward a strong claim for logical taxonomy as the general way in which ethnobiological classification operates universally, hypothesizing a series of levels broadly reflecting

the Linnaean rank: unique beginner, life form, intermediate, generic, specific, and varietal. This is a persuasive argument, and provides a powerful inductive framework for generating data and for making systematic inferences about the properties of organisms. However, nestedness need not imply taxonomy in the formal or domain-specific sense. These features of classification are particularly striking in plants and animals because of the discreteness and concreteness of individual organisms, and because the patterns of physical and behavioral similarity between taxa strongly reflect evolutionary process and phylogenetic distance. So, in the domain of living kinds classificatory tendencies converge in a special way because of regularities in the objective world which is classified, and to which the mind responds, not obviously because of the character of the mind which does the classifying.

We know that taxonomic thinking as a way of representing relationships between things is more important in some cultural populations than in others (see, for example, Lancy and Strathern 1981), and some domains more than other domains, such as natural history and some groups of cultural objects, but even within natural history domains some work better than others taxonomically, such as plants more than fungi (Ellen 2008), and other domains (such as color) are surprisingly resistant to taxonomic thinking, while some subcultural learning and teaching contexts encourage it more than others. Moreover, because of the propensity of most anthropological researchers to rely heavily on an approach embedded in Western science, it is easy to yield taxonomies in patterns of data collected from non-literate informants. In asserting a universal "abstract taxonomic structure" the methodology all too often seems to be one in which inconvenient features of peoples' classifying behavior which do not fit the expected pattern are systematically ignored or explained away as exceptions, until a suitably "taxonomic" pattern is obtained. But if we accept instead the centrality of prototypical thinking and polythesis in classifying activity, it is not at all surprising that it is often difficult to establish systematic and consistent hierarchical relationships between superordinate and subordinate categories (Edelman 1992:236; see also Hunn 1977; Friedberg 1990; Ellen 1993; Sillitoe 2003).

Berlin's model also works best if we claim a universal distinction between general purpose and special purpose classifications (a distinction, for example, that the findings of Atran [1998:563] no longer uphold), between those that are "natural" from those that meet particular specialized cultural requirements, such as cooking. Any demonstration of the empirical primacy of taxonomy depends on the extent to which categories can be shown to be linked in a particular way, despite the existence of other ways of classifying that undermine implicit levels and contrasts, and upon the ease with which transitivity statements can be elicited in fieldwork situations. Atran now accepts that taxonomic organization of the world is much more situationally generated, and does not necessarily define the inferential character of folk biology as suggested in his *Cognitive Foundations of Natural History*. This is consistent with other data (e.g., Ellen 1993:123–124). Like Itza' Maya, Nuaulu do not "essentialise ranks," which would violate their prioritization of "ecological and morpho-behavioural relationships" over abstract principles. Scientific systematics, by contrast, has until recently rejected such cross-cutting classificatory relationships (Atran 1998:561–562). Indeed, a central problem of folk biological methodology has been that much of data are acquired not knowing quite how independent the system of ranks discovered is from the analytic concepts with which we start. A more plausible working model is that we assume for any one population a flexible system of relationships between categories, which allows for the generation of particular "classifications" depending on context, although the aggregation of contexts may well favor particular kinds of "natural" classifications. A good example of the pre-eminence of local ecological and cultural considerations, and also of some general fundamental ambiguities, is found in the position occupied by "palms" in different ethnobotanical schemes and the nebulousness of their position as a "life form," intermediate or "unaffiliated generic." On balance, it must be the case (as Atran asserts), that the denser our knowledge the more we deviate from any general model, and that taxonomies might better be accommodated by treating them as simplifications of experiential complexity in ways which make knowledge less useful. Thus, when we find plant and animal domesticates as salient components in elicited schemes of folk classification we cannot just reject them as "special cases," or cross-cutting utilitarian artifacts, that evolved after the arrival of agriculture, simply because they seem to violate some evolved predisposition.

Modularity and Ethnobiological Knowledge Organization as an Evolved Capacity

We have long known that the brain has a propensity to store information in ways that make best use of the perceptual and cultural resources available, what Rosch (1977) calls "cognitive economy." I have discussed above the role the study of systems of classificatory knowledge have played in exemplifying how the mind models "fuzzy" concepts and "core" prototypes, some of which in turn provide a repertoire of artifacts through the physiology of perception which in turn can be used to organize perceptual and symbolic data.

The concept of cognitive domain as a methodological tool reflecting the tendency to cognize "areas of conceptualization" (D'Andrade 1995:34) has long been advocated, but in addition has given rise to the notion of domain specificity, that is, the idea that the attributes of one domain might be different from another (as between language, mathematical ability, intuitive physics, and so on). Moreover, since their popularization by Fodor (1983), our understanding of the evolution of the hominid brain has been much influenced by modular theories in cognitive psychology, which stress the differential development of categorizing abilities in different functionally discrete domains, which are claimed in some cases to be rooted in evolved neurobiological proclivities. Thus, there are special features relating to essence, rank, and basic category that are more likely to reflect evolved features in the domain of biological knowledge, than in, say, the domain of cultural artifacts (Atran and Medin 2008:65; also Brown et al. 1976 versus Atran 1987).

The difficulty for anthropologists and psychologists alike here has been in identifying cultural and cognitive traits of sufficient discreteness to be accepted as unitary modules in the first place, and the ways in which the human mind unhelpfully interferes with the conventional forces of selection by reforming such units, linking them together in novel ways and attributing to them new (and sometimes contradictory) linkages and meanings (Aunger 2000). If cross-cultural similarities in ethnobiological classification are a legacy of a universal "evolved predisposition" in *Homo sapiens* (Mithen 1996), or if natural history knowledge – say – is a "meme," and if Bruner (1996:101) is correct in his claim that the intersubjective, the actional, and the normative probably all have biological roots in the genome, then science and folk, or indigenous, knowledge are cognitively closer than we might think. In the light of the new neurobiology, however, this view of the brain, with its computational and algorithmic representation, is increasingly incompatible with what we now know of brains and bodies and how they interact with the world.

Thus, categorization and classification are embodied and experienced, not just imposed or constructed (Edelman 1992:236): they proceed as synesthetic processes, combining all our senses (Varela et al. 1993:172–177). Symbols arising from complex cultural traditions mold the prefrontal cortex through neural plasticity to transform our conscious minds. We see a nice illustration of this in Berlin's (2006) work on verbal mimesis, with its strong echo of the relevance of the co-evolutionary.

Ethnobiological Universals

One source of evidence for domain specificity and evolved tendencies has been claims for the existence of lexical and classificatory universals in the natural history domain. Historically, this has been an important area for the investigation of cognitive universals, and although the recognition of universals does not in itself imply non-cultural "evolved" origins, it has often been assumed to represent strong evidence in its favor. Some of the conclusions of this research are still contested, but there is a small but growing body of secure knowledge. Many aspects of rule-governed category formation and classification work in the same way irrespective of cognitive or semantic domain, but there are also significant differences between domains, some of which have major theoretical and methodological implications.

Since folk classifications of biological species must co-evolve with the plants and animals that are their subject, we can agree with Boster (1996), in the most general sense, and at the level of clearly discriminated prototypes of natural kinds, that humans "carve nature at the joints." In other words, there are certain discontinuities that are so protean, so much part of the lives of so many human populations, that they might be said to be universal. To begin with, this appears to be true for natural kinds as a phenomenal type and is evident in the universal recognition of "animacy." Additionally, few would now deny that all classifications display some concept of logically "basic" category or "level" applied to biota (or things in nature, or natural kinds), the segregates of which are then either aggregated or disaggregated to create complex classifications. For Haudricourt (1973:268) and for Berlin (1992) it is the genus that gives us the basic level for plants in many languages, while species obtain priority only with Linnaeus, though doubt has been expressed as to the level at which basic categories of natural kinds might be found (Bulmer 1970; Ellen 1993:67–71).

Universals have also been claimed to exist at the level of "unique beginner," such as plant or animal. The argument here is supported by both linguistic and experimental sorting data, but also by negative inference, in that it is difficult to see how cultural and developmental factors in themselves could generate such salient if sometimes lexically covert categories (Boyer 2001). Ethnobiological universals are also argued for in respect to life forms (e.g., Berlin et al. 1973), some of which appear to be more obvious than others. These latter vary cross-culturally, but do not always partition "the living world into broadly equivalent divisions" (Atran 1998:n. 5). Thus, though the "tree" concept may have existed for millions of years, it has been suggested that the life-form category and term are linguistically recent (Witkowski et al. 1981), while its earliest naming appears to have involved functional considerations reflected in tree–wood polysemy (Ellen 1998:71). The work of Brown (1984) demonstrates the universality of a few life forms and the order in which they are added to language, but also confirms the diversity of the many. Moreover, while some (e.g., Brown 1984; Boster 1996) have emphasized the origins of natural kind classification in evolutionary psychology, we might equally demonstrate non-cultural recognition abilities and the evolutionary antiquity of cross-cutting functional classifications, such as "edible–non-edible" and "predator–non-predator" (Johns 1990).

Only "natural kinds" match directly real and discrete objects in an objective world. But even with biodiversity, some gaps between purportedly discrete kinds and objects are bigger and more salient than others, in most environments, and therefore serve as more widespread (even perhaps universal) markers in classifying behavior. Human experience, in many diverse environments, does not mean, for example, that we automatically recognize a "tree" as a bounded kind of thing, as we can see in any photograph of a stretch of forest. Trees often merge imperceptibly into bushes. The definition is therefore polythetic, single features being neither essential nor sufficient to allocate a percept to a category. In an important sense, then, the objective "thinginess" of the biota sets it apart from many other semantic domains (social as social relations, color, taste, or smell), and what separates it from other domains that classify objects (say, cultural objects) is the degree to which we can organize it according to its plausibly conjectured evolution. Thus, grouping natural objects *a* and *b* is more likely to indicate historical affinities (common origin) than, say, a classification of furniture. To refer to the thinginess of the natural world is simply to acknowledge the universal human imperative to turn the natural world into things and to think of the things so prehended in terms of their essential qualities. This is not to say that such a capacity is innate in the sense of springing into action from the first moment of post-partum development: it is simply to recognize the existence of a process that takes place over time, a consequence of interaction between normal developmental processes and environmental stimuli.

We cannot keep semantic domains separate, and no one domain can be represented in its own terms. It is always necessary to translate into a second domain in order to be understood. This is why the metaphorical and the symbolic are so central to cognition. The way in which we use the domain of social experience to make sense of the natural world has long been argued, by such as Mauss and Lévi-Strauss, but this now begins to make much more sense given what we know about the role and dominance of the social intellect in primate evolution (e.g., Dunbar 2003). But it is precisely this mutual explanation of the material in terms of the social and the social in terms of the material (however arbitrary these ideas might be in empirical terms) that entrenches in cognition the methodology we call Cartesian dualism. Though ultimately a distortion of experience, this notion works sufficiently well most of the time for most of us to place confidence in it for practical purposes. But not only do we use distinctions derived from one domain to organize another; we repress certain characteristics and exaggerate and foreground others to better organize the world. Any one species, entity, or percept is far too complex an aggregation of traits to be stored and retrieved as information in any one-dimensional form. The processes of simplification required sometimes gives us more naturalistic classifications, and sometimes more symbolic ones.

Inferential Knowledge of Living Organisms

By ethnobiological knowledge I have in mind local knowledge of the living environment, including plants, animals, and the human body: ethnobotany, ethnozoology, and ethnoanatomy, including the applied knowledges that arise from these, such as ethnomedicine. Hitherto, most studies of such knowledge undertaken by anthropologists have focused on individual folk species and their classification into more inclusive schemes. But when it comes to understanding how knowledge about the environment is more generally organized, we need to note that identification of types is only the start. Thus, individual natural kinds provide a conceptual focus for the aggregation, storage, and understanding of species-specific knowledge (autoecological knowledge), while the classification of organisms in a particular way provides a basis for inferring features of common biology that may not be specifically remembered. In addition, from systems of partonyms for particular organisms, and groups of organisms, we can further infer aspects of people's biological understanding, and from indirect features, for example leaf variegation in manioc, we might infer important information about the toxicity of otherwise edible tubers. In this way apparently inconsequential features of identification can be seriously adaptive. In this way also we can see how the mind can make sense of ecological knowledge, and transmit it, without necessarily converting it into language (Ellen 2003a:47–48; 2003b:62–63). It is just one of many possible examples that show us that while knowledge of plants and animals may often be lexicalized, we need to differentiate between lexical and non-lexicalized substantive knowledge, and that this non-lexicalized knowledge in non-literate populations heavily outweighs that committed systematically to language.

Taxa-specific knowledge of the above kind needs to be distinguished cognitively from knowledge of general principles of biology that may be more important than simply the aggregation of knowledges of individual species or groups of species. In this kind of knowledge, what is crucial is the ability to transfer (or infer) lessons learned from one organism in one context to a second or more organisms in different contexts. One of the most obvious areas in which we can see this happening is in the transfer of lessons learned in using the properties of medicinal plants for humans to veterinary care, or of inferences about bitterness and toxicity in food to medicinal or poisoning applications, or from observations of the internal organs and functioning of the bodies of hunted animals to understanding the workings of the human body (Ellen 2003b:57–64). While such knowledge is subject to widespread diffusion, sometimes in the hyper-organized form of traditional medical practices, universal human knowledge of generic biological principles has led to the repeated independent discovery of ecological properties using common patterns of causality in different cultural settings (see the work of Sinclair and his group as reported in, for example, Walker et al. 1999). Something similar may be apparent in the demonstration of cross-cultural convergence in adult concepts of biological inheritance found by Astuti et al. (2004), even though patterns of development may vary culturally. Such evidence supports the claim by Johnson-Laird (1982) that storing knowledge as causal hypotheses (or models) is more efficient than "databank" models because humans have insufficient memory to make the right responses by induction alone (and we might add, relying on oral culture and low levels of division of labor).

Ethnoecology, Landscape, and Nature

Not all knowledge of the natural world is perceived, logged, ordered, or activated through models based on individual organisms, nested folk classifications of "natural kinds," or inferences based on observations of general organismic principles. Ethnoecological knowledge of places, or systemically and functionally organized spaces, rather than typologically related organisms, plays an important role in the way we model and understand the natural world. Such folk synecological knowledge involves overlapping understandings of the non-living environment, such as water, soil, rocks, climate, topography, intuitive physics, and computation, and the patterns and movements of astronomical bodies.

People perceive, group, and understand individual organisms in terms of second order categories based on physical and ecological proximity, through what we call habitats, landscape types, or ethnoecological categories. There are a growing number of analyses of how people organize knowledge at this level (e.g., Conklin 1976; Meilleur 1986). For example, some studies on the ethnoecological classifications of tropical forest peoples (e.g., Shepard et al. 2001:31–32) have suggested the existence of common themes and patterns, factors such as topography, flooding, other disturbance regimes and soils generating a small number of general categories, distinctions between primary and secondary forest, including various stages of swidden fallow regeneration. Indeed disturbance history is probably the single most important dimension in classifying forest for people engaged in swidden cultivation. In other words, we find a widespread conceptual model based on a limited number of dimensions of perceived experience. However, these same data also raise issues regarding overall category differentiation, degree of lexicalization and, most specifically, in relation to the claim of the extent to which biotic features – mostly indicator plant species – are used to define more specific habitat types. Other data (e.g., Ellen 2007; Widlok 2008) emphasize the difficulties of eliciting ethnoecological classifications independent of distinctions based on use strategies, land tenure, and other contingent contextual information. These suggest that it is often inappropriate to treat complex multidimensional landscape categories in the same way that many have analyzed folk classifications of species. We should not expect the degree of shared systematic categorization implied in the Matsigenka data of Shepard et al., for example, to be necessarily repeated elsewhere, and would expect people to lexicalize their environment more flexibly and with more limited shared encoding.

The issues raised by ethnoecological classifications lead us directly to the literature on the construction of "nature" as a more abstract category. The category of nature has been extensively critiqued from a perspective of social constructivism (e.g., Descola and Pálsson 1996; Ellen and Fukui 1996), and it is now very clear that not only do many languages have no word for nature, but that the contrast between "nature" and "culture" is far too simplistic to explain how most people perceive, interact with, and represent the world; that the way we define nature alters over time, and that particular human populations use the concept of nature in numerous and often contradictory ways. However, the data elicited by anthropologists on the classification of natural kinds, on symbolic classifications, orientation, and social deixis, provide powerful evidence in support of some kind of cognitive architecture yielding categories at this level of generality, based on (1) the propensity to perceive entities in the real world that represent so many concrete kinds which can then be grouped into increasingly larger groups based on family resemblance (e.g., sparrow–bird–animal, oak–tree–plant), (2) the tendency to distinguish self from other (village:forest, land:sea, here:there), and (3) a notion of internal essence that captures the "nature" of some entity, as when we talk of certain behaviors being "natural." Depending on the social context this can be an affirmative announcement, or it can be negative, requiring control. What is interesting about notions of this kind is that they bring together ideas originating in work on biocognition with ideas generated through work on social cognition (Ellen 1996), reinforcing the argument of the previous section regarding the consubstantiality and essential interdependence of different semantic domains.

As Atran and Medin (2008) have recently noted, there is often considerable variability in the systematic folk ecology of groups living in the same area, as well as qualitative differences in folk biological understanding. Indeed, their data show greater similarities between experts in modern cultures and people from small-scale societies, and greater levels of abstraction and induction in societies where knowledge of, and "cultural support" for, learning about the natural world is eroded as a result of diminishing contact with living kinds in urban societies and in majority culture. There is, therefore, a disjunction between empirical knowledge of biological diversity, objective biological diversity, and linguistic encoding, the consequences of which can sometimes be dramatic. A particular concern is how cognitive and cultural change results in some people protecting their environment and others destroying it. Itza' Maya, for example, with few cooperative institutions but with mutually reinforcing spirit beliefs and rich ethnoecological knowledge, promote forest replenishment and show awareness of ecological complexity and an aptitude for sustainability. By comparison, Q'eqchi (with highly cooperative institutions and dense internally connected social networks) acknowledge few ecological dependencies and foster rapid depletion. Ladinos are in between, closer to the behavior of native Maya than immigrant Maya, it is claimed, because they have more open social networks with close links with Itza'.

The Contribution of Studies of Technological Skills to Cognitive Anthropology

What we conveniently describe as "indigenous knowledge" is inevitably a combination of what Lévi-Strauss recognized as a purely intellectual compulsion on the part of collective human minds to make sense of the world, and useful bits of knowledge to better act upon it. For this reason it is difficult to separate domains of technological knowledge (domains of application) from domains of understanding. Technology draws on both natural history and intuitive physics in order to achieve selected material objectives: organizing time, making artifacts, getting and producing food, managing natural resources, processing food, navigation ... and many more. In cognitive anthropology, the contribution of studies of way-finding has had a particularly privileged position, given the extensive literature on, for example, traditional oceanic navigation (e.g., Gladwin 1970; Frake 1985; Gell 1985; Akimichi 1996). This has raised many issues of cognitive significance, including whether we navigate using map-like structures – abstract networks and spaces viewed from above – or by employing a succession of linear signposts, whether visual, auditory, tactile, or olfactory (Gell 1985). The ethnography suggests that how we combine these strategies depends on the kinds of environments we are traversing (for example, whether dense tropical forest, open desert, or a highly culturally modified urban neighborhood), and on our access to forms of symbolic storage, such as maps *sensu stricto*.

When we look at a particular technological activity we can see that it is composed of cultural elements that we might hypothesize as cognitive "archaeotypes," each having been discovered many times by humans, and for this reason presumably drawing on an evolutionary predisposition to identify and solve problems in similar ways, what Mithen (1996) and others have described as "technical intelligence." What is more difficult to explain are local combinations of these archaeotypes, how people learn to link them together in a process of qualitative innovation (Barnett 1953:7). If we look at the example of Nuaulu sago starch processing in eastern Indonesia (Ellen 2004a), the most complex operation is that linking separation of starch granules through pounding, the addition of water to create a suspension, the combination of pressing of wet pulp and filtering, and the retrieving of flour following sedimentation. There is much to be said for seeing the entire process, from cutting to heating, as a single integrated body of knowledge and material actions, but if we concentrate on starch separation, the key conceptual breakthrough in the innovation of palm starch technology is the discovery that by leaching inedible pith edible flour can be extracted. This required recognition that starch granules could be separated from fibrous pith and that this could be achieved by mixing the unprocessed pith with water, using a semi-permeable membrane to separate starch in suspension from fiber, and then separating the starch through sedimentation. Regardless of the particular constellation of equipment and material actions employed to realize this objective, such a combination of understanding, once embedded in a population's collective knowledge base through repeated sharing, may be said to represent a *cultural schema* in the sense used by D'Andrade (1995) and others (e.g., Gopnick and Wellman 1994; Keller and Keller 1996:22): meaning an empirical generalization representing particular plans, procedures, tools, and artifacts, typically organized through multinodal structures which can potentially incorporate visual, kinesthetic, oral, and propositional information. However, in the case of sago-processing the inscription required *third order* problem-solving. Where palms are domesticated or used for their fruit, cabbage, leaves, leaf stalks, the process by which opportunities might have been prehistorically translated into regular resource use is relatively straightforward and easy for us to appreciate. These innovations required the solving of what we might characterize, cognitively, as *first order* food-processing problems. Where palms are tapped for their juice and subsequently fermented we might speak of *second order* food-processing problems, since the solution requires analogical reasoning, perhaps drawing on existing uses of more readily accessible and useful stem sugars (maple syrup, cane sugar). However, in the case of palms utilized for their solid starch, the cognitive problem might be said to be a *third order* one, since there are few obvious parallels on which to draw. We can observe similar

kinds of cognitive activity in the recognition of toxicity in plants, and in the techniques devised for its reduction (as in processing yams containing dioscorine), and the selective use of low levels of toxicity for therapeutic purposes (Johns 1990).

Intracultural Variation, Change, and Transmission

Early studies of indigenous knowledge tended to consist of connected normative statements, of the kind "The X believe that ..." The methodological challenge to the "omniscient speaker–hearer" model was particularly articulated from within the ethnoscience community. Increasingly, ethnographic practitioners began to actually measure the variable distribution of knowledge within a population (e.g., Gardner 1976), or variation in the significance of particular species (Turner 1988; Stoffle et al. 1990). Studies of variability are now numerous (Berlin 1992:199–231), but once it became empirically evident that fundamental knowledge might vary within a population, the data raised important issues concerning the extent of "cultural consensus" (Romney et al. 1986; Ellen 2003b; Sillitoe 2003:109–116), constraints on transmission of knowledge networks deriving from structured bias and stochasticity (Casagrande 2002), knowledge exchange and flow, the information upon which subsistence decision-making might be based, and strong evidence of the role of social and situational factors. Here again ethnobiological knowledge provided convenient data with which to explore new methods (Boster 1984, 1986), including free-listing and pile-sorting (as in Werner and Schoepfle 1987). Such studies reinforced a distributional view of knowledge, never existing in its totality in any one place or individual, despite the widespread anecdotal reports of the knowledgeability of particular individuals, and the well-documented accounts of key indigenous research participants such as Méndez Ton Alonso (Berlin 2003) or Ian Saem Majnep (Marcus 1991). Indeed, to a considerable extent classificatory knowledge has become increasingly devolved not in individuals at all, but in cultural artifacts, and in the practices and interactions in which people themselves engage. But as knowledge remains orally articulated, or even devolved in non-linguistically coded tacit experience, it often poses obstacles to effective reproduction through the literate mode, inviting serious over-simplification, straining the limits of ordinary language as a medium of transmission, and giving rise to specialized forms of language (such as mathematical notation) or devolved in practical interactive demonstrations of which language may be the lesser part. Consider, for example, how you would explain to a child how to tie a shoelace – over the telephone.

As individuals vary in their classificatory, substantive, and applied knowledge, we can infer that these things are constantly changing. The data concerning how classifications change in the short term through category extension (as reflected in, for example, lexical marking behavior), category obsolescence, are now well attested, though inferences concerning the way ranks grow over the longer term, and how new life forms are added to natural history knowledge, are less secure (Berlin 1972; Brown 1984). Much more attention has been paid in recent years to interindividual knowledge transmission, a focus that has been accompanied by acquisition of data on the distribution of knowledge by age and generation (e.g., Stross 1973). Models for analyzing transmission have been influenced by the work of Luigi Cavalli-Sforza (Hewlett and Cavalli-Sforza 1986; Ohmagari and Berkes 1997), emphasizing simple contrasting types of transmission (vertical versus horizontal) and assuming knowledge to be a kind of stuff to be transmitted meme-like between individuals, rather than the outcome of an interactive process between individuals, or between individuals, knowledge, and the properties of the materials on which the technology depends. There has been particular emphasis on studies of ethnobotanical knowledge erosion, and a body of evidence (e.g., Atran and Medin 2008:47) suggesting that substantive knowledge declines faster that lexical knowledge. However, studies of knowledge acquisition and erosion have tended to focus on acquired or eroded elements of a single domain, as, for example, the transmission of plant knowledge, ethnomedical knowledge, food knowledge, and so on. What such an approach ignores is the relevance to transmission of simultaneous membership of several domains. Thus, erosion of knowledge in one domain may accelerate erosion in another of which that plant is a member; or alternatively, maintenance of knowledge of the plant in the context of one domain will enable retention of knowledge in another. The more complex the domain, the more this kind of overlap is likely to be significant (Ellen 2009).

Atran and Medin suggest that an appreciation of values and meanings in environmental decision-making and management helps to explain why Menominee children reveal progressively poorer subject scores for science as they move through the school system. This is attributed to differences in specific goals, and to media coverage. Expertise cannot be separated from cultural context, even when people engage in the same activities. Moreover, despite common processes for cognizing nature, cultural variation in its understanding is related to critical differences in their respective "framework theories," in decision-making and management, as well as to group conflict and stereotyping arising from these differences. It demonstrates effectively how erosion of knowledge amongst ordinary people is linked to diminishing contact with nature, and the cognitive consequences of how we humans act upon the world in different cultural contexts.

The Impact of Literacy, Scholarly Knowledge, and Science

Folk knowledge of the environment is typically orally transmitted, through imitation, demonstration, and interactive rediscovery. For as long as technical knowledge was oral and shared it was constantly being reinforced by the elasticity of the brain and the distribution of knowledge across individuals, but it was ultimately subject to the cognitive limitations of both brain and body, and in particular "cognitive economy." However, through specialist divisions of technical labor (professional remembrancers, and technical occupational specialization) these limits could be exceeded, a process accentuated through the use of visual images and material culture. This process in turn made it possible for particular domains and classifications to acquire semi-autonomous histories, displaying "emergent" properties and characteristics determined by a cultural framework unfettered by ecological experience and ordinary cognitive constraints. However, writing has been the technology that has had most impact on environmental cognition, permitting long-term storage, unconstrained by (even distributed) memory, and permitting new ways of manipulating data (e.g., Goody 1977; Ong 1982). Writing knowledge makes it more portable and

permanent, increases the quantities that can be stored in one form, allows for new kinds of representation and connections, and reinforces the dislocation that arises when knowledge rooted in a particular place and set of experiences (i.e., local or indigenous) and generated by people living in those places is transferred to other places. Thus, the same Tibetan herbal text might integrate environmental knowledge of medicinally important plants from very different habitats over the wider Himalayan area and as far north as Mongolia. Similarly, people can agree on categories even where there is apparent disagreement over descriptions of what is to be put in them. Such artifacts as manuscripts are every bit as much part of what indigenous knowledge systems can tell us about cultural cognition as data obtained from knowledge transmitted orally.

It is, therefore, perhaps unsurprising that early anthropological models of category formation too were not only heavily constrained by adherence to linguistically defined approaches but also to a writing-based interpretation of how knowledge is everywhere organized, what Bloch (1991) has called the "linear-sentential" model of culture. Moreover, we now understand that the distinctions sometimes made between what we call science and other knowledge-making processes are less than clear. Intuitive or local knowledge exists at the interface of most sophisticated technologies, and in many populations the products of formal science routinely hybridize with established local knowledge to produce new indigenous knowledges. Historically, much European science emerged and built upon what we would now describe as European folk or expert local knowledge (as in the work of Linneaus and Galileo), and during the seventeenth and eighteenth centuries scholars became conscious of this interplay through contact with new knowledge from the rest of the world. Today, things have come full circle, and we can find virtue in looking at cognitive organization of scientific knowledge much as we would look at folk knowledge.

From Cognitive Anthropology to Cultural Cognition

Studies of "indigenous" systems of environmental knowledge have been at the center of cognitive anthropology as it emerged as a distinct intellectual practice during the second half of the 20th century. They have provided a laboratory in which some of the key concepts and methodologies have been fashioned and tested, partly because the physical sense data that are their referents had a greater fixity than, say, social relationships or other indirectly apprehended phenomena. Work on these forms of knowledge has provided data drawn from ethnographic settings on the capacity of the human mind, and of distributed minds, to store, evaluate, and utilize knowledge of the natural world and the broader environment, aided by language; and has been at the forefront of major theoretical advances, in particular in relation to: (1) the universal shared properties of thought in relation to evolved features, (2) the distributed character of knowledge, (3) the role of situated bodily practice, and (4) the social context of knowledge. It has also been important in (5) redrawing methodologically the boundary between psychology and anthropology. Overall, we might characterize this shift (especially in the context of the emerging enculturation of the mind model of contemporary neuroscience) as one from cognitive anthropology to cultural cognition. In conclusion, it is useful to expand upon each of these themes.

Universals and evolved features

Historically, work on natural kinds has been a major forcing ground for identifying the issues and testing propositions. If the work on cognitive universals has sometimes seemed problematic, the capacity of culture and the mind to continually rediscover the same basic ecological processes, through patterns of causality repeatedly in different cultural settings, seems to demonstrate a place for underlying evolved structures in achieving this, but equally demonstrates that at every stage it relies on and is constrained by local cultural and ecological particularities. Similarly, while drawing on social cognition and models, technological knowledge builds upon a knowledge of the properties of natural species, combined with a knowledge of intuitive physics encoded in other ways: knowledge as a musical score as extemporization; the universality of the experimental method.

Distributed knowledge

There is now recognition that culture has allowed for degrees of complexity in the arrangement of categories that individual brains cannot accommodate. The boundary between shared and individual representations is increasingly difficult to maintain (Sperber 1985), such that personal cognitive organization as well as what is shared culturally becomes a proper focus of anthropological scrutiny (Strauss 1992). Thus, following Sperber (e.g., Sperber and Hirschfeld 2006), Atran and Medin (2008) argue that environmental knowledge comprises causally distributed networks of mental representations and external linguistic, social, and material expressions, about complex distributions of causally connected representations across minds. Their point of departure is the modeling of micro-processes of individual cognition and practice, and from this macro-structural norms and other regularities emerge from decentralized local interactions, in which content is unstable and seldom reliably replicated.

Bodily and situational practice

Cognitive engagement with the physical world involves not only interlection but sensation. Much knowledge relating to the functioning of organisms, or systems of organisms, is unlexicalized and unspoken in traditional populations, part of habitual taken for granted practice. Whereas cognition and perception suggest purely cerebral processes, we now recognize them as complexly "embedded," with the character of what I have elsewhere described as *prehension* (Ellen 2005:27–29), and emphasizing the difficulties of distinguishing mind from matter, thinking from doing or speaking, individual from group, cerebral from social, and natural from cultural. Cognition in this sense is context-dependent, involving the whole person as he or she moves around the world in space and time (e.g., Dougherty and Keller 1982). While it can be accepted that the notion of "embeddedness" is often prone to insufficient specification (Vayda et al. 2004:37–38), we cannot empirically understand cognition without going beyond it to show how mental processes relate to habitual somatic behavior. Increasingly our understanding of cognition is therefore "experientialist" and "embodied" (Lakoff and Johnson 1980:178), relying on a definition of culture that is intrinsically interactive and intersubjective, colonizing the different brains it encounters. All of this echoes Varela et al. (1993:173), who emphasize too how sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition. They argue that "mind and the world together arise in *enaction*, [though] their manner of arising in any particular situation is not arbitrary" (177, emphasis added); while knowledge, located at "the interface between mind, society, and culture, rather than in one or even in all of them … does not preexist in any one place or form but is enacted in particular situations" (179).

Social context

Since so much of what we sense and experience is mediated by social consciousness, and since the boundary between the mundane (technical) and symbolic is often unclear, it has sometimes been difficult, in practice, to know how to divide these two axes: symbolic things are in an important sense practical, and practical classifications of the non-social world often rely on metaphors which are ultimately social, as in the use of the terms *genus* and *family* to organize plants and animals. We therefore anthropomorphize nature through cognitive fluidity, merging and transposing different kinds of thought process. And we all know that many cognitive domains overlap not simply in the way they are used to describe each another, but in their empirical content. One striking example of this is the essential unity and continuity of natural and supernatural, of visible and invisible, forms (see, for example, Boyer 1993).

Most practical technologies, including those involving sophisticated insights about the working of the world, are often embedded in folk-cosmological frameworks. This has often led scientists and other experts to assume that the embedded technical knowledge was valueless. Justifying the importance of such knowledge in the context of development projects is sometimes embarrassing and difficult for anthropologists, since it suggests that effective decisions about, say, choice of an appropriate medication, or where to find game, are influenced by irrational claims. But such frameworks need not necessarily reduce the effectiveness of technical knowledge, and may indeed enhance its utility. Notions of myth and sacredness provide what Atran and Medin (2008) have called "cultural support." Thus, describing a group of trees as sacred provides a powerful positive sanction over behavior related to the extraction of its resources. Even the most abstract and sophisticated scientific knowledge will be situated in some symbolic matrix and associated with ideas that are not in themselves "scientific." My favorite example here (Ellen 2004b:429–430) is of the Micronesian *etak* reported by numerous ethnographers (but see particularly Akimichi 1996), in which various kinds of observations and inferences concerning tides, currents, winds, animal behavior, weather systems, and astronomical movements are integrated and understood with reference to mythical and invisible entities and rationalizations to effect an accurate technology of navigation. Similarly, it has shown how more arcane aspects of biocognition actually relate to practical problems of resource allocation and development, and that Marvin Harris's criticism of ethnoscience as mentalist trivia has not been sustained. It is these kinds of interconnections that have finally undermined the classic notion of "primitive thought" and shown it to be chimerical. Studies of local environmental knowledge among traditional peoples have shown us the ways in which different kinds of knowledge might be constituted in different cognitive practices, and how successive versions of "the great cognitive divide" (as – say – between literacy and non-literacy) need to be much more carefully nuanced before resorting to simple dualist typologies. Indigenous knowledge systems are no different from any other kind of knowledge system in most cognitive respects.

The boundary between psychology and anthropology

Perhaps most importantly, and as empirical knowledge systems have been associated with methodological innovations, Atran and Medin (2008) show how cognitive psychology is severely limited by the dominance of laboratory studies using "standard" populations of unknowledgeable college students, which inevitably fail to capture the significance of cultural variation, and therefore have little to say about "real universals," while ignoring altogether certain basic human processes of categorization and reasoning applied to the conception of biological kinds. Here the authors argue for strong universal evolutionary limits on the organization of biological knowledge as a "learning landscape" shaping the way inferences are generalized from empirical instances or experiences.

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