

Intellectual Imperatives in Ethnobiology

NSF Biocomplexity Workshop Report

Ethnobiology: Definition and Background

Ethnobiology is the scientific study of dynamic relationships among peoples, biota, and environments. Ethnobiology is multidisciplinary; the Ethnobiology Working Group (see insert) includes representatives from systematics, population biology, ecology, mathematical biology, cultural anthropology, ethnography, archaeology, geography, pharmacology, nutrition, conservation, and sustainable development. This diversity in Ethnobiology is our greatest strength, allowing us to focus on complex interactions and dynamic integrations among human and natural systems, enhancing our intellectual merit and broader impacts.

For the NSF Biocomplexity workshop on "Intellectual Imperatives in Ethnobiology," midcareer ethnobiologists met on April 4–6, 2002 at the Missouri Botanical Garden. In order to define and focus Ethnobiology—a popular and thriving field—this Ethnobiology Working Group was formed to review vital aspects of the field: research, methodology, analyses, education, and funding. Since 2002, the group has expanded the discussion to encompass the Society for Economic Botany (NYBG, May 2002 and Arizona, June 2003), the International Society of Ethnobiology (Addis Ababa, September 2002), and the Society of Ethnobiology (Seattle, March 2003). A summary of the workshop is available on the web (www.CEEB.info) including a discussion format and funding registry to further broaden the discussion on Ethnobiology and its intellectual mandates.

Ethnobiology is a rapidly growing field of research, gaining professional, student, and public interest within the U.S. and internationally. There is a pressing need in Ethnobiology to define and focus **research** objectives; to explore modern **methodology** appropriate for studying people-biota-environment interactions; to quantitatively **analyze** our multidisciplinary data based on hypotheses; to develop interdisciplinary **education** programs to train students and practitioners of Ethnobiology; and to obtain academic **funding** sources. To facilitate the growth and maturation of Ethnobiology and to seek academic institutional funding sources, the NSF Ethnobiology workshop addressed research, methodology, analysis, education, and funding. As an immediate result of the workshop, the Ethnobiology Working Group is publishing this Ethnobiology bulletin to focus research, support methodologies, encourage quantitative modeling analyses, structure interdisciplinary education, and solicit funding; in the long-term, we seek to support our developing field of Ethnobiology in research and education with interdisciplinary academic funding.

Research objectives in Ethnobiology are currently changing. In the past, Ethnobiology concentrated on cataloging long lists of plants and animals with their associated preparations and uses. Recently our research objectives have become more process-oriented. For example, we now study the processes of cultivation and domestication, the management of useful plant and animal populations, the process of traditional knowledge acquisition and organization, and so forth. Research on process has reoriented the objectives in Ethnobiology and consequently these objectives require redefinition and clarification.





Methodology in Ethnobiology is becoming more experimental, more technological, and more participatory. Passive observation and informant query are reinforced with experimental biology techniques borrowed from molecular, population, autecological, community, and ecosystem biology. Technology, from the molecular to the global level, is becoming progressively more important in Ethnobiology. Simultaneously, indigenous people are becoming increasingly empowered within Ethnobiology to define research, development, and conservation priorities and to participate in the research and education efforts associated with Ethnobiology. Data from these methodologies must be subject to statistical rigor. These methodological changes are profound and require explicit characterization to facilitate their creative utilization within Ethnobiology.

Analyses of ethnobiological data may be undertaken with current demographic models (of plants, animals, and people), with nonlinear analyses to model combined interdisciplinary data, with bioinformatics to analyze the plethora of molecular data generated by relatively simple evolutionary models of plant or animal domestication, and with many other models and methods. We would like to facilitate interactions between ethnobiologists and their applied math colleagues so that these techniques are put to best use in analyzing interdisciplinary, biocomplex data in Ethnobiology.

Education in Ethnobiology must be interdisciplinary, bridging the natural and social sciences. Interdisciplinary education needs to be developed systematically and with the flexibility to accommodate the interests of individual students and the variable strengths of different programs. Basic educational elements need to be defined, such as organismal biology, cultural anthropology, linguistics, archaeology, comparative methodologies, quantitative skills, and evolutionary and environmental ecology. Training in Ethnobiology for U.S. professionals and international counterparts also needs to be reviewed. Ethnobiological education within a research context needs to be developed so that research is an integral part of all educational approaches.

Funding for Ethnobiology is problematic because the field is interdisciplinary and all too often falls between disciplinary research funding objectives. No one disciplinary panel is willing to take responsibility for such a wide-ranging field of study. In contrast, funding for bioprospecting and conservation has transformed Ethnobiology by rewarding these applied goals. Ultimately, Ethnobiology needs to promote its own academic funding objectives, free of disciplinary, commercial, and other agenda. The production of competitive, academic, interdisciplinary grants will be an outcome of the workshop.

The Ethnobiology workshop is coupled with three society-wide discussions on the same topics: International Society for Ethnobiology, Society of Ethnobiology, and Society for Economic Botany. Thus we combine the focused review of thirty-five midcareer leaders in Ethnobiology with widely advertised and broadly based discussions on priorities in Ethnobiology. GO and NGO representatives including NSF are invited to participate as observers. International research partners from the International Society for Ethnobiology are included through NSF International Program funding. This bulletin defines the intellectual imperatives in Ethnobiology to our members, and also supplies information to develop funding consortia.

Intellectual Imperatives:

Forget the answers, what are the questions?

These are exciting times for Ethnobiology, a rapidly and creatively developing field. As a result, however, research is difficult to characterize. Research themes in Ethnobiology at this stage of rapid expansion and exploration are diverse, multidisciplinary, and multifaceted. To explore recent intellectual developments, we choose several representative subjects that are widely addressed: knowledge systems; medicine, health, and nutrition; ecology, evolution, and systematics; community, landscapes, and global trends; and biocomplexity.

Knowledge systems

Both processes and products of knowledge systems are often explored in Ethnobiology. We study the processes by which knowledge in Ethnobiology is created, acquired, transformed, and transmitted. We consider how this knowledge is codified and what the codification tells us about knowledge itself. Variables in knowledge are investigated including age, gender, and culture. Creative interactions between science and traditional knowledge are a major focus of Ethnobiology.

Medicine, health, and nutrition

Medicine, health, and nutrition, beyond the applied fields, demonstrate complex interactions among people, plants, food, microbes, and environment. In particular, medicinal plants are an active area of research in Ethnobiology. At NSF, Director Rita Colwell's development of Biocomplexity was spurred by her investigations of cholera and the complex interactions among environmental, social, biological, and molecular factors. This is a rich realm for Ethnobiology, a field that is centrally positioned to address these interactive factors. Research topics in Ethnobiology include traditional knowledge and health, nutrition, medicinal plants, the influence of human-environment interactions on health, and zoopharmacognosy—medicinal plant use by animals other than humans.

Ecology, evolution, and systematics

Ecology, evolution, and systematics are traditional concerns in biology and at NSF; however, they seldom account for human dimensions except for negative impacts on "nature" or "artificial selection." Ethnobiology, on the other hand, directly incorporates human interactions in all their elaborate complexity into these traditional fields. We can only illustrate these productive inquiries here: How do human use and management of biodiversity affect ecological processes and patterns? How have human interactions with taxa—from gathering to domestication—influenced evolution and systematics, and what trends or differences are there within and among taxa? In the evolutionary process, how are "natural" and "artificial" selection similar and different? While much of biology barely recognizes the role of humans beyond their influence on disturbance and extinction, ethnobiologists are overwhelmed by the creative interactions among people, biota, and their environments. Certainly, it is past time to take our lessons from positive examples of human mediated biodiversity creation and management.

Landscapes and global trends

Smaller-scale human, biota, and environmental interactions often play out at higher levels of communities, landscapes and global trends. Ethnobiology traces these effects and examines their causes. Plant communities such as tropical rainforests—often assumed to be primary, "pristine," even "virgin"—are now recognized as being significantly influenced by human management. Landscape transformations are dependent on distributions of culture, biota, and environments resulting in surprising patterns: biodiversity is correlated with human cultural diversity. The complex links between human cultures and biodiversity are of great concern to Ethnobiology, with broader impacts on both biodiversity conservation and cultural survival.

Biocomplexity and Ethnobiology

Related to many of these intellectual questions in Ethnobiology is Biocomplexity. What is the relationship between human dimensions of Biocomplexity and Ethnobiology? Traditional knowledge systems are the result of interactions among social, biotic, and environmental components of an ecosystem, and these knowledge systems provide feedback mechanisms between biota and human communities. Human interactions with biotic and environmental systems can alter processes in diverse ways: time scales can be altered or discordant oscillation amplitudes can be modified, and transformations can be found in persistence, recovery, and predictability. All of these modifications can promote nonlinear responses. Social, cultural, and political systems should be included in dynamic ecosystem analyses, but little is understood about the controls that drive these systems.





Methods for Ethnobiology

Early in the development of Ethnobiology, description and collection were the prominent methods of research (e.g., Linnaeus' study of the Lapps). Although this tradition continues today with inventories of useful plants around the world, modern methodology in Ethnobiology is proliferating, with hypothesis testing and quantitative methods dominating the field. A definitive aspect of Ethnobiology is its multidisciplinary nature. Hence, the methods used in Ethnobiology research for gathering and analyzing data are not unique to the discipline, but rather are integrated from biological, social, and linguistic sciences.

Science and traditional knowledge is bridged by Ethnobiology. We are in a privileged position to develop theories based on the views of local or indigenous experts. These people are primary observers of Biocomplexity at the level of local landscapes, communities, and populations, and are intimately acquainted with chemical and genetic variation in edible and medicinal biota. These indigenous insights, which can stimulate important leaps in theory, are based on many aspects of day-to-day life. Examples include new theories on types of ocean currents around islands based on indigenous knowledge of master fisherfolk, knowledge of active ingredients of plants and animals or of the distribution, behavior and life histories of birds, insects, fish, mammals, and reptiles, or episodic disturbance events. This knowledge has developed through gathering, agriculture, hunting or fishing over time scales, which are seldom matched by formally trained field biologists and certainly not by recent generations of laboratory scientists. What ethnobiologists offer, with their ability to work cross-culturally, is indigenous insight on complex questions.

Hypotheses in Ethnobiology emanate from diverse paradigms: cognition, evolution, ecology, anthropology, history, and political science are only a few. Ethnobiology research tests hypotheses about interrelationships among humans, biota, and their natural environment by gathering descriptive and/or experimental data. These hypotheses may then be expressed as mathematical models.

Descriptive methodologies have proliferated for interviewing, collecting, and imaging. A wide variety of structured to nonstructured interviews and participatory research may be used to gather information from participants. Many kinds of materials (molecular, biochemical, organismal, cultural, archaeological, etc.) may be collected, preserved, and studied to gather data for Ethnobiology research. Sound recording and imaging methods play a significant role in Ethnobiology research. Large-scale analyses of landscapes using remote sensing and other spatial techniques expand the range of description.

Experimental techniques in Ethnobiology are no less diverse than paradigms, hypotheses, or descriptive methods. *A priori* experimental design for structured sampling may include description and measurement. Hypotheses of efficiency can be tested through reenactments and replicas of subsistence and food processing techniques. *In vitro* and *in vivo* experiments can test the efficacy of medicinals. Mark/recapture experiments and structured sampling can estimate populations. Multiscale sampling can detect scale-dependent patterns. Common garden experiments and reciprocal transplants can test genetic and environmental influences. Experimental hybridization or selection can test domestication theories. Controlled experimental treatments can test the effects of herbivory, fire, disturbance, soils, and other processes. Experimental techniques in modern Ethnobiology are diverse and the value of experimentation in Ethnobiology increases continually.

Data analyses in Ethnobiology include a wide variety of statistical methods, pattern analyses, and mathematical models often adapted from other fields of study. Methods for designing experiments, collecting data, and performing analyses can integrate information from multiple research areas to create a multidimensional picture of the relationships among people, biota, and their environments on a global scale. Currently, there are efforts to coordinate hypotheses and methodologies among Ethnobiology programs to facilitate global comparisons and generalizations.

Funding Ethnobiology

Ethnobiology encompasses many disciplines and combines them in unique ways. This synthesis, which constitutes our basic strength, is also a disadvantage in that integrations of disciplines are difficult within NSF and other scientific and intellectual funding sources. At present, in order to secure such funding, ethnobiologists must separate their work into components that conform to NSF divisions, programs, and panels. Shifting focus to a particular facet of the study relegates synthesis to a minor role at best. Such requirements hinder the development of the field of Ethnobiology by continually requiring investigators to deconstruct their work. Additionally, the absence of formal recognition of Ethnobiology forces ethnobiologists to seek funding from nontraditional sources, which in many cases distances the proposals from peer review. To the extent this occurs, scientific rigor may suffer, since it is through the peer-review system that NSF strengthens scientific disciplines. Contemporary scientific theory and analyses fail to integrate Ethnobiology and reciprocally, Ethnobiology fails to meet scientific standards of research, and both suffer.

Currently, funding for Ethnobiology comes from governmental agencies such as USDA, USFWS, USGS, OECD, and NIH, as well as NSF. Foundations, nongovernmental organizations, and corporations are also potential sources. However, because these funders each have their own mission and set of objectives, ethnobiologists must emphasize aspects of their work that appeal to the funding source, while neglecting the integration of components. Unless the field of Ethnobiology is recognized as a discipline in itself, its development will continue to be hindered by lack of appropriate funding.

International Research and Collaboration

Ethnobiology aims to understand the complex relationships established between human societies and their environments. It is recognized that most biological and cultural diversity—with associated complex interactive processes between humans and the environment—is found in the tropics and in the developing world. Accordingly, much of Ethnobiology has developed internationally, in countries such as India, Brazil, Mexico, and China, where theoretical and methodological developments parallel those of U.S. and European Ethnobiology. As a result, Ethnobiology could greatly benefit from academic exchange and collaborative research among U.S. ethnobiologists, international ethnobiologists, and traditional peoples. International collaboration should be an important component of Ethnobiology research projects supported by NSF and other funding agencies.

With current globalization leading to erosion of both biological resources and associated traditional knowledge, it is crucial to stimulate Ethnobiology studies. Intercultural and international comparative approaches are necessary to better understand the dynamic evolution of human-environment relationships. Beyond intellectual and theoretical research perspectives, such studies may contribute to the formulation of policies and practices for feasible conservation and sustainable development.

In order to facilitate international cooperation in the field of Ethnobiology, the following factors have to be considered: Cooperative projects must support capacity building and exchange among academics, students, and local experts. Local communities and national institutions must participate in defining research scope, purposes, and activities, in order to ensure that research results will be meaningful to all parties. Researchers and institutions must comply with relevant international and national legislation, as well as local concerns. Special attention should be given to developing just agreements on:

- means for benefit sharing;
- the use of materials, derived products, data, and knowledge collected exclusively for aims previously authorized by the community/association;
- conscientious communication of all research and results to the communities with which research is conducted, unless requested otherwise by a community.

These considerations, inherent in international collaboration, lead us to consider ethical questions in Ethnobiology. Although the National Science Foundation does not specifically request such considerations, ethics are so fundamental to Ethnobiology that the Ethnobiology Working Group is adamant about their inclusion (see insert).



Broader Impacts of Ethnobiology

The focus of this evaluation is on **intellectual and theoretical priorities** in Ethnobiology, because of both NSF's mandate and needs within the field. However, since applied Ethnobiology has been such a potent force within the field and since NSF is increasingly interested in broader impacts of research, in this section we briefly explore the application of Ethnobiology to problem-centered research and its relation to theoretical developments in Biocomplexity. Applied Ethnobiology studies at the interface between ecological, social, cultural, and economic systems may be effective at fast-tracking and testing intellectual, theoretical approaches to Ethnobiology.

For **international collaboration**, application is critical with important ethical and political implications. Application directly affects the ease (or difficulty) with which international collaboration proceeds in developing countries with the bulk of the world's biological and cultural diversity. In third-world countries, collaborating scientists, their institutions, and country representatives favor attention to problem-centered research that addresses local or national priorities.

A focus on problem-centered, applied research does not mean that the development of intellectual and theoretical approaches to Biocomplexity are ignored. On the contrary, Ethnobiologists now have a well developed body of theoretical approaches appropriate for modeling, quantitative analysis, and experimentation. We reject any dichotomy between applied and theoretical Ethnobiology research. Not only does purely theoretical research have unintended applied spin-offs, but applied problems are the ultimate model against which scientists can test and refine **theoretical approaches and conceptual frameworks**.



There is **worldwide interest** and enthusiasm among university students in relevant research that addresses applied problems with a robust theoretical framework; this offers great educational and capacity building opportunities. With the NSF emphasis on education and greater impacts of research, applied Ethnobiology—of relevance to students and the public—is very appealing. Ethnobiology is in a position to link research with the more practically oriented public.

We suggest there are **major opportunities** for bridging applied and theoretical aspects of Ethnobiology research, and we encourage NSF and other funders to develop a broad, creative approach to intellectual imperatives, particularly in Ethnobiology.



Education

Education and outreach are major strengths of modern Ethnobiology. Ethnobiology education is taking place at neighborhood garden clubs and preschools and at international workshops from Mount Kinabalu to Madagascar. Undergraduate, graduate, and teacher training workshops abound, with policy-makers taking advantage of recent Ethnobiology training. Texts and manuals are being published every year, and there is a constant stream of popular nonfiction on Ethnobiology including children's books. The Internet is being used—and can be used more effectively—as a tool to spread information and augment relevant discussion in Ethnobiology. Our current goal is to raise the level of sophistication of our training programs in Ethnobiology for students, the public, and our international colleagues. We consider four relevant and interrelated aspects of Ethnobiology education: public outreach and grades K–12; university education (both undergraduate and graduate level); international education; and the integration of NSF programs and requirements.

Public outreach and grades K–12

Many elementary and secondary schools as well as public institutions such as zoos, botanical gardens, and natural history museums offer Ethnobiology programs, but most communities would benefit from greater collaboration and additional opportunities. These programs could include bringing Ethnobiologists into the schools, taking students out of the classroom and into areas where people interact with plants and animals, and giving teachers additional training to enhance the links between the natural world and the classroom. Children and the public in general are fascinated to learn about the uses of plants and animals; Ethnobiology brings concrete meaning to biology and enhances community involvement.

Higher education

Ethnobotany and Ethnobiology courses are also extraordinarily popular at the university level. There are many recent successes in setting up undergraduate majors, masters' degrees, and even doctoral degree programs. Ethnobiology is also promoted through seminar series and external speaker series, through journal clubs or other student clubs, and through summer field training programs. More training programs for university and secondary school teachers, study abroad programs, and hands-on Ethnobiology initiatives both in and outside the U.S. are strongly recommended. At many universities, ethnobiologists are finding it difficult or impossible to crosscut entrenched academic barriers in establishing formal degree programs, a problem that seems inconsistent with student demand for Ethnobiology courses and field training. Thus, there is a need for graduate students not only to acquire expertise in a core discipline so that they are qualified in a recognized field, but also to be trained with breadth spanning natural and social sciences, appropriate for Ethnobiology.

International training

International training in Ethnobiology brings together people from diverse backgrounds—students, teachers, research colleagues, and local experts such as traditional farmers, hunters, fisherfolk, and medical practitioners. Often participatory research and sometimes para-Ethnobiology training are conducted with local people. Hands-on research experience and analyses are offered. Serious issues include the need for coordination of efforts and increased attention to intellectual property. Training ethnobiologists in-country can raise educational standards, promote cultural appreciation and survival, support biodiversity conservation, and bypass problems of biological and intellectual “piracy.”

Research in Education

For more than a decade, Ethnobiology has been easily incorporating research with broader impacts such as educational and community applications. Ethnobiology is integrating research and public needs for:

- enhancement of teaching, training, and learning;
- inclusion of underrepresented groups;
- improvement of educational infrastructure;
- dissemination of results to policy-makers, industry, media, and the general public;
- benefits to the community and imperatives for society.

Because human values and actions are critical to preservation or degradation of natural resources, ethnobiologists have a key responsibility as educators on all levels.





Workshop Recommendations

We request that NSF and other funding agencies support ethnobiologists in several concerted efforts:

- **Scaling Traditional Ecological Knowledge.** Variable interactions exist among people, biota, and environment across time, space, environment, and culture. In searching for common themes and concerns among a maximum number of ethnobiologists, questions of scaling reappear repeatedly, including time, space, environments, and cultures. We propose a new multidisciplinary, multicultural, and international exploration of Ethnobiology focusing on the detection and effects of scaling. The Millennium Ecosystem Assessment has granted preliminary funding for this objective.
- **Collections of Ethno- and Economic Biology (CEEB).** Natural history collections of ethno- and economic biology research are found throughout the world at museums, botanical gardens, herbaria, zoos, universities, and other research institutions. However, we don't know where these collections are, of what they consist, who uses them, or how they can be used. CEEB need to band together to support, define, access, coordinate and integrate these international collections. NSF collections funding is sought.
- **Workshop on models, methods, and analyses for Ethnobiology.** We recognize that ethnobiologists often employ sophisticated biological models, methods, and analyses developed by other fields with simplistic, hammer-and-saw approaches. Our concentration on immediate problems and goals has delayed the development of mathematical expertise, to the detriment of Ethnobiology. As a field, we need to develop greater quantitative and modeling finesse. We will request funding from NSF and other funders for a workshop to bring together mathematical biologists and ethnobiologists for training and collaboration. Our previous interactions with mathematical biologists at our Biocomplexity workshop were creative and enlightening.
- **Interdisciplinary funding for Ethnobiology.** Ethnobiologists have had difficulties in obtaining disciplinary funding because of the interdisciplinary nature of our field. We recommend that NSF and other funding agencies provide funding for Ethnobiology that can be accessed by various programs for interdisciplinary studies. To implement such a program, we would like to bring together directorate and program leaders who potentially or actively support Ethnobiology to address resolution of structural and academic impediments to funding our field. Participation of appropriate divisions and programs would comprise Biology including systematics, biological surveys and inventories, populations, and ecology; Anthropology including archaeology and cultural anthropology; international programs; and interdisciplinary programs like Biocomplexity and various education and gender initiatives.

We recommend that ethnobiologists begin a worldwide effort to counteract deficiencies in the discipline and to strengthen coordination by focusing on the following:

- Ethnobiology research projects should be **hypothesis driven**.
- Appropriate collaborators should be included to ensure **rigor of methodologies from different disciplines**.
- Appropriate and rigorous **statistical analysis and mathematical modeling** should be used to design data collection and for analysis.
- **To bridge disciplines**, joint meetings of Ethnobiology societies should be organized, interinstitutional organization should be developed, and an umbrella organization contemplated.
- **To bridge science and traditional knowledge**, Ethnobiology needs to present the creative and positive interactions among people, biota, and their environment to major scientific organizations.



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Ethnobiology

Ethical Standards in

When scientists who are located at different institutions choose to conduct collaborative research, they commonly develop a written agreement outlining the elements of the collaboration including responsibilities, potential benefits, intellectual property agreements, and distribution of results. These agreements are usually intended to protect institutional, individual and collective intellectual property that is developed or identified within the context of the collaboration. This is a crucial and complex requirement of research in general, and of Ethnobiology research in particular.

Even the most theoretical, intellectual, and noncommercial Ethnobiology researcher cannot escape the fact that their research impinges on the local people with whom they work. Researchers working with local or traditional peoples are in a position of trust at the interface between cultures. Ethnobiologists therefore find themselves in a position where the research process of gathering and publishing data raises many ethical questions. In some cases, ethnobiological knowledge is only obtained from traditional specialists after the ethnobiologist has established credibility within that community and with the specialists concerned. Detailed information can often only be obtained after an extended period of interaction. Researchers inescapably must earn trust to do their work, as Ethnobiology is not only the study of people and their relationship to the natural world, but also a field of study with local people as colleagues, teachers, and research participants. We consequently enter into "collaborations" in which academic institutions and individual researchers form agreements with modern or customary governments, organizations, local communities, or corporations that secure the value of intellectual property generated by or identified through the collaborative research process. Recognition of the unique intellectual contributions made by international research colleagues and their extended communities is a central theme in the ethical standards and unique perspectives of ethnobiologists. Ethical standards have also been widely recognized by groups of indigenous and local peoples as a necessary component of collaboration.

In the past, research has sometimes been undertaken without the sanction or prior consent of indigenous and traditional peoples, resulting in wrongful expropriation of cultural and intellectual heritage, causing harm to and violation of rights of the affected peoples. The research process also often has failed to build the capacity of traditional communities and collaborating countries. In addition, research findings are often inaccessible to the indigenous/traditional peoples who provided the original data and knowledge, with a lack of benefit-sharing mechanisms for commercial use of such knowledge or research findings. Researchers in Ethnobiology need to actively encourage:

- **recognition of the intellectual contribution** made by local or indigenous communities and specialists—such as herbalists, beekeepers, and master fishers—in the development, identification, and conservation of crop land races, new natural products, and environmental services;
- **equitable distribution of benefits** obtained from the use of their resources (including genetic or chemical structures), to assist local communities and the conservation of biodiversity in their environment;
- **technology transfer, infrastructure development, capacity building, community-based education programs, policy dialogue, and local organizations** to better enable the development of crop varieties and natural products for the benefit of local and indigenous communities.

In response to the problems that can arise in the research process, codes of ethics, professional standards, and research guidelines have been developed by professional societies. These include guidelines for best practice developed by the American Anthropological Association (AAA), American Society of Pharmacognosy (ASP), International Society of Ethnobiology (ISE), Society for Economic Botany (SEB), and Society for Ethnobiology (SE). Specific guidelines have also been developed by regional networks, such as the Manila Declaration developed by natural products chemists from the Asia-Pacific region and indigenous communities. Guidelines for codes of practice and of international agreements are developed; adherence to these codes is pivotal in peer-reviewed evaluation of research efforts.

The need for adherence to these professional standards has also been recognized by the National Institutes of Health (NIH) and in research agreements for the ICBG research program, in which NSF has played a role. This is a critical requirement if collaboration between international and traditional peoples is to take place. In addition, unless research is linked to nationally defined priorities of partner countries and institutions, it is bound to be viewed with suspicion by both scientists and politicians in developing countries. For this reason, even when Ethnobiology research has a theoretical focus, it is important to involve international partner research organizations and communities in the process of developing research objectives, to ensure that these goals address local needs and issues. In addition, research results need to be returned to research partners in an appropriate manner.

Prior to the conclusion of most collaborative research efforts, there are three important procedural steps. Aims, products, and local benefits of the research must be defined with local or indigenous communities so that the overall research will include issues of relevance to the community. The first step is verification of research results among the collaborators; the second step is determination of the final disposition of results (publication) and assignment of collective or individual intellectual property (authorship). Ethnobiologists approach the first step in two ways: international and local colleagues confirm results and review final drafts of documents, and the resulting documents are distributed within the communities in which information has been collected. Typically, special documents are generated that are suitable for local education efforts, are written in local languages, and contain information of interest to local communities, which might be of marginal interest to scientific communities. Approval to publish results is acquired from all knowledge stakeholders and any information that is considered to be sensitive, personal, or socially controversial/derisive is deleted. Intellectual property rights of publications are assigned through coauthorship, major acknowledgments of contributions, or receipt of patents, trademarks, copyrights, or other warrants of value recognized by the international community. In some cases, ethnobiologists may also need to honor local cultural traditions of intellectual property rights management and ownership in ways that may seem to be inconsistent with Western traditions. When in conflict, ethnobiologists are ethically obligated to honor the viewpoints of their host cultures and colleagues above those of their own cultures/institutions.

We therefore recommend that the NSF and other funding agencies follow the lead taken by the NIH in the ICBG proposal format, and redevelop the research application forms to assess whether researchers are taking these ethical requirements into account.

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