



NATURAL PRODUCTS RESEARCH AND BIOPROSPECTING¹

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Abstract

Bioprospecting evolved as researchers discovered medicinal and other uses for natural products of plants and other bioresources. Compared to highly extractive commercial activities like mining, logging, shellcraft industry and illegal fishing, natural products research and bioprospecting, particularly the academic phase, requires miniscule amounts of material. In bioprospecting, biodiversity and conservation are important concerns but intellectual property rights on traditional knowledge and equitable sharing of benefits with the community are equally pressing issues. The University of the Philippines Marine Science Institute has much experience in productive collaborative research on marine natural products, from the time when no regulations were in place up to the enactment and implementation of the Wildlife Act and Indigenous Peoples' Rights Act. Together with the University of the Philippines College of Medicine and the Michigan State University, the University of the Philippines Marine Science Institute is now involved in a biodiversity project on marine and terrestrial bioresources under the International Cooperative Biodiversity Groups programme of Fogarty International Center, United States National Institute of Health. Obtaining the Free and Prior Informed Consent of the Kanawan Aytas and preparing a Memorandum of Agreement has provided valuable experience in the recognition of intellectual property rights and the equitable sharing of benefits with poor communities from the coastal town of Morong, Bataan. As much as possible, benefits to the poor communities are provided early on, before commercial applications are yet in sight. With proper measures, bioresources will be renewable and bioprospecting can become sustainable.

1. Natural Products Research and Bioprospecting

The potent effects of some plants on humans have been observed since ancient times. However, scientific studies on compounds from terrestrial plants in Europe did not start till the mid-1800s. The environmental service from biodiversity was in the form of plants/plant parts gathered for treating human ailments. Taking cues from traditional healers, medical doctors, pharmacists and chemists collected plants from forest gardens and meadows to push the frontiers of science and discover new chemical structures. For example, digitalis, a choice drug in the treatment of congestive heart failure was derived from foxglove, *Digitalis purpurea*, a plant long kept secret by an old woman in Shropshire, England, as a cure for

dropsy (Withering W, Linnean Society of London 1785). The anti-malarial drug quinine (1820) was obtained from *Cinchona* bark used by Peruvian Indians to treat fever, and the muscle relaxant d-tubocurarine (1897) was derived from plant species (genus *Chondodendron* and *Strychnos*) originally used as a potent arrow poison in the Amazon.

As the science developed, the "buyers" of these environmental services evolved from individual researchers and their projects to research programs on natural products established in universities. Thus, the anti-cancer drugs, vincristine and vinblastine, derived from the Madagascar periwinkle, (*Catharanthus roseus*), and steroids, derived from *Discorea* species, were discovered

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Box 1. Biologically active compounds initially isolated from terrestrial plants were small. Unlike sugars, amino acids and fatty acids, these compounds (called natural products) are not in the mainstream of biochemical transformation in organisms. This is why they are also designated as secondary metabolites. In the past decade, the term "natural products" has been extended to include bigger molecules and those of animal and marine origin.

Digitalis: www.csd.tamu.edu/FLORA/Wilson/481/medbot/bot2.htm

d-Tubocurarine:

www.phytomedical.com/Plant/Tubocurarine.asp

Discorea steroids: www.raintree-health.co.uk/cgibin/getpage.pl?plants/dioscorea.html

Vincristine, vinblastine: www.phytomedical.com/

through research programs in the early and mid-20th century. However, programs on natural products were largely abandoned in the late 1970s (Balick et al. 1996). The scientists who persisted gathered plant samples from different parts of the world as they invoked the concept of common heritage.

Natural products research regained momentum in the late 1980s when programs on natural products were again established and the buyers of the environmental service expanded to include research institutes and pharmaceutical companies. The high diversity of plants in tropical forests attracted scientists from the US, Europe, and Japan who were interested in exploring the richness of tropical forests for new medicines. Thus, the term "bioprospecting" was coined. Parallel to this development was the expansion of environmental services of biodiversity to include the use of animals (spiders, frogs, snakes, etc.) and marine organisms (gastropods, sponges, tunicates, corals, marine plants, etc.) as part of a "mining field" for bioactive substances that have potential uses as tools in biomedical research, as possible drugs/pesticides, and as models for developing drugs and pesticides.

Countries rich in bioresources often do not have the needed facilities and financial resources for drug development. In late 1980s, scientists in source countries felt helpless about the undue advantage of those from western countries who collected and brought out samples from these source countries for study abroad. The growing dissatisfaction among disadvantaged scientists was discussed at the Seventh Asian Symposium on Medicinal Plants, Spices and Other Natural Products (ASOMPS 7) held in Manila in February 1992, which was attended by roughly 200 scientists from Asia, Europe, Australia, Africa, and the Americas. A committee drafted the resolution that was approved by ASOMPS 7 participants and referred to as the Manila Declaration of 1992 on "The Ethical Utilization of Asian Biological Resources" (Cruz et al. 1992). In line with the Code of Ethics for Foreign Collectors of Biological Samples and Contract Guidelines, the declaration aimed to protect the rights of communities and researchers in developing countries. This was in preparation for the Convention on Biological Diversity (CBD) and Bioprospecting held later in the same year in Rio de Janeiro.

Box 2. *Cinchona*: Traditional Medicine to Commercial Drug, A Classic Example ñ The source of quinine was believed to have originated from the slopes of the Andes. As early as 1565, European writers have described the use by Indians of a bark for curing disease. The first scientific illustration of the *Cinchona* plant (of fevers) was by La Condamine in 1740. Demand for the bark in Europe increased and Peruvian officials prohibited export of the tree. In the 1860s, British and Dutch adventurers illegally smuggled seedlings out of the country to establish large plantations in Java that supplied almost 95 per cent of the world's requirements for quinine until World War II. Later, seeds from Java plantations were brought back to establish plantations in Central America.

(www.cuencanet.com/ortiz/cinchona.htm)

(sres.anu.edu.au/associated/fpt/nwf/quinine/Quinine.html)

2. The Stewards of Biodiversity

The areas of highest terrestrial biodiversity are mostly found in the ancestral domain of indigenous peoples. For example, the ancestral domains of the 18 communities of Magbukún Aytas cover a major portion of the Bataan National Park (BNP) and the Mariveles National Park (MNP). Recently, the Magbukún Aytas at the Kanawan Reservation filed an application for a Certificate of Ancestral Domain Title (CADT) covering about 10,000ha of land bounded in the north by the Boton River of the Subic Bay Freeport Zone and in the South by the Gantuan River near the Morong-Bagac boundary.

Stewardship of the huge ancestral domain will certainly be a problem for the 290 Kanawan Aytas, considering that lowlanders already occupy several hectares of their 165ha reservation. For the first time, in the summer of 2005, the Aytas complained that the potable water supply flowing to the village via a one-inch pipe from the spring had diminished greatly. They suspected this was due to the pumping out of water from the ground by a group of treasure hunters digging not too far from the reservation. Because of death threats they are now hesitant to stop treasure hunters from operating in the area. In addition, Aytas are helpless against what the farmers refer to as “carabao logging,” rumored to be perpetrated by politicians in cahoots with those tasked to protect the environment.

Conservationists, taxonomists, biologists, and bioprospectors must work together with the stewards of biodiversity in the race against time to prevent species extinction. Education and thorough understanding of the Wildlife Act and IPRA by the community is a prerequisite for sustainable use of bioresources and the safeguarding of indigenous peoples (IP) rights over their ancestral lands/domain. In addition, an active information campaign is necessary to make them understand the concepts of biodiversity, conservation, environmental management and sustainable development. In trying to empower

the indigenous community, the approach should be holistic. It should include preservation of the IP cultural heritage, sustainable means of livelihood, and health improvement in addition to information, education and communication (IEC) campaign.

The Philippines has been identified as a top megadiversity country with a lot to offer in terms of bioprospecting. Unfortunately it is also among the top conservation hotspots of the world. Pressures from a rapidly growing population and such highly extractive activities as mining, logging, and clearing of large tracts of land for agriculture and housing projects continue to reduce what little remains of the country's areas of high terrestrial biodiversity. For sustainable management of bioresources to succeed, every Filipino must consider himself/herself a co-steward of the main stewards: indigenous tribes for the country's terrestrial resources and some IPs and local fishermen for marine resources.

3. Laws/Regulations Governing Bioprospecting

Executive Order (EO) 247 on the use of genetic and biological resources was initially drawn up in 1995 in consultation with key members of the Natural Products Society of the Philippines, in the spirit of the Manila Declaration and the 1992 Rio Declaration. The purpose of EO 247, as stated in Section 1, is to “regulate the prospecting of biological and genetic resources to the end that these resources are protected and conserved, are developed and put to the sustainable use and benefit of the national interest. Further it shall promote the development of local capability in science and technology to achieve technological self reliance in selected areas”. Unfortunately, after consultation with various sectors, the final version placed the Filipino scientists at a disadvantage. EO 247 imposed restrictions on the activities of researchers without providing the necessary support and incentives.

The daunting bureaucracy discouraged most researchers who wanted to carry out studies on natural products. The Inter-Agency Committee on Bio-Genetic Resources (IACBGR) rarely achieved a quorum for its meetings, causing long delays in the applications for academic and commercial research agreements (ARA and CRA). In the implementation of EO 247, only the Marine Science Institute was able to obtain two CRAs for its research with the University of Utah. Under EO 247, the UP System was the only university/research institution that was able to obtain an ARA with the Department of Environment and Natural Resources (DENR), Department of Agriculture (DA) and Department of Science and Technology (DOST) as co-signatories. The ARA allowed UP to grant permits for specimen collection to its researchers who were able to obtain Free and Prior Informed Consent (FPIC) certificates from communities where samples are to be collected.

“Bioprospecting” was defined by EO 247 as “the research collection, and utilization of biological and genetic resources, for the purpose of applying the knowledge derived therefrom for scientific and/or commercial purposes.” Due to complaints by scientists, the IACBGR agreed to have “research and collection activities related to pure conservation work, biodiversity inventory, and taxonomic studies” follow the existing permit system instead of the EO 247 procedures (Benavidez 2004). The traditional uses were likewise not covered by the EO.

The deficiencies and complaints about EO 247 were considered in drafting the bioprospecting provisions of the Wildlife Act (RA 9147) of 2001, which was enacted “to conserve the country’s wildlife resources and their habitats for sustainability.” The provisions of RA 9147 that deal with bioprospecting try to address the issues and concerns raised against EO 247. The big change was in the legal definition of “bioprospecting as research, collection, and utilization of biological and genetic resources for purposes of applying the knowledge derived therefrom solely for

commercial purposes” (Benavidez 2004). Commercial bioprospecting is now covered by a Bioprospecting Undertaking (BU) permit instead of the CRA of EO 247 and requires the payment of much higher fees.

For scientific research, a gratuitous permit, instead of the ARA prescribed in EO 247, covers the collection and utilization of biological resources. The permit is issued after the proponent secures a clearance from the Protected Area Management Board (PAMB) and the prior informed consent of the concerned resource providers, including IPs, Local Government Units (LGUs), private individuals or other agencies with special jurisdiction over the specific area. If the resource provider is an IP community, the National Commission on Indigenous Peoples (NCIP) is mandated to assist the IP community in documenting FPIC and negotiating for benefits as stipulated by Indigenous Peoples Rights Act of 1997 and its implementing rules and regulations.

If the applicant is a foreign entity, the Wildlife Act requires the active involvement of a local institution in the research, collection and, whenever applicable and appropriate, in the technological development of the products derived from the biological and genetic resources. EO 247 requires a CRA instead of an ARA whenever a foreign institute/university is involved—even if the study is purely academic. On the other hand, the Wildlife Act does not automatically classify the endeavor as a commercial bioprospecting undertaking. However, the subsequent transfer of the biological resources and use of research findings for commercial purposes are considered bioprospecting and must follow the requirements for a BU (Joint DENR-DA-PCSD-NCIP Administrative Order (AO) No. 1, Series of 2005). The joint AO of 2005 specifically provides that the development of medicinal plants for traditional or alternative medical use shall be primarily governed by the Traditional and Alternative Medicine Act of 1997.

When scientists realized the implications of IPRA on natural products research, most of them gave up working with IP traditional medicinal plants altogether. For someone who is trying to build a career, going through the preparatory requirements for research work on the traditional plants of IPs is not worth the time, effort, and expense. These short-term locally funded projects are too small to cover expenses for obtaining FPICs. Thus for some natural products, scientists shifted to other fields of research and many worked on materials found outside IP areas. So far the only project that has obtained a FPIC from an IP is the UP-MSU project on Biodiversity and Drug Development in the Philippines, which obtained an FPIC and a Memorandum of Agreement (MOA) co-signed by the tribal council of the Kanawan Aytas, NCIP, UP and MSU in June 2005.

4. Costs of Bioprospecting

Most natural products research in the Philippines is supported by small grants for students and researchers although there are a few programs supported by DOST and foreign agencies. In developed countries, including Singapore, mass screening of plants for biological activities is usually done by big pharmaceutical companies or through highly funded research/discovery programmes in universities and research institutes.

The yield of compounds with interesting biological activity is very low, only 10-30 compounds out of 10,000 screenings. After the initial screening for interesting bioactivities and novelty of compound structure, lead compounds are examined for side effects and toxicity to check if the lead compounds have a good protective index (ratio of toxic dose to dose required to produce the desired effect). The compounds undergo more thorough research and development through animal models and several phases of clinical trials before they can be approved as a drug. The numerous steps in development and the stringent requirements for drug approval result in a very high cost of drug development. The R&D (research and

development) time for drug development (initial screening to commercialization) is usually about 10-20 years, and on average, it costs greater than US\$150 million to develop compounds for human use.

Presumably, the cost will be much less if the drug development starts from a traditional medicinal plant, where “human trials” have been done over hundreds or thousands of years. Nevertheless, the isolation of pure compounds responsible for activity, elucidation of structure, and the pharmacological testing on animal models for toxicity, effectivity and protective index take time. Sometimes the effect of the crude plant extract cannot be reproduced by isolated compounds. Instances have been described where several components isolated from medicinal plants are combined to prevent some of the toxic side effects.

Due to the very high cost of bioprospecting, it is almost impossible for poor countries to develop drugs without foreign collaboration or assistance. Pesticides and feed additives cost much less (US\$10-20M) and require a relatively shorter time to develop but the overall cost is still not affordable as far as developing countries are concerned.

4.1 Bioprospecting Fees under the Joint Guidelines of the Wildlife Act

The screening stage for biological activity, isolation of active components, structure elucidation and verification of activities of pure compounds on cell cultures and whole animals together generally constitute what is referred to as academic research. Pharmacological testing on animal models, delivery systems, and clinical trials comprise R&D toward development of lead compounds into commercial drugs.

Under the 2005 joint guidelines of DENR, DA, Palawan Council for Sustainable Development (PCSD), and NCIP, the bioprospecting fee is US\$3,000 for each BU. In addition, the resource

user is required to pay US\$1,000 per collection site to the resource providers for the duration of the collection period. For Filipino resource users with no foreign collaborators/investors, the bioprospecting fee is ten percent of the assessed amount and for Filipino students doing the research as an academic requirement in a local institution and with no foreign collaborator/investor, the fee is three percent. Once the Filipino researcher/student enters into collaboration and agreement with entities with commercial interests for use of the specimens or research findings, the Filipino is required to pay the balance of 90 or 97 percent.

Under the joint guidelines, royalties shall consist of a minimum of two percent of total global sales of the product made or derived from the collected samples paid annually by the resource user to the national government and resource providers. Of this, 75 per cent goes to the resource provider and 25 per cent to the national government through such relevant agencies as the DENR, DA or the PCSD.

5. UPMSI Experience in Natural Products Research and Bioprospecting

The Marine Science Institute has been involved in natural products research since its establishment as a research institute over 30 years ago. Initial focus was on seaweeds; eventually corals, cone snails, sponges, tunicates, seagrasses and other organisms were also studied. The main areas of research have been seaweeds and corals by N. M. Montaña, cone snails by L. J. Cruz, sponges and tunicates by G. P. Concepcion and P. Aliño.

Research on *Conus* venom started in the early 1970s, well before scientists felt there was a need to regulate exploration of biological materials. Even without regulations in place, *Conus* research became a model for collaboration. Both parties benefited greatly from what turned out to be a very productive project between B M Olivera, a Filipino scientist based in the US, with L. J. Cruz, a scientist

from UP. Support for part of the work done in the Philippines was provided mainly by a USNIH grant although initially the Philippine component had grants from NRCP and the International Foundation for Science. Five PhD students and 16 MS students graduated with theses and dissertations on the biochemistry and molecular biology of cone snails. Numerous publications and many patents co-authored by US and Philippine scientists resulted from the collaboration. The project was cited at ASOMPS 7 as a model for equitable scientific collaboration at a time when foreign scientists collected samples from tropical countries for work done in Western laboratories with minimal participation of scientists from the source countries. The success of the collaboration was perhaps because the counterpart scientist in the US was a Filipino citizen and was concerned with the development of science in the Philippines.

Under EO 247, the case of *Conus* research was controversial because the researchers did not collect samples but instead purchased samples from existing shell gatherers. Central Philippines has a big shellcraft industry and hobbyists who collect shells are also customers of the shell gatherers. In both cases only the shells are used and the animal (soft part) is discarded. *Conus* researchers found a use for the animals that would otherwise be thrown away, and the amount required was very small compared to the shellcraft industry requirements. Nevertheless, after a CRA was obtained by Concepcion, Aliño, and Ireland for research on sponges and tunicates, the *Conus* team (Olivera and Cruz) applied for a CRA. It took five months to obtain the PICs after which there was a lengthy negotiation with the University of Utah about the MOA. The quorum requirement for IACBGR meetings was seldom met and processing of the application took two years before the CRA was granted for the *Conus* project in 2002. In the past year, the project expanded to include gastropods related to *Conus* and work involving participation of other scientists (G. P. Concepcion, P. Aliño, S. Licuanan, E. C. Jimenez, A. D. Santos, V. D. Monje and J. Villanueva) from the Marine

Science Institute, National Institute of Molecular Biology and Biotechnology, and the Institute of Chemistry.

As soon as EO 247 was implemented, Concepcion and Aliño applied for a CRA with Ireland (of the University of Utah) as collaborator under the Cooperative Drug Discovery Program of the USNIH. Prior Informed Consent (PIC) was obtained from several municipalities and after a year of negotiations among parties and several presentations at IACBGR meetings, a CRA was granted for the project in 1997. It was a pioneering effort on the part of the researchers to comply with the new regulations and was the first CRA ever granted by the interagency committee. After expiration of the first CRA, the group applied and obtained a renewal within several months.

The UP system obtained a blanket ARA for its researchers and students in 2002. Under the ARA, UP can grant collection permits to UP researchers who are able to obtain PIC certificates from the communities where biological samples are to be collected.

5.1 Bioprospecting and Rural Communities

The exploratory phase of a grant for the collaborative work of MSU with researchers of UP Manila and UP Diliman on “Biodiversity and Drug Development in the Philippines” provided an opportunity for UPMSI to participate in the USNIH International Cooperative Biodiversity Groups (ICBG) program. The program was concerned with getting the proper permits and consent of the communities at the pilot site, the coastal town of Morong, Bataan. The researchers held presentations at PAMB Bataan and the Sangguniang Bayan of Morong, in addition to holding a general public consultation in the town centre. The project was able to obtain the PIC certificate issued by the mayor of Morong on 15 December 2003, and the endorsement of PAMB Bataan and DENR Region III to collect from the

Bataan National Park on 21 November 2003 and 9 January 2004, respectively.

Over a span of several months, many public consultations and meetings were held with the Aytas at the Kanawan Reservation. According to the National Commission on Indigenous Peoples, the ICBG project’s application for FPIC of the Kanawan Aytas submitted on 2 July 2004, was the first ever received by the NCIP on the study of medicinal plants and bioprospecting. It took numerous meetings with the Aytas of Kanawan, Morong, Bataan, and validation by NCIP representatives before the application was finally approved by NCIP on 17 June 2005. The MOA of UP and MSU with the Kanawan Aytas and NCIP was notarized on 21 June 2005, nearly a year after submission of the FPIC application.

The expense, time, and effort involved in obtaining the FPIC are beyond what most projects could afford, especially if the funding was from local agencies. In a way, those who try to go through the legal process to do research properly are “penalized” with the enormous bureaucracy of the FPIC application. This is unfortunate especially when one hears of foreign researchers who are able to obtain samples illegally or through the Philippine National Museum and the Bureau of Fisheries and Aquatic Resources without requesting FPIC of IPs and other rural communities.

5.2 Benefits to the Community

The current ICBG program involves three main components: Biodiversity and Conservation, Drug Discovery, and Scientific and Community Development. In the proposal submitted last February by the UP-MSU team for the main phase of the Philippine ICBG project, four associate programs were included to address concerns on Bioethics and FPIC (AP1); Medicinal Plant Diversity and Drug Development (AP2); Microbial Diversity and Drug Development (AP3); and International Development (AP4).

The ICBG project was seen as an opportunity to catalyze development of the poor communities in Morong. Should any discovery of the project from marine and terrestrial resources of Morong be commercialized, the relevant communities would have a share of the royalties. However, since drug development takes a very long time, the researchers proposed short- to medium-term benefits for the community through the existing Rural LINC program that was established by the Bataan Center for Innovative Science and Technology, Inc. (BCISTI) and the Center for BioMolecular Science Foundation (CBMSF) to help alleviate poverty in the rural areas. (The goal of Rural LINC is to develop mechanisms to mobilize science and technology resources for direct mitigation of poverty. It aims to generate employment opportunities and to establish sustainable means of livelihood as long-term solutions to poverty and sociopolitical instability in rural areas.)

According to the MOA signed by the Aytas with UP, MSU and NCIP, the short- to medium-term benefits to be provided to the Aytas (through the Rural LINC program) would include contributions toward the following, subject to the availability of project funds:

- Educational assistance for high school students
- Skills training for employment as forest guides and laboratory aides
- Technology transfers for the development of sustainable means of livelihood through the cultivation of medicinal plants, reforestation, agroforestry and beekeeping
- Medical missions and training in nutrition, hygiene and sanitation
- Assistance in capability building and leadership training

- Assistance in the establishment of a multipurpose cooperative
- Assistance in securing a CADT.

To assess impact of the project on the Aytas community, a sociocultural index has been defined and developed in consultation with the Aytas. The index is a composite of four development indicators (cultural integrity, education, income and livelihood, and health), which are weighted according to the Aytas' consensus (Motin et al. 2005).

The ICBG project also provides an opportunity for testing the Four-Helix Model (FHM) that we have proposed in lieu of the academe-industry-government Triple Helix Model (THM) for technology development in western countries. THM has not worked well in the Philippines due to basic community problems in the areas of education, public health, sanitation, nutrition and utilization of natural resources, as well as the lack of basic facilities.

As the fourth helix of FHM, the community is very weak in Morong and most of the Philippines. UPMSI proposes to strengthen the community through empowerment via the holistic approach of Rural LINC. This involves education, culture preservation, elevation of health status, and sustainable means of livelihood. The ICBG project has already contributed much to the empowerment of the Aytas of Kanawan. In response to the request of farmers and fishermen, the ICBG project's social scientist (B Motin) has started assisting them in drafting plans for community development.

IPRA does not specifically state the type of benefits to be provided by the resource user to the resource provider. However, the benefits included in the MOA are in accordance with the framework of the existing Rural LINC program of BCISTI in Morong and in line with the concern of the

project scientist to give as much help as possible to the empowerment of the Ayta community of Kanawan, the resource provider.

5.3 The ICBG Project's Focus on Biodiversity and Conservation

The MOA of UP, MSU, Aytas and NCIP defines specific measures for conservation and protection of the ancestral domain of Kanawan Aytas. Within the scope of available funding, UP, with the help of MSU, will provide the Aytas assistance in the formulation of a sustainable development plan for the Kanawan Negritos Reservation and the ancestral domain. UP volunteers and students of MSI's Civic Welfare Training Service course (CWTS) will participate in the IEC campaign on biodiversity awareness and conservation of natural resources in the watershed area of Morong. To minimize collection of specimens from the wild, propagation and culture of pertinent species will be done whenever applicable. The Aytas will be assisted in reforestation of denuded areas and the agroforestry of relevant species.

MSU, in concert with UP, will be responsible for a survey of the abundance of relevant species prior to collection and for ensuring that collection of plant parts will not endanger the life of any threatened species. Minimal amounts of samples will be collected, particularly for those species that have low abundance in the area.

6. Environmental Impact of Natural Products Research (NPR)

Compared to commercial interests like mining, logging, shellcraft industry and commercial fishing, natural products research (NPR) and academic research phases of bioprospecting require miniscule amounts of material, especially with new developments in technology for separation, chemical characterization, and structure determination. (State-of-the-art

chemical and molecular methods can get by with a milligramme down to nanogrammes or less of purified material.)

Legitimate researchers do a preliminary survey of the plant or animal of interest before starting sample collection and the Wildlife Act prohibits killing of endangered species. The researchers are very much dependent on species availability, and survival of the species under study is a primary concern. Programmes in NPR are necessarily multidisciplinary and include biologists, taxonomists, and experts in culturing organisms to ensure minimal impact of NPR on the environment.

Development and commercialization of promising lead compounds from NPR and bioprospecting will require large amounts of material. When big amounts of the compound are needed for clinical trials and commercial development, the usual strategy is to explore chemical synthesis of the compound and/or cell culture of the source organism. In cases where chemical synthesis of the compound has not yet been achieved and the organism is uncultivable, one can resort to agroforestry for mass production. Whenever collection of large amounts from the wild is required, it is necessary to assess the environmental impact and the corresponding payment for the environmental service. Difficult to assess will be the role of biodiversity in ecosystem resilience and its importance in many processes, such as biogeochemical cycles, hydrological functions, soil protection, crop pollination, pest control, and other environmental services (Myers 1996). With proper measures, the bioresources can be renewable and bioprospecting sustainable.

7. Promoting Biodiversity Conservation and Community Empowerment through Bioprospecting

Bioprospecting can be an excellent mechanism to promote conservation of biodiversity. Since

the success of any endeavor in bioprospecting depends on the variety and number of available species, a legitimate researcher/bioprospector will take measures to ensure survival of species. Obtaining a FPIC from an IP community is seen by most researchers mainly as a bureaucratic hurdle. However, the Marine Science Institute's experience in the process has been a great learning experience and an eye opener. It revealed an urgent need to bridge the big gap between resource providers and buyers. As an academic institution, UPMSI has a huge base for an IEC campaign on biodiversity and conservation. Our Rural LINC programme provides a venue for mobilization of volunteer students and faculty/researchers in a concerted effort toward community empowerment. One of the main concerns of Kanawan Aytas is how to ensure that the Ayta culture is not damaged by development arising from bioprospecting. In consultation with the Aytas, the UP-MSU team developed a sociocultural index to assess impact of the ICBG project on their community. The Institute's activities in Morong, Bataan revolve around the holistic framework of the Rural LINC programme, which involves education, preservation of cultural heritage, health improvement, and establishment of livelihood based on the sustainable utilization of bioresources. In bioprospecting, biodiversity and conservation are important concerns but intellectual property rights covering traditional knowledge and an equitable sharing of benefits with the community are equally pressing issues. Done properly, bioprospecting has the potential to reveal, conserve, and harness nature's wealth for IPs and other communities.

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