ISSN 0115-8848

TRANSACTIONS
of the
NATIONAL ACADEMY OF SCIENCE AND TECHNOLOGY
Philippines

28th NAST Annual Scientific Meeting

"The Century of Biology"

12-13 July 2006

2006
Volume 28
Issue No. 2

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Trans. Natl. Acad. Sci. Tech. Philippines
Vol. 28, No. 2

Published by the National Academy of Science and
Technology Philippines
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28^{th} ANNUAL SCIENTIFIC MEETING

"The Century of Biology"

12-13 July 2006, The Manila Hotel

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PHILIPPINE BIODIVERSITY: ECOLOGICAL ROLES, USES, AND CONSERVATION STATUS

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Abstract

The Philippines has been recognized as having one of the world's megabiodiversity centers for terrestrial and near-shore marine fish fauna. This is due to a number of factors: insular condition providing barriers to faunal and floral dispersal, isolated high mountain areas promoting high levels of endemism as a result of geographic isolation, tropical rain forests providing equable climatic conditions year round, and unique geological origin of islands. The paper deals with species of seed-bearing and non-seed-bearing flowering plants, freshwater and top carnivorous fish, amphibians and reptiles, birds, and terrestrial and marine mammals. The main topics discussed are conservation status at the species level, values and uses of biodiversity, threatened and endangered species, recommendations on their conservation.

Keywords: Biodiversity, endemism, conservation, endangered species

Authors' names are arranged alphabetically; corresponding author

Introduction

The Philippines is one of the biodiversity mega-centers of the world, with many species per unit area of land and sea. But it is also considered as one of the world's biodiversity "hot spots," "which are areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat," according to Myers et al. (2000).

The high species richness of the Philippines is due to a number of factors that together have combined to produce conditions favorable for the evolution of plant and animal species. These factors include the country's location in the humid tropics, the equable climatic conditions year round, the diverse microhabitats for plants, animals and other forms of life, the insular conditions in an archipelagic setting resulting in geographic isolation due to marine barriers, the high tropical mountain areas where high levels of endemism at the species level are to be found the movements of land masses during the past geological ages, and the changes in sea levels during the Pleistocene era. The country is close to a large Asian landmass serving as source for the ancestors of some of its fauna and flora.

Despite the rapid destruction of tropical rain forests in the Philippines during the past 50-60 years, many new species of plants and vertebrates (primarily amphibians and mammals), are still being discovered today, an indication of the limitation in the methods used in distinguishing species as well as inadequate fieldwork in the past.

The number of terrestrial species reported in this paper therefore represents the lower end of the estimates as the numbers of endemic species tend to increase with more fieldwork and wider use of new genetic tools for biological systematics studies. Marine species, because of oceanographic connectivity among marine areas, show low levels of endemism, but this is offset by the sheer large numbers of marine species, such as corals, mollusks, and fishes adapted to various marine microhabitats

This report deals only with flowering plants, land vertebrates (amphibians, reptiles, birds, and mammals), one Family of truly freshwater fish and four Families of top carnivorous fish to demonstrate some aspects of evolution and conservation of these two vertebrate groups. A main gap in this paper is that not one group of invertebrates has been included.

In this paper, we have limited our coverage of Philippine biodiversity mainly to a discussion at the species level and the ecological roles, uses and conservation status of these species.

Each of the seven authors contributed to the paper, but it was the first author's responsibility to select parts of each author's contributions for inclusion in the present paper. However, for purposes of publication, each author was requested to review and revise, as needed, the draft on the taxonomic group he was responsible for.

Philippine Flowering Plants (Gymnosperms and Angiosperms)

Plants are the primary producers and provide the habitat infrastructure for many natural and man-made ecosystems. They are an important source of food for humankind and wildlife species. Plants provide ecosystem stability, ecological goods and services such as clean air, potable water, fertile soils, medical and industrial chemicals, genetic material for biotechnology, etc.

The flowering plants or seed-producing plants are composed of the Gymnosperms (with naked seeds) and the Angiosperms (with seeds in closed vessels or fruits). The first group is the more primitive, consisting of 33 species, of which 6 (18%) are endemic to the Philippines. The Angiosperms consist of about 8,120 species of which 5,800 (71%) are endemic.

There are 18 centers of plant diversity in the country. These are areas of high species richness, of diverse microhabitats for plants, and of high endemism. These centers are found on 10 generally larger islands except for Batan Island and Sibuyan Island. About 88 Conservation Priority Areas for Plants have been identified on the basis of endemism, presence of Endangered species, habitat diversity and degree of exploration.

About 491 (6%) species of gymnosperms and angiosperms are threatened (Vulnerable to Critically Endangered). Of the 45 species of Philippine dipterocarps (Family Dipterocarpaceae) 11 are Critically Endangered, five are Endangered and 12 are Vulnerable (DENR Administrative Order No. 2007-01). Our recent survey of southwestern Negros, where the rain forest has been degraded and fragmented, as in other parts of the country, indicates that of the 17 species of dipterocarps reported from the island, five (29%) may have been lost during the past 50-60 years (Paalan et al. in manuscript).

An exciting area for exploration is the search for plant species for specific purposes. Medical products from some medicinal plants are now being sold as food supplements. Maybe, a search for plant species with potential for bio-fuels is in order.

Philippine Ferns (Pteridophytes)

Ferns or non-seed-bearing vascular plants number about 1,100 species, in 144 genera and 39 families, of which 285 (26%) species are endemic to the Philippines (Barcelona, 2002). These plants are important as food, ornamentals, source of medicinal chemicals, and as materials for handicrafts. Some fern species provide raw materials for attractive handicrafts sold to tourists. The Mangyans of Mindoro, for example, use some species of ferns for their body adornment. For these reasons, it is to our interest to conserve them.

About 49 species of ferns are threatened (Tan et al, 1986; Madulid, 2000). The major causes for this are forest destruction and over-collection (Zamora and Co, 1986; Amoroso et al, 1996). These are very evident in mountain forests with surrounding villages frequently visited by tourists as Mt. Mayon and similar places. Among the fern species that are vulnerable to potentially endangered are the 26 endemic species of tree ferns of the genus *Cyathea* (Madulid, 2000). This fern group is over-harvested for ornamental use; the trunks are used as substrate for growing orchids. *Cyathea* crosiers are collected from Mt. Mayon as Teddy Bears. The other fern species that are over-collected are *Lycopodium* spp. and *Platycerium coronarium* from forests of Quezon province. It is suggested to the users of *Cyathea* trunks to cultivate tree ferns, which thrive at mid-mountain elevations (Buot, 1999; Banaticla and Buot, 2003, 2004, 2005, 2006).

Philippine Freshwater and Marine Fishes

There is only one family of truly freshwater fish in the Philippines—the Family Cyprinidae. George S. Myers wrote a paper titled "The endemic fish-fauna of Lake Lanao and the evolution of higher categories" in 1959. In this paper, Myers discussed what he believed to be an explosive species evolution in four of the five genera of the freshwater fish Family Cyprinidae in the volcanic Lake Lanao, Mindanao Island some 10,000 years ago, an estimate disputed by other scientists. Within the four endemic genera 17 endemic species evolved. The total number of cyprinid species in Lake Lanao was 18. When American and German scientists explored the lake several years later, only few (3-4?) of this species flock of 18 were found. The conclusion was that most of the endemic species had become extinct.

Santos-Borja (in the internet), quoting information from certain authors, stated that the eleotrid *Hypseleotris agilis* and the goby *Ophieleotris agilis* have been introduced into the lake and may have caused the extinction of most of the endemic cyprinid species. Earlier it was suspected that the introduction of a species of goby, *Glossogobius giurus* (along with bangus) have something to do with the disappearance of the cyprinid species (information from Professor D.S. Rabor). Professor Pedro Escudero at Mindanao State University thinks that three species, *Hypseleotris agilis*, *Glossogobius giurus*, and *Glossogobius celebius* are the culprits in the disappearance of most endemic cyprinids based on anecdotal reports of Lake Lanao fishermen. It is possible that the introduction of invasive marine species was one of the reasons for the extinctions, but other factors cannot be discounted as no thorough investigations have been conducted.

Coral reef and reef-associated fishes show a high species richness in the Philippines. Marine biologists estimate that 3,000-4,000 species are found on coral reefs in the Indo-West Pacific region. The Philippines is at the center of marine biodiversity in terms of near-shore fishes Carpenter and Springer (2005). Our studies in central Philippines indicate some 200 conspicuous species on reef transects, of which about 125 species in 34 families are used as food (Alcala and Russ 2002). However, only about a dozen families supply some 90-95% of the biomass of the food fishes caught. Among the highly desired species are those belonging to the 4-5 carnivorous families occupying the top of the food webs on coral reefs. In this paper, we deal only with the top carnivores found on reefs.

The numbers of species in these 4-5 families of reef fish found in pristine reefs prior to our regular monitoring of marine protected areas (MPAs) since the early 1980s are not known. But we can have an idea by looking at the underwater survey results in the Visayan waters for a period of 30 years. A total of 69 species of top carnivores in the four Families (Serranidae, Lutjanidae, Lethrinidae and Carangidae) were recorded in our surveys of protected and unprotected coral reefs in the Visayan waters (SUAKCREM unpubl data). Some of these species are no longer found in some reefs. In several regularly monitored MPAs in the Bohol (Mindanao) Sea about 23 species in the four top carnivore Families have been recorded in marine reserves that were fully protected for 22 years (SUAKCREM unpubl data). In terms of the biomass of these 23 species the trend is exponential, indicating that biomass continues to rise with years of protection. From our monitoring data, top carnivorous fish are the first to disappear under heavy exploitation and the last to recover, requiring decades, not few years.

Philippine Amphibians and Reptiles

Philippine amphibians presently number about 102 species, but will increase in number with the application of the genetic and lineage approaches to systematics. This group comprises the tailless amphibians (frogs and toads) and the legless amphibians (caecilians) but lacks the tailed amphibians (salamanders and newts). The latter are temperate forms that were not able to migrate southward in the course of their evolution. A noteworthy example of the latter is the largest species, the Japanese salamander. In size, Philippine frogs and toads range from several cm to ca 1.5 cm in total length. The smallest species has just been described (see Alcala and Brown 1998) from northern Luzon, *Platymantis pygmaeus*, which is a little larger than the smallest frog in Cuba, with a length of 1.0 cm. Many species of Philippine are colorful, ranging in color from green to brown, to reddish, some with colorful spots.

Philippine amphibians are closely associated with close-canopy tropical rain forests. About 85% are associated with wet forests, being highly dependent on and sensitive to moisture (liquid water, high humidity) and relatively low ambient temperatures. Many frog species are dependent on water bodies for reproduction, but a large proportion reproduces directly from eggs to miniature frogs under wet to moist situations in their microhabitats. These characteristics make amphibians good indicators of climate change. Where they no longer occur indicates lack of moisture, which in turn could be due to climate change.

Estimates of Threatened to Critically Endangered amphibian species range from 28 to 63%, depending on who makes the assessment. This difference in opinion is accounted by the fact that many forest species are Data Deficient (which includes deficient knowledge of their systematics and ecology), making judgment of conservation status difficult. However, one fact stands out: all forest-dwelling species are at least Threatened because of the continuing destruction and degradation of close canopy tropical rain forest, the only type of forest that maintains sufficient moisture essential to the life of amphibians and the existence of their microhabitats. Local communities consume common species of ranid frogs in ricefields and forest streams, and if not regulated exploitation could be a threat to these species. Still another threat is introduction of exotic species like the American bullfrog and the Taiwan frog. The former, a predator on other species of frogs, was introduced in central and northern Luzon in the 1980s and the latter in Los Baños in the 1990s (A. Diesmos, pers comm.).

The reptiles of the Philippines are composed of representatives of all four main reptilian groups, namely, lizards, snakes, turtles, and crocodiles. Exclusive of some 15 species of hydrophiid sea snakes and five species of marine turtles, there are 107 species of lizards, 85 species of snakes, three species of turtles, and two species of crocodiles, a total of 197 species, the majority of which are lizards and snakes. About 75% of the reptile species are tropical rain forest-associated species and, like the amphibians, are highly dependent on forest microhabitats. Therefore their future survival greatly depends on the presence of forests. Reptiles differ somewhat from amphibians in that many species can survive in man-made microhabitats and they can withstand drier areas better than amphibians.

There are no estimates of the numbers of Threatened to Critically Endangered reptiles in the various families except in the crocodile group. The Philippine Crocodile is Critically Endangered, and the only extant populations in the wild are in northern Luzon and the Ligawasan Marsh on Mindanao. Both the Salt-water Crocodile and the Philippine Crocodile are found in private farms and in the crocodile-breeding center in Puerto Princesa, Palawan. The Department of Environment and Natural Resources has failed to accomplish the goal of the breeding program on crocodiles, which is to release to the wild, captive-bred individuals of the Philippine Crocodile and to offer captive-bred individuals of the Salt-water Crocodile to the private sector for commercial purposes. Crocodile conservation and utilization are largely in the hands of the private sector.

The three species of monitor lizards are in need of conservation. The common species, *Varanus salvator*, needs a taxonomic review to determine the species limits of the various populations. The other two are distinct: *Varanus grayi*, a vegetarian, is found on Luzon, and its survival in the future depends on the conservation of the rain forest, where it inhabits large trees. The third species, just described, *Varanus mabitang,* a frugivore, is found only in northwestern Panay and needs more ecological study.

Among the skinks, geckos and snakes, the arboreal and burrowing species, being highly dependent on moisture, would most likely become threatened if forests disappear. Forest degradation and fragmentation in southwestern Negros caused the disappearance of about 20% of the species of amphibians and reptiles during the past 50-60 years (Alcala et al. 2004).

The larger snakes, including the python and the rat snakes, are useful to man because of their food and feeding habits being predators of rodents. Even the cobras and their relations, the sea snakes, are useful in the production of antivenins.

In general, snakes and crocodiles, which are top predators on land, perform important ecosystem functions such as keeping the predator-prey relations balanced, recycling of nutrients between land and freshwaters, etc.

Philippine Birds

There are 576 species of birds reported from the Philippines based on BirdLife International. Of this number, 192 (33%) are endemic. More species are slowly added to the list. For example, seven species have recently been added, including the Calayan rail (*Gallirallus calayensis*). Birds have the lowest endemism among the vertebrate classes in the Philippines. This is not surprising, as birds in general are highly mobile exchanging genetic material among adjacent populations.

Of the 576 species, 124 (21.5%) are considered Near Threatened to Critically Endangered. Two subspecies, the Ticao Tarictic and the Siquijor Hanging Parakeet, are extinct. Two more species, the Sulu Bleeding Heart Pigeon and the Negros Fruit Dove, have not been seen since 1891 and 1953, respectively, and are presumed extinct. With regard to the Negros species, one of us (ACA) was with Professor D.S. Rabor at Pula, Canlaon City (2500 feet above sea levcl) when the only specimen of that species was collected. There were two individuals of the species seen; one was shot with a 12-gauge shotgun but a second shot missed the other. No other specimen of this species has been seen or collected since 1953. However, a negative finding always needs confirmation, as shown by the case of the Cebu Flowerpecker, which was missing between 1901 and 1991, but was rediscovered in 1992.

The major threats to birds are loss of forest habitats and hunting. Some birds require different habitats for specific functions. These habitats are needed to ensure survival. For example, the incubator bird requires forest and beaches to complete their life cycle. Other species such as the top predator, Philippine Eagle, requires large areas of rain forest for foraging in order to maintain its population. Still other species such as hornbills require large trees provided only by intact rain forests in order to breed successfully. Strategies to counter these threats are needed to ensure successful conservation. Some of these strategies are information and educational campaigns and participation of local communities and local government units in the conservation effort.

Philippine Marine and Land Mammals

Philippine marine mammals belong to two orders, Cetacea (whales and dolphins) and Sirenia (dugongs). There are 26 whales and dolphins and one dugong, a total of 27, reported from Philippine marine waters (Dolar and Perrin 1996; Perrin et al. 2002; Dolar 1999; Dolar, pers comm). The toothed whales and dolphins are the most common and abundant species numbering 21. There are five species of baleen whales in Philippine marine waters.

Whales and dolphins as well as dugongs undertake long distance journeys in seas that could be under the jurisdiction of several neighboring countries. Their conservation often requires international agreements. The Philippines through

BFAR prohibits killing of marine mammals under the provisions of Fishery Administrative Orders (e.g. DAO 55 of 1991, which protects dugongs in Philippine waters). However, we all know that implementation is often difficult, and marine mammals, particularly dugongs, are often the victims of blast fishers.

The Irrawaddy Dolphin in Malampaya Sound (a 231 km^2 Protected Seascape since 2000) is the rarest and the most Endangered with only 77 animals remaining (L. Dolar, pers comm). The major threat comes from many kinds of fishing gear (gill nets, liftnets, ring nets, crab traps, shrimp corrals etc.) of fishers in the Sound, who form about 70% of the population of 23,000 people (growth rate 6.67% per annum) living in the vicinity of this body of water. Conservation of this species is extremely difficult, but must be done to allow this species to survive in the future. Aside from this species, all other dolphins are threatened by fishing using various kinds of nets.

The best use of marine mammals is for tourism. This non-consumptive use of marine mammals has proven profitable at Tañon Strait near Bais City, Negros Oriental, Philippines. This way, marine mammals contribute to the economy and are preserved for the future.

Some countries intentionally hunt whales for food, claiming that this fishing activity is part of their culture. Such claims are often difficult to resolve in relation to biodiversity conservation. Apparently, the often-cited case of dugong hunting by Australian aborigines has been resolved to the satisfaction of the aborigines and the Australian government.

Land mammals of the Philippines number 179 species, of which 111 (67.4%) are endemic (Heaney et al. 1998). Among the vertebrate groups discussed here, mammals would seem to rank the highest in terms of new species being discovered. New species of rodents have recently been discovered in sub-montane (mid-mountain) and mossy forests. Lawrence Heaney and his collaborators have documented an interesting food habit of this group, their dependence on earthworms as food.

The IUCN Red List of Threatened Animals shows 22 Endangered and Critically Endangered Species and 27 Vulnerable species. These 49 threatened species represent 27% of the total number of the Philippine land mammal species.

Some species listed under Critically Endangered may be virtually Extinct or almost Extinct. One example is the Visayan Warty Pig, which no longer exists as a distinct species because of hybridization with domestic pigs. Another example is the Negros Bare-backed Fruit Bat, which apparently is represented by only few individuals living in marginal microhabitats (aerial ferns) in small forest fragments in southwestern Negros Island (E. Alcala et al. in manuscript).

Like the rest of the land vertebrates, mammals stand to lose more species with the demise of tropical rain forests because a large proportion of them including the larger ones are closely bound to the forest ecosystem. Large species such as the Spotted Deer, Philippine Crocodile, and Philippine Eagle require large areas of appropriate habitats.

Summary of the Conservation Status of Philippine Biodiversity

The numbers of species shown in Table 1 below are approximate. The total number of land vertebrates is 1,054 distributed in 30 million hectares of land area, but the new systematics using genetic tools would most likely reveal additional new species to total approximately 1,100 species. A similar statement can be made for higher plants. As more fieldwork is conducted, more new species are likely to emerge. The number of Threatened to Critically Endangered species indicated in the table below are rough approximations because of lack of precise information.

Table 1. Summary of the conservation status of Philippine biodiversity

Taxonomic Group	Species Richness	Endemic Species		Threatened to Critically Endangered as of 2006	
		Number of Species	% of Total Number	Number of Species	% of Total Number
Seed Plants	10,524	6,286	59.73	696	16.6
Ferns	1,100	285	26	49	4.5
Fish (cyprinids)	18, ca 4 still existing (?)	17	94.1	4	100
Amphibians	102	76(?)	ca 75	29(?)	Ca 28-63
Reptiles	197	138(?)	ca 70	40(?)	ca 20 (?)
Birds	576	192	33	128	22
Marine Mammals	26	-	-	1	4
Land Mammals	179	111	ca 64	49	27

Strategies for Sustainable Conservation of Philippine Biodiversity

The following strategies are suggested to conserve Philippine biodiversity:

1. Establishment of protected areas
2. Prevention of alien invasive species introductions as well as introductions from one habitat type to another
3. Re-introduction of lost species with adequate safeguards
4. Preservation of remnants of original vegetation such as tropical rain forest, mangroves and beach forests
5. Captive breeding of Critically Endangered species and release to the wild with adequate safeguards
6. Use with adequate controls of wildlife species to earn incomes for local communities
7. Collaboration of local government units and local communities, local people's organizations in management
8. Conduct of information and education on biodiversity conservation
9. Encouragement of local government issuances as policy framework for local participation in conservation

Summary and Conclusions

The Philippines is indeed a country with high species biodiversity and high endemism. But it is also a biodiversity hotspot because of the rapid rate of habitat destruction that would hasten extinction. There is reason to believe that extinction rate is about 20% species loss for every 50-60 years. This figure based on limited data on amphibians and reptiles is slightly lower than that predicted (30+%) for Southeast Asia.

The causes of species extinction are mainly habitat destruction and over-exploitation. Another cause is hybridization with domestic species. This is shown in the case of the Visayan warty pig. Still another cause is competition with alien, invasive species as in the case of the cyprinids of Lake Lanao. Among plants, over-exploitation appears to explain local extinctions of some species of dipterocarps (eg., "lauan").

Because loss of biodiversity has many undesirable socioeconomic and ecological or environmental effects that could lead to ecosystem instability and decreased productivity, it is in the country's interest to conserve its biodiversity. Some strategies to do this are given in this paper.

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Trans. Natl. Acad. Sci. Tech. Philippines 28:215—226 (2006)
ISSN 0115-8848

PHILIPPINE SOCIAL SCIENCE IN THE CENTURY OF BIOLOGY ENGAGING THE BIOLOGICAL DIMENSIONS OF BEHAVIORAL AND SOCIAL PHENOMENA*

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Abstract

My main thesis in the paper is that Philippine social scientists need to engage the biological (i.e., genetic and neurological processes shaped by human evolution) dimensions of behavioral and social phenomenon. In developing this thesis, I first broadly clarify the so-called nature-vs.-nurture debate which pits biological explanations against social and cultural explanations, then proceed to briefly explain contemporary perspectives of evolutionary psychology that recast the nature-vs.-nurture debate. In particular, drawing from examples of recent research and theory, I attempt to show that current theorizing underscores the close interaction between biological and socio-cultural processes, and thus there is no need to construe biological knowledge as antagonistic to socio-cultural theorize. I cite some examples to show how social science theories are improved when biological factors are incorporated in the theories. I then discuss the implications to Philippine social science, and suggest that a small sector of the social science community should explore how the biological dimensions of social and behavioral phenomenon can improve our theorizing. I further suggest that there is a need to re-examine

* The ideas in this paper were culled from the proceedings of two Round Table Discussion entitled, "Biology as Destiny" sponsored by the NAST Social Sciences Division. The ideas from this paper come from many brilliant social scientists (and one honorary social scientist) who participated in these RTDs and who I acknowledge as my co-authors for this paper. They are, in alphabetical order, Eufracio Abaya, Michael Alba, Ledivina Cariño, Gelia Castillo, Mercedes Concepcion, Antonio Contreras, Lourdes Cruz, Raul Fabella, Corazon Raymundo, Agnes Rola, and I would like to especially acknowledge the contributions of Cynthia Rose B. Bautista, Emmanuel de Dios, and Ma. Emma C. D. Liwag. Correspondence regarding this paper may be sent to the author at De La Salle University-Manila, 2401 Taft Avenue, Manila 1004. Email may be sent to bernardoa@dlsu.edu.ph.

how Philippine social scientists construe the biological nature of social beings, as this may influence and even constrain how biological knowledge is engaged in theorizing; and to consider some possible constraints within the social science research process in the country.

Keywords: Behavioral phenomenon, social phenomena. nature vs. nature

The Nature-Vs.-Nurture Debate Is Dead! Or Is It?

Any discussion about any compelling human and social phenomenon inevitably makes reference to the so called, nature-vs.-nurture debate. The debate is particularly remarkable in discussions regarding the perceived lows and highs of Filipino achievement. Why do Filipinos generally perform poorly in mathematics and science? Why can't the Philippine develop enough scientists and engineers? Why do girls consistently out-perform their male counterparts in academic achievement in many schools all over the country? But on the other hand, why are Filipinos apparently so gifted in boxing, billiards, singing, and entertaining? At some point in the discussions of these phenomena, some will make some reference to the possibility that there is something in the "nature" of the person or persons involved. But at some point as well, others might counter this notion with arguments appealing to the effect of parenting, of peers, of media, of the church or some other social or cultural institution, and of course of the individual's own free will. So is it nature or nurture? Filipinos are most likely to say it's both and we continue living our lives, particularly as there are more pressing problems we have to attend to.

Recently, however, a small sector of the Philippine social science community was provoked by their idols National Scientist Gelia Castillo, Academicians Mercedes Concepcion, Ledivina Cariño, and Raul Fabella in a roundtable discussion entitled, "Biology as Destiny" purportedly inspired by the book by psychologist Steve Pinker, 2002, entitled, "*The Blank State: The Modern Denial of Human Nature*." The roundtable discussion, not incidentally, was being undertaken amidst the imposing backdrop of the "Century of Biology." Suddenly, it seemed the nature-vs-nurture debate was alive and maybe even quite fierce.

We are all aware of just how old this debate is in the social sciences. The debate of whether to emphasize the biological as opposed to the cultural aspects of human beings has marked the subdivisions of the discipline of anthropology. Sociologists, psychologists, anthropologists, and even political-economists who have looked at criminality, aggression, corruption, and other grave social phenomena have often taken sides in this debate. In psychology the debate has been particularly salient in theorizing about human growth and development, learning, and psychopathology, among others.

In the Century of Biology, more and more behavioral and social phenomena are being explained with reference to DNA, genes, neurons and neurotransmitters, and neurological architecture and processes that have evolved in the same way as our other biological endowments. It seemed important for Filipino social scientists to locate and position their theories and practice in relation to these scientific discourses.

The Evolutionary Psychology of Human and Social Phenomena: What it is and What it is Not

But what are these contemporary discourses that call our attention to the nature-vs.-nurture debate yet another time? Are these contemporary discourses arguing that evolution and biology can fully account for the full diverse range of behavioral and social phenomena? Is the discourse espousing biological or neurological reductionism, and evolutionary or genetic determinism? Is it now truly "Biology is Destiny?"

A thoughtful review of the relevant scientific research literature suggests that it does seem that much of human behavior can ultimately be explained by referring to neurons, synapses, and neurotransmitters, to genetic characteristics and predispositions, and to neural processes that seemed to have evolved following the same Darwinian principles as our other biological endowments (e.g., Pinker, 2002, Chapter 1). Recent scholarship in the fields of cognitive neuroscience, behavioral genetics, and evolutionary psychology have proposed that such biological principles can explain much if not most of human behavior, including perhaps the most "social" and "personal" of phenomena such as culture (Tooby & Cosmides, 1992), social stratification (Barkow, 1992), morality (Katz, 2000), religious beliefs (Boyer, 1992), consciousness (Nesse & Lloyd, 1992), and abstract and higher order thinking (Cummins, 1998). The availability of such biologically-based explanations does not, however, mean that it is the only important explanation of human behavior. Indeed, there are many other levels of understanding human behavior (such as the cognitive-functional level, the social-cultural level, etc.), which were also just as important. Recent scholarship in the cognitive and behavioral sciences has led to theories that integrate these different levels of explanation. The new theories referred to earlier describe how evolutionary processes resulted in biological constraints that afford psychological processes that effectively exploit, adapt and respond to features of the physical environment, as well as of the various types of social interactions embedded in different cultures. We should be very clear at this point that recent biological theories of human and social phenomenon are not arguing for biological determinism. No serious neuroscientist is asserting that naturally selected genes and hardwired neurological processes solely determine all human behaviors. What these biological factors do is to predispose human beings to think about and act on reality in certain ways — ways that were adaptive in the evolution of the human species, perhaps during the Mesozoic Period. But this biological predisposition interacts with a complex set of other factors to determine behavior. Pinker (2004) suggests that behavior is multiply determined by genes, the anatomy and architecture of the brain, the biochemical states of the brain, the person's family upbringing, how the person was treated by society, and the specific stimuli that confront the person at any given point in time. Pinker (2004), thus, wrote:

> "Environmental interventions — from education and psychotherapy to historical changes in attitudes and political systems – can significantly affect human affairs. Also worth stressing is that genes and environments may interact in the statistician's sense, namely, that the effects of one can be exposed, multiplied, or reversed by the effects of the other, rather than merely summed with them."

However, recent theories of the biological dimensions of behavior and social phenomenon underscore the need to fully appreciate the constraints that biology imposes on behavior. In his book, Pinker (2002) has argued that we should stop denying the biological nature of human and social phenomenon, and instead we should come to terms with how biology actually interacts with social structures and the human will.

Removing the "vs." from Nature-vs.-Nurture

Recent scholarship indicates that the most powerful and fruitful lines of theorizing now seek to determine precisely how biology and social and cultural experiences interact to produce human behaviors and social phenomena. One specific area of study that has generated much new insights as well as controversies is the study of the genetic bases of human traits, such as intelligence and personality. Scientific research now indicates that *all* human behavioral traits are heritable (Turkheimer, 2000). Heritability refers to the proportion of variance in a trait that correlates with genetic difference. The rest of the variance in behavioral traits is explained by what is referred to as the shared environment and the non-shared or unique environment. Shared environment refers to the external environment that impacts on a person and his/her siblings (e.g., parents, home life, immediately community, etc.). Unique environment refers to anything in the external environment that impacts on one person but not his/her siblings (e.g. specific relationship with parents, presence of other siblings, experiences with peers, and unique experiences like getting sick or meeting an accident, etc.). The most authoritative measures indicate that the genes account for about 40-50% of the variance in many behavioral traits, while the shared environment accounts for 0-10%, and the unique environment accounts for about 50% of the variance (Bouchard, 1994; Plomin & Daniels, 1987; Rowe, 1994; Turkheimer, 2000; Turkheimer & Waldron, 2000).

Note that even if the supposed influence of the shared environment is weak, we find very compelling examples of the interaction between genes and the shared environment. For instance, studies (e.g., Rowe, 1994; Rutter, 1997) indicate that "[c]hildren who grow up in the same home tend to resemble each other in their vulnerability to delinquency, regardless of how closely related they are" (Pinker, 2002, p. 392). Gottfredson and Hirschi's (1990) study of adopted children in Denmark revealed that biological children of convicted criminals were more susceptible to criminal behaviors compared to biological children of law-abiding citizens — which shows the effect of genes. But this susceptibility to criminal behavior is significantly increased if the biological children of the criminals were adopted by parents who were also criminals and who lived in a large city — which shows the interactive effects of the high-crime social environment.

There are also many gratifying lines of research that show the complex interaction between social psychological phenomenon that are now known to be shaped by biological evolution and cultural environments. One social phenomenon that has been explained using evolutionary theory is social sharing. Kameda et al. (2003) have demonstrated that social sharing is an evolved human response when resources are uncertain. In cross-cultural experiments, Kameda et al. (2003) demonstrated that sharing was a more profitable and stable compared to other ways of distributing resources. However, the studies also demonstrated that cultural factors may also amplify or suppress the evolved disposition to share. For example, people in higher social class contexts are less likely to share unexpected gains, whereas those in lower social class contexts are more likely to do so.

The social phenomenon of mate selection is one of the most well researched areas in evolutionary psychology. Extensive empirical research (Buss, 1998; Buss & Schmitt, 1993; Kenrick & Keefe, 1992; Kenrick et al., 1996) has supported the evolutionary theory prediction that older men are usually attracted to younger women because they are more likely to produce more and healthier children. In contrast, younger women prefer older men because they have more power and resources to endow their children. But in some cultures like the Tiwi of Australia, it is common for young men to marry older women. This is explained by referring to the interaction between culture and evolutionary predispositions. Tiwi men have several wives and all women have to be married all the time. The richer older men marry the youngest women leaving the older widows to the poorer younger men (Kenrick et al., 2003).

These are just a few among the growing number of scientific studies revealing the intricate interaction between nature and nurture (see e.g., Moffit et al., 2006, Nettle, 2006, for more discussion). Understanding the important role of the biological nature of humans and the evolutionary bases of many social phenomena does not imply denying the important effects of social and cultural experiences. Indeed, the emergent scientific theories shown in these few examples are not just biological theories, nor are they purely social theories (see e.g, Cacioppo et al., 2000; Gottesman, 2001; Ochsner et al., 2001; Plomin & Crabbe, 2000). The emergent explanations of social phenomena truly embody the integrated processes that shape behavioral and social phenomena.

Implications for Philippines Social Science: Revising Assumptions about Human Nature in Social Science Theories

In this regard, I think that the more important ideas posed by this line of scholarship on the roles of biological constraints and socio-cultural processes in shaping human and social phenomenon relate to how Filipino behavioral and social scientists do our theorizing. And perhaps, also to how our theorizing relates to social discourses and processes, particularly those outside the academe.

It could be argued that social science theory and research in other countries improved in specific ways when more scientific accounts about the genetic and neurobiological dimensions of humans and the evolutionary basis of behavioral and social phenomena were taken into consideration. In the field of economics, De Dios (2006) noted how assumptions of evolutionary psychology that relate to the human predisposition to reciprocity and cooperation can correct the limitations in the core assumptions of game-theory, particularly as they apply to non-cooperative games. Apparently, the prediction of evolutionary theory that human beings would cooperate under certain conditions of reciprocity can better explain actual data on how people behave in non-cooperative game situations (Fehr et al., 2002; Fehr & Schmidt, 1999), compared to theories that assume that humans would act on the basis of calculated, wealth-maximizing, self-interest. De Dios (2006) further notes how some traditional assumptions about the rationality of human being in economic decision making are actually false; instead, humans think and make decisions based on heuristic strategies that are proposed to be biological adaptations that server evolutionary goals (Gigerenzer & Selten, 2001; Kahneman & Tversky, 1984; Tversky & Kahneman, 1974).

In the field of psychology, theory and practice has greatly improved when scholars and professionals began acknowledging the important neurobiological constraints that underlie many problematic psychological phenomena. For example, an improved understanding of the interactions between genetic risks and environmental risks in psychopathology has resulted in more rational and effective forms of prevention and intervention for many times of psychological disorders (Gottesman, 2001; Moffitt et al., 2006; Neese, 2000; Siegert & Ward, 2002). Recent discoveries related to the continued development of the human brain during the adolescent years (Casey et al., 2000) has also helped psychologists better understand the heightened variability in cognitive development among teenagers, particularly in various areas of reasoning and decision-making (Klaczynski, 2004). More important, research in the field of adolescent cognitive development has shown how the adolescent experiences' and the activities that the teenager engages shape the brain development processes (Kuhn, 2006; Luna et al., 2004).

Similar theoretical and scholarly advancements have been achieved in specific fields such as medical anthropology and demography, where knowledge related to the biological nature of human beings are wedded with personal, social, cultural, and historical constructs.

But what about social science theorizing in the Philippines? My colleagues in sociology (Cynthia Bautista) and political science (Antonio Contreras) noted that the biological dimensions of human nature and of social life has not been problematized in the main streams or threads of social science discourse in recent and not-so-recent history (e.g., theoretical Marxism, structural functionalism, social constructivism, post-structuralism, feminism, post-colonialism, post-modernism to name a few). The various big-theories have some minor presuppositions about biology, but these suppositions are never in the foreground (perhaps with some exceptions in some subfields within anthropology, demography, and psychology).

Is there anything wrong with this? My immediate answer is no. There is so much rich insight that can be drawn from the proper and intelligent use of personal, social, political, and historical constructs and modes of analysis used by thoughtful Filipino social scientists. The lack of references to biology should not limit the useful insights that Filipino social scientists can generate. Indeed, as can be gleaned from various treatises, many of the exciting evolutionary theories of human behavior actually draw from studies of linguists, anthropologists, sociologists, psychologists, and economists who hardly think of the neurobiological dimensions of anything. And thus, I think that the Philippine social science community can grow and thrive as long as thoughtful Filipino social scientists continue to properly and intelligently use social science constructs and analysis.

However, advocates of evolutionary psychology take a very strong position that I think is worth considering. Pinker (2002) for one, argues that by ignoring or neglecting the neurobiological or evolutionary constraints in human and social phenomenon, social and behavioral scientists may be posing theories that are not properly grounded or bounded. Denying the biological constraints and/or affordances of social and cultural phenomenon is an act of gross misrepresentation, just as saying that biology is destiny is another act of gross misrepresentation. One challenge for Filipino social scientists, therefore, might be to determine how to properly engage the biological (i.e., genetic and evolutionary) theories of behavioral and social phenomena. In doing so, it would be important to avoid knee-jerk responses that take extreme and totalizing positions (e.g., that biology is destiny on the one hand or that this thread of scientific discourse has a strong underlying conservative ideological agenda). Indeed, Filipino social scientists should be mindful that totalizing theoretical positions regarding both nature and nurture have been used to justify genocide (i.e., by Hitler, Lenin, Stalin, Mao, Pol Pot). Filipino social scientists should be careful about ignoring the ethical implications of any form of scholarly discourse. Pinker (2002), noted that all core assumptions of the standard social science models carry their respective moral burdens in the same token that application of biological and evolutionary theories also entails ethical dilemmas. Thus, we should warn against unnecessarily privileging either biology or social and cultural life in our attempts to appropriate these threads of scientific and scholarly discourse in understanding and transforming the personal, social, and cultural experiences of Filipinos.

In this regard, it might be important for Filipino social scientists to clarify their own conceptions about the role of biology or the biological nature of humans in their own theorizing. Is biology our destiny? Or does biology define the limits of human and social achievement? In our second roundtable discussion on this topic, National Scientist Gelia Castillo lamented the recent trend to use the expression, "*Pasensiya na, tao lang*" apparently as a flippant excuse for various forms of shortcomings. A social psychologist colleague reminded me that a more benign version of the expression is found in the old romantic ballad, "*Sapagkat kami ay tao lamang*" where again human nature is used as the defense for inappropriate intimate relations. It seems that in popular social discourse, there is the implicit notion that human nature is flawed and that this flawed nature may be used to justify mistakes, poor performance, even misdemeanors and transgressions. But Academician Lourdes Cruz reminded us that for the biochemist, genes define the human potential that can be fully realized in appropriate environments. Thus, the biological nature of humans is a definition of possibility, potentiality, and workability. This view resonates with the Confucian tenet on the perfectibility of all human beings, which underlies the moral notions of self-cultivation and self-improvement in Chinese or Confucian-heritage cultures.

I use these examples to illustrate how some fundamental ideas about the theoretical, social, and practical nature of human nature can have some influence on how Filipino social scientists might want to engage and appropriate biological theories, principles and concepts in social science theory and practice.

But we can raise another concern about how to go about engaging the biological dimensions of behavior and social life in Philippine social science. In our first roundtable discussion, psychologist Emy Liwag raised concern about the prospect that Filipino social scientists will just read and talk about evolutionary, biological and genetic theories of behavior and social phenomenon instead of actually doing research and theorizing about the same. She noted that there are very rare opportunities for Filipino social scientists to engage natural scientists in theoretical and scholarly discussions, much less engage in multidisciplinary research of the same level of sophistication as exemplified in the recent scholarship we have been referring to. Perhaps a greater source of concern should be the research environment within which Filipino social scientist undertake their scholarship. Most Philippine universities do not have substantial financial resources for research that would allow social scientists to undertake long-term research programs that would permit more sophisticated theorizing. Instead, university-based social scientists have to contend with short-term research grants that only allow for diminutive theoretical advancements. Alternatively, they can undertake research projects funded by national and international development agencies but doing so would require adopting the agencies' theoretical and ideological positions in the research approach. Social scientists in the Philippines will need to demonstrate extraordinary levels of creativity to thrive in these less than ideal research environments.

Conclusion

Perhaps the strongest motivation for Filipino social scientists is the desire to see change in a social order that is perceived to be unjust and backward. The work of social change or societal transformation inevitably presupposes certain theoretical propositions regarding human nature and the constitution of social life. There is a growing body of evidence pointing to neurobiological constraints and affordances to behavior and social phenomena, and some related ideas and evidence may undermine certain core assumptions of traditional models in the social and behavioral sciences. Filipino social scientists do not necessarily have to incorporate these neurobiological and evolutionary discourses in their scholarship and practice. Filipino social science can continue to make contributions to human knowledge and Philippine society by drawing from the standard constructs and methods of the traditional social sciences. But there is probably a need for a sector of the Filipino social science community to reexamine these standard social science assumptions in light of these evidences. Doing so would require engaging a strange discourse, but it could point to more fruitful line of theorizing about social and behavioral phenomenon, and might even lead to more realistic interventions for social and behavioral change. Indeed, the most exciting prospects for change would take full recognition of the biological constraints in behavior and the interventions are designed to help transcend, rise above, and even thrive amidst these constraints.

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Trans. Natl. Acad. Sci. & Tech. Philippines 29: 177-196 (2007)
ISSN 0115-8848

Building a Science Culture in the Philippines

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Introduction

I am grateful that the topic of my talk is "Building a Science Culture" and not "Improving Math and Science Education in the Country." This talk of mine went through several versions. Eventually, I realized that I needed to emphasize

"Culture"

as much as or even more than "Science" if I were to help us make progress on the theme of our Annual Scientific Meeting: "**A Progressive Philippines Anchored on Science: Building a Science Culture in the Philippines**".

You have heard enough about our situation in science and mathematics education, that we rank number 36 out of 39 in the TIMSS, that performance on the National Achievement Test (NAT) is below 50% in so many schools and school divisions and so on. The following slides from the presentation of Dr. Vivien Talisayon during the roundtable discussion last February 16, 2007, "Special Science Classes: Summary of Findings" show that even Philippine Science High School (PSHS), our top science high school, performs only at the mean of Singapore, Korea and Hong Kong in mathematics and significantly below the mean in science (Figures 1 and 2).

At the same time, we hear good news: our young people winning prestigious competitions abroad in science and mathematics. We will hear about the work of the Bernidos in Bohol. At the roundtable discussion last February 16, 2007, we were inspired by the work of the Mathematics Trainers' Guild (MTG) and the outstanding achievements of the students in their training programs.

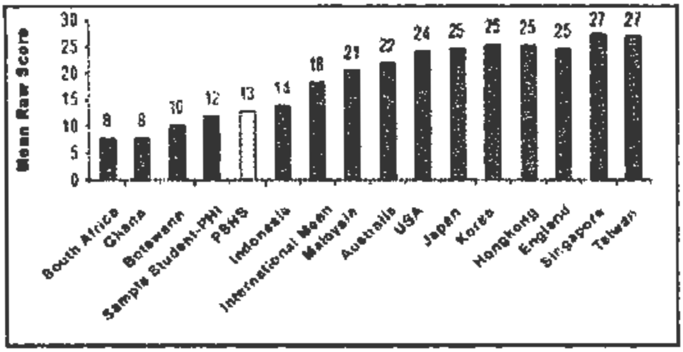

Fig. 1. Mean raw score in Science of PSHS vs sample students of Phil and selected countries.

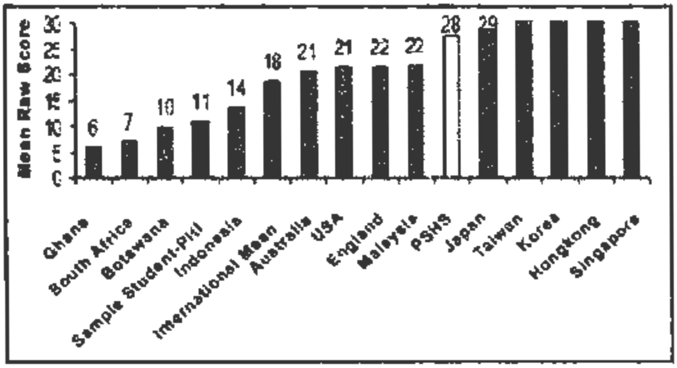

Fig. 2. Mean raw score in Mathematics of PSHS vs. sample students of Phil and selected countries.

We have been at this for a long time. There have been many interventions: the New Math of the 1960s, the Secondary Education Development Project (SEDP), the DOST – DECS Engineering and Science Education Project (ESEP) and the recent Revised Basic Education Curriculum (RBEC). There have been many conferences like ours and many resolutions such as we have been making in our scientific meetings, addressed to DOST, DepEd, CHED and other institutions.

But the same pattern emerges --- a few bright lights and victories and a mass of poor performance. While we are proud of the bright lights and victories, I would like to recall a quote from a Japanese mathematics education colleague, who said, "We believe that a country can only march as fast as its slower members."

The Philippines will march as fast as the majority of our students and not at the pace of the few at the top.

The challenge for us then is to ask how we can make progress for

the majority of our students.

Part I: Defining a Solution

This address is on "Building a Science Culture". The culture of the natural sciences and mathematics is not to bewail or just describe a problem, but to solve them. If we are to be scientific ourselves in approaching the theme of our annual meeting, it is not enough for us to describe the problems or write resolutions about them. We should actually engage the problems and show that we are contributing to solving them. We have to engage Philippine culture and move it into a problem-solving mode, away from a blaming or complaining mode.

Assuming then that we are going to actually engage and help solve the problem, how do we proceed? Particularly, because years of effort and frustration have shown us that the problem is very difficult!

We have to begin by defining what we mean by a solution. Frequently, in research on mathematics and science education (or education, in general), the methodology is to propose an approach towards improving performance, then do a small scale pilot study, which normally shows that the approach works. The approach is then attempted on a larger scale and usually fails. The conclusion is usually to blame the teachers or the principals. But from our point of view of building a progressive Philippines anchored on science, the approach has to be considered a failure. It did not solve the intended problem of improving science or math education on a reasonable scale.

Since our goal is to improve mathematics and science education for the majority, a solution or a possible solution should have the following characteristics:

- be on a reasonable scale, at least a cluster of schools
- can be replicated successfully within normal parameters in the system (including the actual situation of teachers and principals)

Part II : The Way Forward on the Mass (Some Relative Success Stories)

In this address, I would like to share some relative success stories on a relatively large scale. I shall use as a framework a paper I wrote in 1983 for a conference in Japan.

Addressing the Social Context of Philippine Schools: Macro-Problems and Micro-Problems

After a decade of working on math education, I shared my reflections in a 1983 paper for a Regional Conference on Mathematics Education held in Japan:

> "We can classify problems of mathematical education into two types: the first we might call micro-problems or problems internal to mathematical education. These would relate to questions of curriculum, teacher training, textbooks, use of calculators, problem-solving and the like. The second we might call macro-problems. These are problems affecting mathematics education because of pressures from other sectors of society: economy, politics, culture, language, etc. One of the features of a developed society is a reasonable differentiation of sectors and functions of society. While given sectors are, of course, interdependent and affect one another, they also have some reasonable autonomy. School budgets may increase or decrease, but they have some stability and so it is possible to plan. Teachers get a sufficient (though not high) salary so they can concentrate on their teaching chores. But in contrast, structures in developing societies are not sufficiently developed to provide (for example) education and culture with sufficient freedom from the pressures of politics and economics. Teachers may be called upon to perform many civic duties - - to the detriment of their classroom work. Their salaries may not be sufficient for them to be able to concentrate on their work. Budgets may be unstable and information and opinion tightly controlled.
>
> In the first situation (of developed countries), it makes sense to concentrate on internal problems of mathematical education. One has enough scope and freedom within the educational system to study and plan changes with hope of implementation. In the second case, however, the problems which one experiences most intensely are not internal to mathematics education, but due to pressures

> from outside society. Until some structures are established to provide some scope and freedom for the educational system, it is less useful to concentrate studies and plans on curriculum or other internal concerns."

I then went through a more detailed analysis of the challenges of mathematics education from this perspective. In that same paper, I concluded as follows:

> "The improvement of mathematics education in developing countries such as those of Southeast Asia requires continuing improvement of teacher — training, curriculum, textbooks (the internal concerns of mathematical education). However, their improvement is only possible if mathematical education has enough space and freedom (within the pressures of economics, culture, organization of education) so as to be able to plan and implement. It is the experience of developing countries that pressures from other structures of society (economic, political, cultural) are often too strong for the system of mathematics education to work realistically on its internal concerns."

From the experiences that will be described below, we can look at this approach to improving education in the social context of Philippine schools as:

- Creating the absorptive capacity of schools and clusters of schools to take in and implement significant reform and improvement (attending to the macro problems)
- Targeted and focused interventions to address priority needs (academic and non-academic) (attending to the micro-problems). This means meeting the schools where they are, setting next level targets with them, and moving them to the next level.

Part IIa: School-Based Management in TEEP

Our first example of a large scale reform project that tackled the macro-problems (created absorptive capacity in the school and community) and micro-problems (teacher-training, textbooks, lesson guides, etc.) is the Third Elementary Education Project (TEEP).

Engaging the community and creating absorptive capacity and bringing in targeted inputs. The Third Elementary Education Project defines school-based management (SBM) as the decentralization of decision-making authority from central, regional, and division levels to individual school sites, uniting school heads, teachers, students as well as parents, the local government units and the community in promoting effective schools. Its main goal is to improve school performance and student achievement, where decision-making is made by all those who are closely involved with resolving the challenges of the individual schools so that the specific needs of the students will be served more effectively. Its objectives were to empower the school heads to provide leadership and to mobilize the community as well as local government units to invest time, money and effort in making the school a better place to learn, thus improving the educational achievement of the children.

School-Based Management is a framework that integrates several micro factors at play in SBM schools, namely,

- leadership (e.g. dynamic school heads)
- strong local government unit (LGU)-school or school-Parent Teachers Community Association (PTCA) partnership
- access to basic inputs like classrooms and textbooks
- focused teacher-competency development/INSETs (In-Service Training)
- support system at the district/division levels

The community has to be involved and TEEP would not proceed in a given community unless the community raised 10% counterpart funding. This would amount to about P10,000.00. There is a very touching story in Romblon. A community wanted so badly to get a School Improvement and Innovation Fund for their school (this was the overall name of the project support fund) that they each contributed funds from their own meager incomes. Their contribution was mostly in coins. Unfortunately, after counting all the coins on the deadline for approving projects, they had only P9,000 of the expected P10,000. The district supervisor was so moved by the community efforts that she gave the remaining money.

Impact. For the TEEP schools, school-based management has resulted in a bigger share of schools crossing the 75% mastery level and the 60% near-mastery level in the National Achievement Test. TEEP and non-TEEP schools started on the same level in SY 2002–2003 but relatively more TEEP schools attained mastery level in SY 2005–2006. Please refer to Appendix 1 for the comparator groups as well as the tables showing the percent surpassing the 75% mastery level as well as the 60% mastery level, in terms of overall performance as well as specific performance in Math and Science.

It is worth noting the following:

1. With the exception of Aklan+, all clusters experienced a decline in scores and rankings from SY2004–2005 to SY2005–2006. Nevertheless, TEEP SBM provinces sustained their lead relative to all other clusters (cf. Appendix1).

2. There is a relatively stronger improvement in mathematics: 22.6% 9 ELS and 18.2 Non-ELS achieving 75% mastery level, all others are lower, with Pampanga closest at 16.6%. At 60% mastery level, the performance gap is even clearer, with TEEP ELS at 59.5% and non-ELS at 46.3% (cf. Appendix 1).

3. The improvement in mathematics is much stronger compared to improvement in science (cf. Appendix 1).

The importance of addressing the implemented curriculum, the day-to-day work of teachers. What accounts for the significant improvement in mathematics? I received a phone call in August last year from Dr. Cynthia Bautista, excited about some results of their end-project evaluation of the Third Elementary Education Project. There had been significantly greater improvement in mathematics in the National Achievement Test (NAT) in several divisions of the TEEP. The resource persons in the study conducted by the Japan Bank for International Cooperation (JBIC), "Lessons from the Third Elementary Education Project: Transforming Education on the Ground" attributed the very good performance of TEEP in Mathematics "to the Math Teachers' Lesson Guide series prepared by DepEd and Ateneo which TEEP printed and distributed to all its teachers. Written by Master teachers in elementary and high school, the series drew from existing textbooks and improved on them.

Tables 1 and 2 show the scores in Mathematics and Science in the National Achievement Test of the TEEP schools and the comparator groups.

Table 1. Scores in Math in the National Achievement Test of the TEEP Schools and comparators group.

	Math			
	2002/3	2003/4	2004/5	2005/6
TEEP SBM	46.1	54.1	62.0	59.0
AKLAN+	49.9	52.0	58.2	56.4
CAGAYAN+	46.6	51.2	57.1	53.1
ILOILO+	42.1	47.5	54.6	49.7
PAMPANGA+	46.9	55.1	61.3	56.2
NCR	42.0	50.7	60.5	47.7
ARMM	38.4	44.1	44.5	41.8
Total	46.0	52.3	58.9	54.7

Table 2. Scores in Science in the National Achievement Test of the TEEP Schools and comparators group.

	Science			
	2002/3	2003/4	2004/5	2005/6
TEEP SBM	47.1	50.0	60.4	50.2
AKLAN+	46.7	47.5	58.2	49.1
CAGAYAN+	44.4	46.8	55.7	45.3
ILOILO+	41.3	44.4	54.5	44.7
PAMPANGA+	45.0	50.2	60.5	48.2
NCR	42.0	43.2	47.9	43.1
ARMM	40.5	40.2	46.7	37.2
Total	44.4	48.1	58.0	47.1

What are these Lesson Guides? The Lesson Guides in Mathematics were prepared during the term of former DepEd Secretary Raul Roco. He invited us to a meeting in July 2001 to discuss what might be done to improve the performance of students in the different subject areas. We shared with Secretary Roco that the central problems continue to be the lack of teachers, need for teacher-training, lack of textbooks, classrooms and other basic needs.

We then suggested that considering the situation in public schools, e.g.,

- congested classrooms (65 - 70 class size in urban areas)
- lack of textbooks

- lack of library facilities or library materials for teachers
- absence of experts teachers may consult,

the need is to provide textbooks for students and a self-contained reference material (guide) for teachers.

The DepEd was able to provide Math textbooks for all high school students (1:1 ratio) during the time of former Secretary Roco. The series that was reproduced for all students was the only complete series available. Moving from the previous SEDP approach (spiral approach) to the discipline based approach (Elementary Algebra – 1st year, Intermediate Algebra – 2nd year, Geometry – 3rd year and Advanced Algebra and Trigonometry – 4th year), meant literally tearing apart the existing books and putting together the algebra parts, the geometry parts, and so on. (Later on, we realized how much improvement is necessary for the Geometry part. The deficiencies in Geometry were not very evident in the SEDP spiral curriculum.)

This move could not be done for the elementary level since no complete textbook series from Grade 1 to Grade 6 was available.

The Lesson Guides prepared by DepEd and Ateneo were designed to help the teachers in their day-to-day teaching. Each Lesson Guide included:

- objectives for the lesson
- development of the lesson
- suggested examples and exercises
- suggested teaching strategies with provisions for higher order thinking skills (HOTS), multiple intelligences (MI) and values integration

All work in the preparation of the lesson guides was a team effort among the Master teachers from public schools, the DepEd curriculum specialists and experienced teachers from the Ateneo de Manila Grade School and High School as well as the other Jesuit schools.

The preparation of Math Lesson Guides was a large-scale effort within a short time frame. The Lesson Guides for High School Mathematics were completed within August 2000–March 2002 while the Lesson Guides for Elementary were prepared beginning December 2002 until April 2003. Teacher training was conducted for 1,971 high school mathematics teachers in 2002 and 2,210 elementary mathematics teachers in 2003.

The lesson learned from this initiative on Lesson Guides is worth noting:

Focusing on providing enough textbooks, teacher guides or workbooks and working patiently with the teachers to use these well (teacher training) is a way of making progress on a large scale.

It is also important to note that the success of the TEEP schools with the Math Lesson Guides depended in great part on progress in the social environment of TEEP schools brought about by school-based management. SBM created the environment for reform, the absorptive capacity to make change.

Part IIc: Capacity Building for Schools in Payatas Through Project SSPEEd and ACED

The second example is a smaller scale effort by the Ateneo Center for Educational Development to see what it takes to help bring up poor elementary schools, mainly in Payatas, Quezon City.

From research Ateneo had done in the early 1990s (led by Dr. Patricia Licuanan), it was seen that what differentiated high performing public elementary schools from low performing ones, given the same economic and demographic situation, was the leadership of the principal and the support of the community. We used this as a framework for our work with selected public elementary schools.

In 2001, Mr. Washington Z. Sycip, Mr. Alfredo Velayo and this author initiated Project SSPEEd or Sectoral Support for Public Elementary Education. Concerned with the declining standards of education in the country, this project aimed to provide support to particular public elementary schools patterned after the involvement and experience of Ateneo de Manila in the Third Elementary Education Project (TEEP). Project SSPEEd provided support to the following partner schools from 2001 to 2004: P. Burgos Elementary School (Manila), Payatas Elementary School (Quezon City), Bagong Silangan Elementary School (Quezon City), Payatas B-Annex Elementary School (Quezon City) and Kalayaan Elementary School (Caloocan City).

From this project, the Ateneo Center for Educational Development (ACED) learned significant lessons and insights on how to fuse macro-level goals and micro-level initiatives and involvement. Project SSPEEd provided a framework on how institutions can assist public schools develop and at the same time create impact in the surrounding urban poor communities.

When Project SSPEEd ended in 2004, ACED pursued a closer partnership with four public elementary schools in the 2nd district of Quezon City

- Payatas B Annex Elementary School
- Payatas C Elementary School
- Lupang Pangako Elementary School
- Bagong Silangan Elementray School

Given the population of Payatas, these are very large schools.

This closer partnership with the schools began with data gathering. Much work was then done to bring the community together (principal. teachers, parents, baranggay officials, students) and do strategic planning and prioritizing of goals and objectives with them. This partnership, which ACED has carefully nurtured these past years has led to notable results. Because the need for buildings and classrooms came from the shared and careful planning by the whole community, Mayor Belmonte was impressed and moved forward to build the needed buildings, classrooms and comfort rooms. The private sector also came in with other needed inputs, like textbooks, workbooks, etc. The principals and teachers have become more confident and effective in their areas of responsibility as a result of empowerment programs and teacher-training programs. Student achievement has improved in different degrees. The most dramatic improvement is in Lupang Pangako Elementary School where the ranking of the school in the division level has moved up from rank 94 in 2003 to rank 18 in 2004 to rank 16 in 2005 and to rank 9 for 2007.

From Project SSPEEd and the work of ACED in Payatas schools, we have seen two things: the crucial role of the school principal and the community and the importance of a holistic and collaborative approach in school development and improvement. We have also seen that local government, especially Mayors, are a major partner in improving the schools.

The lesson learned from the work with the public schools in Project SSPEEd and ACED is quite clear:

The way forward on the mass is to invest in capacity building for all major players: the principal, teachers, parents and barangay officials. When the principal and the community are organized and have good plans, there can be very good response from local government and the private sector.

Part IId: Building Leadership and Community Support Through Synergeia

The third example is the work of Synergeia Foundation.

Synergeia Foundation, Inc. is a coalition of individuals, institutions and organizations working together to improve the quality of basic education. Synergeia and its partners implement systematic programs to improve the provision of basic education in more than 115 municipalities in the country.

Synergeia has focused on building leadership and community support through the following:

- Focus on Local School Board (Provincial, City, Municipal)
- Engage whole community in assessing situation, setting goals, deciding on priority objectives
- Focus on elementary schools, beginning at Grade 1, especially, English and Mathematics
- Provision of basic instructional materials (lesson plans for day to day use of teachers, workbooks for children, audio-visual materials)
- In-service training for teachers and principals

The programs of Synergeia have already resulted in significant improvements in the reading and mathematics proficiency of elementary students, and more importantly, in local governance. In monitoring the performance of participating schools, Synergeia uses the following metrics:

- National Achievement Test (NAT) for Grade School of DepEd
- DOLCH Basic Sight Words Test
- English Comprehension Test developed by Synergeia

Synergeia in Bulacan. Synergeia began working in Bulacan in

2000 under the leadership of Governor Josie de la Cruz. Over 620,000 pupils from grades one to six in 496 elementary schools in Bulacan are participating in the Synergeia program. In the 2000 National Achievement Test (NAT), pupils had an average score of 39.40% in Mathematics and 40.23% in English. Six years later, after interventions of Project JOSIE, pupils achieved a NAT average score of 64.39% in Mathematics and 65.45% in English.

Synergeia in Lipa City, Batangas. Among the 17 communities that pioneered the reading proficiency program, the most dramatic gain was achieved by Project K in Lipa City, Batangas. At the start of the project, grade one pupils' proficiency was measured at 25%. This meant, children could read only 1 out of 4 words correctly. Mayor Vilma Santos-Recto was floored upon seeing the results. Fueled by the urgency of the education crisis, various stakeholders including De La Salle Lipa, the local DepEd, local school board and parents, worked together to improve the way children learn how to read in school. After one year, the Division Achievement test results showed that on the average, grade one pupils could already read at 54.0%, doubling their score in the previous year's exam.

In 2002–2003, Lipa City's NAT average was 44.85%, in 2006–2007, it was 73.55%. The English average in 2002–2003 was 40.15%, in 2006–07, it was 73.06%.

Once again, the way forward on the mass is to invest in capacity building for the entire community.

The most challenging area of work for Synergeia now is in ARMM. But that has to be for another report.

Part III: The Upper End of the Challenge

How can we close the gap between our top schools and the top schools in the region? Let me now turn to the upper end of the challenge. We have the top of the line, Philippine Science High School, other science high schools and leader schools. In ESEP, we worked to provide laboratories as well as a stronger curriculum and programs for these schools. We can add a list of private schools to these science high schools and leader schools.

As we saw earlier, based on the data given by Dr. Talisayon, even our best schools have a way to go to reach the levels of schools among our neighboring countries. The best way to move forward is to explicitly benchmark with the best among our neighbors.

A framework might be a proposal sent recently by Dr. DJ de Jesus on benchmarking the top schools in the region: Singapore, Thailand, Vietnam, Philippines. On the initiative of the Minister of Education of Singapore and the Deputy Minister of Education and Training of Vietnam, the proposal is to benchmark the top science schools of Singapore, Vietnam, Philippines and Thailand. This could be done by the students from the three other countries competing in the national exams for science and math conducted by Vietnam. Singapore has already accepted the proposal. This benchmarking will also be an opportunity to compare the performance levels that the different schools expect from their students and to see if there are significant differences among them.

You might be surprised to know that the country I would expect to top the group will be Vietnam. From my experience of comparing the development of top talent in the Philippines and in countries like Vietnam, China, etc., what emerges is that, we have to develop a much stronger problem-solving culture. In mathematics, this means problems on the level of the International Mathematics Olympiad. When we benchmark our top students with say, Vietnam, we will find that we cannot compete at their level. Vietnam even during the wars with the U.S. continued to produce teams that would rank among the top in the IMO. I checked on the rankings of the four countries and from 2002 to 2006, Vietnam ranked 5, 4,4,15 and 13 respectively; Singapore ranked 30, 36, 18, 14 and 27; Thailand ranked 21, 19, 35, 23 and 16; the Philippines ranked 74, 79, 79 and 68 (we did not participate in 2006).

We should encourage participation in mathematics and science competitions. We should encourage the work of the Mathematics Trainers' Guild and support its spread to all our science high schools and leader schools. I personally teach a mathematics problem solving course in Ateneo college and we try to develop competitive teams in our grade school and high school and annually hold a competition between them and teams from MTG.

Part IV: Postscript—Focus on the Day-to-Day Classroom (the implemented curriculum)

Teacher Training for Day-to-Day Teaching. We established the

Mathematical Society of the Philippines in 1972, the same year as the establishment of the Southeast Asian Mathematical Society. These societies from the start were involved in helping develop both university and research mathematics as well as mathematics education and teacher training. In our teacher training, I soon realized that our approach of providing generic training and enrichment materials or talks was not addressing the needs of the teachers. They needed something they could use in their day-to-day delivery of their classes. So, together with Sr. Iluminada Coronel, we began to work with their textbooks, providing support exercises, etc. MTAP continues to carry on this work and it was along the same lines that we carried out the work with textbooks and Teacher Guides under then Secretary Roco in 2001. As a side note, when we were discussing this recently with under secretaries and assistant secretaries of DepEd, they laughed and said that teachers have a comment about generic and enrichment type seminars, their Three T's: Tanggap, Tiklop, Tago. That is, they take the handouts, pack them and then put them away.

Benchmarking Using Tests Like TIMSS. One way to move forward is to use exams like TIMSS or College Entrance Tests in the Philippines or School Leaving Exams in other countries (like the Primary School Leaving Exams, O-Level Exams and A-Level Exams of Singapore) not just to compare performance, but to use them as a diagnostic. This means using the exams as a tool to identify the key areas where improvement or progress is most needed. Diagnose why students do poorly in these areas. Then, using the data, develop interventions: appropriate teacher training, workbooks, lesson guides, etc. to address these problems. Measure whether the interventions are working.

We have found it important to engage the teachers in this exercise:

- get the teachers to do the answer key (this helps them engage the challenges coming from the tests)
- get them to correct the students' papers or at least some of them(they will get a lot of "aha" experiences – seeing that what they thought they taught did not really sink in)
- then invite reflection on how to move forward

Conclusion

To move towards "a progressive Philippines anchored on science", it is important that we actually engage the problems that face us and show that we are contributing to solving them. While depressing statistical figures and reports on the state of education in the Philippines continue to discourage us, we look forward to a better future through the inspiring results from initiatives like the TEEP School Based Management Approach, the Math Lesson Guides, the focus of Synergeia on building leadership and community support, the work of Project SSPEEd and the ACED and the dedication of MTG in developing talent among the youth.

We realize the importance of giving attention to the social environment of our schools if we are to improve and develop our schools and educational system. We have seen that to move forward to the mass, it is important to invest in capacity building for the entire school community: principal, teachers, parents and baranggay officials. For the development of our top talent, we see that we need to benchmark explicitly with the best among our neighbors.

Finally, to move towards "a progressive Philippines anchored on science", it is important that we focus on the day-to-day classroom (the implemented curriculum) through teacher training and other interventions that give attention to the day-to-day delivery of lessons and benchmarking activities like learning from best practices of other schools and using reputable examinations to improve the standards of our schools.

Acknowledgements

I would like to thank Dr. Cynthia Rose Bautista for sharing the report and experiences of TEEP. I personally directed the planning that led to TEEP, the development of the Division Elementary Development Plan (DEDP) 1994-98 and it is a tribute to those who carried out the work, especially Dr. Malou Doronila, that we have achieved such significant results.

I would like to thank Ms. Anne Lan Candelaria for the outstanding work with the Payatas Schools. The work has now been taken over by Mrs. Carmela Oracion, who also led the work for developing the Lesson Guides for Mathematics.

Finally, thanks to Dr. Milwida Guevara, President of Synergeia Foundation, and her team for the outstanding work of Synergeia Foundation in engaging mayors and the community, revitalizing the local school boards, and truly improving education for public elementary school students in so many municipalities and cities. I would like to thank Ms. Trissa Manalastas for her patience in organizing the data for me for this presentation.

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Appendix 1: TEEP Comparator Groups and Percentage of Students Surpassing 75% and 60% Mastery Level (Overall, Math and Science)

To determine the comparator groups for TEEP/SBM, the Team examined how each province fared along four poverty indices:

- The Human Poverty Index (HPI),
- the 1997 and 2000 Fixed Level of Living or consumption-based measures and
- the 2000 official poverty line of the National Statistical Coordinating Board.

Comparator groups:

- **ARMM**

  Basilan, Lanao del Sur, Maguindanao, Sulu and Tawi-Tawi.

- **AKLAN+** the clearly poor provinces that satisfied the following criteria:
  - province HPI > median HPI for the country
  - falls below the poverty line based on consumption levels in 1997
  - falls below the poverty line based on consumption levels in 2000
  - falls below the official NSCB poverty line.

  Aklan, Camarines Norte, Lanao del Norte, Northern Samar, Sarangani, Sorsogon, Western Samar and Zamboanga del Norte

- **CAGAYAN+** provinces that satisfy two or three of the above criteria: Agusan del Norte, Albay, Bohol, Cagayan, Camarines Sur, Camiguin, Catanduanes, Cebu, Compostela Valley, Davao Norte, Davao Oriental, Isabela, Oriental Mindoro, Occidental Mindoro, Marinduque, Misamis Occidental, Quezon, Siargao, Siquijor, South Cotabato, Sultan Kudarat, Surigao del Norte

• **ILOILO+** provinces that satisfy only one of the above criteria Bukidnon, Davao Sur, Iloilo, Negros Occidental, Nueva Ecija, Nueva Vizcaya, Occidental Mindoro, Palawan

In addition to the poor provinces, TEEP schools were also compared to non-poor provinces, cities and the National Capital Region.

• **PAMPANGA+** Bataan, Batangas, Bulacan, Cavite, Ilocos Norte, Ilocos Sur, La Union, Laguna, Misamis Oriental, Pampanga, Pangasinan, Quirino, Rizal, Tarlac, Zambales and all cities outside NCR
• **NCR**

Note the relatively stronger improvement in mathematics: 22.6% 9ELS and 18.2% Non-ELS achieving 75% mastery level, all others below, with Pampanga closest at 16.6%. At 60% mastery level, the performance gap is even clearer, with TEEP ELS at 59.5% and non-ELS at 46.3% The improvement is also much stronger compared to improvement in Science.

Percent Surpassing 75% Mastery Level: Overall

GROUP8	2002/3	2003/4	2004/5	2005/6
TEEP ELS	2.6	7.3	16.1	15.0
TEEP NON-ELS	3.2	4.9	13.6	11.2
AKLAN+	4.7	3.3	9.4	8.7
CAGAYAN+	3.5	2.9	9.1	7.0
ILOILO+	1.0	1.0	5.3	1.9
PAMPANGA+	3.5	6.7	15.8	11.0
NCR	0.0	1.3	6.1	0.4
ARMM	0.9	0.2	1.4	0.5
Total	3.1	4.1	11.3	8.3

Percent Surpassing 75% Mastery Level: Math

GROUP8	2002/3	2003/4	2004/5	2005/6
TEEP ELS	7.31	5.0	32.6	22.6
TEEP NON-ELS	8.0	13.4	24.3	18.2
AKLAN+	10.8	10.5	18.5	14.4
CAGAYAN+	8.3	10.1	17.8	11.8
ILOILO+	4.1	5.6	12.0	4.7
PAMPANGA+	8.8	15.6	26.5	16.6
NCR	1.1	7.4	17.3	2.2
ARMM	0.5	5.4	4.3	2.2
Total	7.7	11.7	20.8	13.5

Percent Surpassing 75% Mastery Level: Science

GROUP8	2002/3	2003/4	2004/5	2005/6
TEEP ELS	2.9	4.7	22.0	5.9
TEEP NON-ELS	2.8	2.9	17.2	3.7
AKLAN+	3.9	1.9	14.7	2.1
CAGAYAN+	2.9	1.5	11.8	1.8
ILOILO+	0.9	0.6	8.1	0.6
PAMPANGA+	3.1	3.3	19.5	3.4
NCR	0.9	1.8	11.7	0.0
ARMM	1.4	0.2	2.9	0.2
Total	2.7	2.2	14.8	2.5

Percent Surpassing 75% Mastery Level: Science

GROUP8	2002/3	2003/4	2004/5	2005/6
TEEP ELS	2.9	4.7	22.0	5.9
TEEP NON-ELS	2.8	2.9	17.2	3.7
AKLAN+	3.9	1.9	14.7	2.1
CAGAYAN+	2.9	1.5	11.8	1.8
ILOILO+	0.9	0.6	8.1	0.6
PAMPANGA+	3.1	3.3	19.5	3.4
NCR	0.9	1.8	11.7	0.0
ARMM	1.4	0.2	2.9	0.2
Total	2.7	2.2	14.8	2.5

Percent Surpassing 60% Mastery Level: Overall

GROUP	2002/3	2003/4	2004/5	2005/6
TEEP SBM ELS	15.5	39.3	65.1	59.5
TEEP SBM NON-ELS	15.8	29.3	50.3	46.3
AKLAN+	22.4	24.4	43.3	44.0
CAGAYAN+	16.5	22.4	37.5	32.3
ILOILO+	8.9	14.7	32.3	24.9
PAMPANGA+	16.4	31.9	49.9	40.3
NCR	6.7	19.5	49.8	19.7
ARMM	11.6	13.6	11.1	10.4
Total	15.5	25.6	43.3	37.0

Percent Surpassing 60% Mastery Level: Math

GROUP	2002/3	2003/4	2004/5	2005/6
TEEP SBM ELS	20.5	46.9	66.6	59.5
TEEP SBM NON-ELS	22.5	38.5	54.3	48.9
AKLAN+	31.4	34.0	47.8	43.9
CAGAYAN+	23.0	32.1	44.8	34.9
ILOILO+	14.2	23.9	37.9	25.2
PAMPANGA+	22.9	41.2	53.9	41.8
NCR	10.5	27.8	55.6	17.9
ARMM	5.6	20.4	19.7	14.8
Total	21.8	34.9	48.5	38.6

Percent Surpassing 60% Mastery Level: Science

GROUP	2002/3	2003/4	2004/5	2005/6
TEEP SBM ELS	15.0	33.7	68.6	31.7
TEEP SBM NON-ELS	13.7	24.0	52.3	24.5
AKLAN+	19.5	19.3	47.9	21.8
CAGAYAN+	14.4	17.2	40.6	15.5
ILOILO+	8.5	11.7	35.7	9.8
PAMPANGA+	14.5	25.9	53.0	21.1
NCR	6.1	16.8	52.7	6.5
ARMM	12.4	8.3	20.6	4.8
Total	13.8	20.5	46.5	18.4

Trans. Natl. Acad. Sci. Tech. Philippines 28:215–226 (2006)
ISSN 0115-8848

PHILIPPINE SOCIAL SCIENCE IN THE CENTURY OF BIOLOGY ENGAGING THE BIOLOGICAL DIMENSIONS OF BEHAVIORAL AND SOCIAL PHENOMENA*

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Abstract

My main thesis in the paper is that Philippine social scientists need to engage the biological (i.e., genetic and neurological processes shaped by human evolution) dimensions of behavioral and social phenomenon. In developing this thesis, I first broadly clarify the so-called nature-vs.-nurture debate which pits biological explanations against social and cultural explanations, then proceed to briefly explain contemporary perspectives of evolutionary psychology that recast the nature-vs.-nurture debate. In particular, drawing from examples of recent research and theory, I attempt to show that current theorizing underscores the close interaction between biological and socio-cultural processes, and thus there is no need to construe biological knowledge as antagonistic to socio-cultural theorize. I cite some examples to show how social science theories are improved when biological factors are incorporated in the theories. I then discuss the implications to Philippine social science, and suggest that a small sector of the social science community should explore how the biological dimensions of social and behavioral phenomenon can improve our theorizing. I further suggest that there is a need to re-examine

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* The ideas in this paper were culled from the proceedings of two Round Table Discussion entitled, "Biology as Destiny" sponsored by the NAST Social Sciences Division. The ideas from this paper come from many brilliant social scientists (and one honorary social scientist) who participated in these RTDs and who I acknowledge as my co-authors for this paper. They are, in alphabetical order, Eufracio Abaya, Michael Alba, Ledivina Cariño, Gelia Castillo, Mercedes Concepcion, Antonio Contreras, Lourdes Cruz, Raul Fabella, Corazon Raymundo, Agnes Rola, and I would like to especially acknowledge the contributions of Cynthia Rose B. Bautista, Emmanuel de Dios, and Ma. Emma C. D. Liwag. Correspondence regarding this paper may be sent to the author at De La Salle University-Manila, 2401 Taft Avenue, Manila 1004. Email may be sent to bernardoa@dlsu.edu.ph.

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how Philippine social scientists construe the biological nature of social beings, as this may influence and even constrain how biological knowledge is engaged in theorizing; and to consider some possible constraints within the social science research process in the country.

Keywords: Behavioral phenomenon, social phenomena. nature vs. nature

The Nature-Vs.-Nurture Debate Is Dead! Or Is It?

Any discussion about any compelling human and social phenomenon inevitably makes reference to the so called, nature-vs.-nurture debate. The debate is particularly remarkable in discussions regarding the perceived lows and highs of Filipino achievement. Why do Filipinos generally perform poorly in mathematics and science? Why can't the Philippine develop enough scientists and engineers? Why do girls consistently out-perform their male counterparts in academic achievement in many schools all over the country? But on the other hand, why are Filipinos apparently so gifted in boxing, billiards, singing, and entertaining? At some point in the discussions of these phenomena, some will make some reference to the possibility that there is something in the "nature" of the person or persons involved. But at some point as well, others might counter this notion with arguments appealing to the effect of parenting, of peers, of media, of the church or some other social or cultural institution, and of course of the individual's own free will. So is it nature or nurture? Filipinos are most likely to say it's both and we continue living our lives, particularly as there are more pressing problems we have to attend to.

Recently, however, a small sector of the Philippine social science community was provoked by their idols National Scientist Gelia Castillo, Academicians Mercedes Concepcion, Ledivina Cariño, and Raul Fabella in a roundtable discussion entitled, "Biology as Destiny" purportedly inspired by the book by psychologist Steve Pinker, 2002, entitled, "*The Blank State: The Modern Denial of Human Nature*." The roundtable discussion, not incidentally, was being undertaken amidst the imposing backdrop of the "Century of Biology." Suddenly, it seemed the nature-vs-nurture debate was alive and maybe even quite fierce.

We are all aware of just how old this debate is in the social sciences. The debate of whether to emphasize the biological as opposed to the cultural aspects of human beings has marked the subdivisions of the discipline of anthropology. Sociologists, psychologists, anthropologists, and even political-economists who have looked at criminality, aggression, corruption, and other grave social phenomena have often taken sides in this debate. In psychology the debate has been particularly salient in theorizing about human growth and development, learning, and psychopathology, among others.

In the Century of Biology, more and more behavioral and social phenomena are being explained with reference to DNA, genes, neurons and neurotransmitters, and neurological architecture and processes that have evolved in the same way as our other biological endowments. It seemed important for Filipino social scientists to locate and position their theories and practice in relation to these scientific discourses.

The Evolutionary Psychology of Human and Social Phenomena: What it is and What it is Not

But what are these contemporary discourses that call our attention to the nature-vs.-nurture debate yet another time? Are these contemporary discourses arguing that evolution and biology can fully account for the full diverse range of behavioral and social phenomena? Is the discourse espousing biological or neurological reductionism, and evolutionary or genetic determinism? Is it now truly "Biology is Destiny?"

A thoughtful review of the relevant scientific research literature suggests that it does seem that much of human behavior can ultimately be explained by referring to neurons, synapses, and neurotransmitters, to genetic characteristics and predispositions, and to neural processes that seemed to have evolved following the same Darwinian principles as our other biological endowments (e.g., Pinker, 2002, Chapter 1). Recent scholarship in the fields of cognitive neuroscience, behavioral genetics, and evolutionary psychology have proposed that such biological principles can explain much if not most of human behavior, including perhaps the most "social" and "personal" of phenomena such as culture (Tooby & Cosmides, 1992), social stratification (Barkow, 1992), morality (Katz, 2000), religious beliefs (Boyer, 1992), consciousness (Nesse & Lloyd, 1992), and abstract and higher order thinking (Cummins, 1998). The availability of such biologically-based explanations does not, however, mean that it is the only important explanation of human behavior. Indeed, there are many other levels of understanding human behavior (such as the cognitive-functional level, the social-cultural level, etc.), which were also just as important. Recent scholarship in the cognitive and behavioral sciences has led to theories that integrate these different levels of explanation. The new theories referred to earlier describe how evolutionary processes resulted in biological constraints that afford psychological processes that effectively exploit, adapt and respond to features of the physical environment, as well as of the various types of social interactions embedded in different cultures. We should be very clear at this point that recent biological theories of human and social phenomenon are not arguing for biological determinism. No serious neuroscientist is asserting that naturally selected genes and hardwired neurological processes solely determine all human behaviors. What these biological factors do is to predispose human beings to think about and act on reality in certain ways — ways that were adaptive in the evolution of the human species, perhaps during the Mesozoic Period. But this biological predisposition interacts with a complex set of other factors to determine behavior. Pinker (2004) suggests that behavior is multiply determined by genes, the anatomy and architecture of the brain, the biochemical states of the brain, the person's family upbringing, how the person was treated by society, and the specific stimuli that confront the person at any given point in time. Pinker (2004), thus, wrote:

> "Environmental interventions — from education and psychotherapy to historical changes in attitudes and political systems – can significantly affect human affairs. Also worth stressing is that genes and environments may interact in the statistician's sense, namely, that the effects of one can be exposed, multiplied, or reversed by the effects of the other, rather than merely summed with them."

However, recent theories of the biological dimensions of behavior and social phenomenon underscore the need to fully appreciate the constraints that biology imposes on behavior. In his book, Pinker (2002) has argued that we should stop denying the biological nature of human and social phenomenon, and instead we should come to terms with how biology actually interacts with social structures and the human will.

Removing the "vs." from Nature-vs.-Nurture

Recent scholarship indicates that the most powerful and fruitful lines of theorizing now seek to determine precisely how biology and social and cultural experiences interact to produce human behaviors and social phenomena. One specific area of study that has generated much new insights as well as controversies is the study of the genetic bases of human traits, such as intelligence and personality. Scientific research now indicates that *all* human behavioral traits are heritable (Turkheimer, 2000). Heritability refers to the proportion of variance in a trait that correlates with genetic difference. The rest of the variance in behavioral traits is explained by what is referred to as the shared environment and the non-shared or unique environment. Shared environment refers to the external environment that impacts on a person and his/her siblings (e.g., parents, home life, immediately community, etc.). Unique environment refers to anything in the external environment that impacts on one person but not his/her siblings (e.g. specific relationship with parents, presence of other siblings, experiences with peers, and unique experiences like getting sick or meeting an accident, etc.). The most authoritative measures indicate that the genes account for about 40-50% of the variance in many behavioral traits, while the shared environment accounts for 0-10%, and the unique environment accounts for about 50% of the variance (Bouchard, 1994; Plomin & Daniels, 1987; Rowe, 1994; Turkheimer, 2000; Turkheimer & Waldron, 2000).

Note that even if the supposed influence of the shared environment is weak, we find very compelling examples of the interaction between genes and the shared environment. For instance, studies (e.g., Rowe, 1994; Rutter, 1997) indicate that "[c]hildren who grow up in the same home tend to resemble each other in their vulnerability to delinquency, regardless of how closely related they are" (Pinker, 2002, p. 392). Gottfredson and Hirschi's (1990) study of adopted children in Denmark revealed that biological children of convicted criminals were more susceptible to criminal behaviors compared to biological children of law-abiding citizens — which shows the effect of genes. But this susceptibility to criminal behavior is significantly increased if the biological children of the criminals were adopted by parents who were also criminals and who lived in a large city — which shows the interactive effects of the high-crime social environment.

There are also many gratifying lines of research that show the complex interaction between social psychological phenomenon that are now known to be shaped by biological evolution and cultural environments. One social phenomenon that has been explained using evolutionaty theory is social sharing. Kameda et al. (2003) have demonstrated that social sharing is an evolved human response when resources are uncertain. In cross-cultural experiments, Kameda et al. (2003) demonstrated that sharing was a more profitable and stable compared to other ways of distributing resources. However, the studies also demonstrated that cultural factors may also amplify or suppress the evolved disposition to share. For example, people in higher social class contexts are less likely to share unexpected gains, whereas those in lower social class contexts are more likely to do so.

The social phenomenon of mate selection is one of the most well researched areas in evolutionary psychology. Extensive empirical research (Buss, 1998; Buss & Schmitt, 1993; Kenrick & Keefe, 1992; Kenrick et al., 1996) has supported the evolutionary theory prediction that older men are usually attracted to younger women because they are more likely to produce more and healthier children. In contrast, younger women prefer older men because they have more power and resources to endow their children. But in some cultures like the Tiwi of Australia, it is common for young men to marry older women. This is explained by referring to the interaction between culture and evolutionary predispositions. Tiwi men have several wives and all women have to be married all the time. The richer older men marry the youngest women leaving the older widows to the poorer younger men (Kenrick et al., 2003).

These are just a few among the growing number of scientific studies revealing the intricate interaction between nature and nurture (see e.g., Moffit et al., 2006, Nettle, 2006, for more discussion). Understanding the important role of the biological nature of humans and the evolutionary bases of many social phenomena does not imply denying the important effects of social and cultural experiences. Indeed, the emergent scientific theories shown in these few examples are not just biological theories, nor are they purely social theories (see e.g, Cacioppo et al., 2000; Gottesman, 2001; Ochsner et al., 2001; Plomin & Crabbe, 2000). The emergent explanations of social phenomena truly embody the integrated processes that shape behavioral and social phenomena.

Implications for Philippines Social Science:
Revising Assumptions about Human Nature in Social Science Theories

In this regard, I think that the more important ideas posed by this line of scholarship on the roles of biological constraints and socio-cultural processes in shaping human and social phenomenon relate to how Filipino behavioral and social scientists do our theorizing. And perhaps, also to bow our theorizing relates to social discourses and processes, particularly those outside the academe.

It could be argued that social science theory and research in other countries improved in specific ways when more scientific accounts about the genetic and neurobiological dimensions of humans and the evolutionary basis of behavioral and social phenomena were taken into consideration. In the field of economics, De Dios (2006) noted how assumptions of evolutionary psychology that relate to the human predisposition to reciprocity and cooperation can correct the limitations in the core assumptions of game-theory, particularly as they apply to non-cooperative games. Apparently, the prediction of evolutionary theory that human beings would cooperate under certain conditions of reciprocity can better explain actual data on how people behave in non-cooperative game situations (Fehr et al., 2002; Fehr & Schmidt, 1999), compared to theories that assume that humans would act on the basis of calculated, wealth-maximizing, self-interest. De Dios (2006) further notes how some traditional assumptions about the rationality of human being in economic decision making are actually false; instead, humans think and make decisions based on heuristic strategies that are proposed to be biological adaptations that scrver evolutionary goals (Gigerenzer & Selten, 2001; Kahneman & Tversky, 1984; Tversky & Kahneman, 1974).

In the field of psychology, theory and practice has greatly improved when scholars and professionals began acknowledging the important neurobiological constraints that underlie many problematic psychological phenomena. For example, an improved understanding of the interactions between genetic risks and environmental risks in psychopathology has resulted in more rational and effective forms of prevention and intervention for many times of psychological disorders (Gottesman, 2001; Moffitt et al., 2006; Neese, 2000; Siegert & Ward, 2002). Recent discoveries related to the continued development of the human brain during the adolescent years (Casey et al., 2000) has also helped psychologists better understand the beightened variability in cognitive development among teenagers, particularly in various areas of reasoning and decision-making (Klaczynski, 2004). More important, researcb in the field of adolescent cognitive development has shown how the adolescent experiences' and the activities that the teenager engages shape the brain development processes (Kuhn, 2006; Luna et al., 2004).

Similar theoretical and scholarly advancements have been achieved in specific fields such as medical anthropology and demography, where knowledge related to the biological nature of human beings are wedded with personal, social, cultural, and historical constructs.

But what about social science theorizing in the Philippines? My colleagues in sociology (Cynthia Bautista) and political science (Antonio Contreras) noted that the biological dimensions of human nature and of social life has not been problematized in the main streams or threads of social science discourse in recent and not-so-recent history (e.g., theoretical Marxism, structural functionalism, social constructivism, post-structuralism, feminism, post-colonialism, post-modernism to name a few). The various big-theories have some minor presuppositions about biology, but these suppositions are never in the foreground (perhaps with some exceptions in some subfields within anthropology, demography, and psychology).

Is there anything wrong with this? My immediate answer is no. There is so much rich insight that can be drawn from the proper and intelligent use of personal, social, political, and historical constructs and modes of analysis used by thoughtful Filipino social scientists. The lack of references to biology should not limit the useful insights that Filipino social scientists can generate. Indeed, as can be gleaned from various treatises, many of the exciting evolutionary theories of human behavior actually draw from studies of linguists, anthropologists, sociologists, psychologists, and economists who hardly think of the neurobiological dimensions of anything. And thus, I think that the Philippine social science community can grow and thrive as long as thoughtful Filipino social scientists continue to properly and intelligently use social science constructs and analysis.

However, advocates of evolutionary psychology take a very strong position that I think is worth considering. Pinker (2002) for one, argues that by ignoring or neglecting the neurobiological or evolutionary constraints in human and social phenomenon, social and behavioral scientists may be posing theories that are not properly grounded or bounded. Denying the biological constraints and/or affordances of social and cultural phenomenon is an act of gross misrepresentation, just as saying that biology is destiny is another act of gross misrepresentation. One challenge for Filipino social scientists, therefore, might be to determine how to properly engage the biological (i.e., genetic and evolutionary) theories of behavioral and social phenomena. In doing so, it would be important to avoid knee-jerk responses that take extreme and totalizing positions (e.g., that biology is destiny on the one hand or that this thread of scientific discourse has a strong underlying conservative ideological agenda). Indeed, Filipino social scientists should be mindful that totalizing theoretical positions regarding both nature and nurture have been used to justify genocide (i.e., by Hitler, Lenin, Stalin, Mao, Pol Pot). Filipino social scientists should be careful about ignoring the ethical implications of any form of scholarly discourse. Pinker (2002), noted that all core assumptions of the standard social science models carry their respective moral burdens in the same token that application of biological and evolutionary theories also entails ethical dilemmas. Thus, we should warn against unnecessarily privileging either biology or social and cultural life in our attempts to appropriate these threads of scientific and scholarly discourse in understanding and transforming the personal, social, and cultural experiences of Filipinos.

In this regard, it might be important for Filipino social scientists to clarify their own conceptions about the role of biology or the biological nature of humans in their own theorizing. Is biology our destiny? Or does biology define the limits of human and social achievement? In our second roundtable discussion on this topic, National Scientist Gelia Castillo lamented the recent trend to use the expression, "*Pasensiya na, tao lang*" apparently as a flippant excuse for various forms of shortcomings. A social psychologist colleague reminded me that a more benign version of the expression is found in the old romantic ballad, "*Sapagkat kami ay tao lamang*" where again human nature is used as the defense for inappropriate intimate relations. It seems that in popular social discourse, there is the implicit notion that human nature is flawed and that this flawed nature may be used to justify mistakes, poor performance, even misdemeanors and transgressions. But Academician Lourdes Cruz reminded us that for the biochemist, genes define the human potential that can be fully realized in appropriate environments. Thus, the biological nature of humans is a definition of possibility, potentiality, and workability. This view resonates with the Confucian tenet on the perfectibility of all human beings, which underlies the moral notions of self-cultivation and self-improvement in Chinese or Confucian-heritage cultures.

I use these examples to illustrate how some fundamental ideas about the theoretical, social, and practical nature of human nature can have some influence on how Filipino social scientists might want to engage and appropriate biological theories, principles and concepts in social science theory and practice.

But we can raise another concern about how to go about engaging the biological dimensions of behavior and social life in Philippine social science. In our first roundtable discussion, psychologist Emy Liwag raised concern about the prospect that Filipino social scientists will just read and talk about evolutionary, biological and genetic theories of behavior and social phenomenon instead of actually doing research and theorizing about the same. She noted that there are very rare opportunities for Filipino social scientists to engage natural scientists in theoretical and scholarly discussions, much less engage in multidisciplinary research of the same level of sophistication as exemplified in the recent scholarship we have been referring to. Perhaps a greater source of concern should be the research environment within which Filipino social scientist undertake their scholarship. Most Philippine universities do not have substantial financial resources for research that would allow social scientists to undertake long-term research programs that would permit more sophisticated theorizing. Instead, university-based social scientists have to contend with short-term research grants that only allow for diminutive theoretical advancements. Alternatively, they can undertake research projects funded by national and international development agencies but doing so would require adopting the agencies' theoretical and ideological positions in the research approach. Social scientists in the Philippines will need to demonstrate extraordinary levels of creativity to thrive in these less than ideal research environments.

Conclusion

Perhaps the strongest motivation for Filipino social scientists is the desire to see change in a social order that is perceived to be unjust and backward. The work of social change or societal transformation inevitably presupposes certain theoretical propositions regarding human nature and the constitution of social life. There is a growing body of evidence pointing to neurobiological constraints and affordances to behavior and social phenomena, and some related ideas and evidence may undermine certain core assumptions of traditional models in the social and behavioral sciences. Filipino social scientists do not necessarily have to incorporate these neurobiological and evolutionary discourses in their scholarship and practice. Filipino social science can continue to make contributions to human knowledge and Philippine society by drawing from the standard constructs and methods of the traditional social sciences. But there is probably a need for a sector of the Filipino social science community to reexamine these standard social science assumptions in light of these evidences. Doing so would require engaging a strange discourse, but it could point to more fruitful line of theorizing about social and behavioral phenomenon, and might even lead to more realistic interventions for social and behavioral change. Indeed, the most exciting prospects for change would take full recognition of the biological constraints in behavior and the interventions are designed to help transcend, rise above, and even thrive amidst these constraints.

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Trans. Natl. Acad. Sci. Tech. Philippines 28:227–254 (2006)
ISSN 0115-8848

BIORESOURCE MANAGEMENT AND OUR COMMON FUTURE[1]

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Abstract

Survival of societies largely depends on biological (bio) resources management, which is the responsible use of living resources — plants and animals, and the natural environment that support these, for both traditional and new applications. Bioresources are of two levels — ecosystems and species. Bioresources' utility also vary temporally and spatially. In the early times, when population growth was low and customary rules prevailed, bioresources were not under threat. Collective action evolved in the villages to safeguard the land, water and the biological resources for sustainable use. As countries developed, the state became the more powerful steward of all resources. While protected areas in forests and marine sanctuaries were set-up, the weak property rights, the lure of commercialism and the seeming lack of collective action to protect these resources have led to resource degradation in recent times.

It is hypothesized that governance through policies and institutions influence bioresources conditions. At the ecosystem level, the four cases of best practices cited in the paper showed that community participation, external support and local government leadership were factors for sustainable bioresource management. Species management practices have a dearth of documentation; and the paper poses some management strategies for this level. Among the recommendations is the critical role of science and technology in the development of bioresource management plans and in monitoring of desired outcomes.

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[1] This paper is a synthesis of the discussions during the Roundtable Discussion (RTD) sponsored by the National Academy of Science and Technology (NAST) Social Science Division, March 23, 2006, Philippine Social Science Council, Quezon City. Contributions from the participants of the RTD are gratefully acknowledged.

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Keywords: bioresource management, governance, policy instruments, institutions, genetic diversity

Introduction

The theory that explains the causes of extinction of biological species is still evolving. As a species, the dinosaurs were seen to have inhabited the earth for the longest time, more than 175 million years. Then about 65 million years ago, they became extinct. Scientists have many theories, e.g., due to climate change, others thought that a huge meteorite hit the earth about 65 million years ago and this had caused forest fires. So much smoke and dust filled the air that sunlight could not reach the earth's surface (The Golden Book Encylopedia, 1988). But that was a "millions of years ago" story.

In the contemporary world, about 137 species of animals go extinct everyday, or about 50,000 species each year, a rate not seen since the age of the dinosaurs (Sevin, 2000). Observed causes of such high rate of extinction include habitat degradation and fragmentation, hunting, human and animal conflict, competition with domestic animals for food and water. *Homo sapiens*, to survive, became a cause of lower species extinction.

Current thinkers, however, remind us that societies survive or collapse depending upon how their inhabitants are able to manage the biological resources (or bioresources) —plants, animals and the natural environment that support these (Diamond, 2005). Bioresource management is at two levels: ecosystems and species. Ecosystems management focuses on habitats such as forest, coastal, marine, sloping lands, etc. Species management includes plant and animal species, such as rice and their wild relatives, tree species, animal species. There can also be management of microorganisms and genetic resources now used as inputs in biotechnology transformations.

In his book, Diamond (2005) identifies "failures of group decision-making on part of whole societies or other groups" as a major reason why societies collapsed. According to him, throughout recorded history, actions and inactions by self-absorbed kings, chiefs, and politicians have been the regular causes of societal collapses. As a result of lust for power, for instance, Ester Island chiefs and Maya kings acted so as to accelerate deforestation rather than prevent it.

There were four factors that contributed to this failure of group decision-making (Diamond, p.421). First, a group may fail to anticipate a problem before the problem actually arrives. But this is a constraint of illiterate societies with no writing skills and limited oral transmission. They did not anticipate the extinction problem because they had no prior experience of these problems and may not have thought about the possibilities.

Second, when the problem does arrive, the group may fail to perceive it. The most common situation under which societies may fail to perceive a problem is when it takes the form of a slow trend concealed by wide up-and-down fluctuations, such as global warming, in contemporary times. According to Diamond, politicians call this "creeping normalcy", as it takes "a few decades of a long sequence of such slight year- to- year changes before people realize, with a jolt, that conditions used to be so much better several decades ago, and that what is accepted as normalcy has crept downwards." (p.425).

Third, after they perceive it, they may fail even to try to solve it. There are several reasons for these, which according to social scientists are driven by the theory of rational behaviour, arising from clashes of interests between people. Several of these concepts are well known in the economic and social science literature— "tragedy of the commons"[3], the prisoners' dilemma, and the "logic of collective action". This was the stage of what Diamond refers to as the ISEP— "it's someone else's problem".

Finally, the fourth explanation to the failure in decision making is that societies may try to solve it but may not succeed. The reasons given were quite obvious: the problem may be beyond their capacities to solve, a solution may exist but can be prohibitively expensive, or the efforts may be too little or too late.

On the flip side, Diamond also cites successful decision-making on the part of the whole that has brought about longer existence of other societies, and that included societies of the current times. He attributed the survival[4] to the attitudes of the leaders of these societies.

Contemporary literature has not really developed a theory that may have counter arguments to the point raised by Diamond (2005), but are mostly in support of this. These are studies about incentives of societies to manage their natural resources. The work of Rasmussen and Meinzen-Dick (1995) on roles of local organizations in natural resource management was supported by two major bodies of literature: empirical analysis of forestry, fisheries, grazing, and irrigation management and game theory literature. Resource management literature highlights the physical and technical characteristics of the resource, the characteristics of a group of users, and the attributes of institutional arrangements as key factors affecting the management capacity of organizations. Rasmussen and Meinzen-Dick (1995) further used the simplistic game theory to predict a tragedy of the commons for natural resources, although according to them, "more refined versions provide insights into the role of communication, group size, time horizons, trust, and social norms in supporting collective action"

This paper derives motivation from Diamond's theory. It is hypothesized that governance through policies and institutions influence bioresources conditions.

The paper is structured as follows: Part II discusses the evolution of bioresources management strategies in the country from the economic and political

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[3] The current solution to the tragedy of the commons will be for communities to design, obey and enforce their own rules.

[4] Part of the reason why some societies succeed and other fail involves difference among environments rather than among societies. But while environmental conditions certainly make it more difficult to support human societies, in some environments than in others, that still leaves much scope for society to save or doom itself by its own actions (Diamond, p.438).

development. Part III describes the status of bioresources in the country, using a macro perspective. While the macro story appears discouraging, Part IV showcases four of the current best practices in ecosystem level bioresource management.

These evolving good practices on ecosystem management were influenced by participatory research studies and efforts of local development workers. The RTD centered on discussion about species level bioresource management and Part V tackles the challenges of designing bioresource management plan at the species level. The paper ends with a brief section (Part VI) on recommendation highlighting in particular, the role of science and technology in the development of bioresource management plans and monitoring of desired outcomes.

Bioresource Management in the Philippines

A. Bioresource management strategies in the early times

Historically, institutions influence resource use and management (Rola and Coxhead, 2005). Prior to colonization, tribes and communities managed their communal resources by customary law. Collective action evolved in the villages to share responsibilities to safeguard the land, water and the biological resources for sustainable use. As examples, forest and catchment areas were protected to minimize the processes of erosion and sedimentation, hence, protecting soil microorganisms; maintenance of embankments and water channels leading to paddy lands was a shared responsibility. Riparian zones were observed and safeguarded. Both local knowledge systems and community-based practices may have, in the past, ensured the sustainable harvesting and conservation of bioresources, which helped in the conservation of biological diversity over time. Long-rotation bush farming fallow systems were widely regarded as 'sustainable'.

Colonization created the elite and the masses' division in the Philippines, and the start of clashes of interests in resource use. Customary law cannot accommodate such conflicts. The state assumed the lead role in controlling resource use and access, and new resource management institutions were imposed from outside the community. But even as local offices of national resource management agencies may be established, these had no autonomy and little effective authority. Because state power was low at the frontier; the resource base becomes, in effect, open access. What followed was rapid deforestation, shortening of fallow periods and general degradation of soil and water resources (Rola and Coxhead, 2005).

In the recent times, there is growing community demand for environmental quality and resource conservation. This trend is complemented by a more general decentralization of power and authority. In the best situations, decentralization plus local demands for more environment-friendly development are to be complemented by national laws and policies. In the best outcomes, national agencies, local governments and community groups collaborate to design (and more importantly, to implement) resource management policies that are compatible with individual and community needs and aspirations.

B. Contemporary Bioresource Management Strategies in the Philippines[5]

Structure of Management

Current initiatives for bio resource management in the Philippines were a result of the global views about sustainable development. Sustainable development is meeting human needs of the current generation without endangering the ability of future generations to meet their needs (World Commission on Environment and Development, 1987). The Philippines' response[6] to the call for sustainable development was the creation of the Philippine Council for Sustainable Development (PCSD)[7]. The PCSD is mandated to oversee and monitor the implementation of the Philippine Agenda 21 (PA 21), the Philippines' blueprint for sustainable development, by providing the coordinating and monitoring mechanisms for its implementation. This arrangement was complicated by the fact that by law, the Department of Environment and Natural Resources remained the state's agency for overall management of the country's resources. It was facilitated when local governments began to have power over the resources within their jurisdiction. Several national departments manage resources; and this responsibility is also given to local level institutions.

Governance of Resources

Governance of resources is characterized by a hierarchy of coverage of the institutions (national to local), multiplicity of state and non-state institutions, the different mandates or themes and the issues over its use (technical, social, economic, political) (Figure 1).

The Philippines' configuration of this governance space is in Figure 2.

The national government and its agencies totaling at least six, still have the power over most bioresources management decisions because of political clout and financial and technical capacities. The local governments are seen to be still weak in capacity and financial capability to manage resources; and devolution of this function has not been complete.

Devolution of Resource Management Function

The *codal* provisions of the Local Government Code (LGC) strengthened the legal framework for attaining sustainability at the local level. With this power

[5] The discussion in this section refers to current elements of ecosystems management only, although this is also very important as ecosystems are habitats of the various species of flora and fauna.

[6] As the government's commitment to the Agenda 21 agreed upon during the Earth Summit in Rio de Janeiro in 1992

[7] This is headed by the Director-General of the National Economic and Development Authority (NEDA) as Chairperson, the Secretary of the DENR as the Vice-Chairperson and with membership coming from both government and non-government organizations.

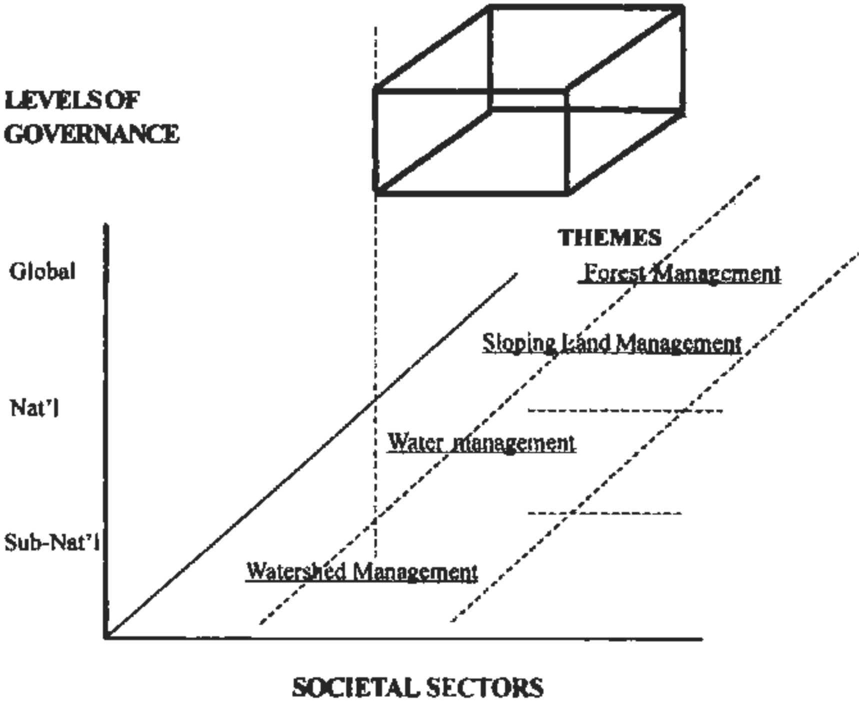

Figure 1. Three dimensions of resource governance (adapted from Malayang 2004).

shift, local governments must assume accountability and responsibility in achieving the sustainable development goals of the country. The local executives (mayors and governors) are given the mandate to "adopt measures to safeguard and conserve land, mineral, forest, marine and other resources of the municipality, city or province". The local legislative bodies are also mandated to protect the environment and impose appropriate sanctions/penalties for acts that endanger the environment. Even the village chiefs (*Barangay* captain) are given the responsibility to "enforce the laws related to population control and protection of the environment". The LGC also invoked the participation of the civil society, and the involvement of the private sector in providing opportunities for financing and developing local enterprises, and provides for the due recognition of ancestral domains and other customary rights in protected areas.

In general, the resource management planning process—from budgeting to implementation, monitoring, and evaluation including the preparation of annual investment plan, originates from the lowest level to the highest levels of governance up to the management plan of the National Economic and Development Authority (NEDA).

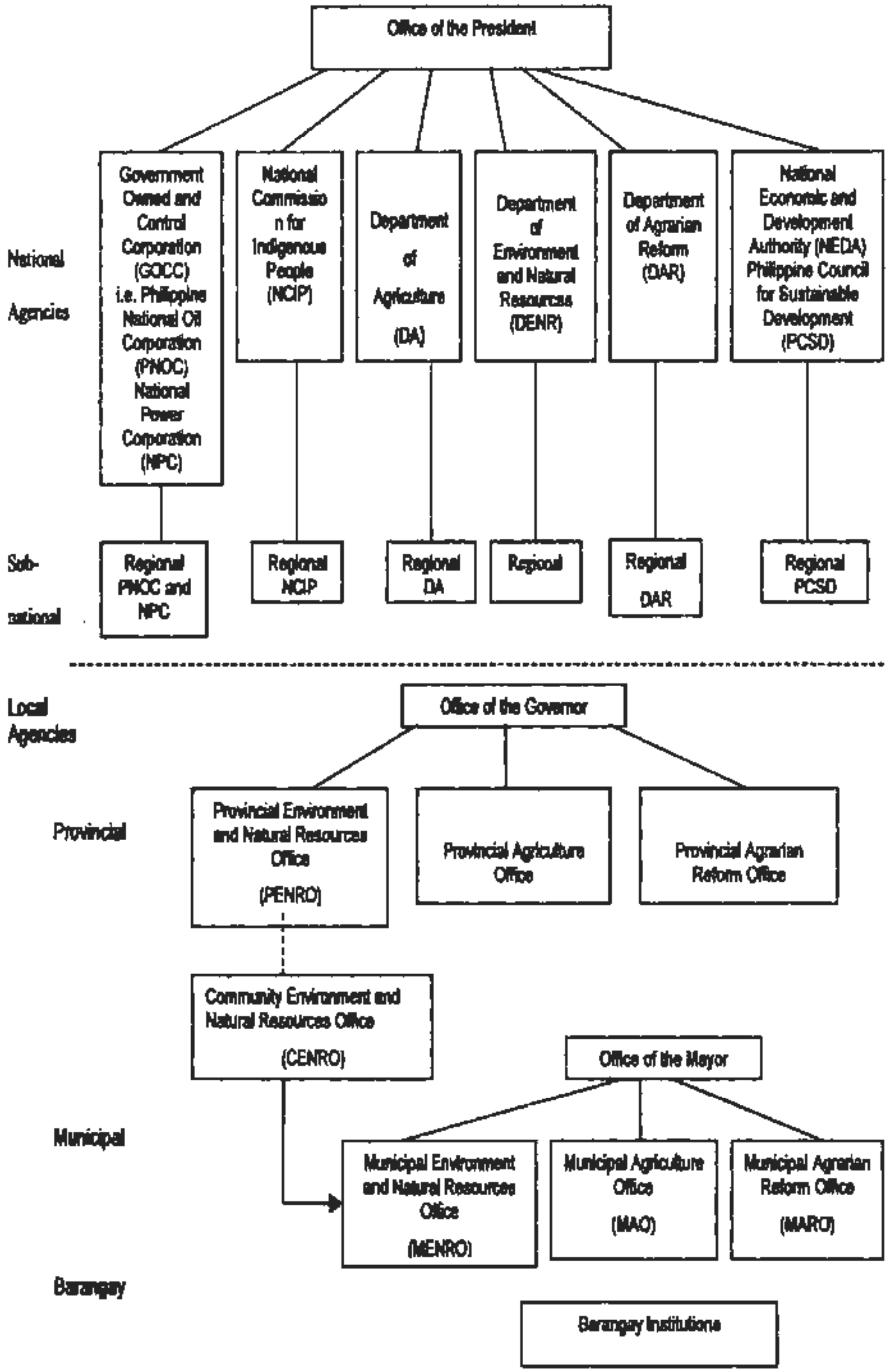

Figure 2. Resources governance in a decentralized system in the Philippines

Policy Instruments

The Philippines is one of the richest countries in terms of statutory instruments. There are policy instruments for forests, lands and water. There are laws such as the Clean Air Act, the Clean Water Act, the Waste Management and Disposal Law, and other environmental laws. Most of these are ecosystem level resource management instruments. The following discussion concerns three policy instruments that significantly influence bioresource habitats:

1. National Integrated Protected Area System of 1992 (NIPAS)-Republic Act No.7586

The NIPAS law recognizes the critical importance of protecting and maintaining the natural biological and physical diversity of the environment and declares it the policy of the state to secure for the Filipino people of present and future generations the "*perpetual existence of all native plants and animals through the establishments of a comprehensive system of integrated protected areas within the classification of national park and provided for in the Constitution*". It specifies areas with unique features for this purpose. It indeed sets the tone for bioresource management in the country. It also recognizes that administration of these protected areas is possible only through cooperation among national government, local government and concerned private organizations.

Protecting the country's natural parks (protected areas) was first recognized in 1932, when the US colonial government sponsored Republic Act 3915 establishing the Philippines' first national parks. The law declared all parks as game refuges and bird sanctuaries, created advisory committees that assisted forestry officials in managing each park and penalized illegal activities such as squatting and poaching.

Currently, for each protected area in the country, there is an assigned Protected Area Management Board (PAMB) that acts as the manager. This board is composed of members of different sectors and coordinated locally. The Chair of the Board is the regional director of the DENR. PAMB also has local government units, civil society, and indigenous communities since many of these protected areas are actually in places where there are indigenous communities. Funds for this management usually come from the national government. But resources are scarce, and most PAMBs may not really be operational at the moment. The PAMB also illustrates the fact that because environment is porous, it is not practical to assign environmental management functions to political administrative units.

2. Indigenous People's Right Act (IPRA)-Republic Act 8371

Hand in hand with the NIPAS law is the IPRA law which renders recognition and protection of the rights of indigenous cultural communities to their ancestral lands to ensure their economic, social and cultural well-being. The main instrument provided is a certificate of ancestral domain title. Under this law, indigenous communities can get titles to ancestral domains that can sometimes cover thousands of hectares, and including so called ancestral waters. This law has created a lot of conflicts between the local state agents and the Indigenous People (IP) communities, especially in the access to community resources. This brings us back to clashes of interest because the group is not homogeneous, and consensus decisions on proper resource use cannot be reached.

For instance, the IPRA stipulates a "Free and Prior Informed Consent" (FPIC) by the IP communities before anybody can access or use resources in the IP areas. This can be a potential instrument for bioresource management, to wit, there should be prior consent of cultural communities to make sure that bioprospecting does not result to biopiracy, the most common sin of many multinationals prospecting in many places around the world. But we do not have a multitude of forest guards and the *bantay-dagat* knowledgeable in the very resources that make money outside of the country. Also, there is a possibility that the people who sign the FPIC can be bribed. And it is very risky socially if any official at the lowest level in charge of protecting the environment can be bribed.

3. Riparian Laws—The Public Land Act and the Forestry Code

The Public Land Act stipulates that applicants wishing to use the river banks would agree to maintain as permanent timberland a strip of forty meters wide starting from the bank on each side of any river or stream. This timberland is to be planted exclusively to trees of known economic value, and that the user shall not make any clearing thereon or utilize the same for ordinary farming purposes even after patent shall have been issued to him or a contract lease shall have been executed in his favor. The Forestry Code on the other hand, provides that 20-meter strips of land along the edge of the normal high waterline of rivers and streams with channels of at least five meters wide should be devoted for forest purposes; and strips of mangrove or swamplands at least twenty meters wide, along shorelines facing oceans, lakes, and other bodies of water and strips of land at least twenty meters facing lakes should also be maintained.

Non-implementation of the riparian laws could have caused the death of rivers in the country (Rola and Tabien, 2001). In current times, most of these areas, which are by law public lands, have private titles. Will local governance be able to rescind these titles and save the riparian areas, thereby minimizing river pollution from agriculture or household sources? Currently, there are programs to mitigate environmental risks jointly managed by some local governments and the community members having properties along the river banks. One of these is the establishment of village nurseries for bamboo that can be planted along the river banks (Rola et al, 2004a).

The lack of or non-implementation of bioresources management policy has brought about the increasing degradation of the country's bioresources as revealed by national level data, shown in the subsequent section.

State of Bioresources in the Philippines

Increased demand for food, clothing and shelter due to rapid population growth are the primary drivers of resource use. Depletion and extinction occur because many resources are non-renewable. Therefore, population management (the demand side) is directly related to bioresource management (the supply side). Given the weaknesses of the institutions in the management of both sides of the equation, the future state of the country's bioresources could be in jeopardy. Recent global assessments concluded that extractive behaviour of the current generation is not sustainable (MA, 2005). The following is a discussion of the available evidences on the state of the Philippine bioresources such as forests, coastal and marine resources, and plant and animal life.

Forests

The land area of the country is about 300,000 square kilometers, most of which was originally forested. In the past, it supplied indigenous Philippine people food, drinks, spices, medicine and lumber. The forests yielded commercial products as well, including the Manila hemp (abaca), used for making ropes, textiles and hats. Bamboo, cinnamon, cloves, and pepper plants, formed a valuable part of the early economy.

When the Spaniards came, there was 90% forest cover. Colonialists found the forests lush, which were eventually used as a vehicle to attain economic progress. Deforestation became rampant as forest products were the primary motor of development. Most of these logs and lumber fed into the ship building of the Spanish colonialists. When the Americans came in 1900, the forest cover was down to 70%. Six (6) million hectares were lost during 300 years of Spanish rule.

The Americans (1901–1944) continued the regalian doctrine introduced by the Spaniards, maintaining the state-controlled management of the forest resources. The Americans' demand for cheap timber was a motivation for formulating policies during its colonial period. As a result of forest destruction, open access to the deforested lands ensued. Absence of institutional arrangements, programs of settlement, and weak property rights accelerated the degradation of forest resources.

In 1944, during the Philippine independence from the Americans, another 6 million hectares were lost. There was a combined loss of 12 million hectares of forest cover during the Spanish and American periods. By 1990, about 40 years after American rule, 14.2 million hectares of forest cover were lost. More forest was lost under the Filipino rule than the combined colonial rule (Ong, 2006). The immediate reasons for the drastic reduction of the primary forest area are large-scale logging and conversion to agriculture, and are strongly associated with the rapid increase in human population, reaching about 70 million in 1997. Over 15 million upland people (Ong, 2006) today threaten the survival of the remaining forests, despite government effort at protection.

Preservation of the primary rain forest should be a high priority for the Filipino people to protect the remaining flora and fauna. The genes that these resources contain can be the source of technological breakthroughs for the future. The bad news is a large number of endemic species in the Philippine tropical rain forest and the forest itself are now threatened with complete destruction, making the country a "hot spot", that is, an area where there is a high probability of species extinctions (Bengwayan, 2002). Already some 52 native vertebrate species are in the critical or endangered categories, and a great many more are listed as threatened. Most endemic land vertebrates (including birds, small arboreal frogs, and many mammals) require primary-forest habitats and fail to survive in highly disturbed and secondary forests.

Coastal and Marine Resources

The islands are surrounded by coral reefs and have one of the richest collection of coral reefs in the world, with about 500 species found in the surrounding coral reefs. Fish of all kinds, shellfish and mollusks, are common and the Sulu pearls are world famous. But the situation in our country as far as our marine bioresources are concerned also looks rather grim. The coral reef ecosystem is a support ecosystem that produces a lot of bioresources in terms of fish, invertebrates, seaweeds and so on. But like any natural system, a coral reef ecosystem can only produce so much. If the pressure on the reefs is beyond the carrying capacity, then degradation occurs. But these ecosystems are resilient. If you release the pressure, then the resource is renewable although it takes a long time. A lot of pressure is now being placed on the marine bioresources because of population pressure. Analysis of marine hot spots in the world revealed that among the ten top marine biodiversity hot spots in the world, the Philippines ranked as number one.

Plant and Animals[4]

Both plant and animal species are abundant in the Philippines; the country ranks twenty-third in the world in terms of the numbers of plants to be found in the country; one-fourth of the 13,500 plant species are endemic to the country. Over one hundred and seventy thousand animal species can be found in the Philippines, ninety-eight of which are endemic. Rare species include the world's smallest monkey, the Philippine Tarsier, the white-winged flying fox, one of the world's rarest mammals, and the Philippine Eagle, the world's largest eagle. The islands have over one hundred ninety-six species of birds, including colorful parrots and many birds found nowhere else.

The number of plant and animal species in the Philippine rain forest is incompletely known. There are an estimated 13,500 plant species, of which about

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[4] Source of data in this section is from Alcala (2002).

8,000 are flowering plants; about 3,200 are endemic. Plant genetic resources for instance, supply the raw materials that breeders and farmers need to attain food security. Once upon a time, corn wasn't corn and coffee wasn't coffee. Farmers created all our crops out of the wild plants. Many of these crops' wild relatives could be in existence, but could also be disappearing fast.

Philippine land vertebrate species number about a thousand: approximately 80 amphibians, some 240 reptiles, 556 birds (resident and migratory), and 174 mammals. It is the exceptionally high level of endemism that is now attracting international attention. Experts say that Philippine mammals have the highest percentage of species endemism in the world on a hectare-for-hectare basis, and this could be true for other groups as well. Seventy-five percent of the amphibians, 70 percent of reptiles, 44 percent of birds, and 64 percent of mammals are found nowhere else in the world. We have an estimate of 11,000 species of wildlife. Half of these are found only in the country, and about 16% are endangered or threatened.

In summary, in terms of bioresources status, the country is considered a hot spot. This is further revealed by the findings of the Yale's 2005 Environmental Sustainability Index, which ranked the country as 125th of 146 countries studied. It will be such an understatement to say that it is important to define strategies to identify, conserve, and sustainably and equitably use and manage bioresources both at the ecosystem and the species level.

Initiatives for Bioresources Management at the Ecosystem Level: Four Cases in the Philippines

The following cases are examples of best practices for bioresource management at the ecosystem level. These initiatives have several common elements including the development of an ecosystem management plan, use of data in the planning process, involvement of external groups in the plan intervention, and collective action by the various stakeholders. The institutional arrangements of decentralized governance and more secured property rights were also found to affect the behavior of stakeholders in bioresource management.

We refer back to Diamond's theory that societies fail to do group decision-making because they were an illiterate society and that community members may not have anticipated the extinction problem. Contemporary issues point to more modern and science-based management approaches, through management plan development, but with mostly external (to the community) support. These "observers" could have some forecasts of future scenarios based on their own experiences, if no interventions were to take place in a particular community. The natural reaction by community members to collectively solve the problem once perceived is also noticeable in these examples. Among the four cases presented below, a couple reveals that environmental degradation is reversible with good bioresource management.

The first two cases are similar: they show that protected area management is important to further the goals of sustainability. The third example showcases community empowerment in monitoring its own bioresource and how these efforts can be integrated in local water governance. The last case refers to the role that community-based technology adoption had in bringing back to life aquatic bioresources in the irrigated rice environment thus, improving the welfare especially of the poor rural folks. All of these cases revealed the importance of collective action and how they sway institutions to achieve more sustainable bioresource management at the ecosystem level. The relevance of the policy of decentralization in bioresource management also becomes apparent.

1. Protected Area Management: The Mt. Kitanglad Range Natural Park[9]

Mt. Kitanglad Range Natural Park (MKRNP) is the headwater source of several major river systems draining North and Central Mindanao, including the Cotabato province. Its creeks and rivers flow in a radial pattern and feed into three major rivers in Mindanao. One of these rivers, the Manupali River is an important water source that drains into the Pulangi River, a source of irrigation and electric hydropower in Bukidnon. In turn, the Pulangi River drains into the Illana Bay, a major waterway for the North and Central Mindanao. Therefore any destruction in the Mt. Kitanglad will affect to a great extent the downstream portion of the Northern and Central Mindanao.. The logging concessions grants that operated in the area in the 1970s through the 1990s resulting in significant deforestation had given impetus for a more proactive protection of the Park by the locals.

The Park, primarily located in the province of Bukidnon encompasses 40, 176 hectares. Seven municipalities and one city of the province share the boundaries at the summit. It is one of the country's priority protected area as provided for in the National Integrated Protected Areas System Law (NIPAS). In following the processes of the NIPAS law, Mt. Kitanglad was proclaimed as a protected area under the natural park category through Presidential Proclamation No. 896 dated October 24, 1996. Republic Act 8978 is its enabling law signed on November 9, 2000.

The Mt. Kitanglad Protected Area Management Board (PAMB) started operations as early as 1993[10], with the Protected Areas and Wildlife Bureau (PAWB) of the DENR spearheading the effort. The PAMB serves as the in-situ policy-making body of the park. It is composed of 59 members from government and non-government sectors, and from local communities. The Regional Executive Director of the DENR-Region 10 acts as the chair of the board, while the Provincial Planning and Development Coordinator of Bukidnon serves as an ex-officio member. Members of the board are the municipal mayors of the eight towns sharing the boundary, 28 barangay captains of the village centers of the buffer zone, 9 tribal leaders, 8 repre-

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[9] Source of data was from Rola et al (2004a).

[10] This could have been spurred by the fact that this site was chosen as one of the ten priority protected areas that would later on have external funds to start developing its management plan.

sentatives from the non-government organizations, three representatives from the media, 1 from the other government agencies and 1 from the people's organization. The office of the Protected Area Superintendent (PASu) became functional in 1994, this office is directly accountable to the PAMB. The Provincial DENR supervises the day-to-day activities but the ground management is by indigenous communities, the local governments, and representatives of the PAMB. Other institutions involved in the management are the special interest groups such as the tenured migrants, industry sector (such as commercial banana, poultry, and relay communication operators) as well as voluntary organizations such as the mountaineering societies, research and academic organizations.

International institutions are also involved in the conservation activities within the park. These external partners are generally not present in other protected areas of the country.

The MKRNP management plan

The Park's management plan completed in 2000 with help of partners from the science community and the NGOs field workers, is now operational. Among its management strategies are the following: (a) adoption and implementation of an effective park protection, zoning, and resource management program; (b) formulation of an integrated policy and livelihood support and assistance framework for the conservation, sustainable use and economic development of protected areas beneficiaries in partnership with the local communities; (c) ensuring biodiversity conservation awareness and information programs; and (d) institutionalization and strengthening of capacities for effective protected area management and supervision. A major part of the management is to ensure that water quality and quantity are maintained in the whole watershed, i.e. both upstream and downstream use.

Implementing the Plan

To make the plan workable for local officials especially those located in the buffer zone, several seminars and training workshops were held to orient and familiarize them with the implementation procedures. At the buffer zone, 370 Kitanglad Guard Volunteers (KGV) administratively under the DENR, guard the forest and watch out for forest fires. These members of the local indigenous communities or the IPs promote biodiversity conservation in the protected area and do patrol activities within the park. They report illegal activities to the DENR and PASu aside from posing as escorts to DENR personnel during visits and are responsible in hauling apprehended logs within the park. They are annually deputized by the DENR to do community-based park protection.

Because the MKRNP was enacted through a national law and PAMB has a legal personality, enforcement and subsequent prosecution of violators of the park ordinances is possible. To illustrate, 79 cases had been filed against forest violators around the park. As a result, the encroachment into the protected areas by those seeking for agricultural and other economic opportunities had been minimized during the past decade (1994–2004).

Financing the Plan

Financial support for the development of the management plan to protect the MKRNP has had humble beginnings. In 1993, municipal mayors had to fund meetings from their own pockets. Having been chosen to be one of the country's 10 sites covered under the Conservation of Priority Protected Areas Project[11] (CPPAP), it was able to have funding for seven years starting in 1994.

During the life of CPPAP, funds amounting to P6.9 million were provided to the indigenous peoples for non-destructive livelihood activities (NDLA), mostly in terms of agro-forestry related projects; and PhP12 million for production related livelihood activities [12]. With the termination of the CPPAP in June 2002, the LGUs and their barangay counterparts took over funding the management of the plan. Other entities such as the DENR and the NGOs, the local indigenous and migrant communities who are directly dependent on the park continue to maintain their stake. In the later years, the local governments have also increased their funding for watershed management activities to as much as P2.6 million for Calendar Year 2002. In March 2004, PAMB, by organizing a water policy forum, solicited funds from the private companies who are resource users of the watershed services, especially water. One source of revenue of the Park comes from user fee charges for the environmental services that it offers.

Financing the plan was facilitated by several factors:

1. engagement of local communities in the activities and hence, some savings in the protection and guarding of the park;
2. local governments committed funds as a result of mutual trust among the membership of the management body, the PAMB; and
3. the trust and confidence given by the private sector to the PAMB in the management of the protected area.

The management process institutionalizes the sustainable management regime as exercised by the empowered communities (of both the IPs and the tenured migrants). These empowered communities enjoy a firm tenure over the resources, are actively involved in biodiversity conservation and protection activities, and supported by the local government, the private sector, and other community members who have internalized conservation values and the respect for cultural integrity.

One lesson learned in this exercise is that the protected area management can be implemented successfully by changing the locus of decision-making from national to local agencies (Sumbalan, 2001). Decentralizing management does not merely mean devolving responsibilities previously concentrated with the national bureaucracy but also means accompanying devolution with decision-making authority to various stakeholders. The experience in Mt. Kitanglad demonstrated that sensitivity and recognition of cultural and local knowledge, as well as, flexibility to negotiate with various stakeholders sustained MKRNP protection and development activities. Decentralization provided a venue for the participants such as the non-government organizations, local communities, indigenous peoples, and other related projects to come together for a common purpose, which is survival.

2. Protected Area Management: The Tubbataha Reef National Marine Park[13]

The Tubbataha Reef National Marine Park covers some 33,200 hectares and lies in the middle of the Sulu Sea, above 150 kilometers away from Puerto Princesa, the capital city of Palawan. The reef structure consists of both fringing and atoll reefs and harbors a diversity of marine life equal to or greater than any other such area in the world. In 1983, 46 coral genera, 300 coral species and at least 40 families and 379 species of fish were recorded. In 2000, 448 species from 57 families of fish were recorded.

In the late 1980s, the conditions of the once pristine reefs of Tubbataha deteriorated due to the destructive fishing methods used by fishermen. These destructive fishing methods were carried out not only by local fishermen but also by migrant fishermen from South and Central Philippines and from Taiwan and China. Though these fishing activities were limited due to monsoon winds, the cover of living coral on the outer reef flats were surveyed to have decreased by 24% within 5 years. The introduction of seaweed farming in 1989 also threatened the reef but fortunately this was stopped in 1991.

The management issues in Tubbataha National Marine Park have evolved substantially since 1989 when reefs were at their lowest point and illegal fishing was rampant. In 1999, Tubbataha was managed and protected and the management plan is now being implemented.

Just like the Mt. Kitanglad, Tubbataha Reef management activity started with its declaration as a natural park through a Presidential Proclamation in 1988. The first draft of the management plan based on limited information was done in 1989. It was only in 1992 that a research expedition collected baseline data on the coral reefs and from there, the Park management plan was re-drafted, though illegal activities still increased. In 1994, the Park was elevated to the World Heritage status, a UNESCO program. In 1996, the Coastal Resource Management Plan (CRMP) refined the management plan in collaboration with external donors and local agencies. The PAMB was formed in 1998; a year later, a Global Environment Facility (GEF) 5-year funding for park management based on the revised plan was approved.

Monitoring of the reef became a joint venture of various organizations, including local people. The fish abundance survey reflected the relative success of the new management since the abundance of fish per unit area was 26% higher on average than in 1996. While illegal activities such as use of explosives in

[13] Source of data was from White and Ovenden (no date).

fishing was contained, the current threat is the ability or inability of the Park managers to maintain constant surveillance in Tubbataha to deter the threat of illegal entry of fishermen from the Philippines and other Asian countries. The Park Navy personnel can take active role in park management.

Whereas MKRNP was managed predominantly by the locals, the management model for the Tubbataha seems to be the predominance of external institutions in its protection and care. With its status as a UNESCO World Heritage Site, Tubbataha has acquired more sustained funding both from national and international sectors possibly because of its environmental services not only to the Philippines but also worldwide.

3. Community-based Water Monitoring in the Uplands[14]

Collective action by community members has made possible the monitoring of water quality in an environment of rapid agricultural growth and urbanization, and the perceived consequence— increased water degradation due to soil erosion and bacterial (*Escherichia coli*) contamination.

The Water Watch Group (*Tigbantay Wahig* in the Binukid dialect) started as a volunteer group in early 1990s to support the community based water quality monitoring project under the SANREM-CRSP SEA[15] that was being implemented in Lantapan, Bukidnon. The objectives of the project were to facilitate the development of water quality and watershed assessments by local communities, and provide physicochemical data that would be used to improve water quality and policy (Deutsch et al, 2001; Rola et al, 2004b). Local citizens, including the native tribe (*Talaandig*) members and migrant farmers volunteered to receive training in water quality monitoring and principles of watershed management.

In 1995, the core group of water monitors proceeded to form a people's organization (The *Tigbantay Wahig*, Inc.) and incorporated themselves as an officially recognized non government organization. The monitoring results of the *Tigbantay Wahig* were disseminated to community members, educators and local policy makers, resulting in more serious actions by the local government for the need to develop a municipal watershed management plan and its implementation strategies. The mandate of this group is ideal in the monitoring and evaluation scheme of the municipal level plan, as long as they can be recognized as such in the formal governance structure.

The group was able to generate support from the local government to continue with their water quality monitoring work making them formal partners in

[14] Source of data was from Rola et al (2004b).

[15] SANREM CRSP brings together researchers from universities and specialist institutes in the Philippines, the U.S., and other countries as well as the International Agricultural Research Centers (IARCs) to work with farmers and other natural resource managers, communities, civil society institutions, and government agencies at local and national levels in the search for the means by which upland communities will be enabled to make better natural resource management decisions. The project funded primarily by the US Agency for International Development was implemented in Bukidnon from 1994 to 2004. Field activities of the third phase (2006-2010) are on going.

the management of natural resources at the municipal level. This move is also in consonance with the local government code provisions to involve communities in the management of resources. But in this case, civil society groups partnering with local governments could have been facilitated by their good mutual relations. This is of course true if the society is culturally and ethnically homogenous. Lantapan is populated by two groups: native Talaandigs and migrants mostly of Cebuano origin.

4. Community-based pest management and the irrigated rice environment [16]

To minimize the social costs to farmers' health and environment of too much pesticide use in rice, the technology called integrated pest management (IPM) was developed and launched in Asia in the 1980s. IPM is defined by the UN Food and Agriculture Organization (UNFAO) Panel of Experts as "a pest management system, that in the context of the associated environmental and population dynamics of the pest species, utilizes all suitable techniques and methods in as a compatible manner as possible and maintain the pest population at levels below the economic injury". IPM uses various techniques such as cultural control, plant resistance, biological and chemical control methods for the management of weeds, insects, rodents, and diseases. It uses pesticide as the last resort in preventing crop losses. Adoption of IPM in the 1980s was not very quick. In the 1990s, IPM extension was transformed: (a) from an individual to a community concern; (b) from an insect pest control to an ecology wide concern, (c) from a linear top down approach to a participatory method of technology delivery, and (d) from a traditional lecture teaching method to experiential learning (Palis, 2002). This was done through the season long farmer field school (FFS).

FFS is a non-formal education approach to IPM extension. It is referred to as "school without walls", where farmers learn together by undergoing an intensive training on IPM over the entire life cycle of the crop. Farmers meet 14–16 weeks, consisting of weekly meetings that last half a day and facilitated by the village agricultural technician. It also has an agro-ecosystem perspective where it builds on biological control as its ecological foundation and it anchored on four principles:

1. grow a healthy crop through the use of resistant varieties, better seed selection processes, and efficient nutrient, water and weed management;
2. conserve natural enemies-beneficial predators and parasites;
3. observe the field weekly to determine management actions necessary to produce a profitable crop; and
4. farmers become IPM experts and trainers.

Farmers who attended the FFS were found to improve their scientific knowledge of the rice ecosystem (Rola et al, 2002).

The study conducted by Palis (2002) in the village of Matingkis, Munoz, Nueva Ecija in both the wet and dry seasons of 1992–95 and 1999 aimed to

[16] Source of case study data was from Palis (2002).

determine the adoption and spread of IPM through the FFS, and assess the impact of IPM on farmer's livelihood and on the development of the community as a whole. The study's results showed that there was a dramatic decline in the proportion of the FFS farmers who were applying insecticides before and during the FFS and the seasons thereafter. Since then, the proportion of insecticide users had dropped considerably. Similarly, the proportion of non-PFS insecticide users dropped from more than 95% for both seasons in 1992 to 35% in the 1995 dry season and 29% in the 1995 wet season. It remained at 30% in both seasons of 1999.

Environmental impacts included the reappearance and perceived abundance of natural paddy foods such as fish of different varieties, native frogs, native snails, and others. Farmers claimed that the government's Masagana 99 program in the 1970s, which brought about intensive use of pesticides, had destroyed the aquatic life in the rice paddy ecosystem. Fishes, even in small streams, died. Fish such as the native *hito*, *dalag*, and *silap*, native shells, and shrimps disappeared shortly after the intensive use of pesticides in the 70s until the early 1990s, before IPM was practiced. Farmers in the study mentioned that they did not eat previously few available foods like tilapia because of the belief that toxic elements from the pesticides may have accumulated in the fish. Dead fish floating in the irrigation canals was an ordinary sight.

Lately, farmers had generally observed increase in the paddy food since the introduction of IPM in the village. Some of the paddy foods that disappeared during the 1970s and the 80s like native snails, small crabs called talangka, and some native species such as *sulib*, *silap*, *ayungi*, *gurami* and *biya* are now reappearing in increasing volumes especially the wet season. Most of these foods, found in the irrigation canals and paddy fields, augment the village food supply and anyone can gather them freely. IPM when adopted by all community members has generated benefits for everyone. Without the farmers' collective action to minimize pesticide use in rice, the resurgence of native food species in the paddy fields may not have occurred.

The cases above demonstrated that it is possible to manage ecosystem level bioresources with local participation, with external support, and with local government leadership. The common thread is that the stakeholders agreed that the resource was an important one for the survival of communities and therefore collective action was not difficult to attain.

Challenges of Bioresource Management at the Species Level[17]

So far, the subject of bioresource management has focused on ecosystems management, mainly due to the available documentation of the cases. As a country, there is a need to look into the species level management needs, where we consider bioresources as inputs to production of goods and services for the satisfaction of human wants and needs. But bioresources (i.e. biological specimens such as plants, animals, microorganisms, etc) are global public goods whose benefits are

[17] With contributions from Macaranas (2006).

indivisively spread among the entire community. Because of this "publicness", markets fail in their allocation and governments have the natural role to provide for these goods.

Policy on Bioresources Management at the Species Level

In an earlier section, data showed that the Philippines is in danger of losing its bioresources diversity, and this loss is shared by the whole world, because of the large number of endemic species in the country. Initiatives for institutional and legislative framework for bioresource management at the specie level have been very limited, if not nil.

The Philippines needs a more aggressive bioresource management policy. As a nation, we are party to international laws and treaties on bioresources conservation and other related issues, but we do not have our own local initiatives.

For instance, the International Treaty on Plant Genetic Resources for Food and Agriculture is a legally-binding Treaty covering all plant genetic resources relevant for food and agriculture. The Treaty is vital in ensuring the continued availability of the plant genetic resources that countries will need to feed their people. Its objectives are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of benefits derived from their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security. Through the Treaty, countries agree to establish an efficient, effective and transparent Multilateral System to facilitate access to plant genetic resources for food and agriculture.

Another important international agreement is the trade related aspects of intellectual properties (TRIPS) agreement which was piggybacked with the World Trade Organization Agreement. This means that countries signatory to WTO like the Philippines are now beholden to accept the trade related aspect of Intellectual Property Rights (IPR). TRIPS noted that national governments have the sovereign right over the biological resources. But increasingly, the implementing rules and regulations that defined these rights are in question by many countries.

To address these concerns, the Philippines issued an Executive Order 247[18] which states that it is the policy of the state to regulate prospecting of biological and genetic resources so that these resources are protected and conserved. Moreover, it requires the consent of indigenous cultural communities, thus, prospecting will be allowed within ancestral lands and domains of indigenous cultural communities only with prior informed consent of those affected communities.

Development of a Bioresources Management Plan

The following are the suggested steps in developing management plan for bioresources at the species level:

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[18] But implementation of these international laws at the local level has been constrained mainly by lack of capacities and resources.

1. Define inputs to the plan

The three inputs needed for this plan are the data bases of the inventory of the bioresources in the country, the database of the skills that are needed in this exercise and the traditional knowledge that connects bioresources to their origins and use.

The more important information for management is the existing inventory rather than the losses because this is where action can be initiated. The absolute figure for bioresource inventory is not known. To start with, activities should involve preparation of an inventory of flora and fauna wealth and their genetic makeup. It will be useless to plan if we do not know the stock, i.e. the number if species we have, and where they are located.

Moreover, we need a database of a worldwide network of Filipino scientists who can help in this inventory work. There were programs to entice scientists to work in the Philippines, but these were not sustained. The contribution of many of these scientists deployed overseas have vastly improved the state of the art of knowledge in many disciplines.

Likewise, the knowledge connected to the bioresources is continuously uncovered or developed by various scientists and are transformed into goods and services through indigenous or imported technologies by business, yet it seems that the Philippines is unable to manage this knowledge base for its own development. It is equally important to document the traditional knowledge that accompany community-based bioresource use and management. Aside from data for planning, there are needs for maps of rural areas.

2. Design strategies for bioresource management

Bioresources management system should be concerned with the vision/mission of what it is we wish to be known for in that area and how we intend to go about achieving that (Macaranas 2006). The Philippines has signed many multilateral environmental agreements and conventions that have shaped responses to the issues of bioresources management at the global and national levels. As discussed previously, we are also known for legislating national laws and developing excellent plans to implement the commitments, crafting programs where civil society plays the central roles, and devising some management processes that are recognized as best practices though not properly scaled up or implemented on a wider scale, to make any dent on the severe environmental problems facing the country.

(a) Participatory Models: Role of institutions and innovative partnerships

Communities have the starring role in the managing bioresources. They can partner with the LGU in this activity. The private sector can also practice their corporate social responsibility by soliciting partnerships with the local communities. But despite some cases of best practices shown by the case studies, there is still fundamentally a lack of collaboration at the local level. This can be caused by lack of trust among the stakeholders.

On the other hand, some of the community-based practices in bioresource management have gone beyond the scope of what is statutory, as provided under the Local Government Code (LGC). For example, innovations like the *bantay dagat or bantay gubat* programs are not in the LGC. But they are actually being done. The cases above show that this cooperation is possible but with the right mix of elements. Therefore there is a need to understand the incentives for communities to behave so that they become stewards and managers of their bioresources. Maybe a study of the system of governance of the IPs can explain some of these differences in bebavior.

(b) Financing the Plan: Investment needs and fund generation strategies

The big question is, "How do we generate the kind of resources to manage our depleted bioresources, conserve them, perhaps rehabilitate and grow the base from which our economic growth may come from?"

A couple of ideas come to light. One is to be familiar with how we can use intellectual property rights of the bioresources, and thus, generate some benefits from its future commercial use. For instance, the ayahuasca plant used as medicine by the Amazon indigenous people, and anti-diabetic herbal concoction used for centuries in India, have been patented in the US, depriving the countries from whicb they originated the right to use them or an equitable share of royalties. There are similar cases for the Neem tree, the Basmati rice, and the Andean root crop maca (Macaranas 2006). Thus, a major policy issue in resource management is, "bow do we really share in the benefits of our own resources, and thus fund their management"?

Second, is the traditional strategy, i.e. to tap the various stakeholders inside and outside of the country. Among these are the public sector, the private sector, the external donors, and the other communities of stakeholders. The public sector can allocate a percentage of our GDP for bioresource management. Trust funds are needed for many of these protected areas.

On the private sector side, it is very clear, that in terms of investments in conservation and in science and technology areas in general, our corporations have a very poor record. There are only very few corporations that make it to the list of those who have some ecological consciousness. These corporations are convinced that we not only share a common future with them but their destiny is in the public's hands.

External donors have been actively supporting us in bioresource management. From 1978 to 2003 or a total of 25 years, available record of inflow of funds for environment was 1.2 billion dollars. External donor can be tapped because the country holds species that are globally useful (as in Tubbataha Reef Marine Natural Park). One way to entice the rich donors or philanthropists will be to name new found organisms after these donors. In other countries, bids to name newly found organisms are offered to interested wealthy persons who can provide the needed financial resources to manage the newly discovered species. Filipinos working abroad, roughly 10% of our population can also be sponsors of bioresources inventory, and conservation programs.

(c) Global trade and bioresources management
Macaranas (2006) summarizes the issues as follows:

> "TRIPS agreement is the major policy area that bears watching since global markets for bioresources will grow increasingly and it is not clear how poor countries may share equitably as their own resources are accessed by both domestic and outside businesses, and traditional knowledge holders may not be properly recognized. These are issues at the heart of its implementation. Rural livelihoods, biotechnology for new products and IPRs eventually converge from these issues."

Furthermore, Macaranas (2006) reminds us that the main concern that must be raised in bioresource management is whether the Philippines has enough skilled human and financial resources to properly implement for its own benefits the WTO and the TRIPS, among other international agreements.

3. Outputs and Outcomes of Bioresources Management Strategies

There is also a need for a scheme of monitoring and evaluation of the plan implementation; i.e. an evidence that there are improvements in the sustainability of bioresources, by establishing indicators. The indicators will assess the benefits and costs of bioresources exploitation, development and utilization. Multidisciplinary research by biologists, governance and management experts, and social scientists will be needed in the monitoring of impacts.

Some Complementary Measures for Bioresource Management

Bioresources management needs macro level policies, other sectoral initiatives and changes in society's attitudes and mindsets in resource use and conservation. The following ideas from the RTD participants are complementary measures for local level bioresource management.

1. Structural changes

   If the economy shifts to more industry or service oriented jobs, then perhaps there will be less damage to our natural ecosystem. Growth of industry and service sectors can relieve pressure in the use of natural resources. To do this, human capacities for industrial or service type jobs will be needed.

2. Use of market instruments

   Markets influence consumption behaviour of people. Prices reflect scarcity. At the species level, bioresources are public and, hence, non-market goods. Therefore, valuation especially of genetic resources will have to be done.

   At the ecosystem level, a strategy is the conservation, protection and restorative (CPR) economics. Massive natural reforestation to restore the required 50% forest cover of the country's land mass and converting it into a business establishment; and a national network of marine sanctuaries to restore marine life will showcase the wealth of the country and will be attractive for ecotourism. Other CPR- like activities include cleaning of rivers, restoring aquatic organisms, establishing urban vegetable farms and herbal gardens. This can be done with private sector participation.

3. Population management

The following is an illustration of the practical impact of population numbers alone on bioresources as discussed by Ong (2006).

> If we use 1.2 billion as a number of people in China, with a one-child policy, then there are 400 million households in China. If one household will consume one chicken a night, that means 400 million chickens. So the first question is how big is the cage for 400 million chickens? The estimate is ten times the campus of Diliman, just to house the 400 million chickens for one night's consumption. And how much feed do you need for the chickens? So farms will have to produce for chickens, not just humans. And how big a farm do you need to produce feeds? How much waste will be produced? And how much feathers will be produced, in case you develop a pillow industry? And remember this is only for one night' consumption; imagine how much China would need in one year.
>
> —Ong (2006)

This point shows that population management is just as important as bioresources management. Population programs have to be seen as complementary measures. Many believe that a vigorous population management effort is essential for the sustainable development of the country.

4. Changing MAPs and bridging GAPs

As discussed by Ong (2006):

> MAP refers to mind set, attitude and practices. GAP is Goal, aspiration, promise. No single individual or organization can be successful in the campaign to save the Philippines from being a biodiversity hotspot. To change mindsets, for instance, one can shift to CPR. Our attitude towards consumer products and our practices will have to change. There is also a need to set goals that will serve as the target, something to aspire, a promise. Changing maps and bridging gaps could be the key to ensure our common future and survive as a people.

This needs group think, social structures and collective action. This means anticipating and working for the common good.

Conclusions and Recommendations

Based on the empirical evidence at the ecosystem level, institutions such as the PAMB and policies such as decentralized governance could potentially have an important impact on bioresource management. While the ecosystems serve as habitats of species, what is perceived to be urgently needed are measures to assure that species are themselves managed properly, in as much as loss of species qualify the country as "hot spots" in terms of internationally crafted biodiversity indicators. Participants to the roundtable discussion had several innovative ideas to make this happen as summarized in the previous section.

From the discussions, recommendations can be drawn as follows:

1. Institutionalize bioresource management planning.
   The major recommendation from the discussions was to make bioresources management an integral part of the development plans. This planning exercise starts at the lowest level of governance.

2. Capacity building will be needed.
   The science community can build capacities at various levels, such as creating database for inventories of species, introducing participatory approaches and defining good governance indicators. Fund management skills by local officials are also to be developed.

3. Science-based bioresource management planning is ideal.
   It was revealed that science contributed to the protected area management planning by supplying the necessary data to the decision makers. In ideal

situations, scientists shall continue to work with the other sectors including government especially in developing monitoring and evaluation techniques to monitor outcomes and evaluate the performance of these management strategies.

4. Multidisciplinary teamwork is imperative.
   Bioresource indicators are biological variables; management and governance concerns are social sciences, therefore, a multidisciplinary team is needed to work with the implementers of the management plan. Researchers and development workers can also help in evolving community-based institutions that would be relevant for bioresource management.

5. Develop a policy on benefit sharing.
   The question of benefit sharing in the commercial use of bioresources should be studied rigorously, to have potential sources of funds for management.

6. There is a need to study the indigenous peoples' governance and management practices, considered as having sustainable outcomes.
   Most of the studies in the past focused on resource management practices, including anthropologic and cultural norms of IPs. Studies can also include their governance sanctions, norms, and incentives.

7. Identify ways to integrate information and communication technology in bioresource governance.
   Maps will be needed, so use of GIS can be handy. Mapping will not only be an exercise of identifying and locating the species, but also of knowing its value or use.

8. More efforts on theory development to support empirical work on bioresource management will be needed.
   Theoretical underpinnings of meso-level analysis of factors that condition governments, the private sector, local organizations and other stakeholders to work together to support a more sustainable, equitable and efficient bioresources management decisions need more study. Understanding these factors may create a more significant dent to achieve sustainable development.

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Trans. Natl. Acad. Sci. Tech. Philippines 28:255–264 (2006)
ISSN 0115-8848

PRI\ RITIES IN THE BIOTECHNOLOGY INDUSTRY CLUSTER

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Abstract

The Philippine National Science and Technology Plan (2002-2020) states that the development priorities in biotechnology are its applications in agriculture, forestry and natural resources, health/medical sciences, environment, energy and manufacturing and process engineering. Applications have been identified in these sectors as follows:

For agriculture and fisheries — varietal improvement and sustainable productioo for food security; for forestry — maintenance and maximization of forestry resources; for health/medical sciences — prevention, diagnosis and treatment of diseases; for marine sciences — development of marine bioindustries; for energy — development of renewable energy resources; for manufacturing and process engineering — development of novel processes of manufacture using life forms as miniature factories to produce the desired products and for environment — bioremediation.

The plan also indicates that the priority researcb and development areas for biotechnology processes and technologies are in the following: plant tissue culture; immuno-based diagnostics, protein and DNA markers; microbial transformations; plant transformations; genome mapping; cloning single genes; and mammalian tissue culture.

The sectoral R&D councils have formulated their medium term plans consistent with the NSTP priorities. In agriculture R&D in biotechnology is geared to generate breakthroughs such as fertilizer substitutes, genetically engineered plants and animals, biological control of pests and diseases, and plant and animal diagnostics. In industry R&D will be focused in the production on specialty chemicals which includes food additives and intermediate chemicals used in food and chemical processing more particularly enzymes, organic acids, polymers for films, coatings and flavoring agents. In health diagnostics which aid in the treatment of diseases as well as development of vaccines especially on emerging diseases and other infectious diseases have been identified.

Consistent with the above priorities and pursuing the strategy of niching and clustering the Department of Agriculture, Department of Trade and Industry and the Department of Science and Technology pushed the creation of a Biotechnology Cluster under the Export Development Council. This is seen as a boost to the development and growth of the biotechnology industry in the country. The two subsectors identified with the their corresponding lines of products and services considered to offer good opportunities are the agricultural and health bioindustry subsectors.

Keywords: biotechnology, agriculture, bioindustry, health, clusters

One of the most important and critical interagency bodies in the country today is the Philippine Export Development Council. It is chaired by the Secretary of the Department of Trade and Industry and there is an equal representation in membership from government departments and from the private sector. The Secretary of the Department of Science and Technology is one of the members of the council and she is officially represented in the council by the Undersecretary for Scientific and Technological Services. One of the tasks of this council is to regularly prepare the Philippine Export Development Plan to define the country's export strategies and programs that shall be implemented by the government and the private sector within the framework of the Medium Term Philippine Development Plan or MTPDP. For instance, the current MTPDP for 2004–2010 rolls out a three-year Philippine Export Development Plan covering the period 2005-2007. This plan referred to as PEDP serves as the blueprint for the government in forming concerted action plans on export development and for private businesses in crafting their industry-and-firm level exporting strategies.

One of the strategic innovations adopted by the Export Development Council is the clustering strategy on the identified export priority sectors and one of the more significant development in sector prioritization is the inclusion of some sectors where the country has potentials even if the production or services sectors are still in their development stages. One such sector is the Biotechnology Sector which is now included in the list of what we may describe as a predominantly 'traditional' listing. Food, Wearables, Aquatic Products and Organic and Natural Products have been very traditional items. In the last two to three decades, however, the Electronics, Motor Vehicle Parts and Construction Materials sectors have become very significant items. In fact, exports in the Electronics and Semiconductor Industry Sector now constitute close to 70% of our manufactured exports. How and why then has Biotechnology entered the picture?

The market for biotechnology products and services worldwide has grown in an exponential fashion. The Philippines, on the other hand, has great potentials in this sector. PCARRD reports that there are more than 300 experts in the field. This may not be a large number but they can do much to elevate the sector into a significant contributor in terms of economic output. Of this number, PCARRD also reports that a third of them are involved in modern biotechnology and the rest are into traditional biotechnology activities. PCARRD also cites that the centers of excellence (COE) for modern biotechnology with moderately adequate facilities are the University of the Philippines Los Baños (UPLB) which includes the National Institute of Molecular Biology and Biotechnology (BIOTECH), Institute of Plant Breeding (IPB), and the Institute of Biological Sciences. The Philippine Rice Research Institute (PhilRice), the Philippine Coconut Authority (PCA) and the Philippine Carabao Center, all attached to the Department of Agriculture are also in this category. The National Institutes of Molecular Biology and Biotechnology (NIMBB) at the University of the Philippines Diliman, Manila and Visayas and SUCs like Leyte State University and the Central Luzon State University have strengths and potentials in this area. Many others are in their development stages. The fact that several priority sectors in the Philippine Export Development Plan are in the food-agri-natural products category makes Biotechnology a very strategic and important field or sector. Biotechnology products would most likely fall in this category but there are also products such as those in the health/pharmaceuticals/ medical sciences sector or what the Biotechnology Cluster in the Export Development Council calls the Bio-industry sector where the market is large and growing and where the Philippines can be competitive not only because of human resources capabilities but also because of the richness of the country's biodiversity. Mention of this Biotechnology Cluster in the Export Development Council at this point brings in the strategy of cluster management.

The National Cluster Management Team (NCMT) of the Export Development Council was constituted to review and validate value chain analysis of the priority clusters. It is headed by the Senior Undersecretary of the Department of Trade and Industry. In mid 2005, the Biotechnology Cluster was constituted with the Department of Science and Technology as the lead and with the DOST Undersecretary for S&T Services as cluster chair. The Cluster Team has an S&T Manager coming from DOST, an Agricultural Production Manager coming from DA, a Business Development Manager coming from DTI, a cluster champion from the private sector, a cluster adviser in the person of Academician Ceferino L. Follosco and a cluster secretariat provided by the Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) of DOST. There is also a Cluster Core Group composed of representatives of stakeholder groups – from business/industry, from R&D institutions, from policy and regulatory agencies, from the academe, and from other government organizations. There are industry champions coming from identified priority subsectors. During the first Biotechnology Cluster Workshop on December 5, 2005 it was agreed that the vision of the Biotechnology Cluster is to develop the Philippine Biotechnology Sector as an export earner within the 2007–2010 period and the focus will be Agri-biotechnology and Bio-industry (which includes Health Bio-industry). The goal is to launch at least five Biotechnology products into the export market in the next three (3) years and to support the long-term competitiveness and sustainability of Philippine biotechnology export products in the global markets.

Market Trends Potential Niches

What trends does this Biotechnology Cluster see as far as the global market is concerned? The Cluster sees a growing demand for agri-biotech products such as marine products like carageenan, API and fluorescent markers; derivatives from medicinal plants like anti-oxidants, enzymes, flavanoids and tannins; oils like those from fish, jasmine, ylang-ylang and coconut (VCO); GMO products like edible vaccines, fortified rice and pesticide free crops; biotech seeds, feed additives and biofertilizers like nitrogen fixation fertilizers and vermicompost. The cluster also sees a lot of opportunities in niche bioindustry products like natural ingredients, herbs/botanicals, and cosmetics and toiletries. And of course medical biotechnology, which is taken as part of the bioindustry subsector, is the largest biotechnology sector worldwide where there are promising niche markets in therapeutics like EPO, insulin and other biogeneric drugs, as well as nutraceuticals, diagnotic kits and validated traditional medicines. As far as vaccines are concerned domestic requirements are currently met by imports both for animal vaccines and human vaccines. Some statistics on DOH vaccine requirements for new born babies annually gives us an idea of local demand:

DPT	-	14.98M doses/year	PhP	97.9 M
Inj. Polio	-	14.98M doses/year		54.67 M
Tetanus Toxoids	-	11.65 doses/year		17.47 M
HiB	-	12.3M doses/year		1.045B
Measles	-	5.98M doses/year		36.47 M
MMR	-	5.98M doses/year		897 M
HepatitisB	-	10.77M doses/year		215.4 M

The total amount is PhP2.31 Billion and this does not include BCG which is currently being produced locally.

Biotechnology R&D Plan

How does the R&D program in the S&T community match these demand projections?

The Philippine National Science and Technology Plan (2002–2020) states that the development priorities in biotechnology are its applications in agriculture, forestry and natural resources, health/medical sciences, environment, energy and manufacturing and process engineering. Applications have been identified in these sectors as follows: For agriculture and fisheries—varietal improvement and sustainable production for food security; for forestry—maintenance and maximization of forestry resources; for health/medical sciences—prevention, diagnosis and treatment of diseases; for marine sciences—development of marine bioindustries; for energy—development of renewable energy resources; for manufacturing and process engineering—development of novel processes of manufacture using life forms as miniature factories to produce the desired products and for environment —bioremediation.

The plan also indicates that the priority research and development areas for biotechnology processes and technologies are in the following: plant tissue culture; immuno-based diagnostics, protein and DNA markers; microbial transformations; plant transformations; genome mapping; cloning single genes; and mammalian tissue culture.

Agriculture and Natural Resources R&D

The sectoral R&D councils have formulated their medium term plans consistent with the NSTP priorities. The Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) presents their Biotechnology Agenda up to 2010 as follows:

> The Philippine Agriculture and Forestry Biotechnology Agenda had been crafted starting 1995–2000 (PAFBA I) and the second phase from 2001 – 2010 (PAFBA II). The R&D thrusts are geared to generate breakthroughs such as crop disease and animal product diagnostics, animal vaccines, novel genes and proteins, genetically modified crops, biofertilizers, biopesticides, disease free planting materials, molecular markers for useful plant and animal traits and plant varieties developed through marker-assisted breeding. Scientific priority R&D are defined for crops, livestock, forestry, agricultural resources and crosscutting concerns.
>
> The crop biotechnology R&D activities focus on nine-major crops namely —coconut, papaya, mango, banana, corn, sweet potato, rice, abaca and endemic plants. Genetic engineering and mutation breeding and employed to develop transgenic varieties of papaya resistant to papaya ringspot virus and with prolonged shelf life, banana resistant to banana bunchy top virus, coconut with high lauric acid content, sweet potato resistant to feathery mottle virus, rice enriched with Vitamin A and resistant to bacterial blight and tungro virus, and abaca resistant to abaca bunchy top and mosaic viruses. Corn varieties resistant to downy mildew and stalk rot complex will be developed through marker-assisted breeding. Organ culture and transformed root of endemic plants is also being pursued for secondary metabolite production. Novel genes are being identified from coconut through molecular cloning and functional genomics. Other R&D areas are DNA fingerprinting for sex determination and diversity analysis, genome mapping, disease diagnosis, proteomics and bioinformatics.
>
> The livestock biotechnology R&D program focuses on the use of advanced reproductive biotechniques like *in vitro* oocyte fertilization (IVF), *in vitro* oocyte maturation (IVM), embryo cropreservation and manipulation, superovulation and embryo transfer (SOET), and somatic cell nuclear transfer for genetic resource conservation, improvement, and utilization.

Characterization and cross-inoculation of microbial population for rumen function manipulation are also being worked out. Recombinant DNA technology and immuno-based systems are being harnessed to develop animal disease diagnosis.

Wood production from forest and nontimber species like mangium, yemane, narra, mahogany, bagras, falcate, bamboo and rattan is the major thrust of the forestry biotechnology research. The program hopes to ensure the availability of quality planting materials using microselection, characterization, macropropagation, and genotype assessment. Biofertilizer from rhizobia and mycorrhizae for selected indigenous tree plantation species are also being developed.

Recombinant DNA technology is applied to enhance the performance efficiency of microorganisms for rapid and effective garbage degradation. DNA fingerprinting and marker technology on mixed microbials is studied to enhance the sequestration of heavy metals in contaminated agroecosystems. Gene marker technology and DNA fingerprinting is applied in developing microbial formulation for the deodorization of livestock and market wastes.

Integral to the framing of an S&T agenda on biotechnology is the need to address crosscutting concerns that would critically affect the research-technology generation-commercialization continuum. When these concerns are addressed adequately, an enabling policy, institution, and macroenvironment will facilitate the emergence of technology-based industries/sectors in agriculture & forestry aside from the usual technology generation and commercialization. There is also a need to bridge the incredible knowledge gaps that exist and to address the general lack of awareness among the population. Rational and science-based discussions of the technology and its related issues can take place if these requirements are met. Seven major priority areas have been identified to address these crosscutting concerns: (1) policy research and advocacy; (2) IEC; (3) ICT; (4) institutional capability; (5) IP and technology management; (6) technology commercialization; (7) ex ante/ex post socioeconomic assessment.

Fisheries and Aquatic Resources R&D Plan

As far as the Fisheries and Aquatic Resources Sector is concerned the Biotechnology Sectoral Plan (2006–2020) has the goal of using biotechnology in the conservation and sustainable use of aquatic resources and in improving the income of fisherfolk/fish farming communities. More specifically the Plan's objectives are : (1) to conserve aquatic and marine biodiversity and enhance the utilization and management of fisheries resources through aquatic and marine biotechnology, and (2) to develop superior cultivable stocks and increase the productivity and sustainable use of culture systems by using biotechnology. The R&D program for this sector includes the following elements:

1. Development of genetic markers for the proper management of aquatic and marine resources.
2. Screening of novel and bioactive compounds for the development of new drugs, pharmaceuticals and therapeutic agents.
3. Bioremediation technologies for the biodegradation of pollutants in pond systems.
4. Development of diagnostics/vaccines for aquaculture and mariculture.
5. Development of genetically improved strains of cultivable species.
6. Establishment of germplasm center of economically important seaweeds and other commercially important aquatic species.

This R&D Plan includes priority R&D activities in Marine Science and in Fisheries and Aquaculture. For Marine Science the priority R&D areas are those on carrageenases and agarases and the isolation and characterization of novel metabolites, enzymes, and bioactive compounds [immunosuppresant, antimalarial, antimicrobial (includes antitubercular, anti-bird flu, anti-rabies, anti-hepatitis *etc.*), anticancer, anti-asthma, bad cholesterol elimination, cardiovascular disease prevention/cure, anti-arthritis, anti-diabetes, anti-obesity, anti-depressant/narcoleptics] from microbial associates of marine invertebrates.

In this R&D Plan also, the priority R&D areas in Fisheries and Aquaculture have been identified. These are in stock management and improvement of cultivable strains, diagnostics, disease control, bioremediation and feed formulation improvement. For stock management and improvement of cultivable strains the specific programs are:

1. Development of genetic markers for species identification, stock monitoring and management, genetic enhancement and selective breeding.
2. Establishment of germplasm center for economically important seaweeds and other commercially important aquatic species.
3. Strain improvement of economically important finfishes for rapid growth and enhanced environmental tolerance.
4. Development of improved cultivable strains of high yield and high quality phycocolloid (agar and carrageenan) producing seaweeds.
5. Development of disease resistant strains of economically important seaweeds.
6. Development of recombinant hormones for growth enhancement and controlled reproduction.

In diagnostics the plan is to develop a Denaturing Gradient Gel Electrophoresis (DGGE) map for aquatic and marine organisms and to develop antibody and DNA – based probes for pathogen detection and identification e.g. for ice-ice disease and other diseases of seaweeds. In the area of disease control the planned programs are the development of vaccines, immunostimulants and probiotics for disease control and water quality management, e.g. for White Spot Syndrome Virus (WSSV) and the evaluation of commercially developed probiotics.

In the area of feed formulation the concern is for improved nutritive value of feed substitutes through microbial inoculants and exogenous enzymes. For Bioremediation the following are the priorities:

1. Development of bioremediation technologies for the biodegradation of pollutants in pond systems.
2. Development of anti-red tide agents including depuration agents.
3. Development of bioweedicides to control weed infestation in economically important seaweeds.
4. Development of biopesticides to control microbial infestation in economically important seaweeds.

Health/Medical Sciences R&D Plan

In health and medical sciences, R&D in biotechnology will focus on the development of vaccines, diagnostic kits and drugs.

Vaccine Development will focus on the development of a local vaccine against schistosomiasis, diarrheal diseases, rabies, HIV and avian flu. Vaccines hold enormous potential for the control of infectious diseases and have global market prospects. The development of a local schistosomiasis vaccine will involve candidate molecules developed by local researchers from the Research Institute for Tropical Medicine with their collaborative partners and the establishment of a current good manufacturing practice (cGMP) pilot plant. This plant serves a multipurpose facility for future R&D work, bench scale production and cater to the distribution needs of the Department of Health's Expanded Program on Immunization. Edible vaccines will be also developed against diarrhea causing agents (*Salmonella typhi* and *S. paratyphi*), rabies and HIV. Edible vaccines use transgenic plants, such as tomatoes or bananas whose genome has been altered and that express the vaccine antigen. The proposed avian flu vaccine will use recombinant technology.

Diagnostics development will focus on the detection of priority diseases (like dengue, schistosomiasis and colorectal cancer). Large-scale production of dengue viral antigen for the dengue detection kit will be continued. Enhancement of a monoclonal based immunoblot assay for the field diagnosis of schistosomiasis will be pursued. The presence of TAG-72 is a useful and specific cell surface tumor antigen marker.

Drug development will focus on essential drugs (off-patent and soon-to-be patent free) and anti-infectives needed by the population. The R&D will focus on bioactive molecules derived from marine (like sponges) or terrestrial sources (like plants) that can be used in drug development. Marine microbial extracts will be tested for its anti-infective activity for TB, nosocomial infections and other viral diseases. Techno-transfer activities will also be pursued for the recently completed AMOR program (Antibody Biotechnology and Liposome Drug Delivery

Technology for Experimental Therapeutics of Breast Cancer) which has proof of principle that its novel drug isolated from local marine and terrestrial sources, and conjugated with a humanized antibody in a liposome delivery system works for breast cancer.

Other Biotechnology Related R&D Priorities

The other R&D Councils of DOST namely the Philippine Council for Industry and Energy Research and Development (PCIERD), the Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) and the collegial body, the National Research Council of the Philippines (NRCP) have also formulated their R&D Agenda for Biotechnology. PCIERD is focusing on two major areas: functional food and biofuels (coconut methyl ester, bioethanol and biodiesel). These will be done in collaboration with PCHRD in the case of functional foods and health protection products. A number of health protection foods are in the market today such as: immunity modulation food, blood fat modulation food, blood super modulation food, anti-aging food, radiation blocking food, weight loss food, intestinal modulation food, etc. PCARRD will necessarily be involved in both functional foods and biofuels.

PCASTRD plans to focus on Bioinformatics and in providing support in general to Biotechnology R&D. PCASTRD will also provide support to the Philippine National Collection of Microorganisms (PNCM) – BIOTECH-UPLB and other well-established culture collections in characterizing their microbial collections at the molecular level, especially those that will be developed as commercial products. The molecular markers will be very useful in protecting the intellectual property claims in these microorganisms. PCASTRD will also help facilitate the submission of proposals to different international funding agencies to make the PNCM-UPLB an International Depository Authority (IDA) for microorganisms which is recognized to handle patented microorganisms under the Budapest Convention.

NRCP shall focus on basic biotechnology research such as screening and taxonomic studies and the development of techniques for molecular analysis. PCASTRD's basic research priorities shall complement NRCP's efforts. These are, in addition to bioinformatics, in the analysis of gene sequences and protein analysis.

The R&D Agenda is long and comprehensive even as there is a deliberate effort to focus and prioritize. It is because biotechnology has applications in many sectors and areas. There are also many potential niches in the market, both local and global, and perhaps the wisest thing to do is to consider the market trends in the time plan for the R&D activities. It is also very timely to consider some macro-level recommendations made by two active members of the Biotechnology Cluster Core Group members – Ms. Maoi Arroyo, CEO and President of Hybridigm Consulting, Inc. and Dr. Evelyn Mae Mendoza of the Institute of Plant Breeding at UP Los Baños, a member of the NAST. Ms. Arroyo, in emphasizing the need to provide Return-on-Investment (ROI), suggests the training of scientists in fundamentals of technology entrepreneurship and in Intellectual Property Protection (IPP), the maintenance of industrial liaisons and close collegial contact, the mitigation of technical risk in R&D as much as possible, doing effective science communication, and the establishment of central laboratories, incubators and innovation centers. She sums it up by saying that any initiative to catalyze Philippine Biotech must be market-based and market validated and it must provide sustainable competitive advantage to early adoptors. Dr. Mendoza, on the other hand, pushes for the adoption of the clustering management approach for Philippine Biotech, the coordination and orchestration of a unified Biotechnology Agenda, the selection and prioritization of appropriate technologies for commercialization, and the implementation of enabling policies for R&D, financing, education and Intellectual Property Rights.

There is really one more basic thing to do: to identify clear targets and milestones and to focus all actions towards the realization of these targets and milestones.

In closing the contributions of PCARRD, PCAMRD, PCHRD, PCIERD and PCASTRD are gratefully acknowledged. Likewise, the outputs of the Biotechnology Cluster with very significant contributions coming from Mr. Danilo Manayaga of Secura International Corporation, Dr. Francis Gomez of Altermed Corporation, Dr. Saturnina Halos of Amichem Corporation, Dr. Corazon de Ungria of the Natural Sciences Research Institute of UP Diliman, and Dr. Ceferino Follosco of NAST have been used as major inputs to this presentation.

Trans. Natl. Acad. Sci. Tech. Philippines 28:265-294 (2006)
ISSN 0115-8848

AGRICULTURAL BIOTECHNOLOGY TRENDS AND CHALLENGES[1]

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Abstract

The main objective of this paper is to assess the leading edges of today's knowledge in agricultural biotechnology at the global scale, and offer some recommendations on the possible niches of the Philippines. Until recently, biotechnology is neatly classified as agricultural (including forestry and aquaculture), health, industrial and environmental. Presently, however, a great revolution is going on. Agricultural biotechnology is invading the other fields of biotechnology! We can call this the third agricultural revolution. The first revolution started the process we now call civilization 10000 years ago; the second (the Green Revolution) saved civilization from hunger about 40 years ago. The third hopes to save us from the problems created by the first and second revolutions and provide the material needs of future generations in a sustainable manner.

The scope of agriculture is now being extended from provision of basic needs, namely, food, fiber and clothing to include needs of modern civilization such as energy, materials, drugs, and industrial products such as enzymes. The definition of agricultural crops is being extended to include not only higher plants, but all photosynthesizing organisms. Techniques traditionally used for industrial scale culture of bacteria and fungi are being applied for single cell, tissue and organ cultures of higher plants and other photosynthesizing organisms. Thus, we are looking forward to a new generation of biofactories and production systems using photosynthesis as the main engine. These biofactories will produce traditional and non-traditional products cheaper, faster, safer and better. It is an exciting future with a lot of promises but many challenges and unknown perils, too.

The niche for the Philippines is dictated by the reality that its land area, the traditional basis of agriculture is limited. In addition, its climate is generally less favorable for traditional agriculture than many other environments. On the other

[1] Plenary paper presented during the Annual Scientific Meeting of the National Academy of Sciences, Philippines, held in the Manila Hotel, July 12, 2006.

hand, the Philippines has a huge surplus of unemployed manpower, sunshine and water. Review of recent literature suggests the following leading edges suitable for the Philippines for scientific and technological development in the field of conventional and modern agricultural biotechnology: 1) new agricultural crops that are less susceptible to the vagaries of local climate and limitations of arable land, 2) new approaches for recombinant DNA technology, specifically plastid engineering; and 3) bioreactors and less sophisticated production systems using higher plant cells and organ cultures, and other photosynthesizing organisms such as mosses and algae.

Scientific literacy is a prerequisite for the third agricultural revolution. A scientifically literate nation will formulate policies that will encourage innovation, deploy its best minds to the service of science and technology, and create a public that is receptive to new ideas. Even as we look to the future, the struggle for public acceptance of the third agricultural revolution is taking place today. There are existing biotechnologies waiting to be used, such as transgenic crops, livestock, forest trees and fishes. These will not prosper if public reaction and corresponding government regulation is guided by imagined risks rather than demonstrated benefits. The paper argues for a system of regulation that will achieve an appropriate balance between the need to assure the public of the safety of agricultural biotechnology and the imperative to explore new technology for solving the problems of modern living.

Keywords: agricultural biotechnology, biotechnology, green revolution, transgenic crops, recombinant DNA

Introduction

The future of agricultural biotechnology is not likely to be limited to transgenic crops grown in the field for clothing, feed and food. Energy, fuels, chemicals and fibers, products that have been traditionally obtained from the petrochemical industry, are likely to be an equally important objective for agricultural biotechnology in the near future, and transgenic crops are expected to make an important input to these goals.

Transgenic crops will not necessarily be grown only in the field, and it will not necessarily involve culture of field and horticultural crops by conventional farmers. Cell and tissue cultures of higher and lower plant forms will find novel uses in pharmaceutical, industrial and environmental applications. Plants are simply more flexible, faster and safer as "biofactories" of useful molecules that were traditionally produced using chemical processes, or biological processes using microorganisms and animal cell systems as platforms. Transgenic livestock and fish will take a little more time to reach acceptance, but lessons learned from the transgenic crops will contribute to the understanding and solution of unique problems in these products.

There will be less controversy in the future as science clarifies the various safety and environmental concerns that dominate today's debate, technology becomes more predictable and less prone to unintended effects, and superstition becomes less of a factor in policy making. Further, the sheer magnitude of problems associated with improving the quality of life of a growing world population will finally convince the world that the imagined risk of genetic engineering is greatly outweighed by its demonstrated benefits.

There were initial concerns that the benefits of agricultural genetic engineering would not benefit the poor and disadvantaged sector of society. We had the same concero when such common devices as the motor vehicle, radio, television, computers, and cell phones first came to commerce. Only the rich could afford them then. But it took less than 50 years for the motorcycles and automobiles to become available for mass consumption, less than 30 years for the computer to reach the farthest end of the planet, and less than 10 years for the cell phone to reach the hands of the poorest sector of society. Today, transgenic corn, soybeans and cotton are grown hy more poor farmers worldwide than rich farmers, only 10 years since their first introduction in the USA. It is only a matter of time before the benefit of transgenesis spreads to other crops, livestock, forest trees and fish. Improved technology will be a crucial factor, as it was in the case of cell phones and other modern gadgets.

In this paper, we are going to show where science and industry are leading agricultural biotechnology and agriculture in general, and how much safer, more predictable, faster and cheaper the basic needs of man are being met hy genetic engineering. Towards the end, we are going to show how a poor country such as the Philippines can benefit from agricultural genetic engineering biotechnology.

Scope of Agricultural Biotechnology

Not too long ago, agriculture was so simple. It simply meant production of agronomic and horticultural crops, on one hand, and poultry and livestock on the other hand. Agriculture includes to some extent, primary processing such as making copra or drying of coffee beans. Then agroforestry came along, together with the concept of industrial tree plantations. The confusion started. Is this agriculture or forestry? Then came aquaculture and integration of farming and fishery, seaweeds. Are "weeds" not supposed to be the concern of plant agriculture? Are not the principles of aquaculture the same as agriculture? After all, fish also need to be fed and protected from pests and diseases, like livestock and plants. Fish breeding is also selection and generation of variability, in the same way that plant breeding is. Government aolved this confusion neatly by putting fishery in the Department of Agriculture, but the status of agroforestry and industrial tree plantations remain contentious.

At the basic level, there is less confusion. Take courses in basic agriculture, forestry and fishery today and you will likely get the same lessons in physiology, biochemistry, ecology and genetics; as well as nutrition, health care, and breeding. The case studies will be different but the principles will be essentially the same.

At the most basic level, there is no confusion. Life is chemistry, guessed Jan Batista van Helmont in 1648. Today we know that this is not only true, but in addition we know that the chemistries of all living things are essentially the same. This has been the fundamental assumption, repeatedly proven, in genetic engineering. Take a gene from a bacterium, and with only a few tricks, it will function in plants, or any other living form for that matter. This is because bacteria and other living forms share many biochemical processes in common. When the human genome was completed, one of the surprises was the discovery of some 100 or so DNA sequences that look like bacterial genes. We share about 40% of our genes with plants; and 98.5% with chimpanzee.

Genetics is a great simplifying discipline, but genetic engineering does the exact opposite. It adds a different level of confusion to that caused by new disciplines such as agroforestry or seaweed farming. When you genetically engineer a corn plant using a bacterial gene and techniques in microbiology, is this microbiology or agriculture? At least on this point, there seems to be a consensus. It is agricultural biotechnology, perhaps because the use of corn is not altered. It is still used for food or feed. Or perhaps it is because one gene from a bacterium does not convert the corn into a bacterium. But when you genetically engineer a corn plant to produce a drug, is this biopharma or agricultural biotechnology? When you genetically engineer a pig to produce organs that can be used for people, is this health biotechnology or agricultural biotechnology?

These questions may sound trivial, but they raise serious challenges to the way we see the biological world, organize, and transmit knowledge today. In the same manner that genomic information has challenged classical taxonomy, genetic engineering poses a challenge to traditional ways of organizing knowledge and technology. This obviously is not a problem for industry, which does not recognize boundaries; but it is a great problem for academe and government; especially for academe, which must reflect new ways of organizing knowledge in its academic programs and organizational structure.

Beyond all these confusions is the fact that traditional agricultural crops and livestock are now expected not only to produce food, feed and fiber; but also energy, fuels, chemicals and materials; even drugs. The need for new crops species to supply sufficient quantities of these needs in a sustainable manner has led to cultivation of traditional forest species. Principles and practices in modern agriculture are being applied to industrial tree plantations and aquaculture. Agriculture is expanding and so is agricultural biotechnology. We do not know where it will end. I have no doubt that many of you will disagree, but this is the premise of my subsequent presentations.

Making Agricultural Biotechnology More Predictable and Safer

1. New tools for documenting the impact of genetic engineering at the molecular level

As a new technology, genetically modified crops understandably create anxiety and fear to the average person. This fear is encouraged by popular movies such as genetically modified fish, snakes, and even ants that eat people. Indeed, fear of the unknown is the element that is being exploited by those who would like to discredit GMOs for whatever reason.

Research has developed new tools that serve to illuminate many of the uncertainties and so-called unintended consequences of genetic modification. One of these tools is molecular profiling, which allows comparison of gene expression of GMOs with non-GMOs at the global (entire genome) level, unlike before when it was only possible to look at the action of one or a few genes at a time. The products examined may be RNA, proteins or secondary metabolites. The limitation of the old method is that it is not possible to determine if the transgene has influenced other genes. It is also not possible to determine in a direct way if novel proteins (in addition to the transgene product) are somehow produced. This limitation gave way to speculations that genetic modification could alter genes that are not meant to be altered, or otherwise result in unspecified interactions among genes leading to the production of new molecules that can be harmful to the environment or human health.

Molecular profiling and microarray analysis have been done with *Arabidopsis*, a model plant, wheat, and potato in recent literature. In the case of *Arabidopsis*, the ATH1 GeneChip from Affymetrix was used to search for transcriptome changes associated with the strong expression of transgenes. From this work, no change in the transcription pattern of approximately 24000 genes could be associated with the transgene expression. The authors concluded that the transgenic and non-transgenic plants were equivalent in their global patterns of transcription.[1]

In the case of wheat, comparison was made between wheat that has been transformed of a phytase gene, and the untransformed version of the same line. A 9K wheat cDNA microarray was hybridized to fluorescently labeled cDNA from developing seeds of the experimental materials. Results of this comparison were validated using real time PCR. The conclusion was that the phytase gene had no significant effects on the overall gene expression patterns.[2]

In the case of potato, a comparison was made in the pattern of proteins among eight GM lines, the parent cultivar Desiree, and a line that had undergone tissue culture only. Only nine out of 750 proteins showed statistically significant differences among the GM lines and the controls. No new proteins unique to the GM lines were observed and there was no evidence for any major change in protein patterns. In addition, the study showed that the differences among non-GM cultivars were much greater than the differences among the GM lines.[3]

Molecular profiling has its own limitation. First, it is not possible to cover all the products of gene action. While present technology now allows a fairly exhaustive coverage of DNA and RNA, a similar coverage of proteins and metabolites is not yet practically possible. In the first place, the profiles of proteins and metabolites, like that of cDNA and mRNA, can be altered by environmental and developmental factors. Secondly, the total number of chemical substances produced by plants is simply so enormous (estimated to be 100,000–200,000), and any single plants would have 5,000–10,000[4]. There is not one analytical method today that can identify and quantify this diversity of substances. But the most important limitation of molecular profiling is the difficulty in interpreting the biological significance of differences in molecular profiles.

2. New tools reduce the element of uncertainty and perception of risk in genetic engineering

a. Selectable markers

The most common marker used in production of current commercial transgenic crops is the antibiotic resistance gene. Although this method has been exhaustively studied and believed to be relatively safe, there is a persistent fear of the antibiotic gene being somehow transferred to human pathogenic bacteria.[5] The following alternative selectable marker genes can be used in future constructs:

- Antibiotic resistance gene of plant origin as an alternative to the *nptII* gene from *E. coli* which is popularly used. This concept was demonstrated using *Atwbc* 19, a gene obtained from *A. thaliana*, and used as a selectable marker in transgenic tobacco.[6]
- Many more novel selectable marker genes that do not involve antibiotic resistance were described by Bajaj and Mohanty 2005.[7]

b. Promoters

Another commonly raised concern regarding the current set of commercial transgenic crops is the use of 35S CaMV promoter, which was obtained from the cauliflower mosaic virus. This type of promoter results in gene expression in practically every tissue of the plant all the time. The level of gene expression is determined partly by the promoter used in the construct. In the case of 35S CaMV promoter, duplication of some sequences and addition of enhancer regions were done to improve gene expression. Critics fear that this promoter may somehow be integrated in cells of the human intestine if the transgenic crop is used for food, and cause unintended effects.[8] However, the more important issue regarding constitutive promoters, in general, is that their use is theoretically a waste of the plant's energy. The ideal promoter is one that will be active only when and where it is needed, and will result in optimum level of gene expression.

Concerns about the "foreign" nature of first generation promoters motivated the use of constitutive promoters obtained from plants such as rice *actin1* and maize *ubiquitin* promoters, which are widely used in monocot transformation.[9] In dicots, a number of endogenous constitutive promoters have been reported but they are not yet widely used. Lately, a new constitutive promoter from *Medicago truncatulata*, designated *MtHP*, was claimed to direct higher levels of gene expression than 35S CaMV.[10]

A truly "clean" transformation system could be visualized as one that uses only DNA of plant origin. One approach is to use a plant-derived (P-) DNA fragment to replace the universally employed Agrobacterium transfer (T-) DNA , coupled with a method for negative selection against marker gene integration. This was used to produce marker-free and backbone free potato, which was claimed to be the first transgenic plants that only contain native DNA.[11] To complement this technique, the desired genes can be obtained from other species of plants of the same or different genera instead of obtaining them from other Kingdoms. Examples of these are Xa21 gene, which was transferred from a wild to cultivated species of rice and ferritin gene, which was transferred from soybeans to rice.

c. In planta transformation

Embryogenic and meristematic tissues are the usual materials used in plant transformation. They have the advantage of ease in handling large number of potential plants, ease in selection and they facilitate recovery of hundreds of transformed plants. However, they have one serious problem: they have to pass through tissue culture stage, including dedifferentiation and embryogenesis. This limits the scope of transformation because many species and varieties are recalcitrant to tissue culture. Further, the tissue culture process often produces mutations that may not only affect the transferred DNA, but give other undesirable plant characteristics leading to the rejection of the lines derived from mutants. In addition, significant epigenetic changes can also occur.[12] The net result is that a plant breeder needs to screen a large population of plants transformed with the same construct to find one that has the desired combination of simple DNA insertion, desired level and stability of gene expression and minimal mutation from tissue culture.

To avoid the problems associated with tissue culture, work on in planta transformation started with the model plant *Arabidopsis* in the late 1980s.[13] Work in the 1990s demonstrated the possibility of transforming seeds, seedlings and flowers of this model plant and subsequently in other species of Brassica such as pakchoi[14] and radish.[15] The technique was as simple as dipping, spraying, or pricking the seeds, seedlings or flowers with the *Agrobacterium* inoculum, growing the plant to maturity, and screening for transformants in the next generation. However, it was not until 2000 that the technique was successfully used in another non-Brassica plant species, *Medicago truncatula*.[16] Recently, in planta transformation of the model monocot species rice[17] was reported. All of these methods relied on the use of *Agrobacterium* as a vector.

d. Plastid transformation

DNA in plants is not solely found in the nucleus. It is also found in the mitochondria and in the plastids (such as chloroplasts, amyloplasts, and elaioplasts). Thus, the possibility of plastid transformation has been recognized and demonstrated in the case of algae in 1988[18], and subsequently in tobacco in 1990.[19]

Plastid genome transformation provides a solution to many of the difficulties associated with nuclear genome transformation. Among these are the problems of site-specificity, gene silencing because of high transgene copy numbers, and low expression levels or conversely, pleiotropic effects due to very high concentrations of foreign proteins in the cytoplasm resulting from the expression of the nuclear transgene (Daniell et al 2002). Plastid transformation benefits from a high frequency of homologous recombination, absence of gene silencing even at very high transgene expression levels, ability to introduce blocks of foreign genes in a single operon, and maternal inheritance (plastid genes are not present in the pollen).[20] The high levels of protein products that could be produced in the plastids, as well as the high quality of these proteins make plastid transformation ideal for many purposes, such as production of pharmaceutical products. The possibility for introduction of multiple genes in a single block simplifies the modification of biochemical pathways. Indeed, the use of plastid transformation for enabling plants to fix N and improving photosynthetic CO_2 fixation have been mentioned as possibilities in early literature.[21]

Nevertheless, the practical application of plastid transformation is fairly recent. A 2000 review by Bogorad noted that tobacco was the only crop in which fertile plants with plastid transgenes have been described. This is partly because many crop plants could only be regenerated using non-green embryonic cells (containing proplastids) rather than leaf cells (containing chloroplasts).[22] Problems such as retention of transgenes in the presence of untransformed plastids, and limitations such as lack of information on genome sequences have slowed progress. Moreover, there are problems associated with post-translational modification of chloroplast-derived proteins, thus this technology is limited to products that are active without modifications (Joshi and Lopez 2005). Lastly, among the methods used to transform plant chloroplasts, only particle bombardment (with its known limitations) has proven to be efficient.

Taken together, the new knowledge and tools would tend to reduce the element of uncertainty in the transformation process as well as on the quality and safety of the product. The in planta transformation systems could reduce the background mutation effects that tissue culture-based transformation systems used before are associated with, making the transformation process less disruptive to the plant genome. The discovery of plant genes, promoters, regulatory elements and selectable markers provides future biotechnologists the option to use these instead of "foreign" DNA. The availability of inducible and tissue specific promoters will be an added assurance that the gene products will only be expressed when and where it is needed, unlike in the first generation GMOs. Gene targeting technology will reduce the uncertainty of the integration site of transgenes among other benefits. Finally, technologies such as plastid transformation provides a degree of assurance that pollen from transgenic crops will be free of transgenes. Indeed, the toolbox for plant genetic engineering has greatly enlarged as a consequence of persistent research.

3. New platforms for transgene expression

a. From microorganisms and animal cells to plants

Plant genetic engineering biotechnology is described today as having three phases. The first phase refers to engineering of input traits: those that benefit the farmer, such as insect resistance and herbicide tolerance. The second phase refers to engineering of output traits: those that benefit the consumers, such as Golden Rice and Vestive™ soybeans that contains a reduced level of linolenic acid. The third phase refers to the production of high value products such as antibodies, vaccines, therapeutic proteins, as well as industrial enzymes and secondary metabolites. This phase is sometimes referred to in literature as molecular farming. Products targeted for molecular farming were traditionally produced using either microorganisms or animal cell culture However, the bacterial system, while having the advantage of low cost, does not always produce the quality of protein that is required. The bacterial protein synthesis machinery does not have the means to perform post-translational modifications necessary for some protein products such as folding, glycosylation, phosphorylation, acylation and the like. On the other hand, animal cell systems are expensive and may pose dangers to human health as they could carry viruses and other pathogens.

Plants are able to perform the post-translational modifications for many proteins and unlike animal cell systems, are less expensive to grow since they utilize cheap inputs such as sunlight, soil and water. Data presented by Hood and Woodard 2002 show that plants can produce recombinant protein at a raw material cost of US$0.10 per gram. In comparison, transgenic chicken/eggs, goat's milk, and microbial fermentation cost US$2.00, US$2.00, and US$1.00, respectively. If the current standard for biomanufacturing, the Chinese Hamster Ovary (CHO), is used, the cost will be US$300 per gram. In addition, it costs more than US$250 million to put up a CHO-based biomanufacturing facility[23]. The first plant species used as a platform for recombinant protein production was tobacco since it was easy to transform and regenerate from tissue culture, but tobacco has the disadvantage of being associated with production of human toxins such as alkaloids[24]. Later studies also showed that tobacco is an expensive crop to grow and has a low protein yield[25].

[1] Finanzen, January 31, 2006
[3] Fields of bioengineered dreams. New York Times. August 16, 2005

Plants for molecular farming can be grown the traditional way in the field. This technique has already given three commercial products: avidin, α-glucuronidase, and trypsin. Other techniques being explored are the use of hairy root cultures and cell cultures.

Hairy root culture

Plant roots have traditionally been used for various purposes other than food such as pharmaceuticals and cosmetics. Roots such as ginseng are highly valued. Extraction and purification of the active principles in roots had been a challenge to biochemists. Usually the yields are low and the active molecules could be altered by the extraction procedure. The cost of isolation and purification of proteins, for example, can be a high as 90% of total production cost[26]. Thus, it would be an advantage if the high value organic molecules can be secreted by the roots in a hydroponic medium, extracted from the liquid medium (an easier procedure than extraction from the root tissues) and subsequently purified. This process is non-destructive to the roots and the roots can continue secretion as the product is being harvested. It will result in a much higher yield of the product over time.

Plants have the natural ability to secrete substances. Phenomena such as guttation and root exudation are well known. Among various plant organs, secretion is especially well-developed in roots[27]. As much as 10% of photosynthetically fixed carbon can be secreted by roots.[28] Root exudates are known to have a natural role in plant protection and in symbiotic interactions with soil biota. Indeed there is a bewildering diversity of primary and secondary metabolites that the roots secrete to the rhizosphere. This capacity for biochemistry offers interesting possibilities for utilization if only roots can be made to grow faster so that it can produce enough quantities of secreted product to make a production system viable. This is made possible through *Agrobacterium rhizogenes*-mediated transformation, giving plants that produce an excess of "hairy roots", which can then be used intact or the roots cultured. *A. rhizogenes* acts in the same manner as *A. tumefaciens*, the workhorse of plant biotechnology. However, instead of inducing tumors, *R. rhizogenes* induces production of so-called "hairy roots". Its plasmid is therefore designated as Ri (root inducing), which contrasts with the Ti (tumor-inducing) plasmid of *A. tumefaciens*.

Plant cell culture

Regulatory approval of the world's first plant-produced recombinant vaccine was recently announced by DOW Agrosciences[2]. It is an injectible vaccine against Newcastle disease of chicken that is produced using tobacco cell cultures. This news moved plant cell culture one step ahead of organ culture (such as hairy root culture) and intact plants in the race for commercial production of recombinant vaccines using plants as a platform. While hairy root culture is still in the realm of proof of concept and scaling up problems, and intact plant culture in the field is struggling with environmental controversies[3], plant cell culture already has a product. Yet, it will not take very long before the next approvals come, because more than 100 field trials for large-scale production of plant-derived recombinant molecules are currently awaiting approval by regulatory agencies (Joshi and Lopez 2005).

However, the DOW product is not the first commercial product derived from plant cell culture. Plant cell cultures have been used commercially to produce secondary metabolites that are produced naturally by plants. Two are in the market today: shikonin and paclitaxel (Taxol). Shikonin is an anticancer, wound-healing and anti-inflammatory, which is extracted from *Lithospermum erythrorhizon.*[29] Paclitaxel, one of the most active chemotherapeutic agents for the treatment of patients with breast cancer, is extracted from *Taxus* spp[30]. Research on plant cell culture leading to these two products became a convenient foundation on which application of recombinant DNA technology was built.

Plant cell cultures have the following advantages compared to whole plants: shorter development cycle, lower variation in yield and quality, and ease in applying good management practice (GMP).[31] It combines the ease and low cost of culture of microorganisms with the ability of higher eukaryotes (such as animal cells) to produce the quality of protein that is required in biomedical applications. Unlike animal cell cultures, plant cells do not harbor human pathogens; they also do not produce endotoxins. When the product is secreted into the culture medium, the cost of extraction and purification is much lower than that of whole plants, where downstream processing accounts for as much as 80–94% of total production costs[32]. Thus, the focus of plant cell culture R and D has been on suspension cultures which secrete the product into the medium, from which it is extracted.

b. From higher plants to other photosynthetic organisms

Successful utilization of higher plants for molecular farming has stimulated interest in exploring the simpler plants and photoautotrophs such as the mosses and algae as alternative platforms. These organisms are believed to require simpler (and cheaper) transformation and production systems and they can produce similar or better quality recombinant products. Indeed, there is an increasing intensity of research on these organisms over the last 10 years, particularly in developed countries. A cursory survey of literature in the Web of Science database gave a total of 1983 and 521 titles for the keyword algae and moss, respectively, for the year 2005. In contrast, for the keyword rice, a crop of global importance, a total of only 3793 titles came out.

The moss as a source of important genes and a platform for recombinant DNA.

The moss is hardly a plant in the traditional sense of the word. It does not have a vascular system, it does not flower and produces no seed. But it is capable of photosynthesis, hence it does not require an external carbon source. It shares many physiological and developmental traits with the higher plants. Indeed, when its transcriptome was compared with the model plant *Arabidopsis*, more than 66% homology was found[33].

Approximately 10,000 species of mosses are known to exist[34], colonizing diverse habitats including harsh environments such as the deserts and the polar regions, where they are the most abundant plants. The *Sphagnum* peat moss can absorb up to 25 times its weight of water and are valuable commercially as nursery media and as a fuel when dry[35].

Mosses are useful to science as model systems for the study of biological processes because of their simple developmental pattern and their similarity to plants in many respects. Plant physiologists have focused on three species: *Funaria hygrometrica*, *Ceratodan purpureus* and *Physcomitrella patens*. The best studied among the mosses, *P. patens*, is a potential source of important genes for improvement of higher plants[36]. It is highly tolerant to salt, osmotic and dehydration stresses. While *A. thaliana* suffers from severe impairment of physiological functions at 100mM of NaCl, *P. patens* can grow at salt concentrations up to 600mM[37]. Plants that had lost 92% of their fresh weight during dehydration were still able to recover upon rehydration.

As a platform for recombinant DNA expression, the moss combines the advantages of microorganisms and higher plants. Like bacteria and yeasts, it integrates foreign genes mainly by homologous recombination[38]. It is unique among plants in this capability. This creates the possibility of targeted integration of foreign DNA which is very useful not only for the study of gene function but also for genetic engineering. This advantage is further enhanced by the fact that the gametophytic phase dominates its life cycle and it is self-fertile.

Its haploid tissue can be propagated vegetatively[39]. Cultivation of the juvenile protonemal stage in a bioreactor system makes it possible to easily recover secreted metabolites and avoid regulatory burdles that are now facing transgenic higher plants. Taken together, the moss bioreactor system can produce products of recombinant DNA cheaper than higher plants. Its main disadvantage compared to microorganisms is its relatively slow growth rate.

Algae as a platform for recombinant DNA

Like plants, algae are capable of photosynthesis. In fact, algae are responsible for about half of the total photosynthesis on earth![40] Algae thrive in diverse aquatic environments, such as the sea, freshwater, in hot springs and even in highly polluted water. They are used as food, fertilizers, animal feed, biofuel, as an agent for bioremediation, and a source of high value products such as pigments, cosmetics and food supplements. Algae are a highly diverse group of organisms – some are related to bacteria, but others are closer to higher plants. They are relatively unexplored. Approximately 36,000 known species represent only 17% of the total number of species that actually exist[41]. Of these, only very few are used in industrial scale.

There are two classes of algae: the macroalgae and microalgae. Between the two, the latter is the favored object of genetic engineering research. The popular species of microalgae include *Chlorella*, *Spirulina* and *Dunaliella*. Aggregately at present, microalgae are economically less important than macroalgae which include seaweeds. Microalgae are used as whole cells or for extraction of cellular products such as β-carotene, phycobiliproteins, astaxanthin and polyunsaturated fatty acids (PUFA). β-carotene extracted from *Dunaliella salina* grown in saline ponds represent more than 80% of the world's supply of natural β-carotene.[42] The main constraint to increased utilization of microalgae for industrial scale production of cellular products is the high production cost. Therefore, there is great research interest in overexpression of desired molecules from endogenous genes or expression of beterologous genes.

As a platform for expression of recombinant proteins, microalgae have the advantage of shorter production time, lower production and scale up costs compared to higher plants[43]. Species such as *Dunaliella* and *Chlorella* grow in saline waters, thus their large scale culture does not compete with conventional agriculture for tbe use of land and water. In the case of bioreactor systems, the requirements are simple since many algae are photoautotrophs. It is possible to develop culture systems that utilize secretory mechanisms through genetic engineering so that the recombinant proteins can be released directly into the culture medium, where these can be extracted with relative ease.

Making Agricultural Biotechnology Work for the Philippines Translating Policy into Programs

So far, agricultural biotechnology has enjoyed good support from various sectors of Philippine society. These include a bighly supportive government, industry and science community. Particularly encouraging is the recent report of a survey[44], which involved middle class youth (average age is 20 years), the future leaders of this country. The survey showed that 80% of the respondents were interested to highly interested in science and technology, and 82% believed that biotechnology will improve their lives. Surprisingly, pest resistant crops were among the products of biotechnology that obtained the highest approval ratings (78%). These are the products, specifically Bt corn, that had the most negative publicity because these are the first products to be released for local cultivation. The Philippines can build on this reservoir of goodwill to develop a program that will not only generate support for biotech products that are being exported to this country, as current short term efforts tend to achieve, but also one that will make biotechnology a creator of local jobs and wealth. A 2004 series of case studies on health biotechnology[45] enumerates the ingredients needed to create successful innovations in biotechnology. We highlight some of the recommendations below.

Political will. This means more than passing a law or formulating a set of guidelines supporting biotechnology; we already have these. It also means policy coherence; we cannot have the Department of Agriculture and the Department of Science and Technology saying yes to biotechnology and the Department of Environment, and various local government units saying no. We cannot have a government saying that biotechnology should move forward, and the same government putting the brakes by imposing stricter regulations that are justified more by politics than science. It also means giving priority to biotech R and D in the national budget as Vietnam has done. It also means responding to the brain drain by creating incentives for scientists not to leave and for those who have left to return as China has done. One such incentive is salary and the prestige that goes with it. Something has to be done about the current situation where knowledge-oriented professions are in the bottom quarter of the salary ladder.

Individual leadership. Historically, leadership is a key element in every field of human endeavor. The leader provides the vision, the direction, and inspiration. This is true for Singapore, whose Deputy Prime Minister Dr. Go Keng Swee dreamed of establishing an institution that is equivalent to the Weizmann Institute of Israel, a state-funded center for scientific excellence. Professors in Malaysia take pride in recalling that one of the first acts that the former Prime Minister Mahathir did when he was new in the office was to elevate the privileges of Professors to the level of Ministers.

Close linkages. This may seem odd for the field of science and technology. People on the streets associate great discoveries with the heroic efforts or genius of one man such as Darwin, Newton, Galileo and Einstein. But these are exceptions rather than the rule. In recent years, great discoveries are products of coordinated work among tens if not hundreds of geniuses. In the field of physics, one is reminded of the Manhattan project in the 1940s that led to the production of the world's first atomic bomb. In the field of biology, one is reminded of the Human Genome Project, which involved five major and fifteen smaller centers in five countries representing three continents[46]. The birth of the science of molecular biology is a product of collaboration between an American (James Watson, a biologist) and an Englishman (Francis Crick, a physicist).

Collaboration among scientists can be done at many levels. It may be as simple as collaboration between two individuals working in the same laboratory or the same department. Or it may extend to collaboration among research institutes crossing national borders. The value of collaboration is repeatedly illustrated in recent literature. Indeed, the 2001 UNDP report on Technology and Development emphasized the need for collaboration. Inspired by the double helix of DNA, the UNDP report proposed a triple helix model of collaboration among academe, industry and government.

To assist researchers in negotiating scientific collaborations, a set of guidelines was proposed by Smalheiser et al 2005[47]. Covered by the guidelines are seven major concerns: 1) sharing of reagents and data, 2) design of experiments, 3) division of labor, 4) publication of results, 5) co-authorship order, 6) access to unpublished data and 7) intellectual property issues.

Enterprise creation. Collaboration between government and the academe in the field of biotechnology is fairly well established in the Philippines. This is partly because of a very strong presence of former university professors in various government departments, either in advisory capacity or as part of the bureaucracy. But this kind of collaboration is not enough to bring the products of research to the consumers. At best, this kind of collaboration will produce 'proofs of concept' that can be published in prestigious journals or earn best paper awards in scientific conferences. Indeed, out of thousands of public sector research projects on plant biotechnology worldwide, there are only two successful transgenic crops that were developed through public sector efforts[48]. What seems to be the missing ingredient? The study by Thorsteinsdottir (2004) sums it up: "private firms were essential for integrating various sources of knowledge in health biotechnology and turning them into products and services".

Delmer 2005 describes the predicament of the public sector: " There are plenty of public-sector scientists who can create transgenic plants in their laboratories. What has been sadly lacking in the public sector is an understanding of how to make strategic assessments of which projects can have the highest impact; how to choose the best varieties for transformation and to design the best constructs to ensure the freedom to operate and gain regulatory approval; the recognition of the need to generate very large numbers of transformants to ensure high levels of expression and the stability of the inserts and to determine the optimal promoter; and a clear plan for the stewardship, uptake, and dissemination of new varieties."

The failure by government and academe to bring products of research to the consumer is not for lack of trying. Recent history in the Philippines is full of heroic efforts by the academe and government working independently or together to bring products of public sector research to the farmers' field. This includes such products as improved varieties of crops, biofertilizers, and biopesticides. The government spent a lot of money training government technicians and putting up seed farms and production laboratories such as insect rearing houses and tissue culture facilities. Many of these did not last very long. When subsidy ran out so did the projects. In many cases, the products were simply not marketable to begin with.

How can the government and academe work with private industry to bring products of biotechnology to the consumers? In developed countries, this is simpler, because private industry exists. In the developing world, it is much more complex, because in many cases, private industry dedicated to biotechnology does not even exist.

There are many models of government- or academe-initiated enterprise creation. Thorsteinsdottir (2004) described some of these. South Korea allows university professors to set up private firms or spin-off companies. China, converted some existing research institutions into companies that manufacture medicine. Favorable policies are essential for private sector participation.

But favorable policy apparently is not sufficient[49]. Private funding is an elusive factor for success. Without money from investors who have faith and experience in the biotech business, it is impossible to support the biotech industry considering the cost not only of R and D but also of complying with regulations, use of intellectual property and neutralizing negative publicity. In India, venture capital is emerging from various sources, including state governments, insurance companies and banking institutions. These, in turn, help encourage foreign investors. In the Philippines, there is really no shortage of capital but what is lacking is the faith in the business prospects of biotechnology; this, at the present time, needs to be imported, in the same manner that we bad to import faith in the business prospects of a seed industry in the 1980s.

Intellectual property. The industrial revolution, the predecessor of the current bioindustry revolution, started in Europe in the beginning of the modern era because it was in Europe where intellectual property was first recognized and protected by law through patents and other forms of legal protection. Innovation was promoted by this policy. Developing countries in Asia that were able to develop domestic industries initially favored lenient patent legislation that allowed them to "reverse engineer" existing technologies. Otherwise, they waited for patents to expire and then they manufactured generic products. This is best illustrated in recent years by generic drugs and agricultural chemicals. But today, these approaches are no longer tenable because of the strengthening global intellectual property regime and the diversity of means for enforcement. In addition, the rapid turnover of technology creates a highly competitive field, where technology serves as the competitive edge. By the time patents expire, the technology would be obsolete. This was true in the computer industry; this is clearly true also for bioindustry. The recognition of this trend has convinced many poor countries to invest heavily on R and D on biotechnology.

The heavy public sector investment in biotechnology now serves as a powerful motivation for developing country governments to strengthen their intellectual property regimes. After all, they need to protect their own technologies from piracy. But even without a sizeable government investment in R and D, the need for an effective intellectual property regime is dictated by the need for private investment.

The real challenge is not how to creatively avoid IP regimes but how to creatively operate within the IP environment. Facing this challenge has been the expertise of private industry that has to deal with IP issues almost on a day to day basis. Unfortunately, to most public R and D institutions IP is an unfamiliar ground.

There are basically two levels of IP concern for the public R and D institutions: how to access privately developed technology for R and D use, and how to bring publicly developed technologies to the consumers via the private sector. There are no clear answers to questions associated with both concerns. However, there are models already in operation[50]. On one hand, access to private sector technologies is being facilitated by such organization as the African Agricultural Technology Foundation, which was established to negotiate access to private sector technologies and assist with stewardship issues. A local example is the recent signing of a license agreement among the Maharasthra Hybrid Seed Company (MAHYCO), a technology donor, the Sathguru Management Consultants Private Limited, as technology facilitator, and the University of the Philippines in Los Banos (UPLB), as technology user. Under this agreement, UPLB will use Bt eggplant parental lines of MAHYCO in a backcross program with elite Philippine eggplant varieties. On the other hand, access to public sector technologies are being facilitated by new models of licensing such as that being developed by the Public Intellectual Property Resource for Agriculture (PIPRA) and by the Biological Innovation for an Open Society (BIOS). Under the open-source licensing promoted by this program, users of technology have free access to technology on condition that improvements that result from this use are placed in the public domain.

Improving literacy in biotechnology

The generally low level of public understanding of the science behind genetic engineering possibly contributes to negative perception and rejection of its products. In a 2002 street interviews in Metro Manila, Jakarta, Beijing, Shanghai and Guangzhou, respondents were asked if they had eaten DNA. Only two of five people gave the correct answer[51]. Only one in three correctly recognized as false the statement "Ordinary soybeans do not contain genes while genetically modified ones do."

Indicators of local public support for science in general are not very positive. The Department of Science and Technology, the national government's arm for R and D and promotion of science has one of the lowest budgets among the major units of the government. College enrollment in natural science programs in 2000-2001 was only 0.89% of the total college population[52]. Salaries of scientists and researchers are in bottom quarter of the list of occupations.[53]

A public that has a low regard for science and does not value innovation is an easy prey for critics of biotechnology who portray the product as a hazardous piece of junk being shoved into their throat by profit hungry businessmen. In the final analysis, this is the root of the controversies regarding biotechnology in this country. If one combines negative public attitude with excessive regulation, the result is a very bleak future for biotechnology. Biotechnology will be selling an expensive product that nobody wants.

The effects of low public appreciation for science and technology include susceptibility to negative propaganda, consumer rejection and excessively restrictive regulations not only of scientific research, but also of technological applications. This cause-and-effect relationship could make a vicious cycle that result in further reduction of scientific literacy and even more restrictive regulations. To break this cycle, the logical approach is to improve scientific literacy.

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[4] Biotechnology Education Websites. 2002. The Agricultural Education Magazine, March April 2002. p28.

Among many fields of science, those associated with biotechnology are most susceptible to misunderstanding today partly because of the negative publicity that has been sustained globally and locally for almost 10 years now. The interested sector of the public has been polarized into those who strongly oppose and those who strongly support biotechnology. Lack of scientific understanding compromises the quality of debates, and argumentation invariably leads to political and ideological domains, which are even more complicated than science itself. Issues become muddled and the outcome could range from extremes to the "safer" no-decision type of decision as postponement (moratorium) or let-the-public decide type of decision as labeling. Yet, these "safe" decisions are not "safe" at all. Even labeling, which sounds so neutral, can cause confusion contrary to what it purports to do, as well as increase the cost of biotech products relative to conventional counterparts[54]. If biotechnology is truly beneficial, as advocates contend, then even the "safe" decisions could deprive the public by default of an important solution to their problems. Thus, any decision about biotechnology carries a risk, which is best assessed on the background of knowledge.

On another vein, literacy on biotechnology is essential today as its impact is so intimate. It is in the food we eat, in human health and integrity of the environment. No technology is more intimately connected to our day-to-day existence.

There are existing global and local programs for public education on biotechnology. These range from industry-supported, which are strongly pro-biotechnology; to those that are supported by known anti-biotech advocates such as Friends of the Earth and Greenpeace. Branches of the Philippine government, such as the Department of Agriculture and the Department of Science and Technology, had been engaged in public information activities which involve multi-media as well as face-to-face seminars since the introduction of the first GM crop (Bt corn) in the Philippines in 2002. The main limitation of these public information activities is that they lack the depth of treatment that is needed for understanding of biotechnology. Typically, the message is so simplified that it creates misunderstanding. For example, powerful images such as Frankenstein-type monsters are being fed to the public imagination by anti-biotech campaigners. Advocates, on the other hand, are tempted to present exaggerated estimates of benefits, extrapolating limited research data, to generate sympathy. Another serious limitation of the current public information approach is that they have very limited reach. In many seminars, for example, it is usual to see the same faces —those who have already made up their mind to oppose or support biotechnology. They attend the seminar not to learn but to push their preconceived ideas; otherwise, to show their support for the organizers of the seminar or amuse themselves with the theatrics of seminar speakers. But the most serious limitation is that current campaigns are fund-driven, and therefore, short-term in nature. At its best, the motives of campaigners are suspect, as they could be perceived as mercenaries working for interest groups. Indeed, in some public debates, opposing camps so successfully picture their opponents as paid lackeys that they end up both discredited in a contest where everyone loses, including the audience.

There is a need for a more sustained, in-depth, far-reaching, and credible public education. This is the key to responsible decisions about biotechnology. The logical venue for this type of education is the classroom—— formal education. Unfortunately, classroom coverage of biotechnology is very limited at present. Interest in classroom coverage of biotechnology can be traced to the first Biotechnology Education Council meeting in the University of Iowa in the USA in 1994, which was convened to help teachers integrate biotechnology in various school curricula[55]. During that meeting, three major hurdles were recognized: 1) educators lacked the content and technical knowledge to feel comfortable about integrating biotechnology in their curricula; 2) there was a serious shortage of money for supplies, equipment and release time for educators to obtain training; and 3) there was little time during the day and in classrooms to prepare and present biotechnology. Since then, the hurdles have been progressively eliminated. Today, there are many internet sites[4] offering free course resources such as course outlines, laboratory manuals, movie clips, graphics and even powerpoint presentations. The initial problem of lack of textbooks in biotechnology has been addressed with publications by such authors as Watson[56], Micklos[57], and Glick[58] in North America and Slater[59] in the United Kingdom. A series of methods oriented books was also published by the Humana Press[60], CRC Press[61] and Oxford University Press[62] among others. E-mail groups of instructors share ideas as well as laboratory techniques. For Science and Society type of courses, books written by scientists include Mendel in the Kitchen by Fedoroff and Brown[63], Biotechnology and Safety Assessment by Thomas and Fuchs[64] and Genetically Modified Planet by Stewart[65]. A number of books written in popular style was written by journalists. Among them is the Biotech Century written by Rifkins[66], which has served as the inspiration of the anti-biotech movement. The Genomics Age written by Smith[67], More than Human by Naam[68] and Genome by Ridley[69] are well received by readers.

In the Philippines, a systematic effort to encourage integration of biotechnology in the undergraduate curricula of state universities nationwide was initiated by the author in 2005. Activities include workshops on biotech course proposal preparation, as well as sharing of teaching resources and experience. Filipino teachers are faced with similar constraints that educators in the USA faced in the early 1990s. But unlike American teachers who have to develop materials from scratch, Filipinos have the advantage of access to many of the resources developed by their American counterpart. What is lacking today is active support from university administrations to develop biotech oriented courses and provide funding for training of teachers, development of libraries and laboratories. It is not as simple as adding one or two courses, because biotechnology covers a broad range of human thought. Its science is rooted in biochemistry, computer science, microbiology among others. Its politics and business is rooted in philosophy, ethics, economics, and religion among others. Full integration of biotechnology in the school curricula may mean no less than an overhaul of the curriculum, a task that will require contributions from Professors, university administrators and the Commission on Higher Education.

We need to rationalize biotech regulations

The Philippines has a good history of making rules and regulations even before there is something to regulate. Call that anticipation, or maybe it is simply easier to make rules than play the game. This is true for biotechnology. The Philippines was well ahead of its neighbors in creating a National Committee on Biosafety in October 1990 through Executive Order 430[70]. The Executive Order prescribed regulation for contained work, large scale contained work and glasshouse trials, and guidelines for single-site field trials. Subsequently in April 2002, the Department of Agriculture issued Administrative Order No. 8, which prescribed the guidelines for commercialization of biotech plant and plant products. This was followed by Memorandum Circular No. 8, effective July 1, 2003, which prescribed the requirements for importation of biotech products. Memorandum Circulars No. 11 and 12 issued in August 2003, further clarified the import rules for biotech products for direct use as seed, food, feed or for further processing.

On the positive side, it is precisely because we have rules that it had been possible to approve biotech activities and products. Other Asian countries did not have the luxury of having rules until recently. This is the reason why the Philippines has the distinction of being the only Asian country that has approved a GM food/feed crop (maize) for commercial cultivation. As of July 2005, the Philippines has approved 19 transformation events for use as food, feed, processing or propagation. Of these, three are approved for propagation. In addition, the country has approved seven stacked trait products for importation for direct use as food and feed.

The bad news is that the regulatory regime of the Philippines for transgenic crops has been considered very strict by international standards. ADB 2001 described the approval guidelines in the following manner:

"The present set of biosafety guidelines is one of the strictest in the world. The guidelines were originally patterned after those first used in Australia, Japan and US during the early 1980s. Since then, all these countries have relaxed most of their guidelines as a result of new technical data and familiarity in dealing with new products. The Philippines, however, has not relaxed its guidelines."

On the contrary, our guidelines have become more strict, as we started to implement the Cartagena protocol even before we have actually ratified it. That is a record by itself! The National Biosafety Framework (NBF), which was recently approved as the new standard for GM crop evaluation is proudly described by its authors as "going beyond the Cartagena protocol". It makes socio-economic, cultural and ethical considerations a requirement for developing biosafety policies[71]. It also mandates "consensus building" and adherence to the principle of subsidiarity, meaning that all levels of government, including the local government units shall participate in implementing the biosafety framework. In short, the approval process becomes a political exercise rather than a biosafety evaluation, which incidentally, is what the Cartagena protocol is all about, which explains why it is called the Cartagena Protocol on Biosafety in the first place. Environmental impact assessment (EIA) is also mentioned presumably as an option that regulators may impose under guidelines yet to be formulated. (The EIA is a process that has been previously imposed only on "environmentally critical projects" such as nuclear power plants). What this means is that the cost of securing approval for GMOs will likely become prohibitive, and only large multinational companies can afford it. Considering that the current biosafety rules are already too expensive, approval of the NBF will effectively prevent the products of local R and D and that of small companies, from reaching farmers. Thus, we can look forward to a biotech future that is dominated by few large multinational companies[72], which is precisely what many critics of biotechnology are trying to avoid when they pushed for strict regulation.

Regulations are formulated for various reasons: ideological, political, religious, social, economic. What we have is a product of all of these, perhaps some prevailing over others. Since I am not an expert on any of these, let me focus on the scientific basis of regulations.

The latest revisions in the procedure for approval of genetically modified crops is based on the Cartagena Protocol on Biosafety, an international agreement that was negotiated during the period 1992 to 2000. The most important assumption that guided the drafting of this protocol is that GM crops are in the same category as nuclear power plants and toxic wastes. This was probably a reasonable assumption in the beginning, when the world has not seen a single GM crop in the field, and we knew very little about the consequences of genetic modification.

Since then, the world has grown more than one billion acres of genetically modified crops in a wide range of environments over a period of 10 years. In addition, hundreds of studies have been completed on the issue of safety of genetically modified crops. The results clearly challenge the validity of the Protocol's assumption. Among the most important reviews of the relevant studies are the following:

1. A GM Science Review commissioned by the UK government and documented in two volumes of reports which were published in 2003 and 2004[73]. The highlights of the reports are:
    a. For human health, to date there is no evidence that currently commercialized GM crop varieties or foods made from them are toxic, allergenic, or nutritionally deleterious.
    b. Transgenic DNA and non-transgenic DNA appear, from studies conducted, to share the same fate once ingested by humans, being very largely, but not entirely, degraded in the gut. There is no compelling evidence of gene transfer from food to bacteria in the human gut. Several research studies have been unable to find transgenic DNA (or its gene products) in milk, meat or eggs produced from animals fed on GM crops.

c. Detailed field experiments on several GM crops, in a range of environments have demonstrated that they are very unlikely to invade our countryside or become problematic plants, nor are they likely to be toxic to wildlife or to perturb soil structure in such a way that the functioning of soil communities is substantially affected.
d. Field studies indicate that there is very little gene flow from transgenic crops to wild relatives.
e. The few studies that have been carried out so far have been unable to detect evidence for horizontal gene flow between GM plants and either bacteria in the soil or viruses.
f. To date, in countries that have the experience of growing GM crops, there have been no reports of their causing any significant environmental damage.

2. A study conducted by the World Health Organization, the results of which were released in 2005[74] . The report concluded that GM foods currently available in the international market have undergone risk assessments and are not likely to present risks for human health in any other form than their conventional counterpart.

3. A study on the adequacy of USA regulation of GM crops, conducted by the National Academy of Sciences[75]. The highlights follow:
   a. It is generally assumed that the risk associated with the introduction of genetic novelty is related to the number of genetic changes and the origin of the novel genes. The committee found no general support for this assumption. A priori there is no strict dichotomy between the possibility of environmental hazard associated with releases of cultivated plants with novel traits and introduction of nonindigenous plant species. However, the highly domesticated characteristics of many cultivated plants decrease the potential of certain hazards.
   b. Both transgenic and conventional approaches for adding genetic variation to crops can cause changes in the plant genome that result in unintended effects on crop traits. A comparison of unintended effects caused by various breeding methods is presented in NAS (2004).[76]
   c. The committee finds that the transgenic process presents no new categories of risk compared to conventional methods of crop improvement but that specific traits introduced by both approaches can pose unique risks.

4. A study on the global socio-economic impact of GM crops, published in 2005[77]. Highlights of the results follow:
   a. There has been about a 14% net reduction in the environmental footprint on the cropping area devoted to GM crops since 1996. The total volume of active ingredients applied to crops has also fallen by 6%.

b. Reduced fuel use from less frequent herbicide or insecticide applications and a reduction in the energy use in soil cultivation. In 2004, about 1,082 million kg reduction of carbon dioxide emissions arising from reduced fuel use of 400 million liters.
c. In North and South America, 2,568 million kg of soil carbon sequestered in 2004.
d. The combined GM crop-related carbon dioxide emission savings from reduced fuel use and additional carbon sequestration in 2004 were equivalent to the removal from the roads of nearly 4.7 million cars.

5. A report of the National Academy of Sciences (USA) on the safety of genetically modified foods, published in 2004[78]. Highlight: The policy to assess products based exclusively on their method of breeding is scientifically unjustified.

In addition to challenging the fundamental assumption of the Cartagena protocol, the above studies clearly show that the current distinction in the Philippines between GM and non-GM as far as regulation has a shaky scientific basis. On the basis of our long experience with plant breeding, experience with biotechnology crops, new knowledge from genomics, and new knowledge about the consequences of transgenesis at the genomic level as presented in this paper, we can support a proposal made last year by a group of authors from different universities in the USA[79]. The principle behind this proposal is stated as: "if a gene or trait is safe, the genetic engineering process itself presents little potential for unexpected consequences that would not be identified or eliminated in the variety development process before commercialization". We have a long history of the safe use of novel varieties using an array of methods, many of which are more disruptive of genomes than genetic engineering. The safe use had been based on an approval process that is based on evaluation of the phenotypes or traits rather than on the process that gave the phenotype.

We quote some of the salient features of the proposal:

1. Some genes presently assumed to be unsafe by the regulatory process should be exempt:
   - *Agrobacterium* DNA. This bacterium transfers DNA naturally to plant genomes. Some plants, notably tobacco, have native genes that are originally from *Agrobacterium rhizogenes*.
   - Plant viral DNA, specifically those used as promoters or terminators, or used to suppress other viral DNA, such as those used in PRSV resistant papaya. These sequences, by themselves, do not pose any hazard. We have been consuming viral sequences in the food we eat long before genetic engineering.
   - Well-known markers that impart antibiotic resistance. During the deregulation process of Flavr Savr tomato, the product of *nptII* gene has

been classified as general recognized as safe (GRAS). Other studies supported this position.

- Selected marker genes that impart reporter phenotypes, such as ß-glucuronidase reporter gene and the green fluorescent protein. There are strong evidences supporting the safety of these genes from the point of view of human health and environmental safety.

2. Create regulatory classes in proportion to potential risk.
   - Low risk – where the imparted traits are functionally equivalent to those manipulated in conventional breeding and where no novel biochemical or enzymatic functions are imparted, such as "domesticating genes" (sterility, dwarfism, seed retention, modified lignin).
   - Moderate risk – plant-made pharmaceuticals and industrial proteins, plants with novel products that have very low human and environmental toxicity, or that are grown in non-food crops and low nontarget ecological effects.
   - High risk – careful regulation of plants producing plant-made pharmaceuticals/industrial proteins is needed during field testing and commercial production where transgene products have a documented likelihood to cause significant harm to humans or environment.

3. Eliminate event-specific basis of transgenic regulation. The assumption of this rule is that the uncertainties associated with transgenesis exceed those of conventional breeding methods such as wide crosses and mutagenesis and they create safety concerns that are not adequately addressed during subsequent steps in variety development. This assumption is not supported by our experience with mutagenesis, a more disruptive procedure than transgenesis, which has produced more than 2000 commercial varieties.

   Another assumption is that the location of a transgene can significantly influence its function or that of endogenous genes. This is not supported by new knowledge about genomes, which shows that genomes are highly dynamic. Total DNA content, the number of genes, and gene order can vary significantly among varieties of the same species. Significant differences in colinearity occur among varieties while retaining phenotypic functions. Transposable elements routinely move into and out of genes, where they can alter gene expression or site of chromosome breakage or rearrangement. It is futile to attempt to define a standard genome for a species or even a variety against which to compare changes due to transgene insertion.

   The use of event-specific regulation has adverse consequences, among which is the use of the same event over and over in a backcross program, rather than direct transformation of elite varieties. This reduces the response time in making useful varieties for farmers and increases the cost of variety creation. For crops that have long life cycles such as fruit trees, the backcrossing approach is practically impossible.

   Lastly, event-specific regulation unnecessarily increases the cost of obtaining regulatory approval.

Summary

The world is ripe for a third agricultural revolution, which is more challenging than the first, the beginning of agriculture itself, and the second, the Green Revolution, because of the limitations in natural resources that we face today. Technology, specifically genetic engineering among others, will be needed to overcome these constraints. Agricultural biotechnology will be needed to provide a growing population not only with the traditional products of agriculture (food, feed and fiber), but also energy, fuels, materials and drugs.

Current concerns about the predictability and safety of plant biotechnology are being addressed by new technologies such as molecular profiling that allow a more comprehensive analysis of the consequences of transgenesis. New technologies such as selectable markers and promoters of plant origin, plastid transformation, cell and organ cultures provide an assurance of safety. There is a clear shift in interest from higher to lower plants such as mosses and algae, as platforms for production of high value industrial and biopharmaceutical products.

To make the third agricultural revolution happen in the Philippines, the paper enumerated three requirements. The first is translating favorable policy into programs. This will require political will, leadership, close linkages, enterprise creation, and ability to function even in the regime of intellectual property rights. The second is improving literacy in biotechnology in order to break the vicious cycle of low literacy, restrictive policies and consumer rejection. The author argued for integration of biotechnology in formal education curricula as a sustainable approach to literacy enhancement. Lastly, the author proposed a rationalization of biotech regulations, observing that the fundamental assumptions regarding safety of GM crops that provided the basis for existing regulations are no longer tenable considering the body of scientific knowledge generated during the first 10 years of GM crop commercialization.

Acknowledgments

The author acknowledges the support of the International Service for the Acquisition of Agricultural Biotechnology Applications (ISAAA), the Department of Agriculture of the Philippines, the University of the Philippines in Mindanao, and the International Rice Research Institute (IRRI), for the research leading to this paper.

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Trans. Natl. Acad. Sci. Tech. Philippines 28:295–299 (2006)
ISSN 0115-8848

PROTEOMICS: WEIGHING THE EVIDENCE

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Sequencing of the human genome was completed in 2001[1], a few years ahead of schedule, one of the implicit aims of which was to identify disease markers. However, to date, we still grapple with the elusive causes of many diseases and the hunt for biomarkers is still on. This is rooted in the fundamental problem that the genome is a mere blueprint for a vastly complex network of interactions orchestrated principally by proteins. The protein complement of the genome is what we refer to as the *proteome* and the variety of disciplines aiming to survey and understand the proteome fall under the umbrella of proteomics. In this talk I wish to explore the state of the field and the various applications of mass spectrometry in this actively growing area.

The complexity of studying the proteome arises from the fact that proteins encoded by genes can undergo a number of processing events that are regulated in space and time. Although a particular organism is endowed with a single genome, there are several corresponding proteomes for each cell population at a certain time and under specific environmental influences. At the molecular level, a single gene encoding a protein yields a product that is then processed (e.g. glycosylation, phosphorylation) amplifying the variants. Considering mature forms, degradation products and processed forms, numbers could easily reach 10,000. Complex biological fluids like plasma[2] not only contain resident proteins but may be invaded by extraneous proteins through tissue leakage. This can represent all the products of the genome, which can increase the 500 or so plasma proteins to about 500,000 products. Because the plasma reflects acquired immunity, the 10, 000, 000 or so immunoglobulins present further increases the complexity we have to deal with.

Given the above numbers, it seems daunting and almost impossible to make sense of the proteome. Fortunately, the methods used to address issues in proteomics simplifies the existing variation into magnitudes more manageable because the techniques offer the possibility for efficient profiling. There is no immediate need to account for all minor differences allowing a survey of relevant protein groups the levels of which change, for example as a reflection of a disease state.

The techniques involved in proteomics include those which can be used for protein separation, identification and quantification. More advanced applications allow for structural analysis, mapping modifications, defining complex interactions and even tracking protein regulation in the cellular context. One of the most common strategies include, 1D and 2D gel electrophoresis; various types of chromatography and mass spectrometry (MS). The latter is powerful as a stand-alone technique in proteomics research but maximal effectiveness is achieved when it is coupled to the above-mentioned separation techniques.

Mass spectrometry (MS) as its name implies basically measures the "weight" of molecules. It is amazing to realise how much information one can get by merely weighing things. However, when one realises that MS offers resolution enough to distinguish a mass difference of a single proton (1 Da) and in some cases even as much as resolving a mass difference in the millidalton range then it is not surprising why this technique is so powerful.

Most of the variations we try to track as indicators of abnormal physiology can be related to a mass change. When two molecules interact or are transformed, there is a corresponding change in mass (except rearrangement reactions). When peptides or proteins are modified chemically, there would also be a change in mass seen as an increase attributed to the moiety added. Because MS allows directed fragmentation, even isomers can be distinguished based on the different fragments generated as a function of structure hence products of different masses are obtained giving insight into chemical structure.

Analytes or samples to be studied by MS can be solid, liquid or gas as starting materials as long as charged analytes can be generated from them because MS depends on gas-phase mass separation and detection of ions (charged molecules). Early methods of ionization were limited to analysis of small molecules. With the introduction of fast atom bombardment (FAB)[3] it became possible to ionize intact peptides. However, it was not until soft-ionization methods namely electrospray ionization (ESI)[4,5] and matrix-assisted laser desorption ionization (MALDI)[6] were developed, that rapid and facile applications to large biomolecules was made routinely possible. These developments in MS were so important it lead to its recognition with a Nobel Prize in Chemistry in 2002[7,8].

MALDI coupled to the time of flight (ToF) analyzer has been a workhorse for the strategy called peptide mass fingerprinting (PMF)[9]. This is based on the fact that proteins having unique sequences also often have distinct patterns of cleavage sites for a given enzyme. The cleaved protein therefore yield peptides that reflect this unique distribution (distinct sequence) allowing the matching of the experimental digest with a theoretical digest stored in databases, thus, aiding the identification of a protein. However, this is not a very high-resolution method which often fails when you are looking at related proteins or isoforms. Therefore it is still important to get actual sequence information which can be obtained through *de novo* sequencing[10].

De novo sequencing can be achieved when powerful mass analyzers for example the quadrupole time of flight (Q-ToF) is used (Figure 1). The Q-ToF is endowed with the capability of performing tandem MS. This refers to the possibility of using the quadrupole as a mass filter allowing the isolation of ions of a desired mass/charge ratio (m/z) and subsequently subjecting these to collisions with inert gas molecules to cause fragmentation. It is because of this that structural information via MS could be obtained from peptides. The weakest bonds happen to be along the peptide bond making the reading of the sequence from the mass differences of the various fragments rather straightforward (Figure 2). Fragment sizes differ by a discernable mass difference corresponding to known amino acids from which the sequence can be pieced together. An additional feature of this strategy is that it allows detection of post-translational modifications when you detect mass differences not corresponding to any of the essential amino acids. Typical modifications may include a mass increase of 80Da for phosphorylation or addition of 16Da for oxidation etc. When the molecules exceed the size of typical peptides such as intact proteins, the energies absorbed by ions in the collision cell are not enough to cause fragmentation but only simple dissociation. Although this cannot give sequence information, it provides useful data in terms of structural organization (subunits that dissociate first may indicate surface binding or a weaker interaction) and stoichiometry [11,12]. Given a macromolecular complex, through dissociation it is possible to detect heterogeneous composition[13,14]. Finally it could

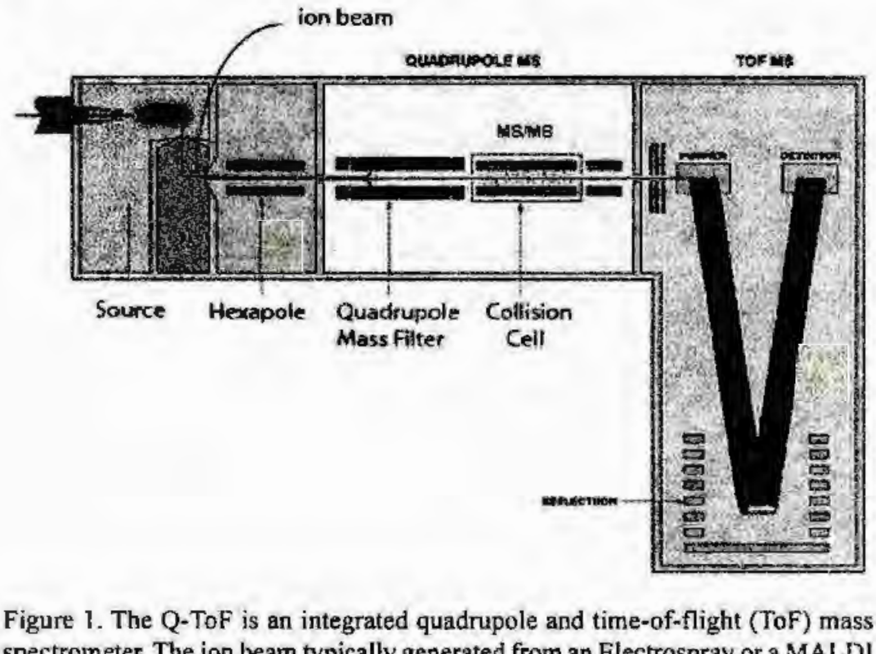

Figure 1. The Q-ToF is an integrated quadrupole and time-of-flight (ToF) mass spectrometer. The ion beam typically generated from an Electrospray or a MALDI source is guided through to the mass filter where specific ions can be isolated and subjected to fragmentation or dissociation in the collision cell (filled with inert gas usually Argon). The product ions are then analysed by the ToF analyzer.

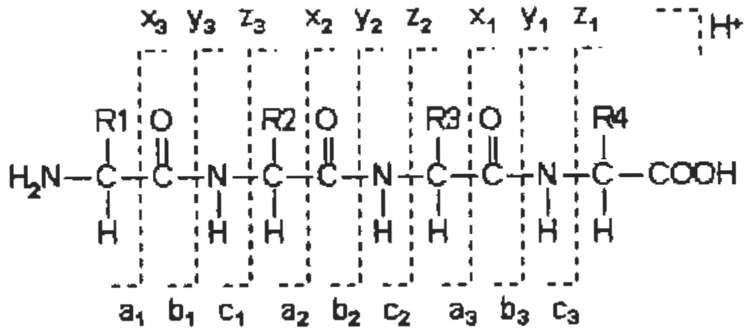

Figure 2. Most common fragments produced by MS/MS are those along the peptide backbone as shown above. To be visible in the mass spectrometer, the fragments must carry at least a single charge. Fragment ions are referred to as a,b,c or their complement x,y,z ions according to convention. The mass differences between fragments should correspond to a particular aminoacid defined by its unique R group or its modified form allowing for sequence information to be derived. (Adapted with permission from Matrix Science)
http://www.matrixscience.com/help/fragmentation_help.html

also set the stage for comparing relative binding strengths of complexes opening avenues for screening of drug binding for example[15,16]. One should bear in mind however that in any MS analysis, the interactions being studied are gas-phase interactions. Though interactions existing in solution may still be reflected in the gas phase, one should not assume that one is still looking at native solution structures or interactions.

In recent times, the application of MS has moved into the realm of MS-imaging[17]. This principally uses MALDI-ToF instrumentation wherein the laser is used to raster over a whole tissue sample (usually mounted on conductive glass). Each spectrum collected over time not only encodes the chemical entities present but also the spatial distribution of those entities over the tissue sample. Through a simple algorithm it becomes possible to display the distribution of specific biomolecules e.g. peptides (at a particular m/z) of choice thus monitoring fluctuations that may be correlated with disease or any abnormal physiology. This is an excellent approach for obtaining global difference maps without previous knowledge of what exact chemical species is of interest.

Mass spectrometry indeed is a powerful technique not limited to mere mass measurements for small molecules but could be powerfully employed for the identification, characterization and structural analysis of any biomolecule particularly proteins. By weighing molecules and their fragments we could weigh the evidences for potential biomarkers related to disease and understanding molecular and cellular networks.

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Trans. Natl. Acad. Sci. Tech. Philippines 28:301–304 (2006)
ISSN 0115-8848

BIOREMEDIATION: A PROVEN AND COST EFFECTIVE TOOL FOR REPAIRING THE ENVIRONMENT

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Abstract

About twenty years ago, bioremediation, the art and science of harnessing the natural metabolic processes of everything from simple microorganisms to plants, to destroy or sequester contaminants, became a real option. The potential to engineer these processes created a new alternative to capital and management intensive mechanically-driven protocols and a thriving industry arose to serve this new strategic approach. We are now experiencing a maturation of this "era of bioremediation", which is further being accessorized with in-situ thermal and chemical oxidation processes for more rapid initial site impacts. Taken all together we are moving into an "era of in-situ treatment", but regardless of how one intervenes with thermal or chemical energy in a contaminated area, biological processes ultimately are needed to finish the operation. Further, there have been many exciting new developments in molecular biology that are now enhancing the science of bioremediation, such that with a more refined understanding of key biological players and processes we can better design and manage bioremediation engineering.

The Republic of the Philippines is like any other with a modern economy- it has severe environmental problems that have reached crisis proportions. However, as an island nation with limited territory, these problems have a special insidious feature; there is no place to run. Fortunately, with the help of powerful natural processes like bioremediation that work around the clock without supervision we have the tools to heal the environment cost-effectively. Consequently, the National Academy of Science and Technology formed a Bioremediation Research Team (BRT), which, after a series of meetings, decided to focus on unattended sources of hazardous wastes, with a special emphasis on the problems of the mining industry.

The issuance of Executive Order No. 270 – the National Policy Agenda on Revitalizing Mining in the Philippines, (January 16, 2004), and the favorable Supreme Court decision on the Philippine Mining Act 7942 of 1995, have led to the revitalization of the local minerals industry, which had become nearly dormant prior to the decision. Such decisions elicited hope in both public and private sectors that a revitalized mining industry could boost the economy; however, there are two main issues attached to the mining industry: abandoned mines and the management of mine wastes. How can bioremediation help? Well, from the top down, we have phytoremediation which harnesses the healing aspects of plants for the more surficial aspects of these abandoned mines while subsurface engineered biological barriers, which rely on microorganism activity, address contaminated aquifers.

The BRT proposes to conduct a project on Field Test Applications of Phytoremediation and Microbial Technologies for the Rehabilitation of Contaminated Mine Sites. This project will utilize established heavy metal resistant plants. Jatropha curcas, commonly known as "tubang bakod", is a prime candidate as it thrives in marginalized land and the nuts can be used as source of biodiesel.

Other projects on "The Use of Local Bioremediation-based Technologies for the Management of Wastes from the Mining Industry" are also being proposed. The BRT, composed of microbiologists, chemists, botanists, foresters, and plant biologists, believes that bioremediation projects are worth pursuing should funds become available.

Keywords: bioremediation, waste management, mining, BRT, Philippine Mining Act 7942

At the turn of the millennium, there was a human interest feature in the presence of centagenarians who were now traversing three centuries of existence. A parallel is drawn to environmental professionals who if present in the 1990s would have traversed three decade-long eras in groundwater remediation. In the 1990s, we were at the twilight of the first "era of mechanical intervention" and this transitioned to the "era of bioremediation". Now we are experiencing the advent of a third era that emphasizes a long overdue hybrid of advanced diagnostic tools that help in the design and management of in-situ remediation processes that employ physical and biological oxidative or reductive processes in "treatment trains". Further we are also starting to harness the power of plants as well as microbes as agents of remediation.

In the "era of mechanical intervention", engineers practiced the art and science of digging and hauling or pumping and treating essentially to the exclusion of all else. Environmental engineering was a design, capital and operationally intensive affair. It was in the moment a logical starting point, and while these methods are well preserved and certainly have their place in the pantheon of treatment options, by force of necessity practitioners began to develop more refined in situ approaches. The power of natural biological processes in remediation was recognized and the potential to engineer them created a new pathway; an industry arose to form and serve the new thinking. Arguably, we are now experiencing a maturation of this "era of bioremediation", and are further witnessing that it is being accessorized with thermal and chemical oxidation processes for a kick start on palpable sources. Perhaps reference should be made to an "era of in-situ treatment", but it is more comfortable to use the first characterization featuring bioremediation, because regardless of how one begins in situ treatment, biological processes ultimately are the closing act.

Bioremediation is a technology that uses organisms (i.e., microbes and plants) to reduce, eliminate, contain or transform to benign products contaminants present in soil, sediments, water and air. Bioremediation is an excellent technological solution to environmental problems and associated impacts to human health and the ecology in general. The nature of the contaminant determines the bioremedial process and it is good to know that there is no compound, whether anthropogenic or natural, that microorganisms cannot degrade. Aerobic bioremediation which requires oxygen is applicable to petroleum hydrocarbons and other aerobically degradable compounds. On the other hand, anaerobic bioremediation can be used for chlorinated solvents and other anaerobically degradable compounds and both processes can be employed for the transformation and precipitation of metals

A concrete example of a bioremediation technology for field application is the use of various solutions of fermentable carbon (organic acids, sugars, etc.) which can be easily injected into the aquifer using direct-push technologies. In one specific example, a time-release lactic acid product was used in treating a 14-acre manufacturing site in Southern California contaminated with chlorinated solvents dominated by perchloroethylene (PCE). An existing pump and treat system was ineffective and caused problematic migration of PCE and so the lactic acid polymer was applied by injection. Anaerobic conditions which support organisms that metabolize chlorinated solvents were created and a substantial decrease in PCE from greater than 20,000 mg/L to 261 mg/L was achieved. The rest was left to natural attenuation and the pump and treat system was shutdown for a cost savings of over $1M.

There are other methods of bioremediation that are "ex-situ" in nature. This modality involves the use of "biopiles" or "land farming", the latter used in conjunction with the use of plants, i.e., phytoremediation. Biopiles involve the biological treatment of above ground mounds of excavated soils by addition of moisture, nutrients, air, or organisms. Land farming is a process of biologically treating uncontained surface soil, usually by aeration of the soil (tilling) and addition of fertilizer or organisms, hence the term farming. Phytoremediation involves the use of selected plants to metabolize and destroy contaminants either in an undisturbed system or as a polishing step to land farming.

In the Philippines, a Bioremediation Research Team (BRT) has been established under the auspices of the National Academy of Science and Technology.

The issuance of *Executive Order No. 270* – the *National Policy Agenda on Revitalizing Mining in the Philippines* last 16 January 2004 and the favorable Supreme Court decision on the Philippine Mining Act 7942 of 1995 have led to the revitalization of the local minerals industry, which was nearly dormant prior to the decision. Such decisions elicited hope in both public and private sectors that a revitalized mining industry could boost our economy. There are two main issues attached to the mining industry: abandoned mines and the management of mine wastes. Although some sectors of the mining industry claim they do not pollute the environment, still environmental and health issues persist. The BRT contends that a balance between industrialization and preservation of the environment is possible and advocates bioremediation as the appropriate approach to meet the challenge posed by these pollutants.

To help resolve these impending problems, a project on Field Tests of Phytoremediation and Microbial Technologies for the Rehabilitation of Contaminated Mine Sites is being proposed. An inventory of heavy metal resistant plants that can be used for phytoremediation and of technologies to ensure higher survival rate of seedlings (microbial inoculation) is currently available. Species that can be planted in abandoned mines have been identified and research on how to increase the survival rates of plants for phytoremediation, such as the use of microbes to promote rapid plant growth, consequently increasing the survival rate of plants even under stressed conditions are being undertaken. *Jatropha curcas*, locally known as "tubang bakod", is a prime candidate as it thrives in marginal land and its nuts can be used as source of biodiesel. Research programs for Jatropha production and utilization as alternative energy source are being undertaken.. The potential of the *Jatropha* plant as a phytoremediation species is enhanced with microbial inoculation.

A microbial-based bioremediation technology is being developed for heavy metal contaminated waste water by Drs. Fidel Rey Nayve Jr. and Catalino Alfafara using bacterial cell component (eps)-malunggay (*Moringa oleifera*) seed complex. This involves growing the bacterium, *Rhizobium*, in an indigenous medium like coconut water. The bacterium grows and produces the extrapolysaccharide compound, EPS, which will then be extracted and introduced into the effluent. EPS will bind the metals and the complex will remain suspended in the effluent. With the addition of malunggay seeds extract, a complex is formed between the extract and the heavy metal-EPS which will flocculate and can be collected. The effluent will become a clear liquid devoid of heavy metal contaminants, which can then be released into a body of water. Other microbial based technologies are also being proposed.

Bioremediation, as a field, is relatively new in the Philippines. With the continuing degradation of the environment on account of pollution, it is imperative that bioremediation, as a cost-effective mitigating measure, be seriously considered. Established technologies have to be tried to ascertain their applicability to local conditions. We hope that such kind of research, aimed at managing pollution in our country, can receive the necessary support.

Trans. Natl. Acad. Sci. Tech. Philippines 28:305–313 (2006)
ISSN 0115-8848

POSITIONING PHILIPPINE ENGINEERING EDUCATION FOR GLOBAL ENGINEERING PRACTICE

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Introduction

The purpose of this paper is to contribute to the current discussions on how to enhance the prospects for Philippine engineers to provide professional engineering services in the global marketplace. The enterprise of producing goods from research and development, product design, manufacturing, sales, maintenance, to disposal, has been a global operation for decades. This has been the case in recent years for information technology systems and software systems. The United States and other countries are starting to outsource engineering services that are tightly specified. These are usually close to manufacturing and minimally involve professional engineering. Although this type of service could provide a new market for Philippine engineering services, the sector of professional engineering that requires a high level of creativity could provide greater economic return for the Philippines. This latter category of professional engineering will require quality assurance commensurate with the capabilities expected of creative professional engineers. This paper focuses on the quality assurance process for engineering education designed to achieve levels of competencies of engineering professionals for the international marketplace.

Quality assurance of competencies of engineers to practice globally demands quality assurance in engineering education that could be regarded as equivalent to those established in countries such as the United States, United Kingdom, Australia, and Japan. Although each country has its own system of accrediting engineering programs at degree granting institutions of higher learning, there is a need to relate the various systems for comparison purposes. There are countries that have mutual recognition agreements (MRA) for substantial equivalency of their engineering education accreditation systems and engineering programs that each accredits. These MRAs are *de facto* standards. The Philippines is not a signatory to any MRA, placing it at a substantial disadvantage.

Desired Goals

A key to the competitiveness of Philippine engineers in the global marketplace is the positioning of Philippine engineering education to be comparable in substance and in quality assurance to those in countries that have reached mutual recognition agreements among themselves with respect to the substantial equivalence of their accreditation processes. Global acceptance of the comparability of Philippine engineering education and its system of quality assurance could be deemed as accomplished when a Philippine organization representing engineering accreditation becomes a signatory to a mutual recognition agreement. Thus a second goal is to seek such a mutual recognition agreement with respect to engineering education accreditation processes.

Courses of Action: Near-term Strategy

There are three groups of MRAs for engineering which we will be described later. In all cases, each signatory represents the single accreditation body for the whole country. Furthermore, the accreditation body is usually an umbrella organization of professional engineering societies. This is not the case for the Philippines at this time. We need to realign our processes if we seek to join one of them.

Restructuring Accreditation of Engineering Programs in the Philippines

Currently, there are several engineering accreditation systems in the Philippines; each system is administered through an association of universities. The evaluators are all from academe in the same association. Aside from a lack of uniform standards for the entire country, there are no representations, direct or indirect, from groups such as employers and professional societies. There is a need to broaden the set of stakeholders to include employers of engineers and professional engineering societies. The following courses of action are suggested:

(a) Unify the several separate accreditation systems in the Philippines under a single organization with a single set of accreditation criteria. Develop a unified accreditation process. The single organization could be the Philippine Technological Council (PTC). PTC could convene a meeting of representatives of various engineering education accreditation bodies and propose to have a single body for accreditation for all engineering schools in the Philippines. This has been suggested by the Foundation for Engineering Education Development (FEED). Define the new stakeholders. This needs to be widely discussed by all stake holders.

(b) Review the accreditation processes of other countries. It will be noted that a common feature is the use of principles of continuous quality improvement, including the primary importance of engineering educational objectives, the need to relate all processes to the objectives, the need to have performance metrics, and the focus on outcomes. This might be a major shift in philosophy compared to the existing accreditation systems. The formulation of new criteria is a critical step and it needs to be widely discussed and accepted.

(c) Decide what body will conduct the accreditation. For example, FEED could be the accreditation organization for PTC, as FEED suggested. All stakeholders should have an influence on how the processes would be structured. This needs wide discussion.

(d) All existing accredited programs should continue to be accredited under the new system for the same period as indicated in the previous accreditation.

(e) Provide a transition process.

Application to the Washington Accord for Provisional Status

Concurrent with the near-term strategy, some attention should be devoted to preparing to apply for provisional status to the Washington Accord [1]. Of the three MRA groups, the Washington Accord is the only one appropriate for the Philippines. The Bologna Declaration is for European countries only. The Western Hemisphere partnership is for North America and South America only. The Sydney Accord is for engineering technology programs only, and the Dublin Accord is for engineering technician programs only. The following are suggested action items:

(a) Develop a time table for implementing the new accreditation process.
(b) Complete at least one cycle of program evaluation under the new system before submitting an application to the Washington Accord.
(c) Establish an arrangement with the Washington Accord group to assist in the preparation for application.
(d) Apply for provisional status. FEED suggests that PTC be the proposed signatory.

Massive Training Program for Accreditation Evaluators

Even without a restructuring of engineering accreditation, it is important to introduce new evaluators to the system. New evaluators provide a fresh perspective, but it is extremely important for the evaluators to understand the goals of accreditation, details of various criteria, avoiding inconsistencies in the evaluation, and rules of behavior for evaluators. Secondly, in the new systems there will be evaluators from industry who will need to understand the application of the criteria as they relate to the missions of the universities. Evaluation teams will include representatives from academia and representatives from industry. Listed below are suggested action items:

(a) Start with a small core of experienced evaluators who will plan and develop workshops in the Philippines.
(b) Develop a time table for training a cadre of evaluators to include practicing engineers from industry.
(c) Consider hiring consultants to assist in the program planning and execution.

Courses of Action: Long-term Strategy

The time scale involved in the near term strategies discussed previously could be of the order of two to five years, particularly in terms of gaining full signatory status in the Washington Accord. Since provisional status will take a minimum of two years after application, this means an estimated time of three years between now and approval of provisionary status. There is much to be done and perhaps the burden is on FEED and PTC to convene a meeting as described previously.

Even as plans are being developed for near term strategies, it is not too early to think of long term strategies. It would take sustained effort to obtain some consensus on what to plan for the long term. Furthermore, as ideas for long term strategies are discussed, some implications for the near term could develop and these might be the basis for some changes in near term strategies.

We need to develop a vision for the Philippines to be a leader in some areas of engineering and not be content with catching up. This is possible with a judicious choice of unexplored territory, potential economic impact, and matching with our own unique talents. This might be coupled with developing some intellectual property.

Preparing for Engineers of 2020

About four years ago, the U.S. National Academy of Engineering established a steering committee to conduct a study of what engineering might or should be like in 2020 and how might the engineers be educated in an effective manner. The concern then was whether the education of engineering students then was appropriate for the practice of engineering twenty years hence. Phase I of the study focused on developing a vision of engineering in the new century. This led to a report, "The Engineer of 2020" [7]. Phase II of the project focused on what engineering education might be, based on the vision in Phase I. This led to a report, "Educating the Engineer of 2020" [8]. Although the recommendations are intended for the U.S., the study involved the global nature of engineering. Many of the recommendations are appropriate world-wide. For example from [7]:

Engineering is about design under constraint (technical, economic, business, political, social, and ethical issues).

- Technological innovations occur at an astonishing pace and this is not expected to slow down in the near future.
- The innovations and breakthroughs redefine the workplace. Some of the recent breakthrough technologies are:
- Biotechnology: tissue engineering, drug delivery engineering, bio-inspired computing, virus protection computer architectures, pumps, filters, detection and early-warning instruments for biological agents.
- Nanoengineering and nanoscience: nanobots, creating and manufacturing structures at the molecular level.
- Material science and photonics: smart materials.
- Information and communication technology.
- Information explosion.
- Logistics.

Some recommendations from NAS [8] are:

- Certain basics of engineering will not change, but the explosion of knowledge and the global economy will reflect an ongoing evolution.
- The economy will be strongly influenced by the global marketplace for engineering services, a growing need for inter-disciplinary and systems-based approaches, and an increasingly international talent pool.
- Reinventing engineering education should be by engineers in industry and academe.
- The B.S. degree should be regarded as "engineer-in-training degree".
- Engineering programs should be accredited at both B.S. and M.S. levels, and the M.S. degree recognized as the "professional" degree.
- Institutions must teach students how to be lifelong learners.
- Institutions should take advantage of the flexibility of ABET's EC2000 accreditation criteria.

Development of a niche for global market for Philippine Engineers

This should be a continuous process that might involve trial and adjustment periods. It should involve a continuous evaluation of our strengths and creative talents that might be unique. This is not to avoid direct competition with others. This is to take advantage of our strengths.

As a start, it would be worthwhile to conduct brainstorming sessions. PTC or FEED could sponsor such events, workshops, or strategic planning. Potential topics should include possible services that might combine professional engineering with other areas such as management of technology, total system solutions, etc. Another possible activity is to conduct a global needs analysis or market analysis of projected needs, particularly ones that would involve our special talents. The concept of "first to market" could apply to professional engineering services, and the development of workshops to prepare to offer the services ahead of others could be a good long term strategy.

Educational Programs in the Philippines for Global Engineering Practice

Intensive English training for global business. In the development of engineering programs, one of the thrusts is to educate students to gain good communication skills, in both verbal and written form. Engineers need to express ideas clearly. In both the national and global arenas, engineers need to present proposals and reports with clarity and brevity. In terms of language, English is the preferred medium for communication for global business. It is important to reiterate the importance of communication skills in the curricula. In addition it may be beneficial to provide post graduate short courses in communications for global business.

Courses in world cultures and customs. The global practice of engineering might take Philippine engineers to various countries in the world. It would be an advantage for Philippine engineers to understand local customs and mores in their temporary places of work. Broad education of engineers should include more humanities and social sciences, and particularly world cultures. Both western civilization and eastern civilization should be included.

Courses in global business practices. It would be good for Philippine engineers to learn global business practices as they relate to engineering. It would not hurt for them to learn Philippine business practices as well. This could be part of some course.

Graduate Degree Programs in Global Engineering Practice

Within the Master of Engineering Program (MEP), it is possible to design a program emphasizing global practice. This could involve adding some courses from a selection in world cultures, global business practices, foreign languages, and a global engineering project. This might be attractive to graduate students from neighboring countries as well.

Restructuring Engineering Degree Programs

In the Philippines there is a strong coupling between licensing through the Professional Regulations Commission (PRC), and the engineering curricula as approved by the Commission on Higher Education (CHED). This situation has both advantages and disadvantages. One of the disadvantages of such a tight coupling is the difficulty of proposing changes in the curricula. One issue is the changing nature of emerging sub-disciplines in engineering. Many of the sub-disciplines are cross-disciplinary. In the Philippine context, they could be covered by two or more licensing boards. For example the field of mechatronix is based on electrical engineering, electronics and communications engineering, computer engineering, and mechanical engineering. In the Philippines, practicing in this field would require three licenses. Teaching a course in this field in the Philippines would require the instructor to be licensed in three professional engineering areas at the present time. Adding such a course with an instructor licensed in only one discipline might entail the concurrence of three licensing boards. Other examples: solar energy engineering which involves electrical engineering, and electronics and communications engineering; intelligent transportation systems engineering, requiring knowledge of electrical engineering, electronics and communications engineering, mechanical engineering, and civil engineering. Philippine engineers are probably not sufficiently educated and experienced in these fields through no fault of their own, and most likely they would not be able to compete successfully in the global marketplace. This points a need for universities and PTC to work with PRC and CHED to allow greater flexibility in the curricula, and enable the teaching of cross-disciplinary subjects. In contrast, engineering programs accredited by ABET and other signatories to the Washington Accord encourage depth in a discipline and breadth in several engineering disciplines. A related feature of ABET accredited engineering programs is a provision for students to work in teams, and opportunity to work in cross-disciplinary projects.

Another characteristic of Washington Accord signatories is the broader science base that is permitted. For example, the life sciences are now permitted to be acceptable science courses. The Massachusetts Institute of Technology has required biology for all engineering curricula for more than 20 years. This is the century of biology and there are numerous connections to engineering. It would be wise to anticipate emerging engineering technologies, based on a wider scope of sciences including biology.

Directly relevant to the global practice of engineering, it would be beneficial to allow some engineering students to study abroad for a year. This could accomplish the objective of learning world cultures and gaining knowledge of foreign languages at the same time. Numerous engineering programs allow and even encourage students to study abroad for a year. Coordination with CHED and PRC would be needed here. One action item for universities might be to develop relationships with universities abroad to establish exchange programs.

Mutual Recognition Agreements for Engineering Programs

The Washington Accord (1988)

The Washington Accord Agreement [1] is a mutual recognition agreement among engineering accreditation bodies of different nations. Originally signed in 1989 by six organizations (from North America, Europe, Africa, Australia, New Zealand, and Asia), there are now nine signatories, and three provisional signatories. The agreement recognizes the substantial equivalence of the accreditation systems and the engineering programs accredited by them.

Bologna Declaration (1999)
This is an agreement among 29 European countries regarding the comparability of their engineering degrees.

Western Hemisphere Partnership
This is an agreement among the United States of America, Canada, Mexico, and Latin American countries regarding the equivalency of their professional engineering programs.
International Accreditation

ABET Substantial Equivalency
The Accreditation Board for Engineering and Technology (ABET) [2], which is the US signatory to the Washington Accord, directly conducts evaluations of engineering programs outside the United States. An ABET Evaluation Team visits an institution and evaluates one or more engineering programs. Although it does not accredit any engineering program outside the United States, it certifies that certain programs are substantially equivalent to those in the United States that are accredited. The ABET criteria are outcomes based [3, 4].
The ABET criteria follow the principles of continuous quality improvement (CQI). CQI transcends its role in accreditation, and we believe that it is a key to the globalization of engineering education [5].

ABET International Accreditation Plan
ABET is at an initial stage of developing plans for international accreditation that will meet standards for full accreditation [6]. The Task Group on International Accreditation appointed by the President of ABET in late 2005 will present a progress report to the ABET Board at its meeting in October 2006. It is expected that ABET will conduct a pilot study involving three institutions outside the United States in the autumn of 2007. ABET will continue to honor its commitment of mutual recognition (Washington Accord and others) with other nations. Very recently, ABET placed a moratorium on further evaluations for Substantial Equivalence. Evaluations in progress and already planned will be completed. It is anticipated that ABET would replace the current "Substantial Equivalence" certifications with International Accreditation when this is fully established.

References

1. http://www.washingtonaccord.org. A mutual recognition agreement known as the Washington Accord was signed in 1989. See the web site for the signatories to the agreement.

2. http://www.abet.org. This is the web site of the Accreditation Board for Engineering and Technology.(ABET).

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9. Technology Mosaic, http://insidehighered.com/ There are various commentaries on trends towards interdisciplinary approaches in engineering in the article.