Plan for the “Research Center for Biodiversity, Academia Sinica” (RCBAS)

“Research Center for Biodiversity, Academia Sinica” Promotion Team

September 1, 2003 (the 5th revision)
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I. Background

1. The Necessity and Urgency of Biodiversity Research

(1) International Trends

Due to indiscriminate human exploitation of the natural world in recent decades, enormous numbers of natural species have been driven to extinction at an unprecedented rate. Earth is now losing more than 100 species per day — a rate that is estimated to be about 1,000 times greater than the past background rate. In order to understand and address the seriousness of this problem and to stem the tide of gene disappearance, species destruction, resource reduction, and ecosystem degradation, the National Academy of Sciences and the Smithsonian Institution sponsored in 1986 a “National Forum on Biodiversity” at Washington, D.C. The term biodiversity — biological diversity — refers to the wide variety of life on Earth, the gene pools these life forms contain, and the variety of ecosystems in which living creatures interact with one another and with the environment.

In the field of biological sciences, the new concept of biodiversity has became a scientific discipline in its own right, integrating the existing disciplines of molecular genetics, systematics, ecology and so on. This new discipline studies the evolutionarily inherited identity and variation of all forms of life ever since life began 570 million to 1 billion years ago. It investigates methods to conserve and sustain natural resources through studies of genes, species, and ecosystems. It emphasizes the importance of biodiversity, upon which all species, including humans, rely for their existence.

After the Forum, the biologists jointly made an announcement to warn the public that the threat to human civilization from species extinction is second only to nuclear wars, and the concept of biodiversity began to catch the world’s attention. At the “Earth Summit” (the UN Conference on Environment and Development) held in Rio de Janeiro in June 1992, more than 100 world leaders approved the “Convention on Biological Diversity”. By December 2002, 187 nations had formally signed this convention. The main object of this convention is to promote and realize, through the efforts of the world’s governments, three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources.

World scientists have also started to take action on biodiversity research. In 1991, prior to
the Rio summit, UNESCO (United Nations Educational, Scientific, and Cultural Organization), IUBS (International Union of Biological Sciences), and SCOPE (Scientific Committee on Problems of the Environment) launched DIVERSITAS, which at that time consisted of three projects: “Biodiversity and ecosystem functioning”, “Origin, maintenance, and loss”, and “Inventorying and monitoring”. In 1996, the partnership was opened to two additional sponsors, IUMS (International Union of Microbiological Societies) and ICSU (International Council for Science), and a partnership with CBD (Convention on Biological Diversity) was initiated. In 2001, the five sponsors requested that the scientific community launch a new integrated biodiversity research program. In April 2002, a new Science Plan of DIVERSITAS was endorsed. It contains three core projects: Core Project 1 – Discovering biodiversity and predicting its changes; Core Project 2 – Assessing impacts of biodiversity changes; and Core Project 3 – Developing the science of conservation and sustainable use of biodiversity.

Today, biodiversity is universally accepted as the foundation for human survival and welfare. It provides humanity with food, fuel, fiber, medicine, and industrial raw materials and the diversified genetic materials along with it prepare the ground to develop domestic species in agriculture, forestry, fishery, and the livestock industry. It contributes to the purification of air and water, the stabilization and moderation of the climate, the generation and renewal of soil fertility (including nutrient cycling), and the maintenance of genetic resources. In addition, biodiversity plays an important role in the aspects of recreation, aesthetics, science, education, culture, and history of humanity. The international community has increasingly recognized the importance of biodiversity research, as evidenced by the growing number of biodiversity-related papers published in international scientific journals over the past ten years.

(2) Challenges Facing Taiwan

Taiwan has a unique geographical environment and bountiful biological resources. By some estimates, Taiwan is inhabited by 150,000 to 200,000 species with great utilization, educational, research, and cultural potential and value. However, Taiwan has long focused on economic development without adequately safeguarding the environment, resulting in environmental pollution, destruction of habitat, depletion of natural resources, and disappearance of species. Unless its genetic pools, economically important species, and ecological systems stay healthy, Taiwan cannot sustain its socio-economic development.

It is estimated that 80% of Taiwan’s native species are still unnamed. According to the species database compiled by Academia Sinica, which is carrying out NSC’s (National Science Council) “Establishing a Taiwan Biodiversity Information Network” project, only
40,000 species have been discovered and reported in scientific papers. In most cases, scientists know only their external features and not their ecology or life cycle. In addition to a lack of understanding of Taiwan’s species and their characteristics, the inability to control either the rapidly changing environment or species extinction makes it difficult to propose any appropriate management models and conservation measures.

In the past 10 years, the government of Taiwan has started to realize the importance of biodiversity and natural conservation, and the people of Taiwan have become acquainted with the concept of ecological conservation. However, conservation is still a hot debate issue, and much work remains to be done. Often, only after Nature strikes back and people suffer, does the public take notice and force government agencies to take countermeasures. For example, after numerous landslides killed many people, the government began to pay attention to hillside soil conservation and began to carefully evaluate hillside development. But questions remain. Is wetland development more important than its conservation? How should roads be built in coastal areas and forests without fragmenting habitats? The government advocates “eco-engineering” without knowing how to carry it out properly and pushes for “eco-tourism” often with the opposite effect. It is at a loss on what steps to take to stop the decline of fishery resources. After invasive species such as pine-wood nematodes (Bursaphelenchus xylophilus) and Mikania micrantha HB K created havoc in Taiwan’s ecosystem in recent years, the government finally decided to hold discussions on how to remove these organisms and reinforce their monitoring and management.

COA (Council of Agriculture), the agency in charge of conservation affairs, pointed out numerous obstacles facing Taiwan’s biodiversity conservation efforts: “the government underestimated the value of biological resources when it was establishing development goals”; “sound and adequate laws and regulations are needed on biodiversity conservation”; “organizations in charge of conservation lack adequate funds, personnel, and power to carry out their work”; “native species and ecosystems are poorly understood”; “the scientific research work on biodiversity conservation needs to be carried out and improved”; “management work in the existing nature protection areas needs to be reinforced and personnel need to undertake more training”; “a website for the system of nature protection areas needs to be built”; and “categories of the nature protection areas need to be further assessed and improved”. The importance of biodiversity research and personnel training cannot be emphasized enough. Whether it’s to pass laws and regulations, to establish conservation areas, or to educate the public, it is scientific research, and not government policy or management, that can accomplish these goals.

After Academia Sinica hosted an “International Symposium on the Future of Biodiversity in Taiwan” in 2000, President Lee made several suggestions to the government based on the
conference summary. Some of his suggestions were endorsed. A Biodiversity Subcommittee subsequently was established under the Sustainable Development Council of the Executive Yuan. And in August 2001, the Executive Yuan at meeting no. 2747 sanctioned a “Biodiversity Action Plan”; each related department of the government was asked to allocate funds to implement biodiversity work. In early 2002, NSC officially founded an academic discipline of “Biodiversity”. Furthermore, NSC allocated 120 million dollars to execute the “National Biodiversity Research Promotional Plan” in 2004.

The academic world since 1991 has started sponsoring various symposia on biological diversity and resources and in recent years has also started establishing related departments and research institutes. Universities such as National Taiwan University, National Sun Yat-sen University, National Cheng-Kung University, National Chung Hsing University, and Providence University have all founded biodiversity or ecology centers and institutes. In 2003, the Ministry of Education provided tens of millions of dollars of funds to help universities execute the “Biodiversity-teaching Improvement Plan”. Other ministries, such as the Ministry of Economic Affairs, Ministry of Foreign Affairs, Ministry of National Defense, Department of Health, and Council of Indigenous Peoples, have all sponsored lectures and promotional events so that their personnel can quickly grasp the concept of biodiversity, coordinate efforts, and see to it that the efforts bear fruit.

2. The Necessity of Establishing a Research Center for Biodiversity in Academia Sinica

(1) Academia Sinica Is Ready for the Challenge

Although various universities have recently established biodiversity-related departments or institutes, and NSC has established its discipline of biodiversity to put into motion scientific projects, Academia Sinica is the place to set up the “Research Center for Biodiversity”. Its Institutes of Botany and Zoology have twenty or so Research Fellows who have, in the past, already engaged in biodiversity research work. Whether it is in academic research, scholar services, consultation for government agencies, or policy-making, they have played important roles and provided essential services. As a group, they are the most qualified scholars in Taiwan to study biodiversity. Moreover, Academia Sinica is the top academic research organization in Taiwan; its stated mission is to promote, coordinate, and sponsor the basic research on biodiversity. With the new “Research Center for Biodiversity, Academia Sinica” will gain more funding, and domestic and international experts can then be hired to conduct key mission-oriented research work. Adding to its existing solid foundation, this
endeavor will enable Academia Sinica to become an internationally renowned institute for biodiversity research and to contribute further to domestic and international societies.

In the “Biodiversity Action Plan” (see appendix 1), which passed the Executive Yuan in 2001, Academia Sinica was designated to render assistance in the areas listed below, with its work evaluated every quarter. The list also describes the work that people at Academia Sinica have accomplished so far.

(a) Establish and integrate a biodiversity database and information network, and periodically update their information (sponsoring agencies: NSC and COA) — Academia Sinica has finished setting up a website (http://www.taibif.org.tw) for TaiBIF (Global Biodiversity Information Facility in Taiwan) and a website (http://taibnet.sinica.edu.tw) for TaiBNET (Taiwan Biodiversity National Information Network).

(b) Investigate, classify, and research biodiversity information (sponsoring agencies: NSC and COA) — Several Research Fellows in the institutes of Botany and Zoology are currently implementing, or are in the middle of applying for, related projects by NSC and COA.

(c) Strengthen research into the monitoring system of biological resources (sponsoring agency: NSC) — Several Research Fellows in the institutes of Botany and Zoology, through their effort in conducting seminars and executing ecology research projects on Chi-Ku Lagoon, Ta-Peng Bay, estuary of Tamsui River, and Kenting Coral Reef, have elevated Taiwan’s monitoring and analytical methods to the level of modeling for community and ecosystem.

(d) Encourage and reinforce agriculture biodiversity research and utilization (sponsoring agency: COA) — Several Research Fellows are entrusted with executing COA and NSC projects.

(e) Strengthen the system of protected areas and restore endangered environmental and fishery resources (sponsoring agencies: COA, NSC, and Environmental Protection Administration) — Academia Sinica has already assisted the government in completing conservation axis in western wetlands and at the present time is assisting COA in drawing up marine protected areas.

(f) Reinforce the investigation and management of invasive species (sponsoring agency: COA) — Research Fellows in the institutes of Botany and Zoology are in the process of applying for projects.
(g) Participate in the activities of international organizations, and encourage and assist non-government organizations to participate in biodiversity work (sponsoring agencies: COA, NSC, and Ministry of Foreign Affairs) — Academia Sinica, representing the government, has joined and participated in the activities of many important international organizations such as IUBS, DIVERSITAS, GBIF (Global Biodiversity Information Facility), BioNET-International, and Species 2000.

(2) Academia Sinica’s History on Establishing a Biodiversity Institute or Center

At the Annual Academic and Administrative Directors Meeting of Academia Sinica in May 1998, a consensus was reached regarding the need to reorganize the six life sciences institutes: their research mission, function, specialties, personnel, and resources all need to be readjusted in order to keep pace with the international trends of life science research in the 21st century. A new Institute of Ecology and Biodiversity was also proposed, its personnel consists of Research Fellows from the institutes of Botany and Zoology who have engaged in ecology and biodiversity studies. After repeated meetings and discussions at Academia Sinica and the two institutes under the stewardship of ex-Vice president Dr. Shang-Fa Yang, no agreement was reached with respect to this new Institute. However, the importance of the discipline was acknowledged and it was agreed that a Research Center for Biodiversity be established as the first step. It can then be changed into an Institute of Biodiversity and Ecology at a later date.

President Lee in 2000 requested that Dr. Kwang-Tsao Shao, the Director of the Institute of Zoology at the time, be in charge of establishing this Center. Drs. Ching-I Peng, Jiunn-Tzong Wu, and Chih-Yu Chiu of the Institute of Botany, and Drs. Lucia Liu Severinghaus, Chang-Po Chen, and Sin-Che Lee of the Institute of Zoology were invited to form a Promotion Team (Drs. Chen and Lee were later replaced by Drs. Hwey-Lian Hsieh and M. S. Jeng). A preliminary plan for the Center was completed by the end of 2000. In September 2001, the Legislative Yuan formally approved revisions to the Constitution of Academia Sinica, legalizing the founding for the Research Center for Biodiversity. In 2002, vice president Dr. Sunney I. Chan directed that the Center be formally established in the year of 2004, with funding beginning in 2003. 5.38 million NT dollars were allocated for preparation work, pilot studies, and exhibits in 2003. Presently, the funding for 2004 has been reduced from an original 59 million to 43 million NT dollars.

The contents of The Plan for Establishing the “Research Center for Biodiversity, Academia Sinica” and the research projects it proposes are the result of numerous meetings among
Research Fellows from the institutes of Botany and Zoology. The plan has been reviewed by the academic advisors for these two institutes, by the president and vice president of Academia Sinica, and by renowned domestic and international scholars and experts in the field of biodiversity. Their valued opinions and recent developments in the field have been taken into consideration and have resulted in several revisions of the plan. This plan is the 5th revision.

In early 2003, Academia Sinica was urged to first form an “Advisory Committee” for the Center. The committee’s function is to guide and assist in reviewing the Plan, especially in the aspects of designing the Center’s infrastructure, determining its research focus, nominating candidates for its Director, and deciding its future direction. Drs. Peter H. Raven and Wen-Hsiung Li, members of the U.S. National Academy of Sciences, were invited by President Lee to assemble this committee and were expected to have it formed by October 2003. A list of its members will be provided separately.

We, the Research Fellows at the institutes of Botany and Zoology, sincerely hope to see the Center established in a timely fashion. It will provide a great opportunity for different institutes and disciplines to cooperate, and will bring together domestic and international experts and scholars to spearhead Taiwan’s biodiversity research and conservation work.
II. The Name of the Center in English and Chinese

Research Center for Biodiversity, Academia Sinica

中央研究院生物多樣性研究中心
III. Mission Statement

Our mission is to promote, coordinate, and sponsor the basic research on biodiversity in Taiwan, to advance domestic and international research collaboration, to combine biological, biotechnological, ecological, and socio-economical disciplines in pursuit of academic excellence and novelty, and to provide the scientific foundation for the conservation, education, and sustainable application of biodiversity.
IV. The Objectives of the Center

1. Provide Guidance, Coordination, and Inspiration in Biodiversity Research

Academia Sinica is the top academic research organization in Taiwan. Its mission is to lead, coordinate, and sponsor domestic and international academic research. It should also be Academia Sinica’s responsibility to actively promote biodiversity-related research.

Recently, many universities have founded biodiversity-related research centers or institutes. In addition to establishing an academic discipline of “Biodiversity”, NSC allocated 120 million dollars to execute the “National Biodiversity Research Promotional Plan” in 2004. The Promotional Plan covers the following:

(a) The establishment and integration of a national biodiversity database.

(b) The compilation of Fauna, Flora, and Micro-Flora in Taiwan.

(c) The strengthening of conservation research on species gene diversity.

(d) The encouragement of studies on agriculture biodiversity and biosafety.

(e) The reinforcement of the monitoring system on biological resources.

(f) The strengthening of the research and management on invasive species.

(g) The strengthening of the research on marine biodiversity and wetland conservation.

Hopefully, the Plan can become a “national project” in 2005 and receive steady and long-term funding.

In order to comply with the Executive Yuan’s “Biodiversity Action Plan”, government agencies such as COA, the Ministry of the Interior, the Environmental Protection Administration, the Ministry of Education, and the Ministry of Economic Affairs have all started to pay attention and allocate funds to the tasks with which they are entrusted. At a time like this, when scholars and resources are scattered across numerous places, Academia Sinica should quickly establish the Research Center for Biodiversity so that it can undertake the role of leader and coordinate efforts.
2. Provide Consultation and Recommendations to the Government

At the level of central government, the Sustainable Development Council of the Executive Yuan has assumed the responsibility for promoting biodiversity conservation. In the future, the Council will need the Center’s recommendations on formulating science and technology research programs such as “Biodiversity and Ecological Conservation”, “Green Silicon Island”, “Sustainable Development and People’s Welfare”, “National Land Use Plan”, and “Environmental Protection”. In addition, the Center can advise the Executive Yuan on how to implement the “Biodiversity Promotion Action Plan”, and can help the government participate in internationally cooperative projects such as DIVERSITAS, GBIF, and GTI (Global Taxonomy Initiative). Members of Academia Sinica have also proposed a “National Biodiversity and Sustainable Development Research Center”. Many researchers, both inside and outside Academia Sinica, will have to work hard on all these matters and would welcome any suggestions and consultations.

3. Advance Domestic and International Academic Collaboration

In conjunction with the National Committee of DIVERSITAS, the Center will promote and facilitate information exchange and research collaboration among domestic and international biodiversity researchers.

The new Science Plan for DIVERSITAS, which was endorsed by the Scientific Committee of DIVERSITAS in April 2002, has three core projects:

Core Project 1 – Discovering biodiversity and predicting its changes. This project has three focuses: 1) assessing current biodiversity, 2) monitoring biodiversity changes, and 3) understanding and predicting biodiversity changes.

Core Project 2 – Assessing impacts of biodiversity changes. This project has two focuses: 1) impacts of biodiversity changes on ecosystem functioning and ecosystem services, and 2) impacts of biodiversity on health.

Core Project 3 – Developing the science of conservation and sustainable use of biodiversity. This project has two focuses: 1) evaluation of the effectiveness of conservation measures and incentives for achieving the conservation and sustainable use of biodiversity, and 2) establishing scientific approaches for optimizing multiple uses of biodiversity, considering
possible trade-offs between economic and environmental goals, and the uncertainty associated with novel developments.

The Center will also try to integrate the three core projects into future research programs.

4. Assist with the Promotion of Conservation Education

The Center can assist domestic research and educational organizations with promoting education and raising public awareness of biodiversity conservation. In this matter, several Research Fellows in the Institute of Zoology have already made considerable contributions. Their effort can be incorporated into the work of the Center so that Academia Sinica’ task on academic services can be further expanded.
V. Infrastructure of the Center

According to the bylaw of Academia Sinica, the Research Center for Biodiversity must have an Advisory Committee consisting of 9 to 19 committee members appointed by the President of Academia Sinica. The Director of the Center will be selected from two to four candidates recommended either by the Director Search Team, which is appointed by the President, or by the Advisory Committee. The Center will have a number of PIs (principal investigators), administrative staff, and technical research staff. PIs can be hired jointly by the Center and the biodiversity-related institutes at Academia Sinica. “Topic Centers”, temporary centers that will implement more complicated projects and require more budget and human resources, and “Research Programs” can be set up under the Center; each is responsible for handling its own mission-oriented work.

The “Bylaw for Academia Sinica’s Centers” is being revised in the year of 2003. One recent revision is to eliminate the clause that deals with the evaluation and dissolution of a research center. A Center will have the same status as an Institute. When a Topic Center or Research Program of a Research Center is discontinued because its mission is completed or because an evaluation deems so, the Research Center itself remains, its newly hired PIs stay on, and the tenure of its jointly appointed PIs is not affected. Additionally, the original Article 16, which deals with the elevation of a Center to an Institute, is to be eliminated, the reason being that a Center, when it has enough full-time PIs, can apply to become an Institute anytime. Since a Center enjoys the same status as an Institute, there is no superior-inferior relationship between them. The only difference is that a Center will have its Topic Centers and Research Programs periodically assessed because it is multi-disciplined and mission-oriented.

It has been suggested that, as a start, the Research Center for Biodiversity establish a Topic Center of “Systematics and Biodiversity Informatics” and four Research Programs. A research project of “Biodiversity Research of the Lanyang River and its Coastal Wetlands” has already been integrated from multiple disciplines and, hopefully, will pass the review and start in 2004. After the assembly of the Advisory Committee and the appointment of the Director of the Center, all concerned parties, which include directors and research fellows of the institutes of Botany and Zoology, can then determine the priorities of the projects and whether some Research Programs should become Topic Centers.

The Center’s research work must be different from that of the two Institutes. Furthermore, questions on what the relationship will be between them, what the future direction of the Center will be, and whether the research fellows at the two Institutes will be transferred to the Center or be jointly appointed, will all have to wait for the completion of the revision of the
Constitution and the decision of the Advisory Committee. Nevertheless, the Center will need five to ten new full-time PIs and will need to jointly hire some researchers from inside or outside Academia Sinica in order to enhance some research fields.
Infrastructure of the Research Center for Biodiversity, Academia Sinica

President & Vice-President of Academia Sinica

Advisory Committee

Director of the Center

Administration

Core Facilities Lab

Library and Information Office
(→ Taiwan Biodiversity Information Network Center)

Specimen Collection Hall
(→ Academia Sinica Biological Museum)

Academic Service Section
(including education promotion and international collaboration)

Research Focuses

Systematics and Biodiversity Informatics

Ecology and Biomonitoring

Evolutionary Genomics

Conservation and Restoration

Germplasm Conservation and Invasive Species
VI. Research Focuses

The aims of the Center are to research and conserve biodiversity, while assisting the government in formulating and implementing national biodiversity policies. In the beginning, the Center’s research objectives will cover five areas that are integrated with each other: Systematics and Biodiversity Informatics, Ecology and Biomonitoring, Evolutionary Genomics, Conservation and Restoration, and Germplasm Conservation and Invasive Species. Of these five areas, Systematics and Biodiversity Informatics will be designated a “topic center”, and the other four will become “research programs”. The priorities of each area will depend on researchers’ specialties, funding resources, and other objective conditions at the time.

1. The Rationale and Approach for Establishing a Topic Center for “Systematics and Biodiversity Informatics”

(1) Systematics

Taxonomy is the most basic discipline of life sciences; however, Taiwan and the world face the serious problem of a shortage of trained taxonomists. In the past twenty years, gene studies and the biotech field have become darlings of the international research community. Moreover, SCI (Science Citation Index) and IF (Impact Factor) have become the benchmarks for academic research evaluations in Taiwan. These factors have influenced biologists and students alike to give up traditional taxonomic work, resulting in the lack of studies for 80% of the world’s species. Studies on archaeabacteria, microorganisms, nematodes and other lower invertebrates, microalgae, and fungi are all lacking. However, these organisms not only are important to the normal function of Earth’s ecosystems and to the studies of evolution and sustainable use of resources, but also have great potential in providing medicine, food, and other essentials in human life. Consequently, the training of systematics experts, which has been requested by CBD, should be the task of Academia Sinica, fulfilling its mission to lead and encourage basic science studies in Taiwan.

Listed below are some concrete approaches:

(a) Promote and implement the plan on surveying biodiversity resources of terrestrial and aquatic organisms in Taiwan and its adjacent islands.
(b) Compile a list of domestic and international taxonomists to facilitate communications in answering systematics and phylogeny questions. Invite foreign taxonomists to come to Taiwan to advise, lecture, and research jointly. Hold seminars and workshops to accelerate the training of local experts.

(c) Allocate scholarships for graduate students. Assist outstanding students and post-doctorates in going abroad to renowned museums to collect early documents, view type specimens, and hold discussions with experts, so that their theses can be more insightful and influential.

(d) Establish an Academia Sinica Biological Museum and promote national archives of biological resources and information. Publish a series of papers, illustrated handbooks, and CD-ROMs on Taiwan’s fauna and flora (in cooperation with Academia Sinica Press).

(e) Launch research and organization work on Taiwan’s wild animal and plant DNA barcoding, focusing on fish and plant seed. Create archives of frozen gene material for wild animals, with fish and marine animals as its focal point.

(f) Assist other research organizations and universities in Taiwan and mainland China in properly identifying specimens in their archives, and organizing and digitizing data.

(g) Work on GTI-related projects and programs that are underway globally, and promote regional collaboration among East-Asian taxonomists.

(2) Biodiversity Informatics

Every task on the Executive Yuan’s “Biodiversity Action Plan” requires knowing the standard names of each species and the composition of various species; therefore, taxonomists are needed to provide this information. Currently, there are only about 6,000 taxonomists worldwide and the ratio of this number to the total number of scientists is still rapidly decreasing; research budgets are also shrinking. It is estimated that Earth has 3.6 million to 1 billion species of organisms; however, of these, only 1.5 to 8 million have been named. In other words, the descriptive α type of taxonomic work has fallen far behind. With the reduced number of taxonomists
and reduced funds, even though identification of microorganism has started to take off since tools on molecular biology were invented, there is still a long way to go with respect to describing all those organisms that haven’t yet been discovered or named.

Fortunately, this is an era of information technology and digitization. If a database can be built and taken online with early classification documents and information on type specimens, and with published text and pictures of species, then it will help reduce money and time needed for taxonomic description and information analysis. Especially in the countries that are rich in biodiversity but have less information or few taxonomists, this approach can greatly speed up work on traditional classification research. To have a complete list of the world’s species in the next 20 to 30 years is no longer an unattainable dream.

CBD specifically pointed out the importance of GTI’s crosscutting issues. It asked each government to address the need for taxonomic work and to establish national or regional biodiversity information exchange facilities. GTI became formally operational in 2002 (http://www-gti.nies.go.jp). GTI asked each government to set up a “National GTI Focal Point” and to periodically submit evaluation reports on classification needs. Its first symposium in Asia was held in Malaysia on September 10–17, 2002. Taiwan was invited to attend and present reports. In addition, GBIF, which was founded in March 2000, has requested each government to set up national websites and integration platforms so that global biodiversity data can be disseminated. Its initial focal point is to establish a database of classification-oriented species names and specimen data. BioNET-International (http://www.bionet-intl.org/), another NGO (Nongovernmental Organization) that was created in 1993 and belongs to the global network for taxonomy, engages in building TCNs (Technical Cooperation Networks) in order to tackle the problems of inadequate taxonomic skills and resources in the developing world. Taiwan, because of political issues raised by mainland China, cannot join EASIANET (the East Asian Network for Taxonomic Capacity Building). Nevertheless, Academia Sinica, using the name of “Academia Sinica, Taiwan”, successfully joined ASEANET (the South East Asian Loop of BioNet-International) in March 2003.

(3) Summary

Taiwan is a subtropical island that straddles the Tropic of Cancer and is at the
adjoining point of the three marine ecosystems of the East China Sea, South China Sea, and Philippine Sea. There are steep mountains and deep ocean floors, creating wide variations in topography and habitat. Of the more than 40,000 species recorded in Taiwan, 5,500 are fungi, 4,000 are vascular plants (about 25% is endemic), 19,000 are insects (about 60% is endemic), 500 are birds, and 2,600 are fish. Additionally, Taiwan has more than 10% of the world’s species of marine organisms and is believed to have at least 150,000 native species overall; it can thus be called a treasure island of Nature. On the other hand, many lower invertebrates as well as deep-sea and deep-soil habitats have not been discovered, described, or recorded, due to a lack of investigation and research by taxonomists. Taiwan also has long focused on economic development without adequately safeguarding its environment. Under the assault of over-development, over-fishing, habitat pollution and destruction, and invasive species, its biodiversity and natural resources have rapidly degraded. Bountiful species in the past have become scarce, even extinct, including many species that haven’t even been discovered or studied.

Consequently, it is recommended that a “topic center” of “Systematics and Biodiversity Informatics” be launched under the RCBAS to promote research work in these fields. There are three concrete approaches: (a) inventory species of Taiwan’s fauna and flora and their basic information; (b) integrate the existing related databases in Taiwan with Academia Sinica’s work on TaiBNET and TaiBIF; and (c) participate in, and in collaboration with, international organizations and programs such as GBIF to facilitate international cooperation.

2. Research Programs

(1) Ecology and Biomonitoring

The intellectual value of ecology and biomonitoring derives from investigating the complicated interactions between organisms and their physical environments. The central focus is to study the forming and sustaining mechanisms of biodiversity patterns in order to formulate ecological models, so that humans can monitor and predict changes in ecosystems. Knowledge gleaned from this research will enable humans to better understand how to maintain, improve, and restore ecosystems that all forms of life on Earth depend on. The Center’s four approaches are listed below:

(a) Help compile distribution data of Taiwan’s animals and plants, utilize GIS
(b) Promote biodiversity research on the Lanyang River and its coastal wetlands, and construct its ecosystem model. This project can be coordinated with LTER’s (the Long-Term Ecological Research which is being conducted by the Institute of Botany) projects at the Fushan and Yuanyang Lake sites. In the future, the project can also extend to the offshore area of Ilan Bay. The newly inaugurated “Academia Sinica Marine Research Station” in Chiaohsi of Ilan County can serve as an operational base for the fieldwork of this project.

(c) In concert with DIVERSITAS and IBOY (the International Biodiversity Observation Year), improve Taiwan’s capacity in the studies of taxonomy, biomonitoring, and biodiversity informatics, and assist in data exchanges with other countries.

(d) Support and coordinate domestic biodiversity and ecology research centers and stations to fully utilize their capacities. Examples of these research institutes include colleges and graduate schools for the sustainable use, conservation, and management of biological resources, founded by National Tsing Hua University, National Taiwan Ocean University, and National Ilan University; the Wetland Ecology Research Center in the Tsengwen Estuary, proposed by the Tainan County Government; and the Marine Research Station in Ching-Wan, proposed by the Penghu County Government.

(2) Evolutionary Genomics

Evolution--the study of how natural selection acts upon organisms and is reflected in the next generation of a population--can be further divided into three research levels: the population level, the species level, and the nucleotide level. The paucity of genomic sequences available from representative organisms has led to common challenges for evolutionists. With the completion of multiple genomic sequences, one of the most important challenges of the this century will be to develop a complete understanding of how a sequence functions to carry out essential life processes, and a major route to that understanding will be comparative analyses of biological diversity. While data from these genomes can provide much insight into evolution, it is important to associate phenotypic variation with corresponding nucleotide changes. One of the missions of RCBAS is to work together with the Academia Sinica Genomics and Proteomics Center to explore the following fields of study.

The comparative genomic study is in fact a branch of evolutionary biology. From
the standpoint of evolution, genome research begins with investigations into historical patterns and phylogeny. This provides a framework for understanding the mechanisms of temporal and spatial gene variations within and among populations of plants, animals, and microbes. Therefore, evolutionary genomics provides a unit—the gene—as the intellectual framework and as a tool to understand the diversity of life: what has changed and what has remained the same, what creates variations, and how organisms adapt.

The Center will promote the following research work:

(a) Comparative studies on the biodiversity distribution patterns and forming mechanisms of the marine organisms of West Pacific islands, using the method of phylogeographic analysis on representative terrestrial and aquatic organisms and the method of molecular marker analysis.

(b) Evolutionary studies on the mitochondria genomics of lower invertebrates and the chloroplast genomics of plants.

(c) Studies on the variation or polymorphism within and among species, through mitochondria DNA sequences of closely related animals, to understand the heredity mechanism for organisms’ diversity in form and function.

(d) Studies on the evolutionary developmental biology of metazoans, to understand their body plan and evolution.

(3) Conservation and Restoration

Biodiversity conservation is culture specific; people’s backgrounds, customs, and attitudes toward the environment vary from region to region. Thus Taiwan cannot blindly adopt Western philosophies and value systems toward nature; it must take its indigenous environments into consideration. To achieve this goal, the Center will render its assistance in the following tasks:

(a) Promotion of conservation concepts. Determine the most practical and effective action plans to implement conservation by way of analyzing historical trends in Chinese culture, Taiwan’s current socioeconomic developments, and people’s life styles.

(b) Promotion of habitat restoration and recovery. In addition to applying engineering technologies and technical procedures, local people’s understanding and
preferences of ecology and biodiversity will be taken into account as well. This particular aspect of biodiversity conservation awaits further study.

(c) Promote and Conservation of traditional knowledge of aboriginal people. The knowledge of aboriginal people on sustainable use of biodiversity resources is well known. To conserve the aboriginal culture usually equals to conserve the natural resources. The Center also sets goals to discovery and to understand the aboriginal knowledge in Taiwan, and to evaluate its effective in the sense of environmental management, species conservation and biotechnology application.

(4) Germplasm Conservation and Invasive Species

(a) Assist in the data collection of useful native species and nonnative species, in order to develop a reference database for proper resource utilization of the former and management and prevention of the latter.

(b) In collaboration with universities in Taiwan, launch research and organization work on the DNA barcoding of native organisms. The Center will handle the work on fish and plant seeds.

(c) In conjunction with the Taiwan government and other research institutes, establish archives of frozen gene material for wild animals, with fish and marine animals as the focal point. The archives will be located in the Specimen Museum of the Institute of Zoology or in the future Specimen Collection Hall of the Biodiversity Center.

(d) Assist in advancing biosafety, such as the examination, evaluation, and management of GMOs (genetically modified organisms). (The Cartagena Protocol on Biosafety, which has been signed by 50 countries, took effect on September 11, 2003.)

(e) Assist the government in identifying the species, origin, and characteristics (such as distribution trend, habitat preference, reproductive ability, extent of invasion, and superiority) of invaded species in order to build a complete database of them. Furthermore, their entry route and medium, residence time and assimilation rate will all have to be investigated and deduced so that effective prevention and control measures can be proposed.
VII. Initial Plans and Research Projects

1. Background

Biodiversity refers to the variety of life on Earth, which is usually described and measured at the level of genes, species and ecosystems by scientists. Hence, the study of biodiversity is a discipline that combines different domains from systematics, ecology, genetics, and evolutionary biology. The Center here in Academia Sinica aims to integrate traditional domains and to promote biodiversity research at any of the above three levels.

The research projects will be cooperated with other universities and research organizations, local and international, as well as in association with the NSC and COA to conduct or implement their projects, such as “National Digital Archives Program” (NDAP), and “National Biodiversity Research Promotion Program.” The initial plans of this Center can be illustrated in the following four areas.

(1) At the genetic level,

RCBAS will collaborate with the Genomics Research Center of Academia Sinica, benefiting from their biotechnology techniques and bioinformatics to advance genetic conservation research, focusing on endemic, endangered, and invasive species as well as economic potential species. Through this collaboration, an evolutionary genomic research program can be developed. Furthermore, integration of population variation, genetic diversity, and database establishment are important for conservation genetics. Thus, RCBAS will promote evolutionary genomic studies of Taiwan’s important endangered and economic species, including their comparative genomics, molecular systematics, molecular evolution, and genetic conservation. The following two are the main projects being proposed this year:

A. Genome-wide surveys and conservation of endemic species and animals and plants of economic importance.

B. Biogeographic study in the Indo-West Pacific region. (This is a theme project of Academia Sinica.)

(2) At the species level,

The first task is the establishment of a species diversity database. Biodiversity
research is built upon studies of systematics. It would be impossible to engage in or carry out any biodiversity study without correct species identification. The Institutes of Zoology and Botany have very strong teams of systematics researchers. Therefore, it would be beneficial to integrate all the researchers and resources of both institutes to review the systematics generated from morphology and take this opportunity to complete a species inventory. This will include building a checklist of species and their diagnostic morphological characters, ecological distribution, and other basic information, and then publishing and/or updating the *Fauna and Flora of Taiwan*, which will be incorporated into a database for search and retrieval purposes. A mirror site will also be created with links to the Integrated Taxonomic Information System, the Global Biodiversity Information Facility, the National Center for Biodiversity Information, the Adaptive Evolution Database, and the Tree of Life databases for the benefit of scientists worldwide. This project, which is consistent with the spirit of the Global Taxonomy Initiative of the *Convention on Biological Diversity*, will also provide the opportunity to train people who are interested in systematics and evolution.

The maintenance of the National Center for Biodiversity Information will be the jobs of this Center, which may require 2~3 technicians or assistants to take care. Followed by the establishment of the building of this Center, Biological Museum Academia Sinica will also be set up to serve the job as an archive unit and research sites for systematics and taxonomy.

(3) *At the ecosystem level,*

RCBAS will coordinate ecologists to select research sites of importance and sensitivity, including both terrestrial and marine habitats. For the conservation and sustainable management of Taiwan’s natural resources, the understanding of temporal and spatial distributional changes of community structures and the maintenance mechanisms of entire ecosystems is necessarily required, which is by all means through long-term monitoring in the sites of interests. The following two projects are proposed,

A. Biodiversity study in the Lanyang River watershed and wetland areas. The Lanyang River watershed area harbors typical mixed coniferous-broadleaf forests and abounds in wildlife resources. This project aims to investigate the major components of ecosystems in the watershed and coastal wetlands, the ecological roles of each resident taxon, and food web structures.

B. Comparative study of the patterns and processes of oceanic biodiversity around
Taiwan.

In 2004, a pilot study of coral reef ecological polymorphism in the Pescadores (Penghu) will be implemented. This will be followed by similar studies in the Green Island, Orchid Island, Pratas Islands, Spratly Islands, Hsiao-Liuchiu, Kueishan, and Pengchiayu.

RCBAS will also assist the government, schools and non-government organizations (NGOs) in advancing public awareness of biodiversity conservation. Finally, Academia Sinica will represent Taiwan by participating in international organizations and cooperative programs related to biodiversity research and conservation. These activities will promote the active exchange of information between Taiwanese and international researchers, and will improve Taiwan’s international image and academic prestige.

(4) Eco-engineering and invasive species

Apart from the above three perspectives of basic research, this Center will also pay attention to the current two issues of urgency in Taiwan. One is eco-engineering and the other is invasive species. Both of which has seriously caused the loss of biodiversity in Taiwan.

Focusing on the former one is because of the river bank and coastal zones are under “cementalization”, leading to the habitat degradation and fragmentation. All the banks of rivers and streams, more or less, has been transformed into canal or covered by cement. The total length of embankment is up to 50% of the total river length and the sum of dams built across rivers is more than 9,000. The coastal areas face the same problem, too. 530 kilometers of costal line, half of the total length, has been covered by breakwaters, piers or tetrapods, which ruins both the intertidal zone and lives of marine organisms there. In recent years, scholars urge the government to face the biodiversity loss problem caused by those constructions and to evaluate the way to develop these areas by integrating ecological perspective. in such a way, eco-engineering gains its position. Eco-engineering, however, is not to pretty up the construction site by building an ecological park aside but goes deep to estimate the impacts on ecosystem, and to figure out the way on how to balance between development and environment. The involvement of ecologists in the project of eco-engineering is therefore definitely required.

The problem of invasive species in Taiwan has evolved into a serious stage. For example, the propagation of land snail *Ampullarium insularum* (of South America)
has damaged 10,500 ha. of farmland, which caused 130 million NT dollars (3 million US dollars) of agricultural loss within a year. Meanwhile, the spread of pine-wood nematodes (*Bursaphelenchus xylophilus*) and Mikania micrantha HB K are also out of control and damage a huge area of forest as well as wild lands. Others such as *Achatina fulica* Bowdich (introduced from Africa) and red ear turtle (*Trachemys scripta*), from Brazil and US also produce unexpectedly disastrous impacts on Taiwan native biota. Once these invasive species become dominant in the environment, threatening other organisms, the cost of recovery will be ruinous and often unattainable. Hence, fostering research on invasive species at this movement is necessary.

One of the Center’s research projects in 2004, “Biodiversity Research of the Lanyang River and its coastal wetlands biology” contains the realms of eco-engineering and invasive species.

2. Initial Research Projects

Currently, the Center has formulated 7 research projects for future research. The budgets for each of them are not allocated in this statement because the research fund may from NSC, COA or the Theme research at Academia Sinica. The research areas of these projects cover from genetic to ecosystem level which let almost all P.I.s currently working on biodiversity at both the Institute of Zoology and the Institute of Botany can actively participate.
Project 1: Genomic studies and germplasm storage of ecologically or economically important organisms in Taiwan and invasive species

1. Background

(1) Species cultivation
The resources of biodiversity will not only help sustain the balance of ecosystems, but will also provide a basis for finding new useful substances to improve human life. For example, the genetic trait of disease resistance in wild corn can be transferred to commercial crop cultivars to improve their production (Wilson 1992, *The Diversity of Life*). In addition, a number of microorganisms have provided chemicals that fight cancer and other diseases. Through genetic modification and environmental adaptation, certain ecotypes of temperate crops have been successfully cultivated in subtropical areas of Taiwan. However, many important germplasms of native microorganisms and aquatic organisms, which have great potential economic value, have not yet been identified or documented, even though a center for the culture and storage of microorganisms and a collection and preservation center already exist in the Agriculture Research Institute of Taiwan. The use of molecular techniques, such as molecular markers, allows the study of genetic polymorphism and the identification of these important organisms, which will remarkably increase our knowledge of genetic resources and will help determine the most effective methods for conservation and utilization.

(2) Invasive species

Charles Elton, an English ecologist made the remark, “We must make no mistake; we are seeing one of the greatest coevolutions of the world’s flora and fauna.” After this statement, Elton proposed several ecological theories on the exotic species, in last recent decades. Today invasive species have become one of the most important issues in the field of environmental conservation and ecology. Recent studies have demonstrated that hybrids interbred between alien species, or between alien and their close native species, all having a potential to produce a new hybrid genotype. These results may change the genetic structure of a population and produce new hybrid type of invasive species (Gaskin and Schaal, 2002).

Invasive species pose a threat to native biodiversity due to changes it causes on the composition, structure and function of terrestrial and marine ecosystem (D’Antonio and Dudley, 1995; Mooney and Hobbs, 2000; D’Antonio et al., 2000). Unfortunately, an invasive species can usually be recognized only when it has already damaged the local ecosystem. Furthermore, the strategy targeted to reduce its impact often comes too late and are rather expensive (Simberloff, 2001). The annual loss of
agriculture caused by alien plants in the United States and Australia is 1.3 billion and 100 million US dollars respectively. In the UK, 430 million US dollars is spent annually on the pesticides towards the elimination of alien plants. New Zealand spends 200 to 600 million dollars on invasive species control.

As for Taiwan, no official documentation about the damage caused by the alien species has ever been estimated and reported yet. Nevertheless, problems such as, agricultural damages, economic loss, uncontrollable hybrids, infectious diseases and parasites, environmental pollution, and breakage of food chain, etc., which are impacted by all kinds of alien species, including the land snail (*Ampullarium insularum*), pine-wood nematodes (*Bursaphelenchus xylophilus*), *Hypostomus* sp., *Procambarus clarkia*, red ear turtle (*Chrysemys scripta*), crawfish, *Mikania micrantha* HB K, *Bidens pilosa* var. *radiata* *Leucaena glauca* (L.) Benth, *Sesbania cannabina* Pers., *Ipomoea nil* (L.) Roth, *Eichhornia crassipes*, etc. are too obvious to ignore. Presently, more than 125 animal and 300 plants have been identified as alien species. However, the lack of understanding of each species, in addition to the very limited availability of data on their origins, numbers, identities, make it extremely difficult to implement measures to control them.

### 2. Project objectives

1. **Species cultivation**

   Methods such as molecular markers and DNA sequence polymorphism will be used to study the genetic diversity of organisms and document these genetic resources. Crops and microorganisms with potential pharmaceutical uses or disease resistance will be selected as the first priority target study organisms.

2. **Invasive species**

   The first and most urgent step is to carry out field surveys to collect the basic information about invasive species, so that a database can be built up, enabling the future research on their residence time, fitness in comparison to their close native species (including competition and hybridization), distribution, genetic structure, invasive mechanism, ranking in terms of their danger and impact on biodiversity and environment in Taiwan. Such information can aid in the predicting the potential dangers of an invasive species and facilitate the formulation of a cost effective strategy and policy on how to deal with them. The earlier all relevant work and research is completed, significant savings in both financial support and human resources will be required.
Another indispensable tool on the way to preventing invasive species from causing damages is educating the public about these problems. While American and European countries have already grasped how important and urgent the problem is, populace in Taiwan are still not familiar with the relationship between invasive species and the loss of biodiversity domestically as well as worldwide. Therefore, it should be mandatory to translate all scientific and technical language papers to level of the general public. This is to allow better understanding of the seriousness of the problems. Thus, prevention of exotic species will be more complete.

3. Materials and Methods

(1) Species cultivation

a. Collection of organisms with economic value. In cooperation with other research institutes in Taiwan, RCBAS will collect, isolate, and document economically important organisms, including crops, fungi, aquatic organisms, etc.

b. Employment of molecular markers and DNA sequence polymorphism to screen collected organisms.

c. Documentation of molecular markers and DNA sequence polymorphism. The fingerprint and analyzed data of each organism will be documented in a database.

(2) Invasive species

Steps to evaluate potential threats of invasive species

a. Do basic surveys into their identities (including species names and origin) and biological traits (e.g. dispersal potency, habitat preference, reproductive abilities, invasion degree, and dominance), in order to establish a database for invasive organisms.

b. Investigate and infer the likely invasion route, residence time, agent, and naturalization rate, in order to propose efficacy prevention and controllable strategies.

c. Design experiments for the understanding of competitions between native and non-native species such as allelopathy, impact on habitat, pollination behavior and reproductive strategy, in order to obtain objective data for evaluation the impact to biodiversity and ecosystem raised by the invasive organisms.

d. Encourage studies on the population genetics of native and non-native species in order to disentangle the speciation and hybridization between them. Furthermore,
monitor their inter-breeding behavior, which can provide us with genetic information for evaluating which taxa have to be conserved and which have to be eliminated in terms of their population.

4. Expected results

(1) Species cultivation

a. Collection and analyses of fingerprints of ecologically or economically important organisms in Taiwan, in cooperation with other germplasm collection centers.

b. Documentation of nucleotide polymorphism of ecologically or economically important organisms, for the study of gene pool diversity.

c. Creation of a database incorporating data from the Research Center for Biodiversity as well as from industry and other research institutes.

(2) Invasive species

a. Completion of a checklist and a database for exotic and invasive species in Taiwan, in collaboration with the efforts from Quarantine Bureau, Forest Bureau, Endemic Species Research Institute, and Universities.

b. Prediction of the threat to biodiversity raised by invasive species and proposal of relevant control and management policies for an early alert and prevention system.

c. Increase in public awareness concerning the threats of invasive species and enabling quarantine and prevention to be more complete.
Project 2: Evolutionary Genomics (I): Evolutionary analyses of the organelle genomes

1. Sequencing and evolutionary analysis of mitochondrial genome in lower metazoans

In vertebrates or higher invertebrates, mitochondrial genome is usually described as an “economic” circular genome by the characterization of intronless, non-repair mechanism, non-recombination, and maternal inheritance. Re-arrangement of protein-coding genes and prone to accumulating mutations are usually observed in the mitochondrial genome among different lineages during the evolution of metazoans. These characterizations provide mitochondrial genome as one of the most important genetic markers for evolutionary biology in the last decade. Nevertheless, recent studies of complete sequences from several cnidarian mitochondrial genomes indicated: (1) linear form of mitochondrial genomes in a hydra and a jellyfish; (2) a repair-like gene similar to that of bacteria found in an octocoral anthozoan; (3) a large fragment of group I intron found in hexacoralian anthozoans, an actiniarian and a scleractinian. Although these findings have challenged the traditional view of evolutionary mechanism of mitochondrial genome for higher metazoans, they also provide us new directions for evolutionary study of mitochondrial genome.

In this project, genomic approach is adopted to reveal the mitochondrial genomes of poriferans, cnidarians, and a mesozoan in order to understand:

(1) Evolutionary pattern of gene order in the mitochondrial genomes of lower metazoans;
(2) Evolution of group I intron in hexacoralian anthozoans, including, actinarians, scleractinians, corallimorpharians, and zoantharians, including:
   (a) Confirmation of existence of group I intron in corallimorpharians and zoantharians;
   (b) Origin of group I intron in anthozoans, monophyly or polyphyly?
   (c) Molecular evolution of group I intron and its application to the phylogenetic study of anthozoans.

2. Nucleotide substitutions in plant chloroplast genomes:

Endosymbiosis of chloroplasts and mitochondria has generated modern plant cells. In past several years, at least ten chloroplast genomes were completely sequenced. Although chloroplast DNA sequences has been widely utilized in plant systematics and evolutionary studies, the process of nucleotide substitution of chloroplast genomes were seldom to be studied in detail (Morton 2000). The early works in studying rate of nucleotide substitution and pattern of nucleotide were often
based on some limited sequences (Wolfe et al. 1987). Morton (1995) compared noncoding regions between rice and maize and found that a transversion bias was correlated to the A+T content of two immediately flanking bases. In addition, we found that the transversion bias in relating to two immediate nucleotide bases was not only observed in the chloroplast but also in the mitochondria and human pseudogenes (Yang et al., 2002a; 2002b). In this project, we will do large-scale sequence analysis in several chloroplast genomes of angiosperms in order to understand:

(1) The evolutionary relationship in these plant genomes;
(2) Influence of sequence context on the pattern of nucleotide substitution; and
(3) Effect of specific nucleotide structure on the rate of nucleotide substitution.
Project 3: Phylogeography of the West Pacific

1. Background and Significance

Phylogography is a field of research concerning with the evolution of organisms by studying the principle and process governing the geographic distribution within and among closely related species. Results derived from phylogeography studies also provide a crucial recommendation to the biological conservation and sustainable management. The Indo-West Pacific, hosting the highest biodiversity on Earth, is one of the highly-populated region by human populations in the world. Both terrestrial and marine organisms are ultimately facing extinction due to over-consumption of land, coastline, and resources by human populations in this region. Conservation and sustainable management of biodiversity in the region will become one of the key issues for the countries around the Indo-West Pacific region in the 21\textsuperscript{th} century.

2. Objectives and approaches

Several hypotheses, including formation of landbridge, tectonic plates, dispersal, and glacial events, have been proposed to explain the mechanism of forming high biodiversity in the West Pacific. In this research program, colleagues with both terrestrial and marine expertise were invited to form an integrated team to study the phylogeography patterns of representative organisms in the West Pacific, including, scleractinian corals, reef fishes, polychaetes, freshwater fishes, insects and birds. Concordance and discordance of phylogeography patterns among different organisms will be elucidated by applying several sets of molecular genetic markers, including mitochondrial DNA, nuclear introns, and microsatellites.

In this integrated project, we will do phylogeographic comparison in order to understand:

(1) The population genetic structure of terrestrial and marine organism in the West-Pacific;
(2) The phylogenetic relationships of sibiling species and germinate species; and
(3) Concordant patterns among different organisms in the West-Pacific.
Project 4: Systematic studies on Taiwan Biota

1. Background and Significance

Biological classification is basic to biodiversity utilization and conservation. Taiwan is a continental island that straddles the Tropic of Cancer. Its subtropical location combined with a tall range of steep, rugged mountains creates a wide array of environments. Ecological features range from tropical to alpine, supporting a rich, diverse biota. The approximately 4000 species of vascular plants in Taiwan (about 20%-25% of which are endemic) constitute one of the most remarkable assemblages of plants anywhere in the world. Their relationships to the plants of other parts of eastern Asia and the rest of the world are so intriguing that investigations of their patterns of distribution and phylogeny represent endlessly interesting topics for scientific investigation. Meanwhile the flora in Taiwan is also abundant. 20,000 insect species (three-fifth are endemic) has been published, and species of vertebrate approximately 3,300, including 2,500 of fish, 500 of birds 100 of mammals, 34 of amphibian, and 29 of reptile. The percentage of epidemic species is particularly high, marine organisms here constitute one-tenth of overall marine species. While lots of species and research topics are waiting to be done, the shortage of students and experts prevent further studying. The Center shall also take responsibility for human resources cultivation and recruitment.

2. Objectives and Methods

(1) Flora and Fungi studies

Even though the 2nd edition of the Flora of Taiwan is nearly completed, many new distributional records, naturalized alien plants, new species, and taxonomic revisions continue to be reported. Study constraints for Taiwanese botanists include: a. limited access to historical literature and type specimens; b. lack of understanding of the variation patterns of species distributed in Taiwan and neighboring countries, particularly mainland China and Japan; and c. incomplete botanical inventories and insufficient support for herbarium/museum collections in Taiwan.

To remedy the above and to bring the taxonomic/systematic research of Taiwan’s flora up to world standards, advice and an agreement on collaboration have been sought and received from Dr. Peter H. Raven, Director of the Missouri Botanical Garden. This collaboration will set up an international editorial committee to produce a modern account of the mosses, ferns, and seed plants of Taiwan. When completed, the new flora project will be published by the Missouri Botanical Garden.
Press. Meanwhile, an electronic, fully databased flora project using GIS and an interactive identification system is being discussed and considered. In this collaborative effort, Taiwanese botanists are encouraged to visit noted botanical institutions such as Tokyo University, the University of Kyoto, the Chinese Academy of Sciences, Harvard University Herbaria, Missouri Botanical Garden, Royal Botanic Gardens at Kew, and others that preserve abundant authentic material and original literature on East Asian botany.

Because Taiwan’s rapidly expanding economic development is placing tremendous pressures on its forests and natural environments, there is an urgent need to implement a comprehensive botanical inventory of the island. This should concentrate especially on areas that are species-rich, unusual, poorly known, or in imminent danger of development/destruction. The collection program will further document the characteristics and distributions of Taiwanese plants, and increase the representation of these plants in the herbaria of Taiwan and the rest of the world. Information on the collections, images, and literature will be computerized, adopting international standards for data retrieval and exchange.

Taiwanese botanists will be encouraged to do field work in eastern Asia, particularly mainland China and Japan, with which Taiwan has close biogeographic relationships. Such expeditions will produce useful samples for comparative studies by both traditional botanists and molecular systematists. Scientists will gain a clearer picture of morphological variations and phylogeographical patterns of East Asian plants.

(2) Fauna Studies
Based on the FishBase in the Institute of Zoology as the paradigm, we are going to build up other database of animals and publish the English version of “Fish Fauna of Taiwan” by the end of 2004 and digitize it at the same time. Meanwhile, the cultivation of systematics people, by long-term academia scholarships or short-term workshops and conference is also one of the tasks.

3. Expected results
(1) Advance biological research activities in Taiwan
(2) In coordination with the National Digital Archive Program”, to set up a database of images of type specimens and the original papers
(3) In cooperation with experts of taxonomy to finish flora and fauna of animals, plants and fungi and to digitize them.
(4) form the basis for biodiversity conservation in Taiwan
(5) Improve the Biological Research Museum in terms of its quality and quantity, and enhance the capacity of Taiwanese Biodiversity Research.

Finally, the Research Center for Biodiversity, Academia Sinica will consolidate the botanical and zoological collections currently housed respectively in the Institutes of Botany and Zoology and combine them into a research museum. Given adequate support for facilities and manpower, the museum will preserve research specimens, provide online database services, coordinate biodiversity research, and promote international collaboration.
Project 5: Establishment of a coordinated biodiversity database (in coordination with Notional Digital Archive Project)

The establishment of a coordinated biodiversity database is fundamental to all disciplines of biological sciences. Biodiversity information is useful for studies in biological taxonomy, evolution, ecology, populations, communities, biogeography, natural history, etc. The combination, overlay, and further analyses of biodiversity data benefit biological research, societal education, and the economy.

While lots of biological databases have been built up or under construction in Taiwan by individuals, research organizations or governmental organizations, the exchanging mechanism among them has not been made yet, which makes all the efforts do not serve their purposes completely well. Hence the establishment of a national biodiversity center is of global importance. Recently, the establishment of biodiversity databases has become a major theme for many research/archive institutions in Taiwan. To integrate biodiversity information and to facilitate database exchanges, a “TaiBNET” (Taiwan Biodiversity Information Network) has been established at Academia Sinica.

Objectives of the coordinated biodiversity databases project

(1) Coordination of faunistic and floristic checklists and relevant information in Taiwan, including:

1. Species name inventory (checklist of the scientific names of species, records of taxonomic research, etc.)
2. Specimen inventory (identification records, verification records, specimen exchange management, etc.)
3. Biological literature inventory and digitalization (catalogue records, full text files, full text images, etc.)
4. Image inventory and digitalization (slides, videos, specimen images, line drawings, images of old literature, etc.)
5. Species information (biogeography, morphology, molecular data, economic value, etc.)

(2) Construction of TaiBNET (http://taibnet.sinica.edu.tw) and our national website, TaiBIF (Taiwan Biodiversity Information Facility, http://www.taibif.org.tw) to integrate certain of well-constructed domestic databases

1. Integration of domestic databases (including technology resources) and collection name list of biodiversity experts and name list of species and other data of importance, such as data of ecological monitoring, invasive
species and endemic species.

2. Apart from the connection among individual databases, the metadata, common homepage and GIS format will also be proceeded so as to facilitate searching process. Promotion of the establishment of a biodiversity information center in Taiwan; sharing of information and expertise among domestic and international biodiversity institutions.

(3) Participation in the GBIF (Global Biodiversity Information Facility) activities and other relevant international affairs

Followed the projects such as Species 2000, ITIS (Integrated Taxonomic Information System), BioNET-International and GTI (Global Taxonomy Initiative), the RCBAS will set up a series of programs in coordinating and integrating biological information and creating exchangeable databases. The structure of the network of database functions as the chart illustrated,

**Expected accomplishments**

1. Establishment of a unified national biodiversity information center that integrates relevant databases and coordinates technology resources.
2. Establishment of a dynamic, centralized biodiversity database to facilitate the effective updating, exchange, and management of data records.
3. Establishment of a systematic biodiversity research procedure and framework that are congruent with those of international biodiversity institutions.

4. Establishment of TaiBNET (Taiwan Biodiversity Network) providing a catalogue of living organisms in Taiwan.

5. Provision of research data to policy makers and educators; promotion of sustainable biodiversity conservation.
Project 6: Biodiversity Research of the Lanyang River and its coastal wetlands
Biology

1. Introduction

Wetlands occur between land and lakes, seas, and rivers, in sheltered places where silt and mud accumulate. Their functions include water retention, purification of pollutants, protection of coastlines, etc. Large amounts of nutritive material are transported through wetlands, and their contribution is essential to the productivity of coastal waters. Wetland ecosystems are both very productive and very vulnerable; not only are they rich in biotic resources, but they also play important roles in biogeochemical cycles. Thus, they provide unique places for the conservation of biotic resources, and are important for the social economy as well.

There are a number of wetlands located throughout Taiwan. Many of them are situated in Ilan County of northern Taiwan. Compared with the wetlands in other areas, those in Ilan County are less polluted and better preserved. The best-known wetlands are the estuaries of the Tsu-An River, Lanyang River, Ilan River, and Dun-San River.

Due to the combined effects of wind, river flow, and tidal movements, various landforms have been created in the wetlands, including estuaries, salt marshes, swamps, grasslands, sandy beaches, and shallow ponds. These provide diverse habitats for a variety of microorganisms, plants, and animals. Due to their topographic diversity, wetland ecosystems are generally highly productive and usually have high species diversity. In fact, wetlands are required by migratory birds as they undergo distant migrations across continents. The estuaries of the Lanyang River (Ilan Co.), Guandu (Taipei), and Chiku (Tainan Co.) have become famous as overwintering sites of some rare species of migratory birds.

Although wetlands are important as repositories of natural resources for society and the economy, their functions have received little attention in Taiwan. The Marine Research Station of Academia Sinica is situated at Jiao-Shi, near the Lanyang River estuary. The facilities of this station provide a base for conducting studies on wetlands in the nearby area.

2. Purpose of the study

The proposal is to begin a long-term study of wetland ecosystems in the estuary of the Lanyang River. This will be linked with ecological studies of the upstream areas and watershed of this river. Initially, the biotic resources will be investigated. Subsequently, the function and roles played by wetland organisms will be determined. The collected data will be used to simulate interactions among organisms of different
trophic levels and environmental factors. Four sub-projects are formulated to achieve the goal of discovering, understanding, and managing biotic resources in the catchments of Lanyang River.

**Sub-project 1: Biological Inventory and Databasing of Lanyang River Basin**

The establishment of biodiversity database is based on within the framework of flora and fauna basic research of the River Lanyang. It includes specimen database, document database, and image database. The biodiversity database can work as an interactive academic platform for environmental monitor, chain research for dynamic connection of ecological food chain, conservation of endemic species, and re-introduction of rare species. Moreover, with the facility of the internet, it can be offered as an inquiry system for the public; as a result, functioning as a means to promote the concept of biodiversity. Besides, all the information is the references to the domestic teaching materials, ecological conservation, habitat recovery, and the development of estuaries. At present, there are three bio-databases built by Academia Sinica, including the Fish Database of Taiwan, the Taiwan Malacofauna Database, and the Database of Native Plants in Taiwan. Based on the original database framework, this project is planned to establish a database inquiry system of the basin of the River Lanyang, to integrate flora and fauna basic research information, habitat geographic information, and exotic species invasion information into the database system, and to shape the whole picture of the River Lanyang’s biodiversity. With the GIS from the specimen database, we can comprehend the species’ diversity, abundance, and endangered situation of the River Lanyang at the current stage, and hereby use this information as the indicators for site selection priority. Also, this information can demonstrate which species is limited in distribution, and if its population stands much behind the standard number. Consequently, the protected species list will be rearranged in a more appropriate way. All in all, the integrity of database is the foundation of conserving and recovering Taiwan’s ecological system. It can also benefit the long-term ecological monitor, and the research about the origin of the endemic species, interrelationship of life evolution, and phylogeography.
Sub-project 2: Catchment-estuary linkages of food web dynamics in the Lanyang River (CEWEB)

Taiwan is an ideal place for comparative ecological studies, since it has a wide range of human activities influencing catchment hydrology and the estuary. Acknowledging that to remedy adverse downstream and estuarine changes, solutions often have to be found and implemented at the catchment level. Lanyang River is a typical Oceania river with high precipitation, a steep slope, a small basin area and frequent flood events. The catchment of Lanyang River is among the few without reservoirs. However, as many other catchments, the upstream of Lanyang River is exploited intensively for agricultural activities. The aim of this project is to relate observed food web dynamics (structure, function, diversity and stability) in streams and the estuary of the Lanyang River back to catchment activities. This ecosystem-scale project is proposed for a period of five years to address the following issues in the catchment of Lanyang River:

1. To construct trophic models by quantifying material flow within food webs of the upstream, midstream, downstream, and estuarine ecosystems.
2. To examine the shifts of food web dynamics in streams from the upstream to the downstream and estuary as one continued system.
3. To simulate the effects of flood events on the food web dynamics.
4. To examine the impacts of agricultural activities and sand-collection fields on food web dynamics in these linked ecosystems.
5. To identify ‘critical thresholds’ for stream and estuarine system functioning.

In this long-term project, the proposed year-by-year details will be:

1. The 1st year will emphasize preparation and intense discussion among principle investigators and the planning of a database for the ecosystem parameters of Lanyang River.
2. The 2nd year will emphasize the construction of trophic models in the upstream and midstream using ECOPATH.
3. The 3rd year will emphasize the construction of ECOPATH models in the downstream and estuary.
4. The 4th year will examine the effects of agricultural activities on food web dynamics in a stream ecosystem by ECOSIM.
5. The 5th year will integrate upstream and downstream food webs from end to end by ECOSPACE.

This multidisciplinary study is expected to be of direct benefit to local, regional, and global catchment management and policy.
Sub-project 3: Biodiversity and function in the forest and agricultural ecosystems in Lanyang watershed

Along various altitudes, the effects of climatic conditions on vegetation types and soil biological activities in a watershed can be altered when the latter is disturbed by human activities, particularly by agricultural land use. This proposed integrated project is aimed to compare the differences between the natural and the agricultural ecosystems from the aspects of biological diversity and function of the Lanyang River Watershed (LRW). We hope to characterize the impact of human disturbance on the ecosystems.

Firstly, an inventory of organisms in the selected common sampling sites of the two ecosystems will be conducted. Basic inventory data, such as flora of seed plants, algae and fungi, together with information of species richness and diversity, will be correlated, with special emphases on the climate and edaphatic conditions. Genetic diversity and phylogeny of seed plants, fungi, and algae will be surveyed using molecular tools. Furthermore, novel genetic resources (for example, terpene synthase gene family) useful for forestry, agricultural and pharmaceutical purposes will be screened. With the aid of different scales of monitoring, from molecular level to satellite remote sensing, the differences in structure and function of the natural and agricultural ecosystems in the LRW will be compared and valuable information will be summarized.

Moreover, influence of the soil physical and chemical properties on the microbial activities and the composition of soil organic matter will be evaluated. The grey system theory will be applied to establish the relationship among various ecosystems and to explore the effecting model between physio-chemical factors and ecosystems at different levels. Data collected from various investigators, such as the contribution of litter fall, soil respiration, decomposition rates, and quantitative characteristics of various elements in surface waters will be integrated to construct a model of element cycle as well as energy cycle in either ecosystem after a study time of ca. three years. The lack of principal investigators with expertise in zoology and statistics has to be recruited in the coming year. Presently, there are 8 projects

1. The effect of altitudinal change on the organic matter composition and microbial function in forest soils
2. Relationship between the diversity of primary producer and surface water quality in the forest and agricultural ecosystems
3. The Change of Forest and Agricultural Ecosystems in Lanyang River Monitored by Satellite Remote Sensing and Grey System Theory
4. Studies on the genetic resource diversity for the endangered gymnosperms in
Taiwan
5. Fungal Classification and Identification
6. Application of Molecular Methods on the Fungal Diversity Studies
7. Comparison of plant diversity between natural forest and agricultural ecosystem
8. Vegetation types and soil CO$_2$ flux
Sub-project 4: Studies on the Maintenance and Restoration of Wetlands Biodiversity

It has been well documented that wetlands are essential to humankind because of the roles they play in flood control, groundwater replenishment, shoreline stabilization, storm protection, climate change mitigation, and water purification, as reservoirs of biodiversity, and in the provision of wetland products, recreation and tourism, and cultural value. By contrast, in recent decades, it has also become evident that these services are rapidly disappearing. Towards the end of the 20th century, developed countries began to recognize that many disasters attributed to economic overdevelopment had produced adverse impacts on human’s survival and living standards. To resolve these problems, maintenance of functioning ecosystems, recovery of destroyed habitats, and mitigation of excessive economic growth have become the most urgent administrative issues for many governments. Thus, in the 21st century, the practice of habitat restoration and implementation of biodiversity conservation are the greatest challenges for governments, scientists, and societies.

Ecological restoration of wetlands is a process carried out at target sites by means of identifying a restoration goal, integrating ecological and engineering principles into wetlands reconstruction while designing with in situ ecological characteristics, and subsequently managing the ecologically functioning wetland habitats. The processes are detailed as 1) determination of the goals, range, and methods for restoration based on a literature survey, research results, and interviews with elderly local residents; 2) participation of scientists, administrators, and local communities in the planning, design, inspection, and adjustment throughout the entire repair process; and 3) sustainable management of restored wetlands.

Along the Ilan coast, northeastern Taiwan, there are four wetlands known to be important habitats for migratory shorebirds, namely the Chuan Wetland, Lanyang Estuary Waterbird Refuge, Litzechien Wetland, and Ilan County Wuwei Harbor Waterbird Refuge. However, different wetlands experience different threats. Abandonment of aquaculture ponds may lead to the disappearance of the Chuan Wetland in the near future. Pesticides and fertilizers have polluted the Lanyang Estuary Waterbird Refuge. Reclamation and consolidation due to drainage have destroyed the property of Litzechien Wetland. Moreover, industrial wastewater and municipal wastes have severely degraded the Wuwei Harbor Waterbird Refuge and resulted in a stagnant water body favoring colonization of so-called eutrophic indicator species, such as common reeds and water hyacinths.

In order to prevent the continuing degradation and loss of wetlands and to repair destroyed wetlands along the Ilan coast, we will conduct a three-phase research
The first to second phases include 1) a review of the wetlands' statuses, 2) establishment of working hypotheses as to what roles each wetland plays in conserving biodiversity at the habitat level, and 3) determination of physical and biological characteristics of each wetland and identification of mechanisms that control diversity, representativeness, or rareness of wetland types of habitats. Physical characteristics revealed on large spatial and temporal scales will also be studied so that landscape and vegetation changes in each wetland and along the entire Ilan coast can be understood. Subjects of the second to third phases are 1) the planning of wetlands restoration, 2) the use of ecological engineering in wetland restoration from design, choice of methods and materials, to construction and final approval of the completed construction, and 3) the sustainable management of restored wetlands. The wise use of wetland services and the carrying capacity of these wetlands will be studied, and conclusions obtained will be incorporated into zoning regulations, monitoring programs, and evaluation of management effectiveness

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1 Requisition of Instruments for Ecosystem Research: a Stable Sulfur Isotope Ratio Mass Spectrometer. The purpose of purchasing and installing a mass spectrometer specific for the determination of stable sulfur isotope ratios in organic and inorganic materials is to provide an understanding through scientific studies of how biodiversity is maintained, how ecosystems operate, and how these aspects are influenced by global climate changes. It has been demonstrated that analyses of stable sulfur isotopic ratios of $^{34}$S/$^{32}$S can be an important means of gaining such understanding. Measurements of stable carbon, nitrogen, and sulfur isotopes have been applied in various studies including paleoclimatic changes, formation of rocks, hydrology, and medical diagnoses (e.g., diagnosis of gastric ulcers). Increasingly, such measurements are needed in the fields of ecology, biodiversity, habitat restoration, conservation, biogeochemistry, and global change, all of which are characterized by multi-disciplinary integration. Currently in Taiwan, there is no mass spectrometer specifically set up for the determination of stable sulfur isotopic ratios. Sulfur is an element characterized by its strong adhesive and corrosive abilities, thus measurements cannot be taken with instruments used for stable carbon and nitrogen isotopes. However, stable sulfur isotopic analyses are known to give more-accurate signatures in tracing the origins of materials and flow pathways of materials in ecosystems. In addition, installation of a stable sulfur isotope ratio mass spectrometer will enhance research effectiveness by eliminating extensive labor required for the purification of sulfur samples. Furthermore, its establishment will speed up data collection and management, since it will no longer be necessary to send our samples abroad for $\delta^{34}$S measurements. For these reasons, acquisition of a stable sulfur isotope mass spectrometer will provide important benefits to biodiversity researchers in Taiwan. Researchers who currently propose to use this instrument are listed here. After this instrument is installed, the number of researchers who will incorporate this approach into their studies is expected to increase. The use of a stable sulfur isotope ratio mass spectrometer in these research projects is expected to be very effective, as it will provide an understanding of the mechanisms of formation and maintenance of biodiversity, as well as the biological, physical, and chemical interactions in the specified ecosystems. More importantly, it will strengthen our abilities to repair degraded habitats and conserve biodiversity for sustainable use.
Project 7: Comparative study of patterns of island marine biodiversity in the West Pacific

Taiwan, located adjacent to the “center of diversity”, is the largest continental island of the West Pacific. The Taiwan Strait, situated to the west of Taiwan and separating it from mainland China, is a shallow channel with sandy or muddy habitats. To the east of Taiwan, the submarine topology drops steeply to 4000 m in the vicinity of the Ryukyu Trench. Taiwan is also situated at the boundary of the largest ocean current system on Earth, the Kuroshio current. The strong Kuroshio current flows northward, passing near Orchid Island and Green Island; a weak side-branch flows through the Taiwan Strait up to Hsiao-Liuchiu and southern Penghu in the winter and crosses the Tropic of Cancer along the western shoreline during the summer. In summer, driven by southwestern monsoons, the South China Sea surface current flows northwards into the Taiwan Strait through the Penghu channel, whereas, cold, fresh China coastal water, driven by northeast monsoons, enters the southern Taiwan Strait during winter. The habitat variability and complex currents provide a base for hosting high marine biodiversity. For example, species diversity of reef organisms on the coral reefs around Taiwan is relatively high, with approximately 300 species of scleractinian corals, 50 species of alcynaceans, 20 species of gorgonians, 130 species of decapod crustaceans, 90 species of echinoderms, 1200 species of reef fishes, and 150 species of algae having been recorded. The high diversity of reef-associated species and the central geographic position along the West Pacific island chain has led to the hypothesis that Taiwan might serve as a "stepping-stone" for the northward and eastward dispersal of shallow-water reef organisms.

Nevertheless, the pattern of marine biodiversity around Taiwan is not homogenous. Preliminary analyses of the distribution of marine fishes and scleractinian corals have revealed an unusual pattern of two distinct provinces, separated by a line that can be drawn from northeastern Taiwan toward the middle of the Penghu Archipelago. Determining whether the availability of habitat or environmental factors has shaped the marine biogeography around Taiwan into two distinct provinces within such a narrow range of distribution is worthy of further examination.

Two approaches are proposed to examine Taiwan’s possible role as a stepping-stone and the mechanisms of the two distinct biogeographic provinces in the waters around Taiwan. First, an intensive community-based study will be launched to investigate marine biodiversity of surrounding islands, including the Spratlys, Pratas Island, Lanyu (Orchid I.), Lutao (Green I.), and the Penghu Archipelago. Second, ordination of cladistic biogeographic analyses will be applied to groups of
taxa, including crustaceans, echinoderms, mollusks, seagrasses, algae, etc. in order to elucidate the concordance/disconcordance patterns of marine biodiversity along the West Pacific.
VIII. Facilities, Human Resources, and Budget Requirements

1. Space

Now, seek for 450 to 900 m² at Academia Sinica to serve as the chairman’s research laboratory, administrative offices, core facilities room, library information room, and academic service room. Adequate space will be ensured before recruiting full-time researchers. Academia Sinica needs to provide space for new members after appointment to their positions. For example, if ten researchers are recruited, ten rooms, about 1200 m² in total, will be needed. Also, the Biological Museum which is currently attached to the research museums of the Institutes of Zoology and Botany should be included in so that Biodiversity research here can be carried out smoothly and serves the functions of research, specimen collections and education all together. Hence, a specified building is required for either the Center or the planned Biodiversity and Ecology Institute.

Currently, the best choice of the building sites seems to be the “yellow building”, the old site of the Institute of Zoology, which is now occupied by the Institute of Taiwan History Preparatory Office. After the Office moving to the Tsai Yuan-pei Research Center for Humanities and Social Sciences, the yellow building can rebuild for the Center’s purposes. Alternatively, the second campus of Academia Sinica at Ba-De, Taoyuan County and the campus of the Combined Logistics Department of the Ministry of National Defense could also be under consideration.

2. Human Resources

Seek international experts with the background of biodiversity expertise for the Director of the Center, ten faculty researchers from Academia Sinica within five years and recruit renowned international experts to join the research. In addition, employ post-doctorates and assistants with functional expenses.

3. Budget

The budget of the Research Center for Biodiversity for the first 5 years has been estimated (see Table 1), and divided into four categories:
(1) Personnel expenses.

Personnel expenses may increase yearly with the set-up and development of the Center

(2) Functional expenses

After being approved and endorsed by the Advisory Committee of the RCBAS from 2004 onwards, it is required a certain amount of expenses to carry out some of the following seven research projects:

Project 1: Germplasm conservation studies of economically important and endangered species in Taiwan and studies of the potential threat posed by invasive species

Project 2: Studies of evolutionary genomics: evolutionary analyses of organelle genome sequences

Project 3: Phylogeography of West Pacific organisms

Project 4: Studies of Taiwan’s fauna and flora systematics

Project 5: Establishment of a database for Taiwan’s biodiversity organisms

Project 6: Biodiversity research of the Lanyang River and its coastal wetlands

Project 7: Comparative studies of Taiwan’s marine biodiversity patterns

(3) Facilities and investments

In the beginning stage, the research projects could be conducted in different institutes, such as the Institutes of Zoology, Botany, Information Science and Earth Sciences, where they have most of the facilities required. Hence, in the 1st year only requires 10 million dollars (28,500 US dollars) for new facilities, an eight-million NT dollars of stable sulfur isotope ratio mass spectrometer in particular. After the Director takes his position, the budget might be adjusted along with the research projects and main programs.

(4) Construction and design of the building for the Center

For the annual budget of construction see Table 1.
Table 1. Research Center for Biodiversity Budget for the first 5 years Units: NT 1000 dollar/ (US dollars)

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
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<tr>
<td>Personnel</td>
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<td>17,000</td>
<td>21,000</td>
<td>22,000</td>
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<tr>
<td>expenses</td>
<td>(51,428)</td>
<td>(485,000)</td>
<td>(600,000)</td>
<td>(630,000)</td>
<td>(657,000)</td>
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<td>Functional</td>
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<td>46,000</td>
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<td>expenses</td>
<td>(817,742)</td>
<td>(1,000,000)</td>
<td>(1,030,000)</td>
<td>(1,310,000)</td>
<td>(151,000)</td>
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<td>Facilities and</td>
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<td>13,000</td>
<td>15,000</td>
<td>10,000</td>
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</tr>
<tr>
<td>investments</td>
<td>(372,857)</td>
<td>(37,100)</td>
<td>(43,000)</td>
<td>(285,000)</td>
<td>(285,000)</td>
</tr>
<tr>
<td>Total</td>
<td>43,471</td>
<td>65,000</td>
<td>72,000</td>
<td>78,000</td>
<td>86,000</td>
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<td></td>
<td>(1,242,029)</td>
<td>(1,856,000)</td>
<td>(2,060,000)</td>
<td>(2,225,000)</td>
<td>(2,452,000)</td>
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<tr>
<td>Construction</td>
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<td>50,000</td>
<td>90,000</td>
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<tr>
<td></td>
<td>(14,300)</td>
<td>(1,428,570)</td>
<td>(2,571,400)</td>
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</table>

**Note:** The budget for 2004 was curtailed to 43 million NT dollars (1,242,029 US dollars) without construction fee by July, 2003.
Appendix 1
The Sustainable Development Council of the Executive Yuan has established a Biodiversity Subcommittee responsible for biodiversity-related work. The “Biodiversity Promotion Action Plan” was officially sanctioned by the Executive Yuan meeting no. 2747 in August 2001.

The missions are:

Mission 1: Establishing foundations for comprehensive works on biodiversity research, management and utilizations

Project 1: Constructing and bridging national biodiversity databases and networks
  Project 1.1: Establishing a National Biodiversity Informatics Center
  Project 1.2: Including certain of the quantified data from biodiversity research into national statistic categories
  Project 1.3: Updating the information required in above two
Project 2: Discovering and understanding biodiversity in Taiwan
  Project 2.1: Identifying biodiversity hotspots in both terrestrial and aquatic areas of Taiwan and census current biodiversity there
  Project 2.2: Completing the figure of distribution of vegetation in Taiwan
  Project 2.3: Figuring the important sites of wetlands and coral reef areas
  Project 2.4: Planning the projects for editing the fauna, flora and microfauna of Taiwan
  Project 2.5: Fostering scientific research on systematics of animal, plant and micro-organisms
Project 3: Setting up monitoring system for biodiversity resources
  Project 3.1: Establishing the programme for monitoring, notably specifying the research sites and methodology
  Project 3.2: Assessing and surveying terrestrial and aquatic biodiversity to predict its changes
Project 4: Developing scientific approaches for sustainable use of agriculture biodiversity
  Project 4.1 Contributing to the capacity to access the impacts of transgenic species on local biodiversity
  Project 4.2: Developing new entities based on the ten patents of agriculture product with the growth rate of 10% per year.
  Project 4.3: Setting up an example area where unites the three aspects of
production, ecology and living altogether, in order to support sustainable use of biodiversity

Project 5: Fostering research into social consequences of traditional knowledge of biodiversity and the way to preserve it

Project 5.1: Completing and publishing the ethno-biological work and registering patents of certain of the ancestral secret knowledge

Project 5.2: Under the framework of biodiversity, examining the relation between the current law and the culture of aboriginal groups.

Mission 2: Optimizing multiple uses of biodiversity

Project 1: Taking measures for bio-safety and management system of biological resources

Project 1.1: Establishing and implementing a system for reporting the impacts of biotech products on human health

Project 1.2: Establishing and implementing a system for assessing and managing the impacts of biotech products on biodiversity resources

Project 1.3: Establishing and implementing a system for assessing and managing the practice of biotechnology on human health and environment

Project 2: Restoring decayed environment

Project 2.1: Identifying the sites of environmental deterioration in terrestrial, aquatic and wetland areas of Taiwan and deciding the priorities and the way to restore

Project 2.2: Setting up the project and its timeframe to clean up polluted rivers by lowering the amounts of nutrients and heavy mental

Project 2.3: Promoting the construction of artificial wetlands and

Project 2.4: Developing the way to restore different types of ecosystem, and evaluate the effectiveness of eco-engineering and the achievements of ecological resources survey

Project 3: Developing management system for protected areas

Project 3.1: Evaluation of the effectiveness of the current conservation measures for protected areas, and extending the marine protected areas up to 50% of the total coastal zone

Project 3.2: Drawing out the Wetland Conservation Axis and searching
for the trade-offs between economy and ecology in wetlands

Project 3.3: Creating conservations measures to encourage non-governmental organizations to participate in the activities of biodiversity conversation

Project 4: Recovering fishery resources

Project 4.1: Evaluating the effectiveness of the policies and regulation for aquaculture, including protected areas and the designed coastal zones for fishing

Project 4.2: Creating and designing fishing grounds suitable for the growth of fishery resources

Project 4.3: Developing techniques for artificial breeding system of aquaculture product and evaluating the impacts on both economy and coastal ecology caused by releasing them into wild

Project 4.4: Decreasing the number of fishing vessels, setting out fish bend system and regulating fishing efforts for the sustainable use of fishery resources

Project 4.5: Helping local governments to take measures for fishing managements

Project 5: Invasive species

Project 5.1: Setting up systems for quarantine, epidemic prevention, and monitoring non-indigenous species

Project 5.2: Establishing the mechanisms for identifying the possibilities of non-indigenous species as invasive species

Project 5.3: Establishing the mechanisms for evaluating, managing and monitoring the influences caused by introducing or importing non-indigenous species

Project 5.4: Taking measures for controlling invasive species with threatening effects on the health of human and livestock as well as biodiversity resources

Project 5.5: Cataloging non-indigenous species and regularly updating it

Mission 3: Building up partnership among different organizations for promoting biodiversity works
Project 1: Encouraging non-governmental organizations to participate in the activities for biodiversity

Project 1.1: Intensifying the dialogue between government and non-governmental organizations, and building up the mechanism and platforms for cooperation

Project 1.2: Taking measures to encourage the participation from enterprises, local communities and conservational groups in biodiversity affairs