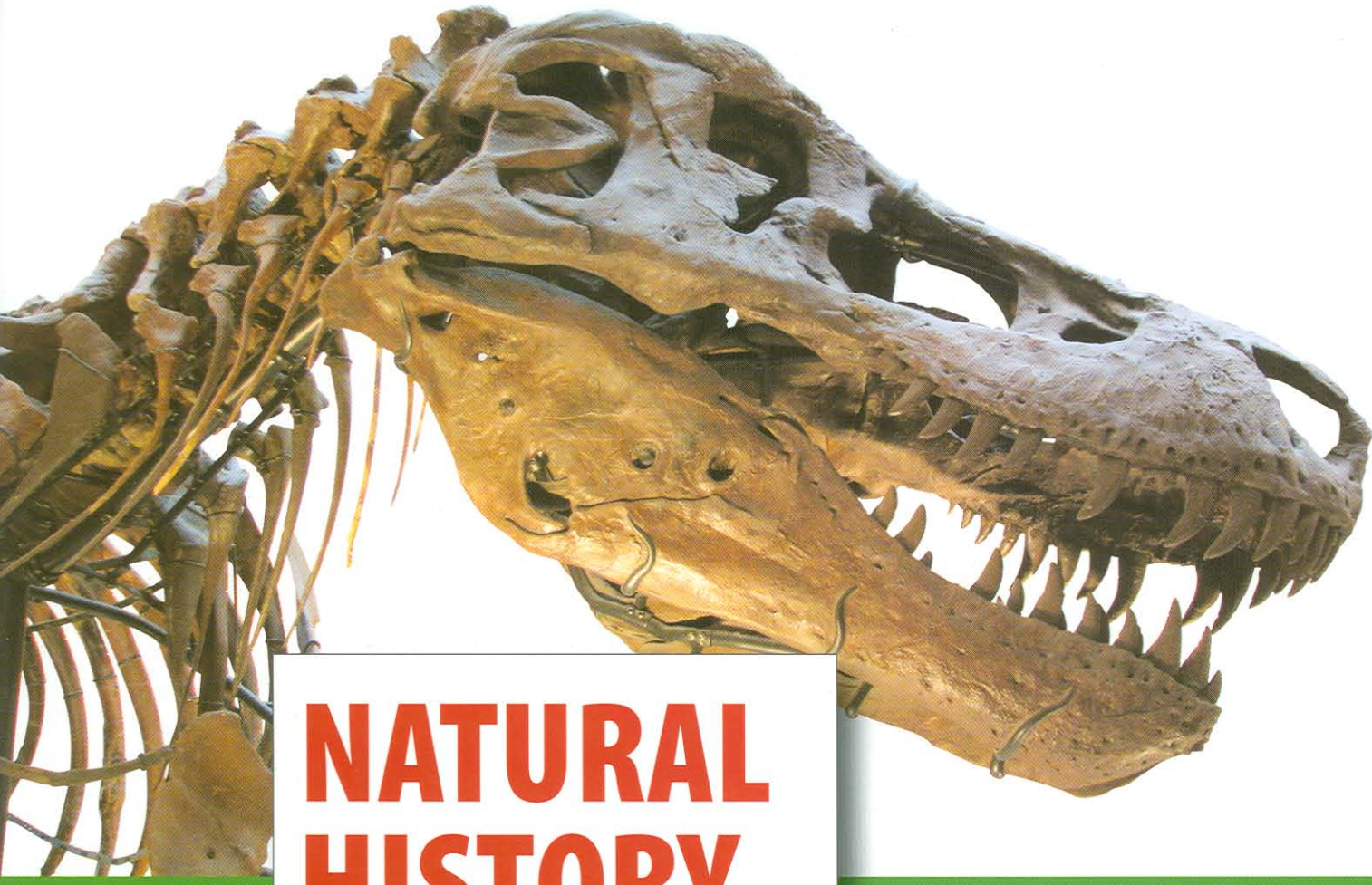

NATURAL HISTORY MUSEUM MALAYSIA

Planning & Development

Natural History Museum Malaysia

Natural History Museum Malaysia

Planning and Development

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Frontispiece: *Licuala cordata,* a rare endemic palm in Sarawak

Foreword

This report, by a team of national and international consultants, deals with the planning and development for a natural history museum in Malaysia, to be known as the Natural History Museum Malaysia (NHM Malaysia).

This report explains the role of natural history museums as custodians of the reference materials upon which scientific knowledge of the natural world is based. It describes how the leading museums of natural history have become centres for cutting-edge scientific research on biological diversity and how they have simultaneously become world-famous for the professionalism and scientific credibility of their exhibitions and educational services.

NHM Malaysia will, through its location and operations in one of the richest biodiversity regions of the world, play a vital role in strengthening the knowledge base for sustainable management of the tropical environment for the benefit of Malaysia and the world.

I would like to thank the United Nations Development Programme (UNDP) for funding this study, the Forest Research Institute Malaysia for

acting as the Executing Agency, the national and international members of Project Team that that carried out the study, the management and staff of all the museums and institutions that welcomed the Project Team, and the scientific community in Malaysia that has been promoting the concept of a natural history museum for Malaysia for many years.

This report was reviewed by the Project Steering Committee established the Ministry of Natural Resources and Environment (NRE) and approved at its meeting on 6 May 2008.

Datuk Suboh Md Yassin
Chairman of the Project Steering Committee
Secretary-General of the Ministry of Natural Resources and Environment

TABLE OF CONTENTS

Kapur (*Dryobalanops aromatica*) forest in Malaysia displaying the phenomenon of *crown shyness*.

EXECUTIVE SUMMARY

Background

Natural history is the scientific study of plants and animals and their natural environments. It provides the scientific basis for the management of the natural environment and the sustainable use of natural resources. It provides the scientific rationale for the UN Convention on Biological Diversity. One of the major thrusts in natural history has been and continues to be the discovery, naming, documentation and classification of all living things. In 250 years of global effort, 1.8 million species of plants and animals have been discovered, named, documented and classified. This accumulated knowledge, coupled with advances in molecular biology, has propelled biology to the forefront of science in the 21st Century.

The centres for natural history are natural history museums. Almost every country in the world has at least one natural history museum and these are nearly always prominent cultural, scientific, educational and architectural landmarks. Many countries are building new natural history museums. Malaysia, although 12th in the ranking of countries by richness in biodiversity, is one of the few countries without a natural history museum.

Malaysia's National Policy and Vision in Biological Diversity

Malaysia's location in Southeast Asia, the region of highest biological diversity in the world, gives it a big advantage in natural history. This is where many new discoveries can be made and where round-the-year field observation and experimentation are possible. Recognizing Malaysia's advantage, a National Policy on Biological Diversity was adopted in 1998 with the Vision:

To transform Malaysia into a world centre of excellence in conservation, research and utilization of tropical biological diversity by the year 2020.

Decision to establish a Natural History Museum

At the Fifth National Biodiversity and Biotechnology Council (NBBC5) meeting on 29 September 2006, chaired by the Prime Minister of Malaysia, a decision was made to establish a Natural History Museum in Malaysia.

Following the NBBC5 decision, the Ministry of Natural Resources and Environment formulated a project to develop a framework for the establishment of the Natural History Museum. A Project Steering Committee was established and a Consultancy Team was appointed to develop the framework. The Team made a study of natural history collections/museums in Malaysia, Singapore, the USA, England and the Netherlands, and its findings are reported here.

The world's leading natural history museums

The leading natural history museums of the world are thriving intellectual centres, generating new knowledge and providing a broad range of educational and scientific services to support diversified modern economies. They are premier visitor centres, showcasing the wonders of biodiversity and reflecting national scientific, artistic and technological capabilities. Their exhibitions inspire visitors of all ages, and are trusted for their scientific integrity, intellectual and aesthetic content, educational value, and global relevance. Simultaneously, they are centres for cutting-edge science. The NHM London houses 350 staff scientists and 70 million specimens representing all forms of life, accumulated in 250 years of global exploration, including fossils that go back hundreds of millions of years. The National Museum of Natural History of the Smithsonian

Birds in flight, at Naturalis, Leiden.

Institution in Washington, D.C. holds an even larger collection, of 126 million specimens. The significance of these extensive collections is that they allow comparative studies to be made across space and time, whereas studies 'on location' are tied to particular locations and times. Furthermore, because museum specimens are real, they hold information that can be progressively unlocked as new scientific tools are developed. Recent advances in molecular biology are providing tools for extracting genetic information from long-dead and even extinct animals and plants. This dramatic new development has made museum collections even more valuable than ever before.

Natural history collections in Malaysia

There are over 22 organizations in Malaysia supporting natural history units and collectively holding 3 million specimens. These include the government departments and institutions responsible for forestry, fisheries, wildlife, agriculture, and medical services; some universities; and some museums of culture and history. The existing units reflect the political and administrative organization of Malaysia, each unit having operational responsibilities only for Peninsular Malaysia or Sabah or Sarawak but not for the whole country, and each unit organized to cover only one particular sector of biodiversity, viz. forestry, fisheries, wildlife, agriculture, or tropical medicine. Working with limited research agendas, on collections defined by administrative and departmental boundaries, Malaysia's natural history scientists have had difficulty developing national overview and even more difficulty developing regional and global expertise. The existing institutional framework is too weak and fragmented to support Malaysia's national policy and vision in biodiversity.

Main recommendations

Status and name of the new natural history museum

The new natural history museum should be established as a statutory body and be designated as the national institution for realizing the national Vision on Biological Diversity. Its name should reflect its national status. Among natural history scientists, the preference is for the name Natural History Museum Malaysia (NHM Malaysia). This is also the choice of the Project Steering Committee.

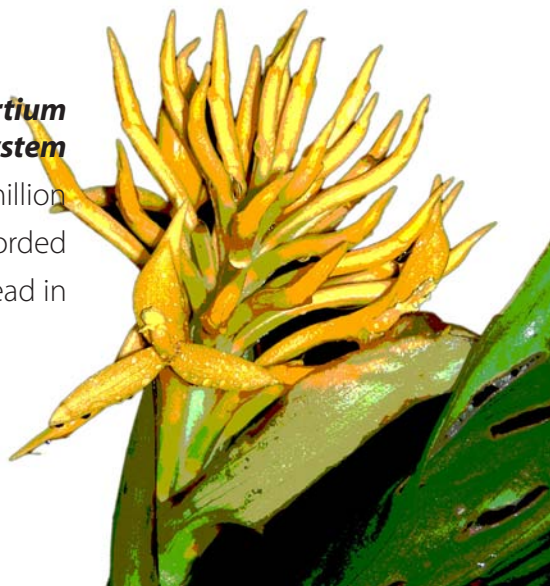
Establishment and performance targets

For NHM Malaysia to be a world centre of excellence, it will need to be equipped with state-of-the-art facilities and its performance must be benchmarked against the leading natural history museums of the world. The establishment and performance targets must include

- excellent physical facilities for the secure storage of scientific specimens
- strong programmes of research by its own staff and associated scientists
- strong programmes in exhibition and other public outreach activities
- rapid build-up of scientific collections
- modern laboratories
- scientific relations with leading natural history museums overseas
- comprehensive library and database facilities
- collaborative programmes with universities
- a peer-reviewed scientific publications programme

Establishment of a Natural History Consortium and Accreditation System

The existing natural history collections in the country, totaling 3 million specimens, are scientific heritage collections that should be accorded national recognition and support. NHM Malaysia should take the lead in



establishing a Natural History Consortium through consultation between stakeholder institutions, to function as a forum for

- establishing national standards for natural history collections
- developing an Accreditation System
- helping members of the Consortium to achieve accreditation through training, staffing, equipment and other support programmes

Projected expenditures

It is estimated that a five-year development budget of RM400 million will be needed to implement these recommendations. This does not include the cost of land (about 50 ha recommended), salaries of permanent staff and other annually recurrent expenditures.

Benefits

Natural history museums are respected worldwide for their ability to provide educational experiences at preschool, school, and adult levels. NHM Malaysia will deliver the benefits of continuing life-long education to all levels of society. In addition, several sectors of the economy will get a very special boost, e.g.

- tourism, because NHM Malaysia will share in the global reputation of natural history museums as premier tourist attractions
- higher education, because the comprehensive collections in NHM Malaysia will enable Malaysian universities to offer world-class tropical biodiversity programmes
- economic development, because NHM Malaysia's growing expertise on natural resources will be available to support the information needs of a growing economy

National and global significance of the Natural History Museum Malaysia

The Natural History Museum, as the national centre for reference materials, information, and expertise in biological diversity, will strengthen Malaysia's ability to sustainably manage and benefit from its rich biological resources. At the same time, Malaysia's entry as a major player in biodiversity research will strengthen global understanding, management, and utilization of biodiversity and help ensure that tropical concerns are well-addressed in global environmental management.

Tyrannosaurus rex at the Field Museum, Chicago.

1. INTRODUCTION

1.1 Background

At the Fifth National Biodiversity and Biotechnology Council (NBBC5) meeting on 29 September 2006, chaired by the Prime Minister of Malaysia, a decision was made to establish a Natural History Museum in Malaysia at national level. Following this decision, the Ministry of Natural Resources and Environment established a Steering Committee and formulated a consultancy project to develop a framework for the establishment of the Natural History Museum. A team of consultants was appointed to implement the project. The team consisted of

- Dr Francis SP Ng, FASc (Lead Consultant)
- Tan Sri Dr Ahmad Mustaffa Babjee, FASc (National Consultant)
- Datuk Dr Mohinder Singh, FASc (National Consultant)
- Datuk Dr Robert Inger (Field Museum, Chicago; International Consultant)
- Prof. Dr Peter Ng (Raffles Museum, Singapore; International Consultant)
- Ms Emma Freeman (Natural History Museum, London; International Consultant)

An unknown mushroom in the Maliau Basin of Sabah.

The Consultancy Team visited 15 institutions in Malaysia that hold and manage natural history collections, four of the best-known natural history museums overseas, and two in Singapore. The reports on these visits are provided in Appendices 1 – 3. The museums and institutions visited were

Malaysia:

- Institute for Medical Research, Kuala Lumpur
- Sabah Museum, Kota Kinabalu
- Universiti Malaysia Sabah, Kota Kinabalu
- Fisheries Research Institute, Kota Kinabalu
- Forest Research Centre, Sandakan
- Sarawak Biodiversity Centre, Kuching
- Sarawak Museum, Kuching
- Forest Research Centre, Kuching
- Universiti Malaysia Sarawak, Kuching
- Forest Research Institute Malaysia, Kepong
- Institute for Biodiversity, Department for Wildlife and National Parks, Bukit Ringgit, Pahang
- University of Malaya, Kuala Lumpur
- National Repository for Agricultural Pests, Agriculture Department, Kuala Lumpur
- School of Environmental and Natural Resource Sciences, Universiti Kebangsaan Malaysia, Bangi
- Muzium Negara, Kuala Lumpur

Overseas:

- The Field Museum, Chicago
- The National Museum of Natural History of the Smithsonian Institution, Washington, D.C.
- The Natural History Museum, London
- Naturalis, Leiden

Great egret, at Kota Kinabalu

Singapore:

- Botanic Gardens Singapore
- Raffles Museum of Biodiversity Research, National University of Singapore

Comparative data for the Malaysian institutions are summarized in Table 1 and for the overseas museums in Table 2.

On 15 November 2007, a workshop was organized in Kuala Lumpur to bring together all natural history scientists in Malaysia. About 150 scientists attended. The workshop served to inform natural history scientists about the consultancy, and it enabled the consultants to interact with and obtain a measure of the interests and concerns of the participants. Proposals for a national natural history museum have been made by Malaysian scientists through governmental and non-governmental channels for over 20 years. The decision by the Government to establish such a museum was welcome news to the participants of the workshop.

1.2 Terms of Reference

The Terms of Reference (TOR) of the Project Management Team (incorporated into the TOR of the Lead Consultant) and the responses of the Project Management Team are as follows:

Terms of Reference	Responses
Provide recommendations for both short- and long-term strategies towards the establishment of a natural history museum (NHM) in Malaysia that will complement the biodiversity initiatives in the country.	Short- and long-term strategies are covered in Section 4: An Institutional Framework for Realizing the Vision; Section 5: Human Resources; Section 6: Physical Infrastructure; and Section7: Budget and Funding Mechanisms.
Make recommendations as appropriate, on programmes for scientific work and other activities for natural history inventory, research, conservation, education and public awareness that can be supported by a NHM in Malaysia.	Recommendations for inventory, research, education and public awareness are made under Subsection 4.4: Establishment and performance standards; Subsection 4.6: Public support; Box 2: Reaching out to the region, the tropics and the world; Box 3: North – South collaboration; Box 5: Synergy in collections and research; and Box 6: Excellence in exhibition and public engagement. A Policy Studies Unit is proposed that will, among its responsibilities, develop conservation programmes.
Provide technical inputs to the Project Steering Committee and National Project Director for museum collections, state-of-the-art curation, exhibit design and human resource planning and development for the NHM in Malaysia.	Section 2: Review of Natural History provides an account of museum collections, state-of-the-art curation, exhibit design, human resources planning and development in the leading museums of the world. It also reviews the state of natural history collections and activities in Malaysia. The difference gives a measure of the distance Malaysia has to cover between now and 2020.
Provide expert advice and to assist in the curation of existing museum collections, especially in the pilot project stated in the project.	Subsection 4.5: Establishment of a Natural History Consortium and an Accreditation System deals with support for existing natural history collections. The pilot project was to digitize and make available on the World Wide Web rare reference works in natural history that natural history scientists in Malaysia have always had trouble accessing. This pilot project was to be subcontracted to the team involved in the international Biodiversity Heritage Library Project, but this team was unable to make progress. The pilot project had to be terminated.
Review and reconcile all relevant technical reports and information produced by the project.	All relevant technical reports have been reviewed and cited.

Table 1. Main natural history collections in Malaysia

	Institute	vascular plants	bryophytes & algae	fungi & lichen	mammals	reptiles & amphibians	birds	insects	crustaceans & spiders	fresh water fish	marine fish	molluscs	others
1	DoA	30,407						60,000	200			150	200
2	DoF	60	102		2				50	378	1,147		
3	FRC, Sabah	254,000	526					100,000					
4	FRC, Sarawak	200,000	290	4,500				458,133					
5	FRIM	300,000		1,360		2,106		620,200					100
6	IMR				10,000	5,000	500	1,500				3,500	1,500
7	IMU		160										
8	Jabatan Muzium Malaysia	1,439			1,191	316	4,328	17,623		92	2,498	13,468	108
9	Jabatan Muzium Sabah	7,624		124	3,519	5,194	3,628	5,639	304	2,893	272		
10	MARDI	22,100		2,029				29,000					
11	Marine Research, Sabah Parks		32		6	5			2		6	81	10
12	PERHITAN				6,329	2,000	720	4,000	20	577			
13	Sabah Parks	27,842	54	1,174	1,821	7,920	2,527	52,106	312	2,652		487	
14	Sarawak Biodiversity Centre	5,946	93		94	441		4,079	7,801	913		468	11,952
15	Sarawak Museum				12,000	3,400	12,000	102,200	1,000	4,000	1,500	1,200	1,000
16	UKM	72,000						130,000					
17	UM	65,000	29,000		1,227	1,110	455						
18	UMS	2,800	3,600	200	1,086	2,141	472	100,000		2,588		60,617	
19	UNIMAS	2,500	20	2,500	1,977	1,600	65	48,110	220	1,130	100	570	1,474
20	UMT					50		300	60	1,000	500		
21	UPM	2,168											
22	USM	12,000											
	Total	1,005,886	33,887	11,887	39,252	31,283	24,695	1,732,890	9,969	16,223	6,023	80,541	16,344
Grand Total		3,008,870											

DoA: Department of Agriculture; DoF: Department of Fisheries; FRC: Forest Research Centre; FRIM: Forest Research Institute Malaysia; IMR: Institute for Medical Research; IMU: International Medical University; MARDI: Malaysian Agricultural Research & Development Institute; PERHILITAN: Department for Wildlife and National Parks; UKM: Universiti Kebangsaan Malaysia; UM: Universiti Malaya; UMS: Universiti Malaysia Sabah; UNIMAS: Universiti Malaysia Sarawak; UMT: Universiti Malaysia Terengganu; UPM: Universiti Putra Malaysia; USM: Universiti Sains Malaysia).

Table 2. Comparison of selected natural history museums

	Natural History Museum, London	National Museum of Natural History of the Smithsonian Institution, Washington, D.C.	Field Museum, Chicago	Naturalis, Leiden	Raffles Museum of Biodiversity Research, Singapore	Botanic Gardens Singapore
Establishment year	1753	Opened 1910	1893, as the Columbian Museum of Chicago	1820, as the National Museum of Natural History	1849, as the Raffles Library and Museum, absorbed by NUS in1996	1859
Legal status	A non-profit organization under Dept of Culture, Media and Sport	Government organization	A non-profit organization	A Foundation established by Act of Parliament to manage national collections	A department of the Faculty of Science, National University of Singapore	A department of the National Parks Board of Singapore
No of visitors a year	3,200,000	7,200,000	2,000,000	300,000	Not applicable	3,200,000
No of visiting scientists a year	9,200 (2005/06)	7,748 (2007)	607	250	100	37
Governing Board	Board of Trustees of 12 members	Advisory Board of 22 members	Board of Trustees of 80 members	Governing Board of 7 members	Not applicable	National Parks Board of 10 members
Size of collections	Total 70 m specimens. Animals 28 m Plants 5.2 m Minerals 350,000 Fossils 9 m Insects 28 m	Total 126 m specimens. Insects 30 m Plants 4.5 m Fish 7 m	Total 23 m specimens	Total 12 – 15 m specimens Insects 5.3 m Other invertebrates 2.3 m Vertebrates 1 m Fossils 1 m Rocks and minerals 440,000	Total 500,000 specimens Animals over 400,000	Total 650,000 plant specimens
Scientific fields	Botany Entomology Zoology Paleontology Minerology	Anthropology Botany Entomology Mineral sciences Palaeobiology Zoology	Anthropology Botany Zoology Geology	Zoology Entomology Geology	Zoology Botany	Botany
Admittance	Free	Free	By ticket	By ticket	Free	Free
Days closed	Christmas Day	Christmas Day	Christmas Day	Mondays	Weekends	Weekends (herbarium only)

2. REVIEW OF NATURAL HISTORY

2.1 The scope of natural history

Natural history is the scientific study of plants and animals and their natural environments. In particular, it deals with the discovery, naming, documentation and classification of all forms of life, collectively known as biodiversity. It is the science most closely connected with

- survey and management of natural resources
- bioprospecting for useful species and natural products, e.g. new species for horticulture and new products for pharmaceutical use
- search for biological processes with agricultural and industrial potential, e.g. for biological control of pests and diseases, bioremediation of polluted soil and water, and biological conversion of biomass to energy

Natural history provides the scientific rationale for the UN Convention on Biological Diversity[1].

Discoveries in natural history have consistently made up a large proportion of published scientific discoveries in the world. In 250 years of global scientific effort, about 1.8 million species of plants, animals,

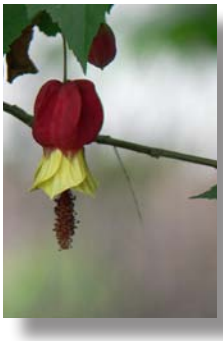


Table 3. Number of species known to science[2]

Kingdoms	Described species
Bacteria	4,000
Protictists (algae, protozoa, etc.)	80,000
Animals	1,320,000
Fungi	70,000
Plants	270,000
Total	1,744,000

and other living things have been named, documented and classified (see Table 3). This accumulated knowledge, coupled with advances in molecular biology, has propelled biology to the forefront of science in the 21st Century.

2.2 The method of natural history

Natural history as a science dates back to the 1700s (see Box 1), but the practice of preserving specimens from nature began earlier, with herbal medicine. To meet the need for accuracy in plant identification, authenticated specimens were preserved for reference by pressing, drying and gluing such specimens to sheets of paper. On the same paper, the name of the plant and other notes would be written in, together with the signatures of those responsible for the names and annotations. Such authenticated and annotated specimens were used in reference and teaching and sometimes bound into books. The idea of preserving specimens for reference and teaching was extended to animals, minerals, and other natural objects, and the buildings housing such collections became the first natural history museums.

The anchoring of the name of a species to a particular specimen preserved in a museum has become the standard practice for all species. New specimens are identified by matching with existing named specimens.

Specimens that do not match anything already known may then be interpreted as new species.

The particular specimen serving as the anchor for a name is designated as its holotype. Additional specimens of each species serve to provide fuller information about the species. Dates and localities of collection, and descriptions of habitat, are particularly important and are preserved together with the specimens. Thus almost every statement about a species is backed by a preserved specimen and its notes, and these are available for cross-checking and verification at any time.

Natural history museums accept responsibility for preserving the reference specimens together with the data associated with them, and making them available for scientists to study. Museum collections allow scientists to work out the geographical distribution and habitat of each species, to compare species that never occur next to each other in nature, to

Box 1. Natural history as a science

The mission to map and understand the full extent of life on earth has been one of the driving global missions of science. Its leading personality was Carl Linnaeus (1707 – 1778) a professor at the University of Uppsala in Sweden, who in his own lifetime, built up a world collection of 14,000 plants, 158 fish, 1,564 shells, 3,198 insects and 1,600 books. This collection is now owned by the Linnean Society of London. Linneaus developed the 'scientific' or 'binomial' system of naming species. 'Binomial' refers to the two words that make up the name of a species, e.g. *Hibiscus rosa-sinensis,* of which the first word, *Hibiscus,* denotes the scientific group or genus (pl. genera) to which the species belongs. The binomial naming system requires the discoverer of a new species to find out what existing species it resembles most and to maintain such species within the same genus. The naming of a species thereby incorporates the first stage in its classification. Genera are grouped into families, families into orders, and so on up to the level of Kingdom. Classification is what converts an otherwise hopeless jumble of names into structured knowledge. Common names are a hopeless jumble whereas scientific names are anchored to a system of structured knowledge.

By the time he published the 10th edition of his Systema Naturae (1758), Linnaeus had named 7,700 species of plants and 4,400 species of animals. After Linneaus, the total number of species known to science has been increased to its present total of over 270,000 plants and over 1,320,000 animals. The original two Kingdoms (Plant and Animal) have been split into five (Table 3), and more changes are being proposed. The manner in which the inventory and classification of life has been carried out—any person with knowledge and interest can take part—reminds of the way today's Wikipedia, a global public encyclopedia, has come about.

The mission to document and classify all life on earth represents a very large segment of the total scientific activity in the world, but the mission is a still a long way from completion. Estimates for the total of number of species range between 5 and 100 million!

compare specimens from different periods in time, and to detect changes in biodiversity and environment. There is continuous synergy between natural history collections and natural history scientists: good collections attract the attention of the world's scientists, who review and keep the collections up to date with current concepts in classification. Poorly-managed collections do not attract scientific attention and quickly lose scientific relevance.

2.3 The functions of natural history museums

The best-known natural history museums in the world are major visitor/tourist landmarks, staging exhibitions that inform, entertain and inspire. However, it is the quality of the scientific collections and scientific research at the back that provides the authority for the exhibitions in the front. Hence the leading natural history museums excel in three core functions:

- management of scientific collections
- scientific research
- exhibitions and outreach programmes

In consequence, such museums are

- major visitor/tourist attractions
- centres for advanced training in the life sciences
- providers of advisory and consultancy services to a wide range of users

2.3.1 Management of scientific collections

The most important physical resources of a museum are its collections of natural history specimens. The Natural History Museum of London holds 70 million specimens representing all forms of life, accumulated by 250 years of global exploration, including fossils that go back hundreds of millions of

years.[3] It continues to add to its collections at the rate of 150,000 specimens a year. The National Museum of Natural History of the Smithsonian Institution in Washington, D.C. holds 126 million specimens.[4] The level of comprehensiveness of a museum collection and the quality of its maintenance or curation define the level of research that the museum can support.

DNA research at the National Museum of Natural History, Smithsonian Institution, USA

In a museum with comprehensive collections, species that never occur side by side in nature, species that no longer exist, and specimens collected recently, can all be laid out beside each other in the laboratory for comparative study. Scientists with new questions are often able to find the answers in a comprehensive museum collection. Hence the leading museums attract visiting scientists from all over the world. The Natural History Museum in London attracts over 9,000 visiting scientists a year. The National Museum of Natural History in Washington, D.C. attracts about 8,000. Visiting scientists magnify the power and prestige of museums. The leading museums welcome visiting scientists and further engage the experts of the world by allowing them to borrow specimens for study. The Natural History Museum in London loaned out 70,000 specimens to 3,084 experts or venues/centres in 2005/06. The National Museum of Natural History in Washington, D.C. and the Field Museum in Chicago loaned out specimens to 1,562 and 663 venues/centres respectively in 2007.

Each specimen in a museum is a real record of something from a

particular place and time. For many species, museum specimens are the only indisputable evidence of where and when the species used to occur and of the environments in which they lived. The effects of climatic and other forces, if they have affected the lives of living things, are captured and fixed in museum specimens, waiting to be deciphered by scientists with the right tools and questions. The electron scanning microscope is an example of a tool that allows new details to be mined from museum collections. Even more dramatically, advances in molecular biology are making it possible to extract genetic information about extinct species from long dead and even fragmentary specimens.

Opp page:
Snake collection at the Institute for Medical Research. Kuala Lumpur

Realizing the unique scientific and strategic importance of their collections, the leading museums have given top priority to the effective and permanent preservation of their collections. At the National Museum of Natural History in Washington, D.C. a new magnificent facility called the Museum Support Center has been built to house the museum's collection of 126 million specimens. At the Natural History Museum in London, two storage facilities are being built, known as Darwin Centres One and Two. At Naturalis in Leiden, its 15 million specimens are kept in a specially designed 20-storey block that towers over the city of Leiden—this facility is sealed off from the outside world by double walls, absence of windows, totally controlled and uniform temperature and humidity, filtered dust-free air, and UV-free lighting.[5] In all the leading museums, there is a constant watch for beetles and other insects that degrade specimens. Specimens are cleaned by deep freezing at -18ºC to destroy insect pests and their eggs.

2.3.2 Scientific research

Because much of the biodiversity of the world still remains unknown, the discovery, documentation and classification of species remain a major research activity of all museums.

As a product of such research, new, interesting and useful species are made known for horticultural, agricultural, pharmaceutical and other uses. New species have driven and inspired horticulture ever since the introduction of tulips from Turkey to the Netherlands in 1593.

Nature is a vast laboratory of life that has generated not only millions of species but also millions of solutions to the problems of life on earth. These solutions include natural processes for biological control of pests and diseases, for bioremediation of polluted environments, for the biological conversion of biomass to energy, and even for the extraction of minerals from soil and water. A major part of biotechnology has to do with the harnessing of such processes for industrial-scale application.

Natural history museum scientists are increasingly involved in research to improve our understanding of the processes driving change in the environment. Such understanding is essential for the design of methods for conservation and management of the environment. For example, the dangers of uncontrolled pesticide usage came to light when scientists compared eggs preserved in museum collections and found that the eggshells of eagles and other birds of prey had become thinner and more fragile after the widespread introduction of pesticides in agriculture. Birds of prey occupy the top positions in their food chain and accumulate toxins picked up by lower members of the food chain. The fragility of eggs was the reason for the decline observed in populations of such birds. This knowledge contributed to better controls over the use of pesticides in agriculture and to the rise of organic farming.

The scientific reputation of a natural history museum is based on the quality of its scientific publications. The leading natural history museums

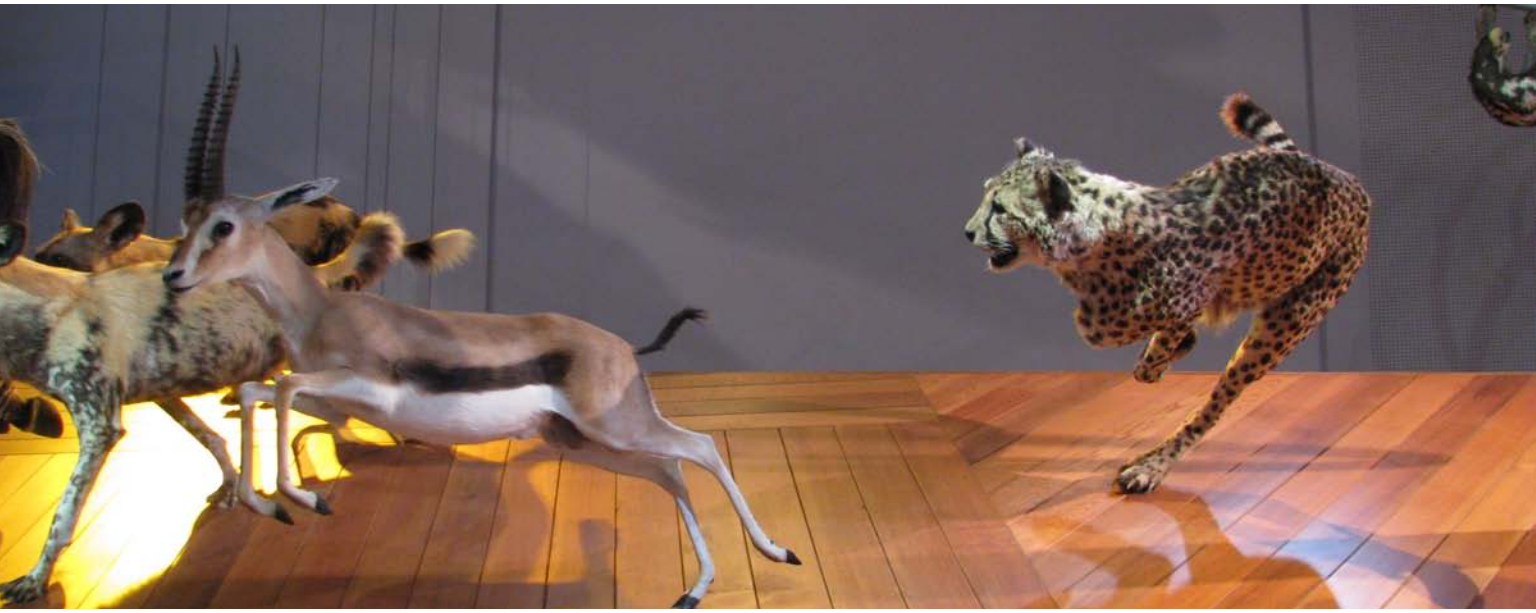
maintain their scientific credentials through the publication of peer-reviewed articles, journals and books.

2.3.3 Exhibitions and outreach programmes

The leading natural history museums organize informative, culturally-enriching, and often spectacular exhibitions aimed at all levels of society, from children to senior citizens. These attract millions of visitors, national and international each year, e.g. 7.2 million at the National Museum of Natural History in Washington, D.C. and 3.2 million at the Natural History Museum in London. A survey commissioned by the American Association of Museums in 2001 found that 87% of Americans view museums as the most trustworthy sources of objective information—followed by books (61%), television (49%), newspapers (34%) and the Internet (23%). As a primary resource for educating children, schools were rated first in importance (98%) followed by museums (86%).

Natural history museums have found that people think and learn in many different ways. Natural history museum exhibitions use "specimens, models, dioramas, hands-on activities, videos, animations, artists' renderings, and audio components geared to communicate complex messages succinctly and clearly while accommodating a wide variety of learning styles" (quote from the 2006 Annual Report of the Field Museum[6]). In all the four leading museums visited by the consultants, exhibitions and associated outreach activities are managed by full-time professionals with expertise in events-management, designing, writing, graphic arts, model-making, education, science communication, public relations, information technology, and related subjects.

As the quality of exhibitions has improved, the leading museums have discovered that there is a world demand for educational experiences of high scientific value. The exhibition *Ice Station Antarctica*, currently on



A cheetah in action — new dynamism in museum display - at Naturalis, Leiden.

show in the Natural History Museum in London, is booked as a traveling exhibition for the next five years. The Field Museum's traveling exhibition *A T. rex Named Sue* has been in many parts of the US and Asia. It is rented at USD95,000 per three months. During its stint in Singapore it not only paid for itself but also made a good profit for its sponsors. Touring exhibitions increase the museum's profile overseas and provide additional income that can support the museum's activities.

Because of rapid changes in natural history and all areas of science, and increasing levels of anxiety over the state of the environment, there is a need to keep the public informed and updated on a continuous basis. Natural history museums have been the most successful of all public institutions in catering to public information needs about the natural environment. The busiest natural history museums not only deliver outstanding educational experiences in the form of blockbuster exhibitions, but also arrange lectures and other special events, and put heavy emphasis on the maintenance of active and popular websites.

2.3.4 Major visitor/tourist attractions

Natural history museums are major visitor attractions. Local people interested in their own country and international visitors wanting to know more about the country they are visiting, would normally think of a museum as the best place for information. Children are particularly attracted to dinosaurs, mammals, birds and reptiles, while adults may head for the minerals and gems, the wildlife photo gallery, and so on. Natural history museums increase understanding of the natural potential of a country. It contributes to the sense of national identity and to a better understanding of the natural relationship of the country with its region and the world.

2.3.5 Centres for advanced training in the life sciences

The leading natural history museums attract thousands of visiting scientists from all over the world (9,200 at NHM London in 2005/06, and 7,700 in the National Museum of Natural History in Washington, D.C.). The universities situated nearby benefit greatly from proximity to such museums, and collaboration is strengthened by the appointment of museum staff as adjunct professors at the universities and the appointment of university professors to honorary positions in the museums. Young scientists training in such museums, being exposed to global collections and global experts, quickly develop global competence and ambitions themselves, and are positioned to become the scientific leaders of the future. Working together, the leading natural history museums and their associated universities have produced most of the leading biologists of the world.

2.3.6 Providers of advisory and consultancy services

The range of specialist advisory and consultancy services that a comprehensive natural history museum can provide is indicated by the following client list of the Natural History Museum, London (viewable on

the NHM website "Science enquiries and NHM consulting"):

- the food industry and retailers
- customs officers, importers and shipping agents
- health authorities, public analysts, laboratories, veterinary practices, including officers requiring identifications of venomous or noxious species
- farmers, agriculturists, horticulturists and gardeners
- scientists, environmentalists and agencies undertaking terrestrial, marine and freshwater surveys
- the legal profession requiring expert witnesses
- forensic scientists and the police, including officers investigating evidence relating to fly larvae or the movement of contraband
- publishers requiring validation of technical content (both images and text)
- mining, petroleum, water and waste disposal industries
- material technologists, architects and other users of building stones
- auctioneers requiring information on amber, carved materials, and natural history artifacts

2.4 Natural history in Malaysia

2.4.1 The state of collections

There are 22 institutions in Malaysia holding natural history specimens (Table 1). The total number of specimens is about 3 million. The older collections were established in government departments, primarily to provide scientific identification services, and this is still their main function. In the fight to control tropical diseases, it was vital to accurately identify the organisms causing sickness and death so that research could be targeted at them. Similarly, it was necessary to identify the diseases and pests of crop plants and livestock. In the case of forestry, it was necessary

to identify trees so that their timbers could be better promoted in the international timber market and the forests could be more scientifically managed. Correct identifications were also necessary for the management of fisheries and wildlife, to support quarantine efforts at national entry points, to enable certification of timber and other exported natural products (often required under WTO regulations), to support legal and commercial transactions involving biological materials, and to provide verification of materials used in pharmaceutical and food products.

Identification is done by comparing specimens against a reference collection of authenticated specimens. Once a well-authenticated reference collection has been established, routine identifications by

Wet Collection (preserved in alcohol) at the Natural History Museum, London.

comparison can be done by para-taxonomists. Para-taxonomy is effective for the identification of specimens from an area against a reference collection from the same area, e.g. a specimen collected in Sabah against a reference collection from Sabah. A para-taxonomist would not be able to identify a specimen that is not already represented in the reference collection. The development of a reference collection of authenticated specimens requires the combined skills of many taxonomists, each one a world specialist in a particular group of plants or animals. Building up a comprehensive collection of authenticated specimens therefore takes an immense amount of time and effort. The current fee charged for expert identification by the Natural History Museum, London, is £89 per specimen. The £89 charge conveys a message—that an expert identification service is valuable and should not be treated lightly. This charge is levied for 'commercial enquiries' and may be waived. The Forest Research Centre in Sabah receives free identification support from NHM London. The Institute for Medical Research in Kuala Lumpur gets free identification support from the National Museum of Natural History in Washington D.C.

Natural history museums do not charge each other for identifications. Such services are provided under scientific exchange agreements. NHM Malaysia, as the national focal point for natural history, would be able to obtain identifications through its exchange agreements with other natural history museums in the world, and in turn support the identification services of natural history units throughout the country.

Authenticated reference collections, once they have been built up, are invaluable national assets. In our study, we found the standard of maintenance of collections in Malaysia to be below international best practices except in the new facilities at the Universiti Malaysia Sabah. Almost nowhere are the collections stored under round-the-clock air-conditioned, humidity-controlled, UV light-shielded, and totally pest-free conditions. The up-

grading of standards requires urgent national attention, otherwise some priceless authenticated reference collections, representing many decades of scientific effort, will be lost. Common problems are loss of expertise and breaks in continuity when experienced staff retire, lack of space, and insufficient funds for maintenance. Nationally, it is not generally appreciated that the 3 million collections in the country collectively constitute a priceless national scientific heritage. This is in sharp contrast to the situation in, for example, the Netherlands, where the natural history collections are treated as the scientific heritage of the nation. The nation pays Naturalis, a non-profit foundation, to look after the collection and sends inspectors to check that the collections are looked after according to very stringent standards.

2.4.2 The state of research

Natural history collections in Malaysia are limited by state and national boundaries. As a result, the scientists associated with them work within small intellectual boxes. For example, a scientist working on a museum collection in Sabah would have Sabah specimens to examine but very few from outside Sabah. In such a situation, it is not possible for the scientist to decide whether a specimen new to Sabah is really new to science. It may be a species already known across the border, in Kalimantan, Brunei, Sarawak, Philippines or Peninsular Malaysia. All the natural history units in Malaysia are in this limiting situation. No natural history unit in Malaysia has responsibility to overview the whole of Malaysia or Southeast Asia.

As for the monitoring of changes through time, there are very few specimens from over 100 years ago. The vast majority of specimens collected over 100 years ago from Malaysia were deposited overseas, but there are many collections going back about 50 years, and these are important. For example, an identified collection of fishes from the waters of Sabah made 50 years ago contains information about the fishes and

Opp page:
An unknown climber, one of hundreds of climbing species in Malaysian forests.

waters of Sabah at that time. If the collection is lost, it will be very costly to build up another identified collection and the new collection will not contain information about the past.

Because of the segmented and limited nature of Malaysian natural history collections, only few scientists in Malaysia have pan-Malaysian experience. Only a few have made impact regionally or globally, although in its wealth of biodiversity, Malaysia ranks 12th in the world (see Table 4).

Table 4. World biodiversity rankings according to the National Biodiversity Index (NBI), based on vertebrates and vascular plants.

Rank	Country	NBI
1	Indonesia	1.000
2	Colombia	0.935
3	Mexico	0.928
4	Brazil	0.877
5	Ecuador	0.873
6	Australia	0.853
7	Venezuela	0.850
8	Peru	0.843
9	China	0.839
10	Costa Rica	0.820
11	Madagascar	0.813
12	Malaysia	0.809
13	Panama	0.793
14	Philippines	0.786
15	Brunei	0.777
16	Papua New Guinea	0.775
17	Guatemala	0.744
18	India	0.732
19	Bolivia	0.724
20	Equatorial Guinea	0.714
21	South Africa	0.714
22	Cuba	0.703

Southeast Asia, has been a magnet for natural history scientists and graduate students from Europe, North America and Japan. However, it is rare for a Malaysian natural history scientist to do field work in a neighbouring country. The natural history scientists of neighbouring countries like Indonesia, Philippines, Thailand and Brunei also tend to confine themselves to their own countries. As a result, the regional experts on Southeast Asian natural history are based almost entirely in Europe, USA and Japan. Whenever regional expertise is needed, the experts have to be invited from outside the region. For example, in a conference on mosquitoes and mosquito-borne diseases organized by the Academy of

Sciences Malaysia in year 2000, regional overviews on the ecology and taxonomy of mosquitoes had to be provided by invited Japanese experts who had worked on mosquitoes all over Southeast Asia.[7] No Southeast Asian mosquito scientist had regional expertise. Malaysia can and should play a pivotal role in breaking through habits rooted in the colonial past that have inhibited cross-boundary scientific collaboration in the region (see Box 2).

2.4.3 Exhibitions and public outreach

Box 2. Reaching out to the region, the tropics and the world

As a result of the colonial history of Southeast Asia, linkages between natural history museums have been parallel and separate: Malaysia and Singapore with the United Kingdom, Indonesia with the Netherlands, the Philippines with the United States, and Vietnam, Cambodia and Laos with France. This has hindered the advancement of knowledge in natural history across Southeast Asia. The species in the region are closely related to each other and may even be the same species. Without a holistic regional overview, many studies in natural history undertaken in the former colonies have been deficient due to ignorance of what lies over the borders. NHM Malaysia should initiate links with museums in neighbouring countries for the exchange of duplicate specimens and for the organization of joint expeditions to promote collaborative research and region-wide knowledge in biodiversity.

Neighbouring countries should initially be defined as those of Southeast Asia but a significant percentage (5 – 10%) of Malaysia's biodiversity cannot be satisfactorily interpreted without reference to the greater Asian region that includes India and China.

In terms of species, Malaysia shares many agricultural and horticultural plants and weeds with tropical America and tropical Africa. In terms of ecology, countries in the whole of the tropical belt share many common features due to similarities in climate. We also share many economic interests, and these are expanding as Malaysian businesses grow and as Malaysian graduates take up employment overseas.

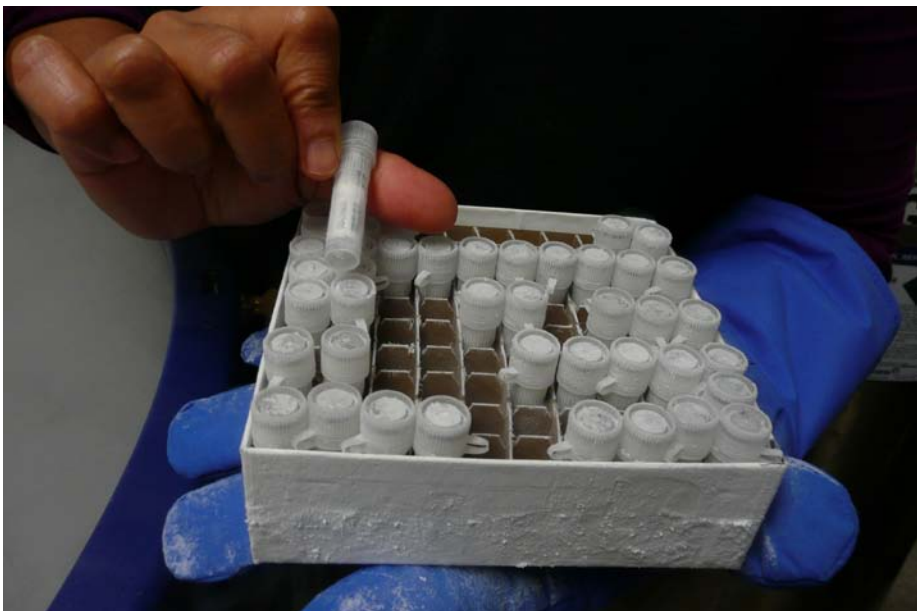
NHM Malaysia, as a resource centre for Malaysian scientists, businesses, students, and others should, though international networking, build up its ability to provide support for Malaysia's national, regional and global interests even though its focus will be on Malaysia and its immediate region.

Since the natural history collections in Malaysia are mostly collections established within government departments to serve the departments' own needs, public outreach programmes have never been priority activities. Wherever exhibitions have been set up, they have been the result of one-time efforts. Newly developed exhibitions look fresh and attractive while old ones deteriorate through time.

The popularity and effectiveness of an exhibition are best indicated by the number of visitors. Institutions that host exhibitions and other public outreach programmes should monitor their effectiveness through visitor records and establish mechanisms for prompt remedial actions whenever a decline is indicated. Regular monitoring is rarely practised in Malaysia.

2.4.4 Training and professional development

Natural history museums with comprehensive scientific collections attract scientists from all over the world and become places where young scientists can meet and work with experienced scientists. In such



Tissue samples stored in liquid nitrogen

an intellectual environment, young scientists naturally develop global ambitions and capabilities. A good natural history museum would serve as a central resource that all the universities can use.

Malaysia needs a natural history museum with collections large and comprehensive enough to support the universities in the development of world-class training programmes in the life sciences and in the management of natural resources and environment. Such training will increase in importance as natural resources and the environment become critically endangered by the unintended consequences of human activities. Malaysia could be the centre for such training in the tropics.

Rare plants in the Conservatory of the University of Malaya, Kuala Lumpur.

3. MALAYSIA'S NATIONAL POLICY AND VISION ON BIODIVERSITY

3.1 Malaysia's international biodiversity interests and commitments

The Convention on Biological Diversity[1], internationally negotiated and adopted in 1992, puts a responsibility on national governments to conserve biodiversity, use it sustainably and share the benefits arising from the use of genetic resources in a fair and equitable way. This "most complex and wide-ranging environmental treaty in existence" calls for a high level of integrated knowledge and coordinated action on the part of national governments in matters concerning biodiversity, genetic resources and environment.[2]

Already, economic activities such as ocean fishing, trade in animal products as diverse as ivory, furs, shark's fins, timber, orchids, birds, and other forms of wildlife, the management of forests and freshwater systems, the use of biofuels, the regulation of genetically modified organisms and the management of genetic resources, have come under critical international scrutiny. International regulations have already come into effect in many areas of concern. The health of biodiversity is intertwined with the health of the environment and both are under increasing pressure, with effects

spilling across national boundaries. Ultimately it is the health and well-being of humanity that is at stake. Continuing international and national assessments on the state of biodiversity and biological resources require sustained and comprehensive attention by governments.

3.2 Assessment of biological diversity in Malaysia

Following the Convention on Biological Diversity, the Ministry of Science, Technology and the Environment Malaysia commissioned a Malaysia Country Study on Biological Diversity[8]. This study, entitled Assessment of Biological Diversity in Malaysia and published in 1997, contains many recommendations, one of which is to establish a national institute on biodiversity.

3.3 National policy and vision

In 1998, the Ministry of Science, Technology and the Environment published the National Policy on Biological Diversity[9] with the vision statement:

> To transform Malaysia into a World Centre of Excellence in Conservation, Research and Utilization of Tropical Biological Diversity by the year 2020.

3.4 Decision to establish a Natural History Museum

At the Fifth National Biodiversity and Biotechnology Council (NBBC5) meeting on 29 September 2006, chaired by the Prime Minister of Malaysia, a decision was made to establish a Natural History Museum in Malaysia.

4. AN INSTITUTIONAL FRAMEWORK FOR REALIZING THE VISION

4.1 Mission and status of the Natural History Museum

With the decision made at the Fifth National Biodiversity and Biotechnology Council (NBBC5) meeting to establish a Natural History Museum in Malaysia, we recommend the Natural History Museum to be designated as the national institution for realizing the vision of the National Policy on Biological Diversity.

The new museum should be established as a statutory body under the Ministry of Natural Resources and Environment. This Ministry is appropriate because it oversees most of the departments concerned with nature and environment, in particular Forestry, Wildlife and National Parks, Minerals and Geoscience, and Environment. An Act to establish the new museum will need to be prepared by the Ministry.

4.2 The name of the museum

The name of the museum should reflect its national status. The Consultancy Team considered a dozen possible names and found that among natural history scientists, the most preferred name is Natural History Museum Malaysia (NHM Malaysia). This is also the name preferred by the Steering Committee.

A budding scientist at the Investigate Centre, NHM London.

4.3 The Governing Board

In common with other statutory institutions in Malaysia, NHM Malaysia should be governed by a Board appointed by the Minister. Its members should be eminent persons from the Government at Federal and State levels, and from corporate, civic, and academic organizations. The Director-General should be a member of the Board.

4.4 Establishment and performance standards

To be comparable with other world centres of excellence in natural history, the new museum will need to be be equipped with state-of-the-art facilities for natural history, and its performance must be benchmarked continually against the leading natural history museums of the world. The implementation and performance targets must include

- excellent physical facilities for the secure storage of scientific specimens
- strong programmes of research by its own staff and associated scientists
- strong programmes in exhibition and other public outreach activities
- rapid build-up of scientific collections

Box 3. North – South collaboration

The early European explorations of the 18th and early 19th centuries resulted in collections of plants and animals all of which were brought back to Europe for study and housed in the then newly established museums. From mid-19th century to mid-20th century, collections were carried out mainly by scientific expeditions from Europe, with most of the materials being sent back to European museums, but duplicate collections were maintained in regional colonial museums, notably in Singapore and Bogor. Scientific analysis of the biodiversity of Malaysia and adjoining territories was pursued first by Europeans and later by American, Australian, and Japanese biologists, who published their results in journals and books in their home countries.

Following Independence, Malaysian biologists have been carrying out explorations on the biodiversity of Malaysia, but the 250-year tradition of collecting, research, and publication by biologists of the North means that the bulk of the physical and intellectual resources still remain in the North. For the NHM Malaysia to become a strong contributor to global knowledge in biodiversity, it should work with scientists and their museums in the North in partnership and exchange programmes. Such programmes could include

- visiting curatorships and fellowships
- joint research programmes
- training programmes
- joint field efforts to collect specimens and information on biodiversity
- joint authorship of research papers and books

For example, an expert from overseas could be invited to spend one to three months in residence at the new museum, making joint field collecting trips, directing the preparation of the new specimens, and identifying these and others already in the collection. The new museum would benefit from access to the older museums' collections, stimulation of the scientific staff, training in collecting, preservation, and maintenance of specimens, and joint publication of scientific work.

Holotypes of newly discovered species should remain in the new museum but the remainder of specimens collected under these programmes should be divided between the new museum and the home museum of the visiting scientist by prior agreement. Many museums allow their curators to travel for field work only if the work results in additions to their collections. A partnership and exchange programme should result in

- growth of the collections
- training of staff and students
- increase in knowledge of the biodiversity of Malaysia and adjacent regions

- modern laboratories
- scientific relations with leading natural history museums overseas (see Box 3)
- comprehensive library and database facilities (see Box 4)
- collaborative programmes with universities
- a peer-reviewed scientific publications programme

4.5 Establishment of a Natural History Consortium and an Accreditation System

The existing natural history collections in the country, totaling 3 million specimens and managed by different organizations under different federal and state mechanisms, should all be recognized and supported as national heritage scientific collections.

Many of the existing collections suffer from lack of continuity in staff expertise. Typically, these collections represent a small part of the activities of a large organization (government regulatory department, university, or museum of culture and history). The person who builds up the collection in a lifetime of effort would retire and the replacement officer would be someone new to the discipline, not fully appreciative of the scientific value of the collection, and too low in the hierarchy to get support from higher levels in the organization. The collection deteriorates physically. The number of visiting scientists declines to zero. The public stops referring to the collection because the absence of expertise cannot be disguised. The collection sinks lower and lower in the organization's order of priorities. Instead of knowledge of biodiversity being built up progressively year by year, we face the prospect of knowledge being eroded year by year on many fronts. Malaysia's ambitions to be a leader in tropical science based on its wealth in biological diversity cannot be realized under such circumstances.

Box 4. Natural history in the Information Revolution

There is a quiet but massive revolution taking place in the management of scientific information. Modern science is based on the premise that knowledge is most reliable and beneficial to society when it is open, transparent, and publicly accessible. However there has been a limitation to accessibility due to the cost of storing, multiplying and distributing paper documents. This limitation has now been removed by advances in digitization of information, and the removal of distribution, storage and other barriers by the global reach and power of the Internet. Now the information resources of the world's natural history museums can be made truly public.

The most exciting prospect is that all of the world's scientific literature, beginning with the rare old classics carefully preserved in the great libraries, are being digitized and made available freely to the public on the Internet. Some of these books are so rare that a copy cannot be found even within the combined library holdings of the ten largest museums in world. As for current and copyrighted publications, more and more publishers are putting their publications on the Web and providing free and open access. The world of scientific publication is being shaken up drastically.

The movement to make digitized images of type specimens available on the Web is gathering strength, especially for plant specimens, which are flattened and easy to photograph. All the type specimens of plants of the world are likely to be available in the next ten years. Technology is now moving to the stage where a three-dimensional specimen such as an insect can be mounted under a microscope in a museum and revolved, manipulated, and image-transmitted instantaneously to a viewer elsewhere.

Even more significantly, the collector's notes made at the time of collection, which include details of location and date of collection, are now being painstakingly transferred into electronic databases to be made available on the Web. It is such information that gives a specimen its scientific value. Access to such information has always been very difficult because a collector makes notes only once, and copying such information has been a tedious process. Museums are now tackling the problem with determination, and database platforms are being developed to handle the vast amounts of information rapidly and reliably.

To reverse these negative trends, NHM Malaysia should take the lead in establishing a Natural History Consortium, to function as a forum for

- establishing national standards for natural history collections
- developing an Accreditation System
- helping members of the Consortium to achieve accreditation through training, staffing and other support programmes

The Consortium should be established as soon as possible through consultation between stakeholder institutions.

4.6 Public support

The leading natural history museums, particularly those in the USA, derive strength from the public and have established many mechanisms for cultivating public support. Support may be in the form of (a) volunteers working as guides, interpreters, researchers and research assistants, (b) gifts of specimens, and (c) donations, endowments, and financial sponsorship of exhibits, equipment and events.

The best place to obtain exposure and training in museum public relations and fund-raising would be in a non-government museum in the USA, such as the Field Museum in Chicago, where public relations and fund-raising are regarded as part of the job of everybody involved with the museum, from its president to its scientists, ticket counter staff, security officers, volunteer workers, members and donors.

4.6.1 Council of Trustees

A Council of Trustees should be established by the Board to advise the Board on the management of gifts, donations, endowments, and income from membership and museum enterprises. The Council will help to raise funds for the museum, oversee its investments, and provide assurance to the public that the agreed terms of donorship will be respected.

4.6.2 Membership and Fellowship systems

We recommend the establishment of a system by which the public may contribute to the support of the museum through membership. Members pay a membership fee and may be provided with membership privileges such as newsletters, previews of exhibitions and other events. Corporate Members are corporations which support the museum with corporate donations. A membership system would strengthen the finances of the

museum. At the same time, membership growth or decline will provide an objective measure of the quality of management.

Individuals who have made distinguished contributions in natural history should be recognized through the award of fellowships. To initiate the fellowship system, the first Fellows—to be known as Foundation Fellows—should be appointed by the Minister upon the advice of a committee set up for this purpose by the Ministry. Thereafter, new Fellows should be persons nominated by two Fellows, and approved by the existing body of Fellows. Honorary Fellows will be non-citizens nominated by two Fellows and approved by the body of Fellows.

4.7 Code of Ethics for Museums

The museum should be a member of the International Council of Museums (ICOM) and subscribe to the ICOM Code of Ethics for Museums, viewable on the ICOM website. The ICOM Code sets the minimum standards of professional practice and performance for museums and their staff. The guiding ethos of ICOM is "service to society, the community, the public and its various constituencies." The guiding principles of the ICOM Code of Ethics for Museums are as follows:

Museums preserve, interpret and promote the natural and cultural inheritance of humanity

Principle: Museums are responsible for the tangible and intangible natural and cultural heritage. Governing bodies and those concerned with the strategic direction and oversight of museums have a primary responsibility to protect and promote this heritage as well as the human, physical and financial resources made available for that purpose.

Museums that maintain collections hold them in trust for the benefit of society and its development

Principle: Museums have the duty to acquire, preserve and promote their collections as a contribution to safeguarding the natural, cultural and scientific heritage. Their collections are a significant public inheritance, have a special position in law and are protected by international legislation. Inherent in this public trust is the notion of stewardship that includes rightful ownership, permanence, documentation, accessibility and responsible disposal.

Museums hold primary evidence for establishing and furthering knowledge

Principle: Museums have particular responsibilities to all for the care, accessibility and interpretation of primary evidence collected and held in their collections.

Museums provide opportunities for the appreciation, understanding and promotion of the natural and cultural heritage

Principle: Museums have an important duty to develop their educational role and attract wider audiences from the community, locality, or group they serve. Interaction with the constituent community and promotion of their heritage is an integral part of the educational role of the museum.

Museums hold resources that provide opportunities for other public services and benefits

Principle: Museums utilise a wide variety of specialisms, skills and physical resources that have a far broader application than in the museum. This may lead to shared resources or the provision of services as an extension of the museum's activities. These should be organised in such a way that they do not compromise the museum's stated mission.

Museums work in close collaboration with the communities from which their collections originate as well as those they serve

Principle: Museum collections reflect the cultural and natural heritage of the communities from which they have been derived. As such they have a character beyond that of ordinary property which may include strong affinities with national, regional, local, ethnic, religious or political identity. It is important therefore that museum policy is responsive to this possibility.

Museums operate in a legal manner

Principle: Museums must conform fully to international, regional, national, or local legislation and treaty obligations. In addition, the governing body should comply with any legally binding trusts or conditions relating to any aspect of the museum, its collections and operations.

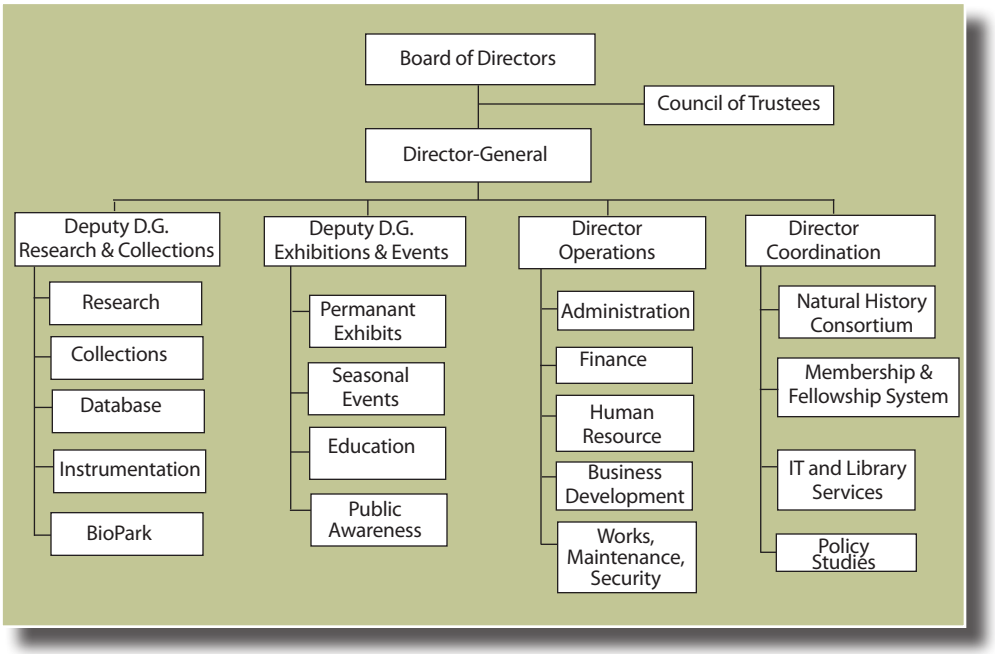
Museums operate in a professional manner

Principle: Members of the museum profession should observe accepted standards and laws and uphold the dignity and honour of their profession. They should safeguard the public against illegal or unethical professional conduct. Every opportunity should be used to inform and educate the public about the aims, purposes, and aspirations of the profession to develop a better public understanding of the contributions of museums to society.

Tiger *(Panthera tigris)*

4.8 Proposed organization

We propose that the museum be organized into four divisions each consisting of a number of operational units.



4.8.1 The Research and Collections Division

This Division will manage research and collections (see Box 5) and be responsible for

- research in traditional and molecular taxonomy, biodiversity, ecology and conservation
- the collection, preparation, preservation, labeling, cataloguing, storage and maintenance of dry and wet specimens of fauna, flora and minerals
- the databases of information on specimens in the collections
- the scientific instruments, facilities and laboratories, such as electron microscopes, facilities for tissue storage, and laboratories for molecular biology

- the BioPark, which will be a living laboratory and a model conservation area in an urban setting, to provide expanded possibilities for research, public education, and conservation of living genetic materials

4.8.2 The Exhibitions and Events Division

This Division will promote excellence in exhibitions and public engagement (see Box 6) and be responsible for

- permanent natural history exhibitions, which though 'permanent', will need to be upgraded from time to time
- seasonal (temporary) events to focus on issues of current interest, including traveling exhibitions to cater for distant audiences
- educational programmes to introduce children to science, to support the school curriculum, and to support teachers in the environmental and life sciences
- public awareness programmes on issues of current interest including organization of seminars and the development and maintenance of the museum's websites.

Exhibitions may be designed in-house, outsourced in part or whole, hired, or purchased.

Mineral Gallery in the Field Museum

4.8.3 The Operations Division

This Division will be responsible for

- the Administration unit
- the Finance unit
- the Human Resources unit
- the Business Development unit
- the Maintenance and Security units

Box 5. Synergy in collections and research

A natural history museum's contribution to knowledge is based on the synergistic relationship between collections and research. In simple terms, collections are samples taken from nature at particular times and places and preserved as physical evidence for reference and to support current and future studies. A collection by itself is not knowledge. Knowledge is made by researchers who study and interpret the evidence. Since interpretations are based on collections, interpretations are subject to revision as collections grow in quality and quantity. Collections of groups that have been neglected before, collections from localities previously underexplored, and collections based on new methods of detection, all have the potential to change our understanding of nature. Old specimens already interpreted, can be reinterpreted in new ways when re-examined alongside new specimens.

Collections programme. The most acclaimed natural history museums, like the Natural History Museum in London, the Field Museum in Chicago, and the National Museum of Natural History of the Smithsonian Institution, have had over 100 years to accumulate large and comprehensive collections. To establish a significant collection within ten or twenty years will be an immense challenge for the new NHM Malaysia, requiring a sustained goal-driven effort with three general thrusts:

- Thrust 1: To build up collections representative of the country's total biodiversity. This thrust has two components: (a) short-term efforts to plug knowledge gaps in lesser-known groups of organisms, and to explore lesser-known geographical regions and habitats, and (b) a long-term target to build up the total collection.
- Thrust 2: To build up collections of those groups of plants and animals that the museum's staff and research associates will specialize in. No museum has expertise in everything. Instead, museums are defined scientifically by the particular areas of strength in which they publish the most research papers and books.
- Thrust 3: To build up representative collections of plants and animals of Southeast Asia. This third thrust will be linked to partnership and exchange programmes between NHM Malaysia and the natural history museums in neighbouring countries.

A good way to build up collections would be through expeditions. Scientists from other museums can be invited to participate, and specimens can be shared among the participating museums. Such expeditions will promote networking between participating natural history scientists.

Those parts of the country that are underexplored are the most likely to yield new discoveries. Groups of organisms that have been neglected, such as mollusks, nematodes, certain groups of insects, and macro-fungi, will present the best opportunities for making

whole suites of discoveries. Attention should also be given to fossils, of which there are few collections in the country.

NHM Malaysia can lay the foundations for future impact by establishing what will become globally important ecological benchmarks. This can be done by selecting key habitats (terrestrial, aquatic and marine) for repeated collecting and monitoring. In this way, the collections of the present will yield maximum information when studied alongside collections to be made in 5, 10, 50 or 100 years from now.

Research Programme. The research programme of NHM Malaysia should have the following broad goals:

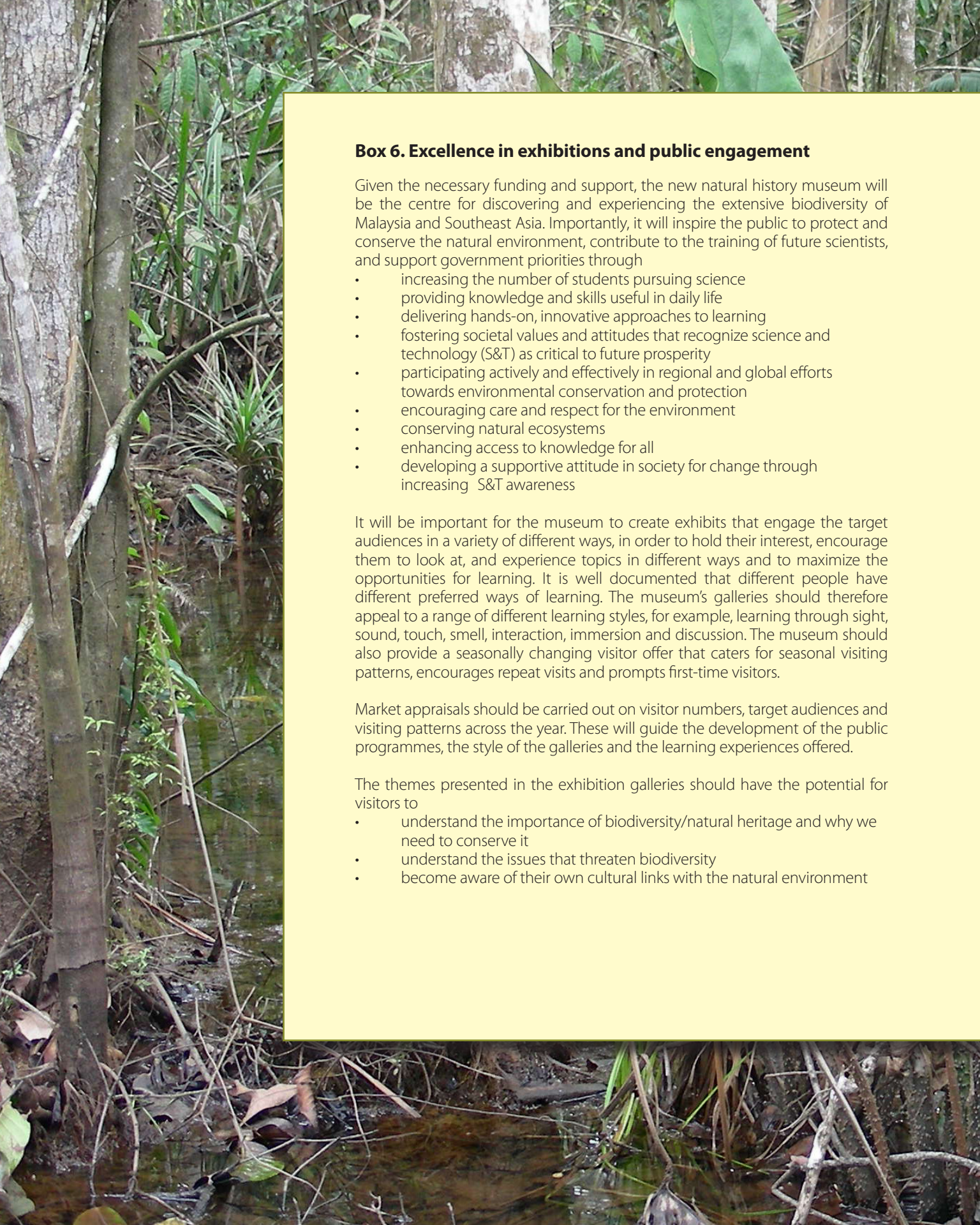
- add to knowledge of the biodiversity of Malaysia
- contribute to understanding of the relationships of the biodiversity of Malaysia with that of adjoining territories of the wider world
- contribute to the professional training of young scientists and scientists-to-be

The selection of the scientific staff is critical to the success of the museum. Since the scientific impact of a natural history museum is measured by its scientific publications in refereed scientific journals, the scientific staff should be selected on the basis of their ability to contribute to science by publication.

The publication impact of a museum can also be raised with the help of research associates. These research associates may be scientists from anywhere in the world who can contribute to the research programmes and add to the international status of the new museum. A budget should be set aside to support visits by short-term researchers (one to two months) or longer-term ones (six months to a year).

A comprehensive natural history museum is a resource that students in disciplines related to natural history—taxonomy, ecology, evolution, conservation and environmental management—will find vital to their professional development. Students may study under the guidance of the museum's scientists and use the museum's collections to advance their studies. This relationship may be formalized by universities giving honorary faculty appointments to museum scientists, and the museum appointing university scientists as museum research associates.

Synergy between research and collection is promoted by the physical design of buildings. The duplex modules at the Museum Support Center of the National Museum of Natural History in Washington DC provide a good example whereby scientists and laboratories are located close to the reference collections.



Box 6. Excellence in exhibitions and public engagement

Given the necessary funding and support, the new natural history museum will be the centre for discovering and experiencing the extensive biodiversity of Malaysia and Southeast Asia. Importantly, it will inspire the public to protect and conserve the natural environment, contribute to the training of future scientists, and support government priorities through

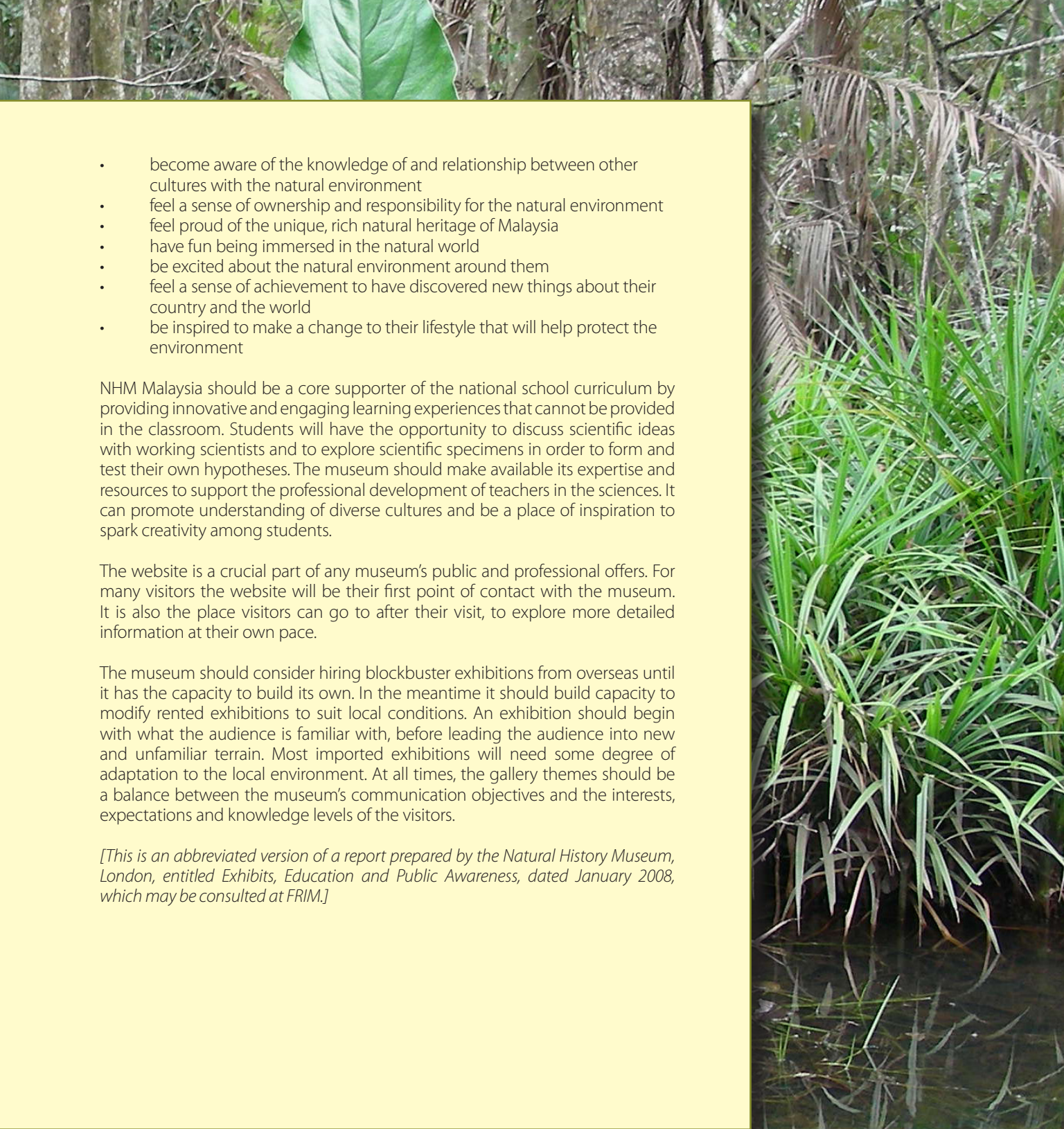
- increasing the number of students pursuing science
- providing knowledge and skills useful in daily life
- delivering hands-on, innovative approaches to learning
- fostering societal values and attitudes that recognize science and technology (S&T) as critical to future prosperity
- participating actively and effectively in regional and global efforts towards environmental conservation and protection
- encouraging care and respect for the environment
- conserving natural ecosystems
- enhancing access to knowledge for all
- developing a supportive attitude in society for change through increasing S&T awareness

It will be important for the museum to create exhibits that engage the target audiences in a variety of different ways, in order to hold their interest, encourage them to look at, and experience topics in different ways and to maximize the opportunities for learning. It is well documented that different people have different preferred ways of learning. The museum's galleries should therefore appeal to a range of different learning styles, for example, learning through sight, sound, touch, smell, interaction, immersion and discussion. The museum should also provide a seasonally changing visitor offer that caters for seasonal visiting patterns, encourages repeat visits and prompts first-time visitors.

Market appraisals should be carried out on visitor numbers, target audiences and visiting patterns across the year. These will guide the development of the public programmes, the style of the galleries and the learning experiences offered.

The themes presented in the exhibition galleries should have the potential for visitors to

- understand the importance of biodiversity/natural heritage and why we need to conserve it
- understand the issues that threaten biodiversity
- become aware of their own cultural links with the natural environment



- become aware of the knowledge of and relationship between other cultures with the natural environment
- feel a sense of ownership and responsibility for the natural environment
- feel proud of the unique, rich natural heritage of Malaysia
- have fun being immersed in the natural world
- be excited about the natural environment around them
- feel a sense of achievement to have discovered new things about their country and the world
- be inspired to make a change to their lifestyle that will help protect the environment

NHM Malaysia should be a core supporter of the national school curriculum by providing innovative and engaging learning experiences that cannot be provided in the classroom. Students will have the opportunity to discuss scientific ideas with working scientists and to explore scientific specimens in order to form and test their own hypotheses. The museum should make available its expertise and resources to support the professional development of teachers in the sciences. It can promote understanding of diverse cultures and be a place of inspiration to spark creativity among students.

The website is a crucial part of any museum's public and professional offers. For many visitors the website will be their first point of contact with the museum. It is also the place visitors can go to after their visit, to explore more detailed information at their own pace.

The museum should consider hiring blockbuster exhibitions from overseas until it has the capacity to build its own. In the meantime it should build capacity to modify rented exhibitions to suit local conditions. An exhibition should begin with what the audience is familiar with, before leading the audience into new and unfamiliar terrain. Most imported exhibitions will need some degree of adaptation to the local environment. At all times, the gallery themes should be a balance between the museum's communication objectives and the interests, expectations and knowledge levels of the visitors.

[This is an abbreviated version of a report prepared by the Natural History Museum, London, entitled Exhibits, Education and Public Awareness, dated January 2008, which may be consulted at FRIM.]

Publications of scientists of the Field Museum, Chicago

Except for Business Development, such units exit in most public organizations and their functions are well known. The Business Development unit will be responsible for generating income through entrance tickets, operation of cafeterias, souvenir shops and bookshops, renting out of space for private functions, renting out of exhibits and traveling exhibitions, and other business activities. The Business Development unit should model its activities on the income-generating experiences of the Field Museum in Chicago and other natural history museums in the USA.

4.8.4 The Coordination Division

This Division will be responsible for

- Administrative support for the Natural History Consortium and its Accreditation System
- Administration of the membership and fellowship systems
- Information Technology (IT) and library services including engagement in international information projects pertaining to natural history
- Policy studies on biodiversity, conservation, environment and related issues of national and international concern

5. HUMAN RESOURCES

An organization is as good as the human resources that lead, manage and operate it. There is no substitute for personnel driven by passion for the work they do. Managerial, technical and scientific qualifications, though formally required, will not be sufficient to create a centre of excellence. The aim from the start should be to establish an institutional culture with high professional and ethical standards.

To launch the museum and to provide training and leadership during its establishment period, experienced senior staff will have to be recruited on contract while permanent staff are being trained. Such senior contract appointments should not be limited to Malaysians. In some areas of museum development, there may be no suitable Malaysians available.

It would also be useful to have some junior positions available for young graduates or 'post-docs' from overseas to help broaden the outlook of local scientists and to promote the museum among young scientists internationally.

The Director-General should be a scientist and manager with ample

experience in project implementation and management, and in public relations.

All senior staff should regard public relations as part of their job and be provided with guidance and training in public relations. Senior scientists will be expected to lead the institute's scientific programmes and to train young scientists. The serious lack of taxonomists in certain areas, e.g. fungi, mollusks, certain groups of insects, and nematodes, will need to be addressed; such neglected areas will provide good opportunities for discovery. When fully operational, the museum is expected to have scientists in Biodiversity, Ecology, Ethnobiology, Arachnology, Entomology, Herpetology, Ichthyology, Malacology, Mammalogy, Marine Biology, Mineralogy, Ornithology and so on. These scientists will provide the country and the region with a comprehensive range of scientific research, education, conservation and advisory services. Because the shortage of taxonomists is a universal problem, the museum may play a role in the development of taxonomists for the tropical world in years to come.

Lifelong education of all staff should be a policy of the museum. As a general principle, all staff should be trained and skilled in whatever duties they are assigned to perform. The training of scientists, technicians and other staff should commence well ahead of the completion of infrastructures. It is proposed that two modes of training be adopted. One is the training of trainers at established foreign museums. The second mode is training conducted locally by local and international experts, particularly in techniques of collection, preparation, cataloguing, recording, storage and managing specimens as well as preparation of specimens for exhibitions. In the long term the institute itself should aim at becoming a national and regional training centre.

The great hall of NHM London

The scientists will be expected to become world leaders in their chosen fields of research. To enable them to concentrate on science they should be provided with good career paths within the museum by allowing for parallel/column-rise promotions as in other statutory bodies like FRIM and MARDI.

Technicians with special skills, including taxidermists and illustrators, are in short supply, and good ones are difficult to retain. The technical staff should also be provided with good career paths within the museum.

Due to the complexity and stringent requirements of the environmental control facilities in the buildings, a team of engineers and technicians would be necessary to check, service and maintain the facilities of the museum. It is recommended that this service be contracted out to competent companies or special units of the Public Works Department (JKR).

The external security of the museum (grounds and perimeter) can be contracted to security organizations, but the internal security would require specially trained and motivated officers who can help direct visitors, maintain order in crowds, keep watch on valuable exhibits, and monitor the CCTV surveillance system. Internal security may be better organized and managed as an internal staff function.

An estimate of the human resource requirements for NHM Malaysia is provided in Table 5, in which the salary scales suggested are guided by the scales currently applied at research institutes in Malaysia. The entry point for any scheme will be based on qualifications and experience as decided by the Jabatan Perkhidmatan Awam. It is assumed that the buildings will be ready for occupation at the end of year 3, but staff will be recruited, trained and operational before then. The exhibition galleries should be open in year 4.

Table 5. Projected human resource requirements
[10th Malaysia Plan: Year 1 to Year 5]

Designation	**Yr 1**	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**
Director-General (VU 5)	1	1	1	1	1
Deputy DG (VU 6)	1	1	1	2	2
Senior Research Officer (Q 54)	4	4	8	8	12
Research Officer (Q 48)	9	11	18	25	32
Asst. Research Officer (Q 36)	6	8	16	16	16
Asst. Research Officer (Q 27)	4	4	8	10	10
Business Dev. Ex. (Q 43)	-	2	2	2	2
Asst. Business Ex. (Q 41)	-	-	2	2	3
Marketing Ex. (Q 43)	-	-	1	1	1
Asst. Marketing. Ex. (Q 41)	-	-	2	2	4
Technician (Q 17)	10	20	30	30	30
IT Officer (F 54)	1	1	1	1	1
IT Officer (F 44)	2	2	2	4	4
IT Officer (F 38)	2	2	2	4	4
IT Assistant (FT 26)	4	4	4	4	6
Instrument Operator (F22)	4	4	4	4	6
Computer Technician (F 17)	2	2	2	4	6
Admin. Officer (N 54)	1	1	1	1	1
Events Ex. (N 41)	1	1	1	2	2
Asst. Admin. (N 36)	2	2	2	4	6
Junior Admin. Asst. (N 11)	-	2	2	2	3
Office Asst. (N 1)	1	1	2	2	2
Public Relations (N 22)	1	1	1	1	1
Asst. Public Relations (N 17)	2	2	2	4	4
Publication Officer (N 41)	-	-	1	1	1
Asst. Public. Officer (N 17)	-	-	1	2	2
Personal Asst. (N 26)	2	2	3	3	3
Personal Asst. (N 22)	2	2	6	8	10
Audio/Visual (N 17)	1	1	1	2	2
Storekeeper (N11-17)	1	1	1	4	4
Librarian (S 48)	-	-	-	1	1
Asst. Librarian (S 27)	1	1	1	2	2
Accountant (W 52)	-	-	-	1	1
Asst. Accountant (W 36)	1	1	2	4	4
Audit (W 27)	-	-	1	1	1
Designer (B 38)	2	2	2	4	4
Illustrator (B 38)	2	2	2	4	4
Photographer (B 17)	1	1	1	2	3
Artist (J 22)	-	-	-	2	4
Charge-Man (R 17)	-	-	-	1	2
Workshop/Carpenter (R 9-22)	-	-	2	6	8
Driver (R 3)	6	6	8	16	20
Manual Worker (R 1)	8	8	8	15	25
Security (R 4)	-	2	4	6	8
Total	**85**	**105**	**159**	**221**	**268**

Opp page: The Kinta weed, *Papilionanthe hookeriana,* one of about two thousand orchid species in Malaysia.

6. PHYSICAL INFRASTRUCTURE

The estimated internal space requirement is 39,800 sq m (Table 6). Natural history museums everywhere are specially designed landmark buildings, but where the scientific collections have outgrown the available space, there is a trend for the scientific collections and laboratories to be moved out of the iconic main building to new buildings of plainer design. We recommend two separate designs for NHM Malaysia: an iconic landmark building for exhibitions and administration, and a plainer complex for collections and research. The designs should allow for effective security and easy maintenance, and incorporate the 'green standards' being devised and adopted internationally for buildings and grounds. Attention should be paid to energy and water conservation measures, the harvesting and use of rainwater, the composting of kitchen and garden waste, and ease of access by public transportation.

6.1 Requirements for the Exhibitions and Administration Building

The building to house exhibitions and administration should include an impressive lobby/ entrance hall with high ceilings, eight galleries for

exhibitions, rooms for seminars and meetings, studios and workshops for the preparation of exhibitions, restaurants/food courts, souvenir shops, bookshops, storerooms, and rest rooms. This building should cater for one million visitors per annum, with peaks on weekends and public holidays. For comparison, the Sarawak Museum has recorded up to 500,000 visitors in one year.

It is expected that the museum will attract high visitor numbers initially following its public launch. If there are no new exhibitions, visitor numbers are then likely to drop over the following two or three years. The museum should plan to launch new exhibitions every year and to refresh the permanent galleries in rotation, starting at about year five. The renewal of the galleries in phases should be approached as part of regular ongoing museum development. Hence, the exhibition galleries should be designed so that each gallery can be closed for renewal without in any way interfering with visitor flow and other activities. The lobby and seminar rooms should be accessible for evening functions. Passages and lifts should be wide enough for the movement of large exhibits. The building should be designed so that the administration part is internally separated from the public part.

The exhibition galleries must be air-conditioned at 25°C round the clock and protected from damp. The roof must be completely leak-proof and moisture-proof and the floor insulated from soil moisture. Ventilation and lighting must be completely controlled.

The restaurants/cafeterias, souvenir shops and book shops must be designed and located so that they contribute positively to the visitor experience. Good food and good shopping should be among the attractions of a natural history museum.

6.2 Requirements for the Collections and Research Complex

The collections and research building should be designed as a series of interconnected modules that can be added to from time to time. Visitors to these buildings will be mainly those with scientific business.

Each module will consist of two parts separated by a wide corridor. One side will accommodate the scientists, laboratories, offices, and specimen-preparation rooms, and provide a comfortable work environment, open to natural daylight through glass windows. The other side will be for the permanent storage of the museum's scientific collections, sealed off environmentally by close-fitting doors and totally shielded from UV light. It will have no windows. The lighting will be UV-free and only switched on when necessary. The internal climate will be maintained round the clock at 25°C and at 55% Relative Humidity. This part of the module will only be accessible to staff and visitors with special passes.

The interface between the two parts of each module should be carefully considered during the design phase so that access by the scientists to the collections is not hampered. The design of the Museum Support Centre (MSC) in Washington DC is close to the ideal. In the MSC, scientists only have to cross a dividing corridor to get to the collections.

Initially, two modules should be built, one for fauna and the other for flora. As the collection grows, more modules should be added without interfering with basic concepts.

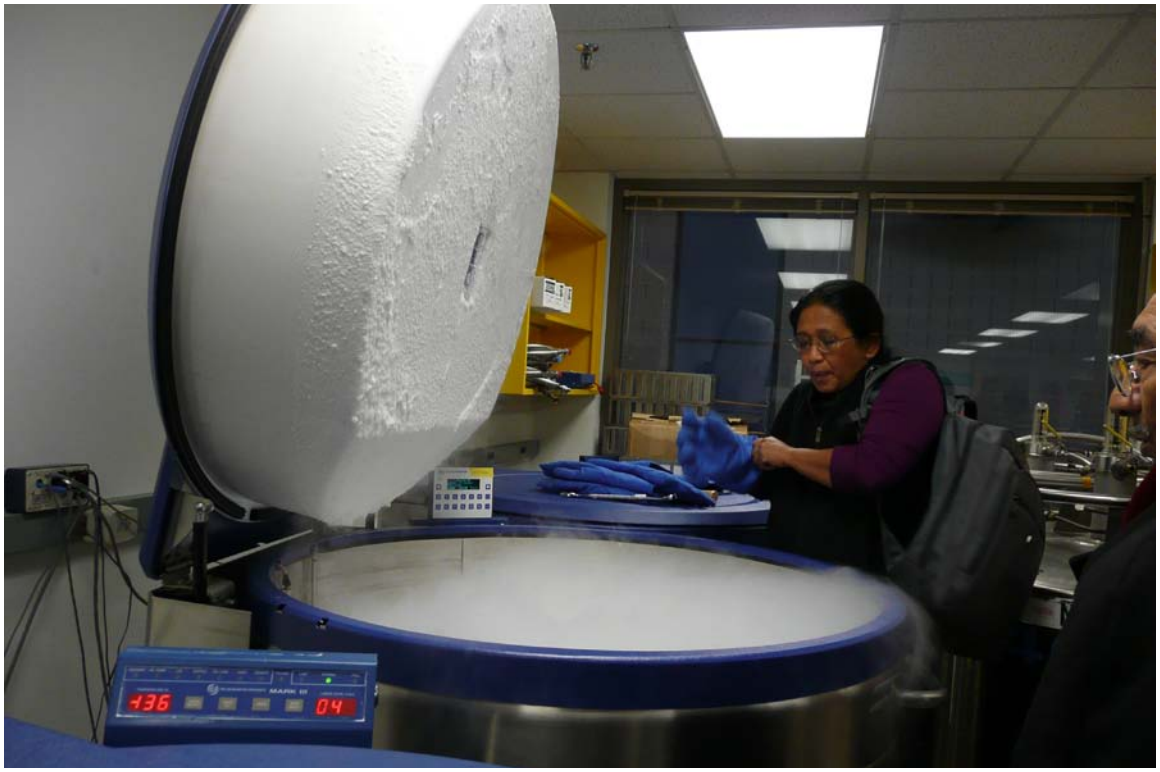

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Table 6. Space requirements

Exhibitions and Administration Building	
Public areas	space (sq m)
Lobby	200
Great Hall	1,500
Seven permanent galleries @ 1,500 sq m	10,500
Plants; mammals; birds; reptiles and amphibians; fish; invertebrates; minerals	
One seasonal gallery	1,500
Children's gallery	500
Workshops, studios, storerooms	3,000
Theatre for 500 persons	500
Four seminar rooms with movable partitions	500
Restaurants, canteens, shops	500
Rest rooms and miscellaneous	2,100
Restricted areas	
Administration and finance	2,000
Total	22,800

Collections and Research Complex	
Library/documentation/database/reading rooms	1,000
Rooms for 20 scientists @ 50 sq m each	1,000
Laboratory spaces for visitors, students and technicians	1,000
Molecular biology laboratory	500
EM and SEM laboratory	200
Specimen preparation area for plants	500
Specimen preparation area for animals	500
Scientific collections	
Herbarium	4,000
Fauna and minerals	7,500
Rest rooms and miscellaneous	800
Total	17,000
Grand total	**39,800**

Opp page, top: Bird's eggs at Muzium Negara, Kuala Lumpur.

Opp page, bottom: Facility for low temperature storage of tissue samples, at the National Museum of Natural History, Washington, D. C. demonstrated by staff member Nor Faridah Dahlan

7. BUDGET AND FUNDING MECHANISMS

We estimate that a development budget of RM400 m will be needed to establish the NHM Malaysia in five years, based on the breakdown in Table 7.

Table 7. Development Budget

	RM million
Buildings	120
Fixtures and fittings	20
Equipment	20
Development of exhibition galleries with purchase of exhibits	180
Contract staff	20
Manpower training	10
Support for Natural History Consortium and Accreditation System	20
Acquisition of the foundation collections	10
Total	**400**

The annual recurrent expenditure is expected to be:
Year 1: RM 5 m; Year 2: RM 7 m; Year 3: RM10 m; Year 4: RM 14 m; Year 5: RM 18 m.

The cost of the buildings is about RM 3000 per sq m. This is higher than normal buildings because of the need for special internal environmental controls, state-of-the-art fire and other safety features, and special requirements for electron microscopy and other laboratories.

The exhibition galleries must be ready on opening day. Exhibits that can be depended upon to make memorable impacts, such as dinosaurs, mammoths, and whales are expensive. The leading museums of the world have all found that the development of an exhibition gallery requires an experienced team about three years of intensive work. Our estimate of RM180 m for the development of exhibitions in a combined area

Children on a discovery tour at the Botanic Gardens, Singapore.

of 14,000 sq m (the Great Hall and all the galleries) is equivalent to about RM12,900 per sq m. For comparison, the average cost of exhibition galleries in NHM London is about at £1,500 per sq m. Most of the materials and skills will have to be imported in Malaysia.

The budget item under Contract Staff, of RM20 million, is for the hire of staff on 1 – 5 year contracts while permanent staff are being recruited and trained. Contract staff will be experienced and senior staff already equipped with the required expertise for their jobs. They will play the all-important roles of establishing the museum, recruiting and training permanent staff, and laying the foundations for future success.

The new museum will have to initiate a crash programme to acquire a sizable 'foundation' collection of natural history specimens representative of major habitats and life forms in Malaysia. Expeditions will have to be organized in collaboration with partners in the Natural History Consortium.

Natural history collections demand state-of-the-art maintenance. In Malaysia's climate, any decline in maintenance, even for a few months, will have serious consequences on the collections. The cost of maintaining the collections will increase from year to year as the collections increase in size. Hence the budget for the new museum must include provisions for an annual increase proportionate with the rate of growth of its collections and exhibitions and to cover the cost of maintaining the buildings and facilities.

The museum should be funded primarily by the Government as a public institution responsible for what will become the growing and increasingly valuable national scientific heritage collections. The Natural History Museum in London and the National Museum of Natural History

of the Smithsonian Institution in Washington DC are similarly funded by their national governments. However, they are also supported by the public. These museums have found that members of the public respond positively when given the opportunity to share in the museums' development and mission.

If the museum is located in a central location within easy reach of a large population of residents and visitors, it can and should, after establishment, aim for at least 30% of its annual expenditure to be met from its own fund-raising and income-generating activities.

Provision should be made for the new museum to

- solicit and receive gifts, donations and endowments
- establish a membership system
- earn income in various ways, e.g. entrance tickets; renting out of space, materials, exhibits and facilities; and operation of food outlets, bookshops and souvenir shops

Birds of Southeast Asia, at the Naturalist, Leiden

8. LOCATION

The leading natural history museums are easily accessible to the public. In Washington, London and Leiden, the museums of natural history are close to other scientific and cultural institutions, to form national complexes for science, culture and learning. The location of a natural history museum should take into account the desire of visitors to fit two or more experiences into one day, e.g. a museum visit plus shopping, or a business meeting plus museum plus shopping. A poor location will have a serious dampening effect on the number of visitors and make it difficult for the museum to sustain good visitor facilities.

We recommend a location that has room for modular growth of buildings in the future and for the development of a biopark. An area of about 50 ha would be ideal. For comparison, the Botanic Gardens Singapore occupies 52 ha and is within walking distance of the business, shopping and entertainment complexes of Orchard Road.

Possible locations are

- Federal Hill (Bukit Persekutuan)
- Bukit Kiara
- Putra Jaya

Of these, Federal Hill, close to the heart of Kuala Lumpur, would be most ideal. The large size of the resident and visitor population in Kuala Lumpur will ensure that the high investment needed to stage world class exhibitions will be supported by the maximum number of people.

Insects of the world, in the NHM, London, demonstrated by Max Barclay (left) and Howard Mendel (right).

Dipteris lobbiana, one of hundreds of fern species in Malaysia.

9. PROJECT DEVELOPMENT

9.1 The interim period prior to the 10th Malaysia Plan

In the interim period before the 10th Malaysia Plan, a project management team should be established by the Ministry of Natural Resources and Environment to

- facilitate the drafting of the Act to establish the Natural History Museum Malaysia
- acquire the site
- initiate the development of the master plan, the building designs, and the tender process
- establish temporary quarters until the new buildings are ready
- initiate the establishment of the Natural History Consortium and Accreditation System

9.2 Medium-term development under the 10th Malaysia Plan

In the medium term, which will coincide with the 10th Malaysia Plan, the following activities should be in place:

- award of contracts for work on buildings and grounds
- hiring, deployment and training of staff according to the human resources plan
- planning and design of exhibition galleries and sourcing of services and exhibits

- occupation of the completed buildings in Year 3 of the Plan Period
- installation of equipment and exhibits in Year 3
- installation of the scientific collections and commissioning of laboratories in Year 3
- official opening of the exhibition galleries in Year 4
- launching of research programmes in Year 4
- establishment of membership and fellowship systems in Year 4
- launching of the scientific publication programme at end of Year 5

Starting in Year 5, the museum should gear itself to a cycle for redevelopment of galleries at one gallery per annum and one new temporary exhibition per annum.

The seladang, (*Bos gaurus*), in Malaysia

9.3 Long-term development

Since each gallery will take an average of three years to plan and implement, NHM Malaysia should target, by its 8th year, the capacity to plan and develop three or more exhibitions simultaneously.

NHM Malaysia should aim to attract gifts of scientifically valuable specimens from individuals and institutions and to undertake initiatives to increase public knowledge via public contributions, e.g. the establishment of a virtual museum of public-contributed digitized / photographic images. This will require the establishment of a good reputation for managing resources for the public good.

Natural history museums are respected worldwide for their ability to provide educational experiences at preschool, school, and adult levels. NHM Malaysia will deliver the benefits of continuing life-long education to all levels of society. In addition, some sectors of the economy will get a very special boost, e.g.

- tourism, because NHM Malaysia will share in the global reputation

of natural history museums as premier tourist attractions
- higher education, because the comprehensive collections in NHM Malaysia will enable Malaysian universities to offer world-class tropical biodiversity programmes
- economic development, because NHM Malaysia's growing expertise on natural resources will be available to support the information needs of a growing economy

9.4 International review

At the end of the first five-year plan, there should be a review of NHM Malaysia to assess how it is progressing towards becoming "a world centre of excellence in conservation, research and utilization of tropical biological diversity", and to recommend adjustments where needed. The Review Team should include local and overseas experts covering the major functions of (i) collections management, (ii) scientific research, and (iii) exhibitions / public outreach. The reviewers may also be invited to review human resources development and other matters that the Board of Directors may decide upon. Measurable indicators that should be examined by the Review Team should include the following:

Collections management:
- physical condition of the specimens and their storage facilities
- progress of computerization of collections data
- size and coverage (taxonomic and habitat) of collections
- effectiveness of the Natural History Consortium

Scientific research:
- programme of research
- number of peer-reviewed publications by staff and associates
- number of visiting scientists using the collections each year
- number of students using the collections for thesis research

Exhibitions and public outreach:

- number of visitors to the exhibition galleries each year
- amount of financial support from the public (donations, fees, sales, etc)
- growth of membership

The frequency of future reviews should be decided by the Board of Directors when they assess the outcome of the first review.

9.5 Development timelines

The great hall of the Field Museum, Chicago.

The proposed development timelines and milestones are indicated in Table 8.

Table 8. Development timelines and milestones

			10th Malaysia Plan					
Activity	**-2**	**-1**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Years 6 to 2020**
Appointment of Project Manager and core management team								
Drafting of the Act								
Acquiring the site								
Preparing master plan and building designs, and tender processing								
Occupation of temporary quarters								
Establishment of Natural History Consortium								
Awarding of contracts for buildings and grounds								
Hiring, deployment and training staff								
Planning exhibition galleries and sourcing for services and exhibits								
Occupation of completed buildings								
Installation of equipment and exhibits								
Installation of scientific collections and commissioning of labs								
Launching of exhibition galleries								
Implementation of research programmes								
Implementation of membership and fellowship system								
Redevelopment of permanent galleries								
Development of temporary exhibitions								
Implementation of scientific publication programme								
International review								

10. NATIONAL AND GLOBAL SIGNIFICANCE OF THE NATURAL HISTORY MUSEUM MALAYSIA

The Natural History Museum Malaysia, as the national centre for reference materials, information, and expertise in biological diversity, will strengthen Malaysia's ability to sustainably manage and benefit from its rich biological resources. It will provide a whole range of services that existing institutions cannot provide.

The scientific resources and knowledge needed for global management of biological diversity have always been concentrated in countries with long-established natural history museums. Malaysia's entry as a major player in biological diversity research will strengthen global understanding, management, and utilization of biological diversity, and help ensure that tropical concerns are well-addressed in global biological diversity and environment management.

Herbarium of the Forest Research Centre, Sandakan

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Monophyllea hosfieldii, an endemic species bearing one leaf per plant

Bukit Takun, a limestone hill in Selangor

Appendix 1

REVIEW OF NATURAL HISTORY COLLECTIONS IN MALAYSIA

Introduction and overview

There is no institution in Malaysia dedicated fully to natural history, but there are 22 institutions that maintain natural history collections (Table 1). Collectively, these 22 institutions hold about three million specimens. Each institution is defined by region as Peninsular Malaysia, Sabah or Sarawak, and by sector such as health, forestry, fisheries, agriculture, wildlife and culture. No institution has overview of the biological diversity of Malaysia as a whole.

Natural history collections in Malaysia were established primarily to provide identification services. When a specimen has been identified by an expert who has been able to match it against a type or other authenti-

cated specimen, such a specimen itself serves as an authenticated specimen for the identification of other specimens. It takes a lot of time and effort to get a collection identified. An identified collection is an invaluable reference tool, not only for the identification of new specimens, but also as a record of what existed where and when. For example, a collection of fishes from the waters of Sabah made 50 years ago would contain information about the fishes and waters of Sabah 50 years ago that would not be available from any other source. Even if a book has been written on the fishes of Sabah, the book cannot substitute wholly for the specimens, because specimens are real whereas a book is an interpretation.

In our review, we found the state of collections management in Malaysian institutions to range from fairly good in some places to deplorable in others. The upgrading of standards in collections management requires urgent national attention, otherwise some priceless reference collections will be lost forever. The international standard is for museum collections to be kept at constant low temperature and humidity, totally protected from sunlight, and free of fungal and insect pests, at all times.

The role of exhibition and public education is being undertaken with energy and enthusiasm at various institutions. The Forest Interpretation Centre of the Forest Research Centre in Sabah and the Rainforest and Environment Exhibition Gallery at the University of Malaya are outstanding examples. Both facilities are relatively new and spacious. Older exhibition galleries such as those at the Institute for Medical Research and the Zoological Museum at the University of Malaya suffer from lack of space. The major museums in the world have placed exhibitions in the hands of full-time specialists, but exhibitions in Malaysia are still amateur efforts.

INSTITUTE FOR MEDICAL RESEARCH, KUALA LUMPUR

Date of visit: 17 October 2007

The Institute for Medical Research (IMR), funded by the Federal Government, was established as the Kuala Lumpur Pathological Institute in 1900 by order of Sir Frank Swettenham, then head of the British Administration, to carry out research on tropical diseases—causes, prevention and cure. The natural history collections in the IMR consist of animals that have actual or potential impact on human health as pests, disease carriers, or hosts of potential diseases.

Mosquito specimens

The IMR established a Biomedical Museum in 1954. This has two small galleries for displaying small vertebrates: mammals, birds, snakes and frogs. Entrance is free.

The insect collection, consisting of mosquitoes, flies, cockroaches, fleas, bedbugs and other insect pests and vectors, is kept in the Entomology Unit. This

IMR Heritage building

collection dates back to the beginning of the IMR in 1900. The collection was important enough that during the World War II, it was packed up and sent, first to Singapore, and then to Australia, ahead of the Japanese Invasion. After the War, the collection was returned to the IMR.

The natural history collections are housed in old buildings which have

been gazetted as heritage buildings. The rooms are small and already crammed from floor to ceiling. There is no space for expansion. Because of their heritage status, the buildings cannot be renovated to meet the requirements of a modern museum. There is also little or no funding for collection of new specimens.

The natural history collections are used mainly for identification and teaching. The identification function provides critical identifications of pests and vectors. The teaching function is associated with the SEAMEO-TROPMED programmes in applied parasitology, entomology and acarology. These six-month courses are held annually and students come from all over the tropics, especially from tropical Asia.

New species are confirmed at the National Museum of Natural History of the Smithsonian Institution in the US, by taxonomists who have established a relationship with IMR. An older working relationship with NHM London has lapsed.

Top: Storage room for insects
Below: Exhibit of birds

Natural History Gallery

SABAH MUSEUM, KOTA KINABALU

Date of visit: 29 October 2007

The Sabah Museum is funded by the State Government of Sabah. The museum concentrates on the cultures of Sabah, and on the interaction of culture with the natural environment. The grounds, in Kota Kinabalu, cover 43 acres. Within the grounds are the main Museum building, a separate building housing the preparation rooms, another building for the Museum of Islamic Civilization, an ethnobotanic garden, and a heritage village (Kampung Warisan).

Preparations room

In the main building, the entrance foyer displays the skeleton of a Bryde's whale recently beached in Sabah. Upstairs are cultural galleries displaying handicrafts, ceramics, musical instruments, woven materials, tools and other cultural artefacts, complemented by natural history galleries displaying mammals, birds and insects. There is a display of plants that have played or continue to play significant roles in the lives of the people.

The annual operational budget of about 11m, increasing at the rate of

about 10% per annum, is provided mainly by the state government. The museum employs a taxidermist. Identification work is done by parataxonomists. The museum earns about RM0.75 m per annum from entrance tickets. There is a shop for books and souvenirs, operated privately by a concessionaire. The museum promotes local handicrafts by holding a Craft Exotica exhibition annually at the Kampung Warisan.

Bryde's whale in the great hall

The Wet Collection

THE NATURAL HISTORY MUSEUM OF UNIVERSITI MALAYSIA SABAH (UMS), KOTA KINABALU

Date of visit: 29 October 2007

The natural history collections of the Universiti Malaysia Sabah are used to support research and teaching. There are four large collections rooms: for insects, vertebrates, herbarium, and wet collections. The rooms are modern and spacious, with state-of-the-art compactor shelves, 24-hour air conditioning, dehumidifiers, dust filters, automatic fire extinguisher system, automatic sliding doors, etc. Much of the equipment was donated by Japan through the Japan International Cooperation Agency (JICA). The specimens are databased using a data management software system MUSEBASE developed in Japan by Fujitsu, based on MUSETHEQUE, a system used by many museums in Japan.

Students using the Herbarium

FISHERIES RESEARCH INSTITUTE, KG LIKAS, KOTA KINABALU

Date of visit: 30 October 2007

The Fisheries Research Institute

Below: The fish collection

This Institute is funded by the State Government of Sabah. It houses a large collection of fish, in hundreds of museum glass jars. The collection, representing the physical evidence of the condition of fisheries in Sabah going back 50 years or more, together with the records left by the collectors, are irreplaceable scientific data for interpreting the fisheries environment in Sabah. We found the collection in an open-sided shed at the back of the Institute, without air conditioning and exposed to strong side light. All the specimens have been irreparably bleached by sunlight.

The fish collections

In the Herbarium

FOREST RESEARCH CENTRE, SEPILOK, SANDAKAN

Date of visit: 30 October 2007

The Forest Research Centre is part of the Forestry Department of Sabah, funded by the state government. It holds three natural history collections: herbarium (plant collection), xylarium (wood collection) and insect collection. In 2007 it opened an attractive exhibition centre, known as the Forest Interpretation Centre, within a landscaped garden of rare and interesting plants.

The Wood Collection

The herbarium has had a history of disasters. It was originally located within Sandakan town. This was destroyed in 1945, by wartime bombing. The second time, in 1961, it was destroyed by a fire spreading from a nearby factory. The first 10,000 collecting numbers were lost in these disasters, but their duplicates survive in other parts of the world. The herbarium


NO PARKING

Entomology display

Opp page: The Herbarium Building

has now grown to over 250,000 specimens and is housed in a new modern building equipped with locally-made compactor shelves. There are over 400 type specimens, which are kept separately in a cabinet for types. The herbarium and its two research officers are active participants in research under the Tree Flora of Sabah and Sarawak project.

The wood collection was started in the 1940s and contains over 4,000 specimens of wood representing 1,000 species, 400 genera and 96 families.

The entomological collection, started in the 1940s is managed by two research officers. New species are described with help from the Natural History Museum London.

SARAWAK BIODIVERSITY CENTRE (SBC), SEMENGOH, KUCHING

Chemicals Extraction Laboratory

Date of visit: 31 October 2007

The SBC is a corporation set up and funded by the State Government of Sarawak. It has 27 research officers, mostly working in the chemistry laboratory. Its natural history collections are obtained from two sources: inventory projects and documentation of traditional knowledge. The SBC carried out an inventory of the Bau Limestones which resulted in a collection of 3,910 plant and 11,062 animal specimens. The traditional knowledge documentation has yielded thousands of plants for chemical analysis and 230 species for growing in the Laila Taib Ethno Garden. Many of the plants in the Laila Taib Ethno Garden have never been seen in cultivation before and some are new species.

In the Chemistry Lab, chemicals are extracted from plants and stored dry in vials. Each extract is cross-referenced to a plant specimen in the herbarium. Correct identification of the plant is vital for identifying the source of the extract, but identification is hampered by shortage of botanical expertise in Sarawak.

Laila Taib *Ethno Garden*

The work room

SARAWAK MUSEUM, KUCHING

Date of visit: 1 November 2007

Bird specimens

The Sarawak Museum, established by Charles Rajah Brooke in 1891, is the oldest museum in Malaysia. It is funded by the state government. It covers culture, history and natural history, but the natural history part has been gradually diminished. The plant collection was transferred to the herbarium of the Forestry Department in 1970. The animal collection has remained at the museum but this collection may be split up, with the research collections transferred elsewhere, leaving only the exhibition specimens in the galleries.

The dry research collection of animals is housed in a building dedicated to this purpose—the Natural History Building. This has a large working room and many wooden cupboards. Small specimens fill the drawers. Large specimens like crocodiles are stored on top of cupboards and under the tables. This collection has been worked on by many generations of visiting scientists, making the Sarawak Museum an important reference centre for scientific work in the tropics. The building is air conditioned during the

day but not at night. There is one post each for curator of natural history, assistant curator, and taxidermist.

The wet collection, consisting of thousands of bottled specimens, is kept in an old house where it is protected from rain, but the house itself is a wooden building in dilapidated condition. There are plans to move the collection to the Forest Research Centre for safe-keeping. Considering that this collection has a history of more than 100 years, its safety and management should be a matter of great concern.

The public galleries are in the main building. The natural history section displays mammals, birds, reptiles, fish, mollusks and other animals. The museum attracts up to 500,000 visitors per annum, of whom about 150,000 are tourists from overseas. There is no entrance fee but there is a collection box for donations. There is a small shop in the museum operated by a concessionaire.

Left: The Wet Collection
Right: Display of birds

Top: Insect Collection
Mid: The Herbarium
Bottom: Databasing specimens

FOREST RESEARCH CENTRE, KUCHING

Date of visit: 1 November 2007

The Forest Research Centre, formerly the research arm of the Forestry Department, is now administered by the Sarawak Forestry Corporation. It houses a large herbarium, a large collection of insects, and a collection of fungi including specimens of wood fungi. There is a separate wood reference collection kept at the Timber Technology Laboratory in another location in Kuching.

The herbarium collection, managed by one research officer, is the oldest plant collection in Malaysia, with specimens as old as 120 years, transferred to it from the Sarawak Museum. The herbarium holdings include 200,000 mounted sheets and a wet collection of 2,000 specimens. The type collection, of 1,500 plant specimens, is the largest and oldest in Malaysia. The herbarium and its staff are active participants in the Tree Flora of Sabah and Sarawak project.

The entomology collection is managed by two research officers. It includes the canopy insects collected by a Japanese project at Lambir.

There is a small collection of fungi and bryophytes.

FACULTY OF RESOURCE SCIENCE AND TECHNOLOGY, UNIVERSITI MALAYSIA SARAWAK (UNIMAS), KUCHING

The newly equipped herbarium

Date of visit: 2 November 2007

The Faculty of Resource Science and Technology has a herbarium managed by two botanists, and an insect collection managed by one entomologist who specializes in microlepidoptera. A start has also been made to establish a vertebrate collection. The campus is new and the laboratories and collections rooms are spacious and well-equipped. The collections are used for courses in biodiversity assessment,biogeography, phylogenetics, systematics, water management and wildlife ecology.

Right: A collection of micro-lepidoptera
Overleaf: A collection of bats

FOREST RESEARCH INSTITUTE MALAYSIA, KEPONG

Date of visit: 12 November 2007

The Forest Research Institute Malaysia is funded by the Federal Government. Its herbarium dates back to about 1918 and now houses about 300,000 specimens, mostly of forest plants of Peninsular Malaysia. This herbarium has been a centre of taxonomic research ever since its establishment. Its first significant taxonomic publication was C.F. Symington's Foresters' Manual of Dipterocarps, published in 1941 during the Japanese Occupation of Malaya. From the 1960s to 1980s it was the centre for the Tree Flora of Malaya, published in four volumes under the leadership of Dr T.C. Whitmore and Dr Francis Ng. It is now the centre for the production of the Tree Flora of Sabah and Sarawak, headed by Dr E. Soepadmo, now in its sixth volume, and the new Flora of Peninsular Malaysia, headed by

Wood Collection

Dr Ruth Kiew, that will replace the outdated Flora of the Malay Peninsula produced by H.N. Ridley in the 1920s. The herbarium has just recruited 10 new botanists and will soon be moving a new herbarium building with twice the capacity of the present herbarium.

Top: The Herbarium Collection
Bottom: Dr Lee Su See explaining the Fungus Collection
Opp: The Botanic Garden

The Entomology Laboratory specializes in studies on termites, butterflies and fireflies. It has a collection of dry and wet insect specimens. Termites are major pests of timber, while fireflies have made their habitat in Kuala Selangor a world-famous ecotourism attraction.

The Mycology Laboratory was set up for research on fungal pathogens of trees and timber and on forest mycorrhizae. It houses a growing collection of macrofungi but the storage facilities are improvised and cramped. There are no fungal taxonomists in Malaysia to deal with the wealth of fungal diversity.

The Wood Anatomy Laboratory houses about 10,000 timber and bark samples cross-referenced to voucher specimens kept in the herbarium. The collection is managed by two research officers and supports the identification and training services of the laboratory. About 20 persons are trained each year in this laboratory in timber identification for the timber industry.

The Institute is located in a spacious forested campus, part of which is being developed into a Botanic Garden. In the forested area there is a stand of trees of kapur, *Drybalanops aromatica*, that has become world famous as the icon of *crown shyness* in the forest canopy. The campus is open to the public as a recreational park. An entrance fee is charged.

INSTITUTE FOR BIODIVERSITY, DEPARTMENT FOR WILDLIFE AND NATIONAL PARKS (PERHILITAN), BT RINGGIT, KRAU GAME RESERVE, PAHANG

Date of visit: 13 November 2007

The Insect Collection

This museum is new and attractively laid out. It is funded by the Federal Government as the research arm of the Department for Wildlife and National Parks. It houses a research collection of vertebrate specimens including mammals, amphibians and reptiles, birds and fish and an insect collection. The museum collection was started in 1989. A bigger facility is being planned for which RM25 m has been allocated. The museum has five posts for

Skin of a python

research officers. Nearby is the Elephant Centre which houses elephants captured in areas where they have come into conflict with people. The capture, translocation and upkeep of such elephants are major activities of the Department. The elephant centre attracts about 10,000 visitors a year.

The Bone Collection

Left: Herbarium
Right: Bryophyte Collection

THE SCHOOL OF BIOLOGICAL SCIENCES, UNIVERSITY OF MALAYA, KUALA LUMPUR

Date of visit: 14 November 2007

A bryophyte specimen

The museum facilities in the University of Malaya are basically for teaching and research purposes, but there is a Rainforest and Environment Exhibition Gallery which was opened in year 2000. The exhibition is bright and spacious and attracts 10,000 visitors a year. Entrance is free.

The herbarium is modern and holds about 100 type specimens. The voucher specimens of the KL series supporting the Phytochemical Survey of Malaya are preserved here. There is also a large bryophyte collection, probably the largest in the country.

There is a herbarium of seaweeds and seagrasses in another part of the building. This is the largest collection of seaweeds and seagrasses in the country.

Nearby is a conservatory with an impressive living collection of slipper orchids and other rare plants.

The Zoology Museum is in a small four-storey building. The ground floor houses the wet collections of invertebrates, fishes, frogs and reptiles; the first floor is for exhibition; the second floor for entomology, parasites (as wet collections) and hard corals; the third floor is for birds and mammals. Compared with the botanical collections at the University, the zoological collections are poorly funded, and the space is totally inadequate for proper storage, display, exhibition and interpretation.

Rainforest and Environment Exhibition Gallery
Bottom: The Faunal Collection

The Insect Collection

NATIONAL REPOSITORY FOR AGRICULTURAL PESTS, DEPARTMENT OF AGRICULTURE, KUALA LUMPUR

Date of visit: 28 January 2008

The Department of Agriculture manages the National Pest Repository for pests of agriculture, including insect pests, weeds, plant pathogens and nematodes. The collection was started in about 1939. Its oldest specimen is a weed collected by H.N. Ridley in 1892 from 'the Cottage' at Taiping. The data on the insect collection are being been entered into a database using the program ACCESS. The Repository will be moved to Serdang in 2009 to the new Department of Agriculture Complex now under construction.

Above: Collection of paintings of insect pests of agriculture
Right: Painting of a pest life cycle

The Department has a small one-room exhibition gallery on agricultural pests, which is open upon request.

The Repository is responsible, under Malaysia's WTO commitments, for surveillance of pests in agricultural products for export. To fulfil its commitments, it has to be able to identify pests, but with the retirement of experienced staff, there has been a loss of taxonomic expertise for the identification of pests and weeds.

SCHOOL OF ENVIRONMENTAL AND NATURAL RESOURCE SCIENCES, UNIVERSITI KEBANGSAAN MALAYSIA, BANGI

Date of visit: 29 January 2008

The School of Environmental and Natural Resource Sciences maintains botanical and zoological collections. The botanical collections cover higher plants, ferns, mosses and algae, and include 27 type specimens. The animal collections cover vertebrates and invertebrates and there has been particular interest in entomology. A journal of entomology *Serangga* is published here with financial support from the Muzium Negara.

There is a small zoological museum which, due to lack of space, spills over into the corridors and passages.

The university is situated beside the

Bangi Forest Reserve and 100 ha of this forest has been designated as the University Forest. There is a fern garden of 7 ha established within this forest.

The staff are concerned about the poor state of the facilities under which they have to work. During our visit, there was a power failure and this has been a recurrent event for years. The walls of the building are mouldy, and the animal specimens are in poor shape, with hair dropping off from the preserved skins.

Loss of experienced staff is a serious problem. As the staff retire, their positions have been left vacant. In the corridor are many boxes of plant specimens from Sabah that used to be housed in the herbarium of the University's branch campus in Sabah. These were moved to Bangi when the branch campus was closed over ten years ago. Owing to shortage of staff, the specimens are still in their boxes, unavailable to scientists who want to work on them.

Left: Herbarium
Right: Vertebrate Gallery

MUZIUM NEGARA, KUALA LUMPUR

Date of visit: 3 March 2008

The natural history gallery of Muzium Negara has been dismantled and the exhibits are now kept in storage pending the development of a new building for natural history. However, because of insufficient financial allocation, the building has not been constructed and there has been no progress in the past few years. The museum has five curators for natural history: three for fauna, one for flora and one for minerals. Its collections include gifts from by private collectors, e.g. a collection of butterflies by H.R.M. Storey and a collection of bird's nests and eggs, various mounted vertebrates and a wet collection of fish. The museum also holds natural history specimens confiscated by the authorities, which have to be kept as evidence in court.

Left: A tapir in storage

The Wet Collection

Mounted small mammals

The number of visitors to the museum has varied greatly between years. In recent years, the highest figure was 737,600 in 2002, and the lowest was 161,200 in 2004. There is an entrance charge of RM2 per person, but school children are exempted. The museum is closed one day a year, on Hari Raya Puasa. On other days, it is open from 9 am to 6 pm.

Appendix 2

STUDY OF MAJOR NATURAL HISTORY MUSEUMS

INTRODUCTION AND OVERVIEW

The Consultancy Team made a study tour of four major museums of natural history in December 2007. The museums were the Field Museum in Chicago, the National Museum of Natural History of the Smithsonian Institution in Washington DC, the Natural History Museum in London and 'Naturalis' in Leiden. These four museums are situated in prime locations in their respective cities, close to commercial, cultural or educational centres.

Museum funding

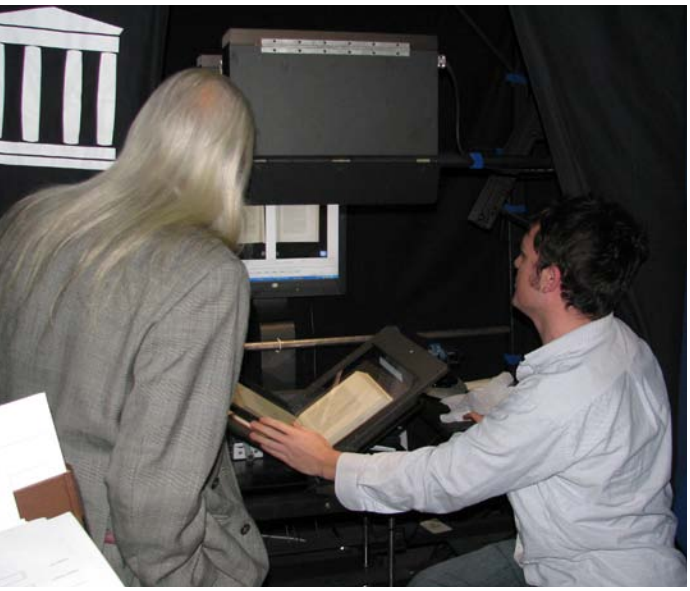
The Field Museum is a non-government organization financed by funds raised by the Museum itself. The other three are financed by their

respective national governments, though all are engaged to some extent in fund-raising activities.

Museum core activities

All these museums are engaged in three core activities: scientific research, collections management, and exhibition. Exhibition is their most visible activity, but it is scientific research that gives a museum authority and credibility. The scientific collections in a museum enable scientists to work on materials from all over the world and from different periods in time. All the museums are involved, in association with universities, in advanced training of scientists.

Biodiversity literature being scanned for global free access on the Web under the Biodiversity Heritage Library (BHL) Project, at the Natural History Museum, London



Exhibition

In all the four museums, exhibition and associated public outreach and educational activities are managed by full-time professional staff with expertise in events-management, designing, writing, graphic arts, model-making, education, public relations and information technology. The research scientists act as content advisors to ensure the scientific accuracy of all museum productions. Museums have found that people think and learn in many different ways. Museum exhibitions have to use "specimens, models, dioramas, hands-on activities, videos, animations, artists' renderings, and audio components geared to communicate complex messages succinctly and clearly while accommodating a wide variety of learning styles" (quote from the 2006 Annual Report of the Field Museum). To encourage repeat visits by the public, special temporary exhibitions are staged throughout the year to complement the permanent exhibition galleries, but permanent exhibitions are also reviewed and renewed regularly. The

busiest museums arrange lectures and other special events every week. In addition, all the museums maintain active websites. The major museums take pride in the variety and excellence of the experiences they offer, and in their ability to engage people of all ages, from preschool children to senior citizens. Judging from the crowds of visitors, museum exhibitions are holding their own successfully against shopping malls, amusement parks and other facilities competing for public attention. In a study on credibility in the US, museums have been rated the most trusted of public institutions. This is testimony to the ability of US museums to combine show-business professionalism with scientific excellence.

A laboratory at the Field Museum, Chicago

Collections management

At Naturalis, research and collections management are separate departments of the museum. In the other museums, research and collections management are combined. However, the new buildings specially designed to house the natural history collections at the Natural History Museum in London (Darwin Centres One and Two) and at the National Museum of Natural History in Washington (Museum Support Center) are indications of increased emphasis given to collections management. There are many reasons for the increased emphasis. Type specimens are irreplaceable. Many species no longer exist where they used to exist. Some are extinct. The preserved specimens are records of the prevailing conditions at the times and places where they lived. A time-series of specimens provides a record of how changes in the environmental have affected a species or community of organisms. For example, scientists have discovered, from preserved museum specimens, that the eggshells of predatory birds have become thinner since the widespread introduction of pesticides in agriculture. The effects of climate change are also captured in museum collections in various ways. Classic examples are trees with growth rings reflecting the environmental conditions prevailing for every year of their growth. Hence museum collections enable scientists to decipher environmental and other trends that may have regional and global security implications.

Since museum specimens are real specimens, the information they contain are forever fixed, to be extracted as and when new tools are developed. Until the mid-20th Century, scientists could only study specimens with magnifying glasses and microscopes. Then scanning electron microscopes were invented, and more information could be extracted from the specimens. With the development of refined chemical techniques, even very small samples could be chemically analysed. Now, with new molecular techniques, molecular and genetic information can be extracted.

Public engagement: the President of the Field Museum addressing supporters (members) of the museum at the book launch of Birds of Peru

The collections continue to yield information and become more valuable with time. However, the scale of complexity of biodiversity is such that no major museum has enough scientists to work on all its collections. There are large collections that have not yet been sorted, because each new expedition results in collections that take many years to work through, and there are not enough scientists for the task. All museums depend on visiting scientists to complement the museum's own scientists in deciphering and interpreting their collections. Collections management involves not only maintaining collections in pristine condition so that no information is lost, but also in getting specimens to the scientists who can interpret them, and making it possible for visiting scientists to work comfortably and efficiently on the collections.

Playlab at the Field Museum—a gallery for children

Scientific research

In the core area of scientific research, the pressures on museum scientists have increased greatly in recent years. The scientists employed for research are required to be world leaders in their respective fields of research, to win competitive research grants, and to attract circles of research associates, students and volunteers around themselves. This is the principle of

leverage as applied to science. In the past, the bulk of museum science was in the documentation of biodiversity but now, museum scientists are expected to enquire into the origin and significance of biodiversity and to improve our understanding of the forces of change. Scientists are evaluated on the impact of the papers they publish, and this has had a major effect on the questions that scientists choose to work on. The major museums now recruit scientists very selectively, for qualities of scientific originality and leadership. At the same time, the research scientists are held responsible for the scientific content of the museum's exhibitions and public outreach activities.

Fossils for children to handle

Museums in the information revolution

Modern science is based on the premise that knowledge is most reliable and beneficial to society when it is open, transparent, and publicly accessible. However, there was a limitation to accessibility due to the cost of storing, multiplying and distributing paper documents. This limitation has now been removed by advances in digitization of information and by the global reach and power of the Internet. (See box 4)

The most exciting prospect is that all of the world's scientific literature, beginning with the old classics that used to be carefully guarded in the great libraries, are being digitized and made available freely to the public on the Internet.

In May 2007 a web-based initiative, called the Encyclopedia of Life, was launched by a consortium consisting of the Smithsonian Institution, the Field Museum, Harvard University and others. It is a global effort to document all 1.8 million species of living things on the Web. There will be

An ancient 'herbal' of medicinal plants, pressed, dried and preserved for reference

a web entry for each species, consisting of text, video, photographs, sound, location maps and other information as available. The encyclopaedia will be built on the expertise and integrity of thousands of experts around the world in a wiki-style environment. The MacArthur Foundation and Sloan Foundation have provided USD12.5 million to support the enterprise.

Museums in public engagement

Where museums are funded by government, the public tends to be passive beneficiaries. The Field Museum is exceptional in that it is not funded by the national government. The local government in Chicago provides about 30% of its funding but the museum has to raise the rest by a very active public engagement programme. The degree to which

the people of Chicago identify with their museum and take pride in supporting it is quite remarkable. Other museums are not as driven in their public engagement programmes but all depend on volunteers and 'members' to support the museum and help run the museum's activities.

Museums in the 21st century

Far from being 'museum pieces' themselves, the major museums have become thriving scientific, cultural, and educational establishments. A visit to the national museum of a country reveals more about the state of science, culture, and education in the country than almost anything else. It is clearly apparent that the strength of the major natural history museums rests on their reputations as scientific institutions. A museum's scientific reputation gives it public credibility and attracts financial support.

The tradition in all the major museums is for the research scientists to determine their own research programmes and to take personal responsibility for them. The organization influences the direction of research only in broad terms, e.g. by defining the geographical context (Netherlands and Southeast Asia in the case of Naturalis), by defining the fundamental research questions (in the case of the Natural History Museum London) and by differential allocation of resources (more for zoology than botany in the case of the Field Museum). Increasingly, research positions are being internationalized in order to obtain the best candidates. Self-driven scientists with a passion for scientific discovery and the ability to inspire others, are in great demand.

There is a global revolution in data management, which will result in the world being flooded with scientific data that used to be inaccessible. This will benefit countries with the institutional capacity to put

globally-available data to good use. All countries aspire to be part of the Knowledge Economy, but countries without institutional capacity will miss out completely. Natural history museums are key institutions in the Knowledge Economy. They generate knowledge and raise the level of scientific literacy in a country. No other institutions set themselves the target of educating all levels of society from young children to senior citizens. No other institutions enjoy as much public credibility as natural history museums. Such credibility has been earned by the great museums through hard work, good management, and world-class science.

THE FIELD MUSEUM, CHICAGO

Dates of visit: 3 - 7 December 2007

Foundation, Location and Public Significance

The Field Museum was established in 1893 with an endowment of USD1 million from a businessman, Marshall Field. The Museum is housed in a massive square building with seven floors, two of which are underground, at the edge of Lake Michigan, close to the commercial centre of Chicago and next to the Shedd Aquarium and the Adler Planetarium. The local government provides an annual contribution to the museum, but about 70%, of the Museum's annual budget is raised by the Museum itself through fund-raising and business activities. The building houses 23 million reference specimens. It attracts 1.5 – 2.5 million visitors a year and is open every day of the year except on Christmas Day. Visitors buy an entrance ticket, with discounts for members and Chicago citizens. Entry is free for school parties of young children.

Marshall Field, US business leader who funded the establishment of the Columbian Museum of Chicago in 1893, renamed in 1910 as the Field Museum of Natural History

Governance and Management

The Board of Trustees has over 80 members, including many CEOs of corporations and other civic leaders. All board members are expected to bring money to the museum. The Board meets three times a year, receives the Annual Report, approves the budget, and appoints the President and new board members. Board members also serve on the Museum committees for governance, budget, investment, finance, facilities, science, and public relations.

The Museum is headed by a President, John McCarter, who has had working experience in Federal Government, corporate consultancy, and academia. The President appoints 10 Vice Presidents, viz. an Executive Vice President for Finance and Facilities, Vice President for Institutional Advancement (Operations Development, Sponsorships, Corporate and Foundation Giving), Vice President for External Affairs and General Council, Vice President for Auxiliary Boards and Board Relations; Senior Vice President for Strategic Initiatives, Senior Vice President for Environment Culture and Conservation, Senior Vice President for Museum Enterprises (Exhibitions, Marketing, Public Relations, Web Communications, Membership, Museum Stores, Special Events and Group Sales), Senior Vice President for Collections and Research (Anthropology, Botany, Geology, Zoology, the molecular laboratory, and the journal Fieldiana), Vice President for Administration (Human Resources, Information Technology, Education, Library), and Vice President for Operations (Guest Relations, Houskeeping, Protection Services). The Museum employs over 500 staff members.

Exhibition and Education

Exhibition

The exhibitions of the Museum occupy galleries of various sizes, located on the ground, first and second floors. Some of the permanent exhibitions

Grand entrance

showcase priceless examples of museum art that can no longer be reproduced, e.g. beautiful 3-D models of plants, and dioramas of animals resting, playing or hunting in family groups. The Museum stages about five special exhibitions a year, each taking up to four years to plan and implement. At any time, the exhibitions staff are engaged in 12 or more exhibition projects in different stages of planning and design. Special exhibitions are on show for three to six months each.

Each exhibition is planned around a theme or story line. As visitors proceed from the entrance to the exit of each gallery, they experience a story told through specimens and pictures accompanied by short, engaging narratives. The story ends at the exit. A small shop is located at the exit to display and sell merchandise related to the theme of the particular exhibition.

View of Chicago from the Museum

Exhibitions are of various sizes, requiring between 800 and 8,000 sq ft each. Exhibitions are almost entirely developed and produced in-house, by staff totalling about 100 persons, with a wide range of qualifications such as in history, literature, anthropology, science, linguistics, architecture, industrial design, and art. The Museum has well-equipped facilities for printing and artwork, and workshops for wood-working, metal-working and plastics moulding. However, most of its animal models are made by commercial service providers. An exhibition requires an adequate 'staging area' of up to 20,000 sq ft for developing and assembling the exhibits. Without such a staging area it would be impossible for a museum to develop its exhibitions in-house.

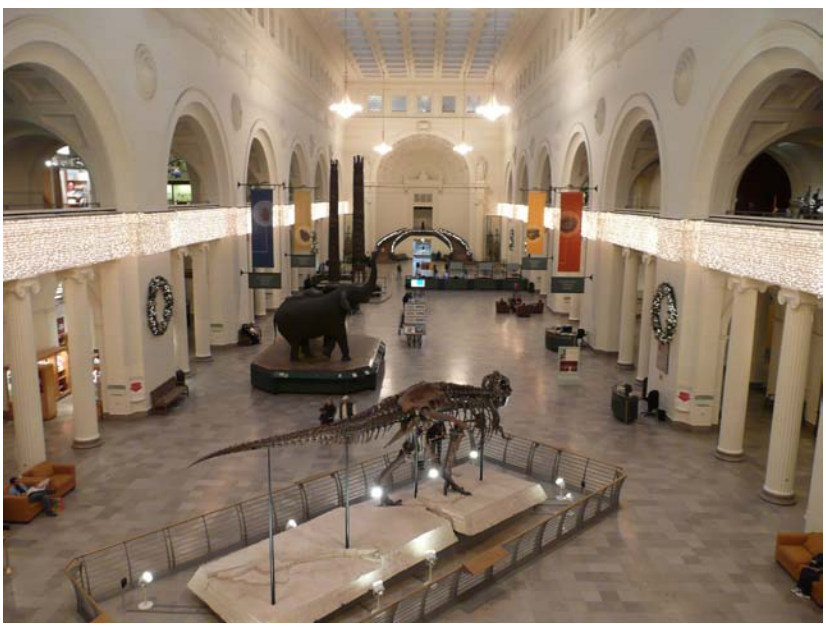
An exhibition starts with an idea, which may originate from anywhere. If accepted, this idea is taken up by a team which carries out initial research, writes the story line and lists the kinds of exhibits required, in consultation with museum curators, educators, fund-raisers and marketers. Research is also carried out to assess public perceptions, and costs are estimated. The project goes through the stages of design and visualization, including the building of three-dimensional scale models, before final production. An outline is prepared for marketing purposes, to solicit funding. The

development of exhibitions generates continuous excitement, brings repeat visitors and enables the Museum to maintain the interest and support of donors, members, volunteers and the media.

The exhibition galleries are serviced by volunteers trained to explain and discuss exhibits with visitors. We spoke to one such volunteer, a retired engineer, who used to bring his children regularly to the Museum. The Museum inspired his children to take up science and engineering. The children have grown up and become successful in their professions. In retirement, the father volunteers to help other people enjoy the Museum. There are 400 – 500 such volunteers, who take turns to provide services at the Museum.

After their period of display at the Museum, the Museum's special exhibitions are marketed as 'travelling' exhibitions. There are currently 11 such travelling exhibitions, including the dinosaur exhibition *A T. rex named Sue* that has been in Japan, Thailand and Singapore.

The great hall



In partnership with National Geographic, the Museum organizes a lecture programme of nine popular lectures a year.

Education

The education activities of the Field Museum are run by 23 staff members and 200 volunteers. The staff members have a variety of skills and interests including teaching, project design and management, performing arts, biology, archeology and paleontology. For school children there are special galleries that engage children in activities that will keep their attention, including a very innovative and popular 'playlab' for preschool children where young children are introduced to nature study. This has lots of play activities that encourage observation and simple experimentation, assisted by volunteers who love working with children. The Museum hosted 250,000 student visits in 2006. Its outside events (e.g. fossil hunting expeditions) engaged another 35,000 students.

The Field Museum is involved in developing the curriculum for schools in Chicago. It supports local schools by loaning them specimens for teaching. It has 170,000 specimens out on loan to schools. It organizes special programmes for school teachers to prepare them for bringing students to the museum in group visits. The programmes for teachers cater mainly to primary school teachers, because it is in primary schools that each class is closely managed by one teacher, who can be motivated to organize a museum visit.

Collections and Research

The Collections

The Museum holds a global collection of 24 million specimens in four departments: Anthropology, Botany, Geology, and Zoology, of which Zoology is the largest. Each department occupies its own part of the building, with its own offices, collection rooms, labs, and library, but all the departments share a molecular lab, a scanning electron microscope lab, and an elemental and isotope lab. Collections and Research employs about 165 staff members and have the services of 400 volunteers.

Tyrannosaurus rex, the most feared dinosaur, in the great hall

Deer in Mammals Gallery

The collections are shielded from sun and UV light and the collections rooms are kept under conditions of low humidity and low temperature round the clock. Wet collections are kept in bottles of 70% ethanol, the levels and concentrations of which are regularly monitored and maintained.

Curators

The senior scientific staff members are called 'curators'. There are about 35 curators. A full Curator is equivalent to a university professor, and many Curators hold adjunct professorial appointments at the University of Chicago and other universities. Associate Curators are equivalent to Associate Professors and Assistant Curators are equivalent to Assistant Professors. Positions are advertised and appointments are made after broad consultation among the curators. About 25% of curators are of overseas origin. Curators establish research programmes in areas of their own choice, which need not be the areas defined in the advertisement for the position. It is considered more important to recruit an outstanding scientist than someone less outstanding who fits the position advertised. Curators are expected to lead the way in research, publish regularly, project a good public image of themselves and the Museum, attract curatorial endowments (endowments that help pay the salaries of curators), obtain research grants from the National Science Foundation (such grants are awarded to fewer than 20% of applicants), and attract a circle of graduate students, research associates and volunteers to work around themselves. Curatorial staff begin as Assistant Curators without tenure. Assistant Curators get promoted to Associate Curators after five years, during which time they are expected to have obtained one National Science Foundation grant, and published several research papers. Those who fall below expectations are given one year to look for another job.

The fish Gallery

Curators Emeritus are retired curators who continue to work in the Museum and are treated as full staff members but without salaries. Adjunct curators and Research Associates are non-staff scientists given staff facilities to do research at the museum.

There are about 100 graduate students in the Museum who work on the collections for their own thesis research projects and 12 'post-docs' with doctoral degrees, who are employed on fixed contracts.

Collections staff report to curators and are responsible for managing the collections. They are not required to do research.

Interns are high school and college students who work for short periods and receive a small stipend to cover transport and lunch expenses.

Volunteers work at the Museum without pay but have to be serious and professional. They are terminated if they do not keep to their agreed hours and duties.

There are one or two administrative staff in each department who provide office support.

Botany

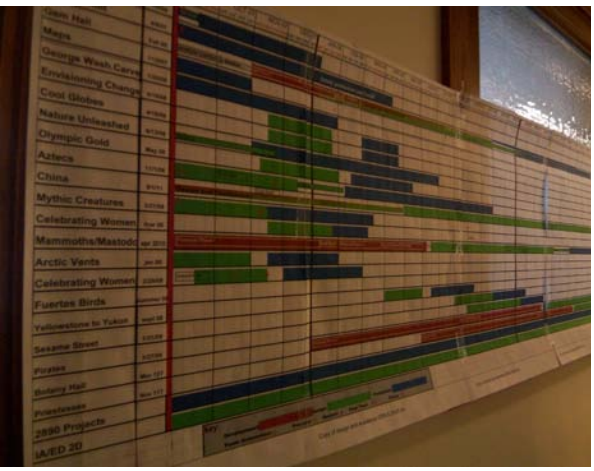
The herbarium holds 2.7 million specimens, of which 2.2 million are vascular plants. There are two curators for flowering plants, two for mycology and one for lichnology. The majority of collections are from Central and South America. Types are in the process of being scanned and will be made available for viewing on the Web. The Field Museum is also in the process of digitizing type specimens held in European herbaria and has already covered over 70,000 specimens. Specimens are filed in motorized compactor units operated by push button. Bulky collections (e.g. cacti, large fruited specimens) are filed in boxes, one box per number, designed to fit into the herbarium shelves.

Zoology

In Zoology, the emphasis is on mammals, birds, amphibians, reptiles, fish, molluscs and insects. In general, there are two curators for each of the above areas. There are 18 million reference specimens, of which 12 million are insects. Each collection ranks globally among the top five in their class, in terms of size and coverage.

Scientific data management

The value of a scientific specimen or collection lies in the data associated with it. A specimen without data such as place and date of collection and associated information is of little scientific value. Most of the requests that the Museum has to deal with are actually for data rather than specimens, and the data are in notebooks, labels, registers and catalogues kept with the specimens. Now, the data are being transferred to digital format for better security and accessibility.



Flowcharts tracking the progress of exhibitions under development

After years of trial and error, such electronic databases have become stable, and efforts are being made to standardize database formats across museums so that data can be shared. The final aim is to make databases available as a free global public resource. Already, the information on the Internet has cut down greatly the volume of requests that used to consume a lot of museum curatorial time.

Tissue collections

One of the new developments in museum management is the collection and storage of tissue samples. Some species are easier to identify by their DNA than by morphological characters. For identification of fragmentary material, DNA often offers the only solution. In principle every species can be identified by its DNA, and DNA barcoding of all species has become technically possible. To pave the way for this development, museums are beginning to take tissue samples from all new collections, to be stored for future DNA analysis and other kinds of analysis that may be developed in the future. For plants, young leaves are dried in silica gel and stored dry. For animal tissues a small sample of about 1 cm cube can be cut out from the liver or some other tissue and stored in 95% ethanol in small tubes. The tubes are sealed and stored in freezers at -15°C or in liquid nitrogen.

Library

The library employs 12 staff and has a volunteer support group of 'Friends of the Library'. It is organized into a main library housing interdepartmental books and journals, and smaller departmental libraries located within each department. The departmental libraries contain the books and journals that are most used by the scientists of that department. This is a great time-saving arrangement. However, the main library and the departmental libraries are all managed centrally. The library also maintains archives of films and photos, and a display of rare books.

Peacocks in the Bird Galiery

Top: Studio for design

Mid pic: A museum workshop

Bottom: Studio for concept developmen

Institutional Advancement

This arm of the Museum is responsible for raising donations from individuals, foundations and corporations. This is a staff activity because it is considered important for the Museum to interact directly with its supporters. The Museum estimates that it spends about 15 cents in raising each dollar of donations. It produces an Annual Report, the most important readers of which are the donors who support the Museum. Practically all the lecture halls, classrooms and galleries are named after donors who pay for the naming privilege.

Museum Enterprises

Revenue-earning activities

Museum Enterprises is a unit that employs 200 staff and earns income for the Museum through sales, rentals and commissions. It raises 28% of the Museum's operating funds.

Most visibly, there is a cafeteria (the Corner Bakery) and a MacDonalds outlet in the Museum that pay rental to the Museum for their space, and a percentage from sales. Also very visible is a large store selling books, rocks, toys and souvenir items. Every special exhibition includes a small store at its exit selling items related to the special exhibition. *Museum Enterprises* is responsible for all operations from sourcing of merchandise to inventory and sales.

After closing time, the grand hall, as well as the lecture halls, meeting rooms, outdoor terrace, and other spaces, are available for rent. The main galleries are spacious and the largest can hold 10,000 people. The grand hall, with its dinosaur and elephant exhibits, is a popular venue for wedding receptions and children's birthday parties. *Museum Enterprises* holds a liquor license and maintains a short list of approved caterers and

service providers for food, décor, lighting, movable furniture etc. The caterers and other service providers pay the Museum a commission on the fees they charge their clients.

Museum Enterprises markets group tours, especially to foreign and special groups. It also markets the travelling exhibitions, publishes books (usually with a co-publisher that has a distribution network), and sells consultancy services. It does its own marketing research to keep its fees and charges competitive.

Public relations

The public relations office defines its mission as "getting the word out on what the museum is doing". It produces the quarterly illustrated magazine *In the Field*, which is the main organ of communication with the 45,000 'members' of the Field Museum. Members pay an annual donation to support the museum. The magazine carries news about the Museum and descriptions of forthcoming events.

The PR office cultivates close contact with the media. It produces a press kit for every museum event. Press kits contain stories as well as CDs with images that reporters can use. These are sent to TV and radio stations, newspapers and other media in the city, state and beyond, but mainly covering an area within a day's drive from the Museum. It arranges previews of events for the media and invited guests before such events are open to the public.

PR does not pay for publicity and cannot control what the media produces. It works by building trust with the media as a trustworthy provider of information.

Human resources development

Curators are considered equivalent to professors in universities and associate curators to associate professors. It is very costly to recruit and train new staff, but a certain level of turnover is considered healthy because each time a vacancy arises, it gives an opportunity to review job descriptions and to make organizational changes to keep the Museum in line with changing opportunities and needs.

New employees are reviewed after six months. Otherwise, reviews are held annually. Staff members are reviewed by their supervisors on a one-to-one basis. They are provided with job descriptions, and are informed of what is expected of them individually. There is a system in place for appeal and counselling.

Bird Collection

Fund-raising

Fund-raising is a pervasive feature of museum management. It is undertaken with enthusiasm by everybody, from the Board and President to all staff members and volunteers.

We saw the President in action one evening, at a ceremony launching a book, *Birds of Peru*, held in the main auditorium. Before an audience of several hundred supporters of the Museum, the President lavished praise on the book and its authors and supporters. He was obviously No

1 cheerleader. After him other speakers and the authors gave speeches, all in praise and support for those who had contributed to the book, which had taken 50 years to produce. During the cocktail party before the launching we talked to some members of the Chicago public that had turned up for the event. They were 'members' of the Museum, who had become members by making annual donations. Members get invited to museum functions and receive its quarterly magazine *In the Field*. People went home from this event feeling they had done something worthwhile for science and conservation, and for Peru.

During our tour of the Museum and its many departments, we met many people and were impressed by the way all were willing to talk enthusiastically about their work. The Museum hosts many visitors and every visitor is treated as an actual or potential supporter. Every staff member is expected to 'sell' the Museum to members of the public. In

Frog Collection

this way, fund-raising efforts are not confined to the fund-raising and marketing departments, but spread out across the entire organization. For example, the Vice President for Collections and Research, Lance Grande, estimates that he spends 25% of his time in fund-raising activities.

After its establishment with seed money from Marshall Field, the Field Museum has maintained its momentum by cultivating public support, and the public has responded magnificently. Members and supporters of the Museum, and the citizens of Chicago in general, evidently take great pride in their museum, which has become a world-class scientific, cultural and educational institution through their support.

Plant Collection

THE NATIONAL MUSEUM OF NATURAL HISTORY OF THE SMITHSONIAN INSTITUTION, WASHINGTON, D.C.

Dates of visit: 10 – 11 December 2007

Foundation, Location and Public Significance

The National Museum of Natural History is one of a complex of 19 great museums under the Smithsonian Institution. The Smithsonian Institution was founded by the US Government in 1846 with an endowment from an Englishman, James Smithson, who willed his entire fortune to the US Government to found an establishment "for the increase and diffusion of knowledge". The Smithsonian Institution is financed by the US Government but raises 30% of its budget through fund-raising activities. Every American wants to visit Washington, D.C. at least once in a lifetime, and this 'pilgrimage' almost always involves visits to the museums of the Smithsonian Institution.

The National Museum of Natural History occupies a huge building occupying two city blocks (the size of 18 football fields), located centrally on the National Mall, close to the Capitol and other national monuments and museums. With a floor space of 1.5 million sq ft overall, of which

Grand entrance

Dome of the Museum

the exhibition and public space occupies 325,000 sq ft, this is the largest museum of natural history in the world. The number of visitors to the National Museum of Natural History is about 7.2 m a year. In peak seasons, there may be 30,000 visitors a day. The Museum is open every day except on Christmas day. Entrance is free.

Governance and Management

As a component of the Smithsonian Institution, the natural history museum comes under the overall administration of the Smithsonian Headquarters Organization, known as the 'Castle'. The Castle manages the security, custodial (cleaning and maintenance) and business activities across the Institution. The business activities include the letting of space for private functions, the letting of space for restaurants, and the management of shops within the Museum. The Museum operates on a budget of USD120 m a year, with a workforce of over 1,000 persons and 600 volunteers.

View of the Capitol (the U.S Senate and House of Representatives), from the Museum

The head of the National Museum of Natural History is Acting Director Dr Paul Risser whose background is in research (plant ecology) and academia. Under the Director are three Associate Directors, for Operations (including Budget and Finance, Information Technology, Personnel, Facilities Operations, and Museum Support Centre), Public Programs and External Affairs (Exhibitions, Education and Outreach, Administration, Public Affairs, Development, and Special Event), and Research and Collections (Anthropology, Botany, Entomology, Mineral Sciences, Paleobiology, Vertebrate Zoology, Invertebrate Zoology, and Laboratory for Analytical Biology).

The Museum has an Advisory Board which reviews the state of research and collections and helps in fund-raising. The Smithsonian Institution itself has a Board headed by the Chief Justice of the United States and includes three members of the House of Representatives and three members of the Senate.

Strategic Goals

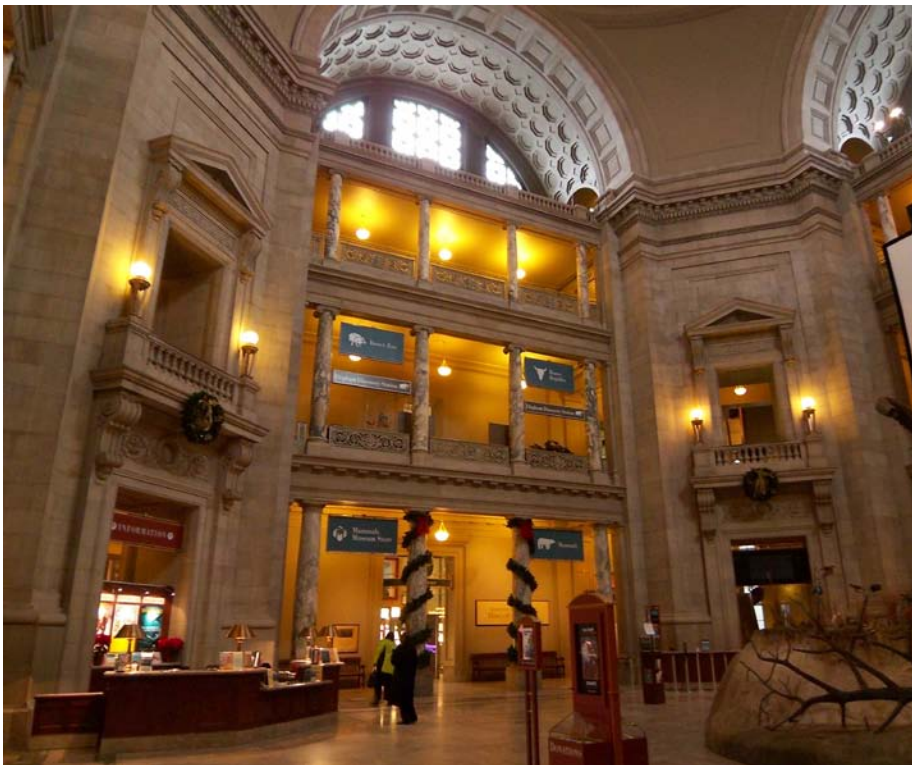
The strategic goals of the Museum, stated in its strategic plan for 2004-2008, are

- to strengthen the visibility, value, and impact of its science by integrating research, collections, exhibits, and education
- to lead the global community of natural history museums in programmes of science, collections management, exhibits, and education
- to transform the Museum's staffing, management, culture and infrastructure to support the Museum's mission, vision and strategic plan
- to increase and diversify the Museum's funding to address strategic priorities

MISSION

To inspire curiousity, discovery, and learning about nature and culture through outstanding research, collection, exhibitions, and education.

"Understanding the natural world and our place in it"



The great hall

Exhibitions, Education and National Outreach

The museum organizes permanent and special (temporary) exhibitions. An exhibition may take up to three years to stage. Most of the cost of exhibition development is raised from donors. Currently three exhibitions are being prepared. The most ambitious exhibition under development is *Oceans*, which will cost USD60 m to set up and a USD10 m endowment to support its annual maintenance. A model of a whale to hang from the

African elephant in the great hall

ceiling will cost USD250,000; a huge aquarium tank for corals and fish will cost USD700,000 per annum to maintain; a giant squid will be displayed in large tank containing an expensive non-inflammable preservative; there will be huge images projected on the walls, and a theatre to simulate an experience in deep ocean exploration. Another exhibition, *Human Origins* will cost USD30 m and be funded by two donors, each contributing USD15 m. The third one, on butterflies, will include an indoor butterfly house for 500 living butterflies of 24 species, which will be supplied by butterfly farms in South America and replenished continuously—the life-span of a butterfly being about two weeks.

An exhibition starts with an idea which goes through an exhaustive process of approval, consultation and development involving the preparation of scripts and illustrations, the identification and refinement of the message or purpose in relation to the target audiences, and the development of previews by computer, such previews being used to allow more participants to be involved in the review and refinement

of visuals and texts. The design and implementation of exhibitions are contracted to outside service providers. For an exhibition occupying an area of 10,000 sq ft, the staging area has to be about 15,000 sq ft of which 5,000 sq ft will become a storage area for the crates and other materials in which the exhibits came in, and which will be needed when the exhibition is dismantled and moved out. The packing, unpacking and checking of items, followed by repacking, are major logistical exercises best reduced to the minimal number of moves. The design and location of elevators and passages close to galleries are very important so that the development of one exhibition does not affect the operation of other exhibitions.

Exhibitions are family oriented, with the texts pitched at the level of 10 – 14 year olds, written like newspaper stories with punchy headlines and story lines.

Research and Collections Management

Research

The Museum employs 100 PhD scientists and provides facilities for another 30 from other agencies in government, including the US Geological Survey's Biological Resources Division, the Department of Agriculture's Systematic Entomology Laboratory, the Department of Commerce's National Marine Fisheries Service Systematics Laboratory and the Department of Defence's Walter Reed Biosystematics Unit.

The collections total 126 million specimens. In 2007, the scientific collections were referred to by over 7,748 visiting scientists.

The Museum's scientists exercise traditional freedom to pursue long-term scientific studies, and are encouraged to apply for external research grants to support their research programmes.

Holding room for incoming crates

Open shelves waiting for large sprcimens

Wet Collection

Collections Management

The Museum is developing a Collections Management Policy. This is required by the Government and by the Museum's Board. The policy requires that the collections be defined and ranked by 14 criteria so that the Museum can evaluate the relevance of each collection to the Museum's mission, formalize legal ownership, identify weaknesses and strengths, keep track of the physical condition and usage of each collection and decide on manner of disposal if necessary. The policy will enable the Museum to decline gifts of specimens that do not meet legal and scientific criteria, such as specimens with ambiguous or undetermined ownership and specimens with inadequate collection data. Specimens and collections that are to be disposed of may be given to colleges for use in teaching. The policy is dynamic and is reviewed from time to time. In special cases, exceptions to the rule may be written in. Registrars document gifts and loans. Every year there are about 800 gift accessions and an average of 2,000 loans signed in and out.

Museum Support Center MSC

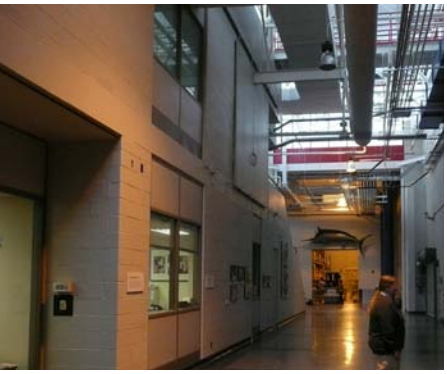
The Museum has run out of space and is now in the process of moving most of its collections to a new facility outside the city, called the Museum Support Center or MSC. It is also renovating its central building in stages according to a master plan that is implemented in annual stages at a budget of USD22 million per annum. As each part of the building is renovated, its equipment is upgraded.

The Museum Support Center, costing USD42 m has been established to house 25 m specimens, especially wet collections in ethanol, which constitute a fire risk. MSC has a footprint of 100,000 sq ft and is equipped with state-of-the-art equipment and safety features. Most scientists are expected to remain in the Museum and commute to the MSC to work on specimens. Visiting scientists are provided with working space at the MSC. The facilities at the MSC are so good that more and more staff scientists are considering moving there.

Membership

The Museum actively recruits members, who are called 'Museum Associates'. There is a programme of talks almost every evening that people buy tickets to attend, but 'Museum Associates' get a discount. There are 45,000 associates.

A museum laboratory



Wide corridor between the two parts of a MSC duplex: laboratories on one side, collections vaults on the other side

Biodiversity Heritage Library (BHL)

The National Museum of Natural History is a member of a consortium of ten major museums in US and UK driving the development of a virtual library—the Biodiversity Heritage Library (BHL)—with technology provided by a non-profit partner, Internet Archive. The aim is to digitize all the biodiversity literature of the world on an open access Internet platform. This means that researchers anywhere in the world will, for the first time in history, have access to all published information. Files can also be made available for those who want to develop linkages to other files (repurposing).

Scanning is done on special machines at very high resolutions (up to 1 mb per page). The books are placed on special cradles that allow for two facing pages to be flattened and scanned at the same time. Further correction of page curvature is done with software. OCR is carried out on the texts, and the software identifies species names (including probable species names) for checking and confirmation by eye. 'Taxonomic intelligence' software is being developed to link up synonyms, spelling variants, and misspellings for each species so that the library can be searched under any species name that has appeared in the literature.

Internet Archive was founded by Brewster Kala with support from the Sloan and other foundations to promote open access to published information via digitization. Additional information on BHL is provided in this report under the Natural History Museum, London.

THE NATURAL HISTORY MUSEUM, LONDON

Dates of visit: 13 – 15 December 2007

Foundation, Location and Public Significance

The Natural History Museum was founded through the efforts of Sir Hans Sloane (1660 – 1753) who, while serving as physician to the Governor of Jamaica for 15 months, carefully recorded the island's natural history, and returned to London with hundreds of plant and animal specimens. By the time he died, in 1753, Sloane had amassed a collection of 80,000 specimens and books in his London home, which was consulted by other scientists, including Carl Linnaeus (1707 – 1778). Sloane left all his property to the nation in his will. The Museum occupies a magnificent large building specially designed for its purpose, in South Kensington. The building was completed in 1881. Situated close by are the Science Museum and the Victoria and Albert Museum. The Natural History Museum houses 70 million specimens, collected from all over of the world, representing all groups of living things, fossils, rocks and minerals. The Museum houses nearly 850,000 type specimens. It attracts over 3 m visitors a year (registered electronically by sensors at the public entrances). International visitors account for 30% of visitors and local visitors from within two hours driving distance account for 40 – 45% (percentages obtained by sampling exercises). Entrance is free except to Special Exhibi-

The iconic main building

tions, of which two or three are staged each year. The Museum is closed only on Christmas Day.

Governance and Management

The Museum was established by Act of Parliament as a non-profit organization. It is funded mainly by the Government and is governed by a Board of Trustees. There are 12 trustees of whom eight are appointed by the Prime Minister, one by the Government upon the recommendation of the Royal Society and three are co-opted by the Board itself. The present

The great hall

Chairman is Mr Oliver Stocken. The Board of Trustees appoints the Director, currently Dr Michael Dixon, who was previously Director-General of the Zoological Society of London. The Board conducts an annual review of the performance of the Museum. New members of the Board attend a one-day induction and training course. Five sub-committees report to the Board of Trustees. These committees cover (i) audit, (ii) finance, (iii) remuneration, (iv) Darwin Centre Phase Two and (v) Nominations to the Board and its sub-committees. Staff salaries are determined by the Board. For scientists the salaries are generally equivalent with salaries for academic staff of universities.

A dinosaur greeting visitors at the great hall

Under the Director of the Museum, there are six Directors, in charge of (i) Public Engagement, (ii) Science, (iii) Finance, (iv) Human Resources, (v) Estates, and (vi) the Walter Rothschild Museum at Tring. The Museum employs 850 staff.

Public Engagement

Role

Of the Museum's total staff, about half are employed under Public Engagement, which is responsible for exhibitions, learning activities, design, events, fund-raising, public communications and maintenance. The aim of public engagement is to increase scientific literacy in society by making knowledge available in visually and intellectually stimulating and friendly formats.

Each exhibition project team has a 'champion' to deliver the project and a team to prepare the content and design, develop learning activities, design a marketing campaign, produce related website activities and

generally manage the project. An exhibition takes up to three years to prepare. The design is done in collaboration with outsourced design companies and the first result is a 'Concept' with text and graphics that can be used in bids for raising financial support. A Concept may take eight months to prepare. If support is secured, the Concept is moved to Scheme Design and then Detailed Design followed by implementation-production. Implementation of exhibitions is by outsourced contractors, but multimedia is done in-house. One advantage of outsourcing is that each contractor brings its own style and the result is a diversity of styles across exhibitions whereas in-house work may result in a single in-house style.

Permanent exhibitions are no longer as permanent as before. Current thinking is to upgrade them in 10 to 12 year cycles. The Museum is currently preparing a gallery re-development programme for the Museum's permanent galleries. This involves master-planning the public spaces and developing a suite of concepts for new galleries. Each existing gallery will require preparing a Concept and raising funds for its implementation.

Two or three Special Exhibitions are staged each year, each for a period of 6 to 12 months, after which they can be rented to other organizations and countries. Summer blockbuster exhibitions are most often aimed at the Museum's largest target audience—families. The current *Ice Station Antarctica* exhibition (to be on for one year) is already booked to travel overseas for the next five years. The Museum's Art/Science programme delivers one exhibition per year that is often a collaboration between artists and scientists. *Wildlife Photographer of the Year*, an annual competition that aims to find the most stunning and original wildlife pictures taken by photographers worldwide of all ages, becomes a touring exhibition after its debut in the Museum.

Public engagement is not confined to staff of the Public Engagement Department. The scientists are expected to do their part by publishing books and papers for scientific and general audiences and to give talks and presentations, including impromptu ones to visiting groups. They are featured in the *Nature Live* programme, a daily programme giving visitors an opportunity to talk to scientists. Scientists may also be assigned to exhibition development teams.

Left: Mammal Gallery in traditional style

Right: Mammal Gallery in modern style
Opp page, top: Herbivores
Opp page, bottom: Reptile Gallery

Investigate Centre

This is a special centre for children of ages 6 – 14 years. Created and managed by Dan Wormald, this centre exposes young people to the processes of science rather than to packaged information. A large assortment of specimens (rocks, bone fragments, skins, dried plant parts, shells, fossils, etc.) are placed in drawers, and visitors can pull out any drawer, touch the specimens, and examine them closely under a lens or microscope, or call up an SEM image on computer. There are four work stations provided with such equipment. Visitors are encouraged to formulate and test their own hypotheses. The staff are trained as facilitators to help the visitors ask probing questions and to look for evidence in the specimens, as


Feeding separately
Long - distance travellers


REPTILES

real scientists would do. The Centre includes an enclosed garden with a pond. Here visitors can examine aquatic life, soil organisms, plants and insects. The Centre caters for 80,000 visitors a year. According to Dan, the centre is, in principle, suitable for people of any age since the specimens are real natural objects, and visitors learn about them through their own exploration.

Science

Research

The Natural History Museum is a major research organization, employing 350 scientists as researchers, collections managers and technologists, headed by Richard Lane, Director of Science. The Museum hosts visiting scientists from all over the world, at the rate of over 9000 a year. It processes over 50,000 scientific enquires a year from the public.

Holding the oldest and most comprehensive collections of biological and mineral specimens in the world, the Natural History Museum is a

unique resource that continues to grow at an average rate of 150,000 new specimens a year. About five years ago the Museum went through a re-branding exercise to determine how best to use its unique resources, in particular what scientific questions it should concentrate on. Since a museum collection is a sample from the real world, it can be used to produce conceptual models of the world. The value of a model is that it can itself be analysed and experimented upon to see how well it explains the real world. A model is an instrument, and a public museum collection is a public domain instrument that can be used to investigate questions that cannot be investigated in other ways, e.g. to find out which are the biodiversity hotspots in a country, to identify gaps in knowledge, and to highlight and predict areas of concern. The scientific agenda of the Natural History Museum is now focused on six fundamental questions about the processes that generate biodiversity, and their implications—broad questions about the universe that require groups of researchers to work in collaboration.

Left: Display of gold minerals
Centre: Mineral Gallery and collection
Right: Wet Collection in Darwin Centre One

These questions are

- What determines biological diversity in a changing world?
- How do large-scale physical and biological processes and their interactions influence the evolution of the earth and other planets?
- What are the relationships between biodiversity and ecosystem functioning?
- How do interactions between hosts and their parasites impact on disease epidemiology and control?
- How is the diversity of phenotypes, genes and genomes related to environment and evolution?
- What form does the Tree of Life take?

The scientists at the Museum develop their own areas of research but new scientists are increasingly being recruited for their potential contribution to teams that can work on these six questions. The Museum differentiates between 'strategic' appointments of versatile scientists who have a proven record of scientific leadership, and 'tactical' appointments of junior scientists whose work will complement those of the senior scientists. For example, a person who works on the evolution of arthropods could be complemented by a person who works on plants that co-evolve with arthropods. Research appointments no longer fall within the traditional compartments of Botany, Zoology, etc.

Ichthyologist Oliver Crimmen demonstrating a preserved fish

The Museum looks for the best candidates in the world. The British

scientists who get appointed usually have had overseas experience, but 85% of appointments are made from international applicants. The Museum does not hire unless it has found the right candidate, because a poor candidate is recognized as a long-term liability until he or she is retired or separated. Many of the 350 research scientists are on contracts funded by research grants.

There over 150 post-graduate students doing research at the Museum. The post-graduate students are registered in universities in the UK and abroad, but spend 30% or more of their time at the NHM, with an NHM staff member acting as principle supervisor or advisor. There are 60 scientific associates who are unpaid, often retired staff, who do research in the Museum. There are also many volunteers who donate time to the Museum, working under the direction of researchers and collections managers.

The Museum runs two Masters Programmes organized in conjunction with the Imperial College nearby: in Advanced Methods, and Biosystematics.

Collections management

Collections management has become more demanding because of rising standards of care for specimens—no more use of poisons, greater dependence on strict hygiene, more emphasis on quarantine and deep freezing—and the growing need to conform to legal requirements for record keeping of gifts, loans, and other acquisitions.

Since no museum has enough resident experts, museums welcome and provide facilities for visiting experts. Specimens are also sent out on loan and such loans require recording and tracking. In 2005/2006, the museum loaned over 70,000 specimens to over 3,000 venues across the world.

Insect Collection

Laboratory for fossils

Collections managers often have a Masters in museum studies. They are not expected to do research but must be able to dialogue with researchers. The Museum employs about 70 professional staff for collections management.

At the new museum extension Darwin Centre One, which was designed to provide modern facilities for storing specimens, there are glass windows through which visitors can see how specimens are stored and how scientists work. Darwin Centre One houses the wet collection of 22 million specimens preserved in alcohol, ranging from microscopic plankton to a giant squid, and facilities for the scientists who work on them. Darwin Centre Two, under construction now, will house the entomology collection of 28 million specimens, the botany collection of 3 million specimens, and the scientists who work on them.

Fund-raising and marketing activities

Government grants covers 60% of operating expenses. The remaining 40% is raised by the Museum through various fund-raising and marketing activities. The scientists compete for research grants, some of which are national and some from the European Union. The exhibitions group develops concepts that are used to interest donors. There is also income from training courses run by the Museum in collaboration with Imperial College.

The Museum rents out space for the operation of restaurants and halls for private functions after hours. It operates the souvenir shops within the Museum. It markets travelling exhibitions, and museum consultancy services. The NHM has been involved in the planning and design of exhibitions in Dubai (The Restless Planet), Japan (UK Pavilion in the Aiki Expo), the UK (Jurassic Coast World Heritage Site), Qatar (Lost Worlds exhibition) and Kenya (National Museums of Kenya redevelopment plan).

Membership

The public are encouraged to become Members of the Natural History Museum. The membership fee for adults is £50 per annum. Members are invited to special events—lectures, behind-the-scenes visits, guided tours, children's workshops, previews of Special Exhibitions—and are provided with the quarterly magazine *Nature First*. The fee is treated as a gift to help finance the NHM.

Miscellaneous

Care of fossils

Fossil specimens are often brittle and easily damaged. Small specimens are stored individually in close-fitting boxes made of acid-free cardboard,

resting on bases of inert polypropylene 'corex'. Larger specimens are supported on cushions or fitted into cradles of corex, the bases of which are hollowed to conform to the specimen. This is to prevent specimens moving and rubbing against each other or on other surfaces when drawers are opened and closed or when specimens are being moved. Crumbly specimens are strengthened by impregnating with an acrylic adhesive Paraloid B72 which can be removed totally if necessary. Paraloid B72 can also be mixed with glass beads to act as a filler-cum-adhesive.

Display and care of mineral specimens

Most of the older natural history museums include minerals in their collections. NHM London houses probably the best mineral collection in the world. There are 177,000 mineral samples, of which 12,000 are on

Fossil mollusk collection

display in glass-topped cases in the minerals gallery. Below the display cases are locked drawers in which the research specimens are kept. Hence the same gallery serves two purposes: exhibition and specimen-storage. Valuable exhibits are displayed in a special high security room known as *The Vault*. Of the 4200 species of known minerals, 2,500 are represented in the Museum. The geology team of 35 scientists in NHM London is one of the largest teams of geologists in the UK.

Fossilized plant parts

Tissue collections

The Museum is building up collections of tissues for DNA and protein analysis. Samples are stored in special refrigerators. Under the Frozen Ark project, tissues are taken from endangered species and stored at -80°C as a strategic conservation measure should the species become extinct. Other specimens are stored at -20°C.

European Union initiatives

The European Union encourages the exchange of scientists between European countries by funding travel and other expenses through the SYNTHESYS initiative, designed to promote cooperation between museums in Europe. SYNTHESYS also funds the development of museum databases that will eventually be linked into a pan-European information domain.

Souvenir shop in the Museum

The Union also supports a project to raise the standards for museums on a rating of A to D. The assessment is done on-site by visiting teams of assessors. In the beginning, museums were reluctant to join the scheme but more and more are now joining because the museums now realize that they benefit from being assessed and being advised on how to upgrade themselves.

The Biodiversity Heritage Library (BHL)

The Natural History Museum is one of ten leading US and UK museums that have come together in a project to get all the world's biodiversity literature digitized and made freely available on the Internet. The BHL project involves very high quality scanning of publications using special scanners developed by Internet Archive, an American non-profit organization. There are 20 machines in Washington and Boston operated in two shifts a day. Four million pages have already been scanned. The

target is 25 million pages. The emphasis is currently on old literature not under copyright. Literature under copyright is subject to negotiation with copyright holders.

Two scanned copies are produced, one of which is displayed as a scanned page and the other is subjected to Optical Character Recognition (OCR). Taxonomic Intelligence software is being developed which will identify species names in the texts. All names referring to the same species will be eventually identified and linked so that name searches can be made using any name, in whatever be form it may have appeared in the literature (including spelling variants, mis-spellings and synonyms).

More and more countries have expressed interest in joining in the programme, which will eventually include scientific literature in German, French, Chinese and other languages. The whole project will require such large memory resources (10 – 20 petabytes) that eventually it may have to be run by a consortium of portals linked to a central portal.

Restaurant in the Museum

Portrait of Alfred Russel Wallace, author of *The Malay Archipelago*, the great classic of natural history

Library

Of the 1.8 million known species in the world, over 50% are from the tropics, so in a sense, information about them is being 'repatriated' to the tropics via this project. Interestingly, 25% of species names have occurred only once in the literature, indicating that after their first publication, no further information on them has been added.

More information on BHL is provided under the National Museum of Natural History of the Smithsonian Institution.

NATURALIS: THE NATIONAL MUSEUM OF NATIONAL HISTORY, NETHERLANDS

Date of visit: 19 December 2007

Foundation, Location and Public Significance

Naturalis is the name specially coined for the National Natural History Museum of the Netherlands, established in 1820. It is located close to the historic University of Leiden, the ultra-modern Science Park and the Central Railway Station. The foundation collections were donated by members of the Netherlands Royal Family, who were avid collectors of natural curiosities in the 1600s and 1700s. The museum holdings now total 15 million specimens, many of them important historic collections made by employees of the Dutch trading companies operating overseas and especially Indonesia. The collections are housed in a 20-storey building that towers over its surroundings. The museum's missions are to

- increase understanding of nature through research
- make knowledge available to the public

Contrast between the windowless Collections Tower Block and the amply transparent Exhibitions Building

Exhibitions Building and Collections Tower Block

- care for the national natural history collections

The exhibition galleries attract 250,000 to 300,000 visitors a year and are closed on Mondays. Visitors pay an entrance fee.

Governance and Management

Naturalis is a Foundation established under an Act of Parliament for the purpose of managing the scientific collections of the country. It is funded almost entirely by the Government through the Ministry of Culture and

Higher Education. The budget is planned in four-year cycles. The annual allocation is treated as a management fee paid by the Government to the Foundation. Government auditors check on how well the collections are managed. One indicator is that a specimen should be produced on demand within five minutes.

The museum is headed by a General Director. It employs about 20 professional staff in administration and finance and is organized into three divisions: Public Programmes, Collections, and Research, with 50, 35, and 20 professional staff respectively.

Naturalis is managed by a Board of seven members. The Board meets

Clockwise: Big mammals greeting visitors
Herbivores
Carnivores

quarterly and approves the budget. It has the power to appoint and terminate the General Director and to appoint new Board members to replace retiring ones.

Public Programmes

Public Programmes cover the design, implementation and management of the public display galleries and the delivery of other public information and education services.

The Museum's galleries occupy a five-storey building adjacent to the 20-storey collections tower. The first and second floors are merged to accommodate tall exhibits such as a huge dinosaur. Display shelves are usually made of transparent glass or acrylic. There are sections for gems, various groups of vertebrates, and paleobiology. There are special (temporary) exhibitions lasting about 10 months, and permanent exhibitions which last longer but no longer as permanently as before. Guided tours are available for school groups. Each guide takes up to 20 students. About 18,000 primary schoolchildren visit a year, of which 80% come on guided tours. Secondary school students come in larger numbers, about 25,000, of which 70% come on guided tours.

Animal models for exhibition are made by external service providers, often in the countries of collection, e.g. in Vietnam and Philippines. The trend is for exhibitions to be implemented by external service providers, with the Museum staff acting as content developers and coordinators.

The Museum's websites attract 3.5 million visitors a year. The success of the websites is due to good concepts (good identification of needs and gaps), reliability (current science), good partnerships (using experts from everywhere) and good illustrations. One product is a catalogue of species in the Netherlands. Another is the linkage of species locations to Google

maps. Another is the mapping of the Netherlands through geological time, with locations of fossils. Another engages people in recording whale beachings on the coast of the Netherlands.

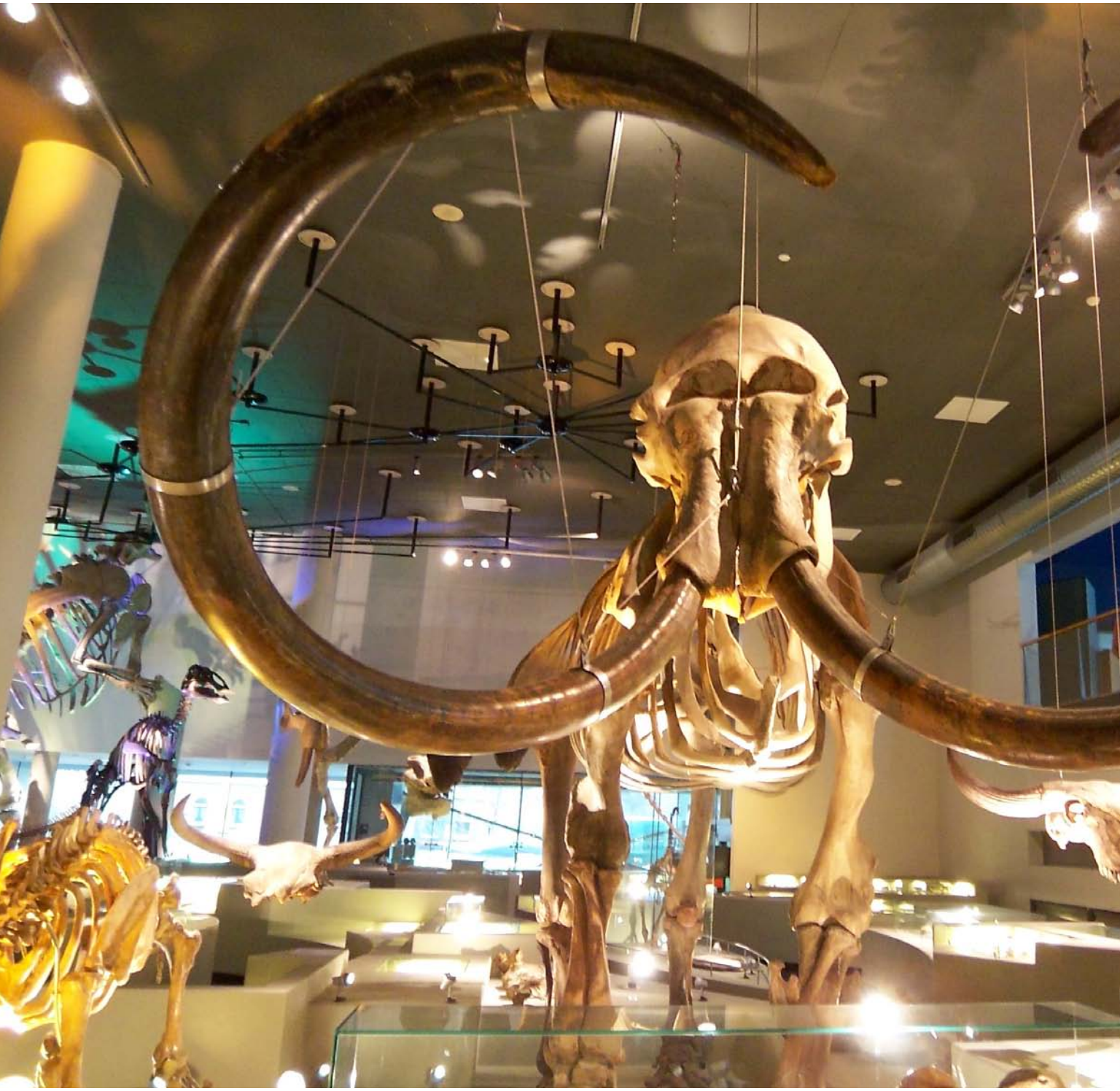
Naturalis also organizes each week a web conference in which a school group interacts with a scientist while the scientist does a dissection, stuffs a bird, or digs up a fossil; this is for schools located in the more distant areas of the country. Education programmes are all developed in-house.

The museum shop, selling books and souvenirs, is at the single public exit/entrance, which visitors have to pass through twice, as they enter and as they exit. The museum bookshop offers the most comprehensive collection of natural history books in the country. The cafeteria is outsourced, but the museum shop is managed entirely by Naturalis. These businesses are regarded as services, not profit centres, and do not make much money for the Museum.

Collections

Collections come under a Director of Collections, who with 35 professional staff, are responsible for 12 – 15 million specimens. The collections are housed in a 20-storey 'Tower' building measuring 20 m x 20 m that has no windows. The tower building has double walls, to keep the internal climate stable at 17ºC and 50% RH. The internal air is kept fresh by ventilators. Insects can only enter by creeping in under the tight-fitting doors; to keep them out, the floors are treated with residual poison three times a year. Specimens taken out of the collection have to be placed in deep freeze for one week before being returned to the collection rooms. The collection is outstanding for birds, of which there are 10,000 species worldwide, 8,000 species of which are represented in this collection.

Wet collections are in special rooms with extra safety features, e.g. with



A mammoth

Display of comparative anatomy

Mineral Gallery

Bird collection in the Tower Block

light switches located outside the rooms so that there is no danger of electric sparking inside the rooms, and the floors are designed so that any spilled alcohol will drain out quickly through openings in the floor (this is also the case at the MSC and Darwin Centre One)

Contrary to the practice in many other new and refurbished museums, the storage cabinets are nearly all fixed units with shelves open on all sides rather than movable closed compactor-cabinets. This was the deliberate decision of the former (late) General Director who preferred specimens to be kept visible, free from vibration (from movement of cabinets), and open to air circulation. It was explained that closed cabinets create pockets of still air and high humidity. An open system provides better air circulation around the specimens and allows the collections managers to keep all specimens in full view. The absence of movement and vibration is better for the preservation of delicate specimens. Specimens are in complete darkness unless people are working in the rooms. People are advised not to stay longer than two hours at a stretch in these rooms, because the absence of natural light is thought to have negative health effects. The internal atmosphere is impressively dust-free and free of odours, and the colours of the specimens are impressively preserved.

Formerly the collections were managed as 20 – 25 separate collections, each managed by a scientist with one or two assistants. As a result, the policy for each collection was different depending on the scientist in charge. Now all the collections are unified under one policy and managed by one Director. The scientists are now either collections managers or researchers but not both simultaneously.

Some collections managers specialize in the care and management of

specimens, others in recording of specimens as digital images and in the compilation of databases using the software program RECORDER, which is suitable for plants, animals and minerals. RECORDER is an open-source program. Naturalis is very happy with this database program.

Collections staff and visiting scientists have their work spaces located within the Tower.

Primate collection in the Tower Block

Research

Research comes under a Scientific Director and is organized into three departments: Zoology, Entomology and Geology. There are 20 full-time researchers of whom four hold concurrent university positions as professors, which allow them to supervise PhD candidates. There are also a number of retired scientists, who continue to work voluntarily, as well as visiting scientists and other volunteers.

Common-user facilities for research include a microscopy lab, SEM lab, molecular lab, and library. The research activities include taxonomy, molecular phylogenetics, and DNA barcoding. Researchers determine their own research programmes, but with emphasis on the natural history of the Netherlands and Southeast Asia. The Division organizes one large expedition a year, mostly in Southeast Asia. In 2007 the expedition was to a forest in Vietnam. In 2009, the expedition will be to a marine park in Sabah. The annual expeditions are the main sources of new materials for the collections. The research emphasis is moving from inventory of biodiversity to studying processes of change: including the effect of climate change on biodiversity and the effect of invasive species.

Naturalis publishes three journals and its own series of books, e.g. Fauna Malesiana. Researchers are evaluated by production of research papers,

citation criteria and journal impact factor. Researchers are also challenged to compete for research funds from the National Science Foundation and the European Union.

Discussion with the Acting Director, Dr Dirk Houtgraaf

The Acting Director, Dr Houtgraaf has produced a book, *Mastering a Museum Plan*, which provides information on the establishment of Naturalis and the development of museum exhibitions. The museum began basically as a place for research. Its current public programme is only 10 years old, but the new emphasis on exhibitions and other public-oriented activities has changed the work culture.

Naturalis is not responsible for managing plant specimens at present. Plant specimens are mainly in the Herbarium of Leiden University and other universities. Universities also have their own zoological museums. However, Dr Houtgraaf says there is a plan to merge all university museums with Naturalis to form a large entity to be called the National Centre for Biodiversity, which will hold a total of 57 million specimens.

The income of Naturalis consists of 85% from government allocation and 15% from entrance tickets, with a small profit from the shop and cafeteria businesses and the organization of conferences. Conferences make some money, but their main value is in scientific networking. To Dr Hourgraaf's regret, Naturalis does not have enough rooms for conferences and meetings of various sizes.

Birds of Southeast Asia

Field Museum

2006 Annual Report of the Field Museum.
The Field Museum Exhibition Process. Version Jan 12, 2007.
Collective Knowledge: The Value of Natural Science Collections.

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Appendix 3

STUDY OF THE BOTANIC GARDENS AND THE RAFFLES MUSEUM OF BIODIVERSITY RESEARCH, SINGAPORE

INTRODUCTION AND OVERVIEW

Singapore has two natural history museums—the Botanic Gardens and the Raffles Museum of Biodiversity Research. These two museums began as the regional museums for natural history of the British-administered territories in Southeast Asia before independence. With independence, Singapore inherited the two regional museums, while Malaysia was left without any natural history museum of comparable stature.

The Government of newly-independent Singapore initially had no interest in natural history, so both museums went through a steep period of decline. The Raffles Museum, originally a museum combining natural

history with anthropology, became the National Museum of Singapore, but the new National Museum of Singapore had no place for natural history. The natural history collections were packed up in crates. The iconic whale skeleton that used to hang from the ceiling of the Raffles Museum was sent to Muzium Negara, Kuala Lumpur. The other crates were moved from place to place by concerned scientists in Singapore who took it upon themselves to save as much as they could of Singapore's scientific heritage for the day when, perhaps, the Museum would be restored. The collections suffered from 14 years of neglect. Some specimens were lost.

The Botanic Gardens survived because it served as a public park, and had a new role to play in the development of Singapore as a garden city. However, its scientific role was greatly diminished compared with its earlier role as the leading centre of tropical botany in the world. During the colonial period, Directors and Assistant Directors of the Botanic Gardens Singapore had included H.N. Ridley, pioneer of the rubber industry; I.H. Burkill, whose monumental two-volume Economic Products of the Malay Peninsula remains the primary reference source on the natural resources of Malaysia and Southeast Asia; E.J.H. Corner, who pioneered research on tropical trees and fungi; R.E. Holttum, who pioneered research on orchids, ferns and ornamental plants; and J.W. Purseglove, whose four volumes on tropical crops remain key references for tropical agriculture today.

At one stage, institutions in other parts of the world began to consider buying up the museum collections from Singapore.

The Raffles Museum came back to life after it was incorporated into the Faculty of Science of the National University of Singapore as the Raffles Museum of Biodiversity Research. Plans are now being made to relocate the Museum to a new museum complex to be specially designed and built.

The Botanic Gardens is once again becoming a major tropical research centre with the appointment of international scientists, and the establishment of a new herbarium building and new research facilities.

Main Building

THE BOTANIC GARDENS SINGAPORE

Children's Fantastic Forest

Public reading room and reference centre

-Date of visit: 26 February 2008

The Botanic Gardens Singapore was founded in 1859. In 1990 it became part of a much larger organization, the National Parks Board (NParks). The National Parks Board manages 55 parks and nature reserves in Singapore, totalling almost 2,500 ha. The Botanic Gardens occupies 52 ha, within easy walking distance from Orchard Road, the commercial centre of Singapore. It is open daily from 5 am to midnight and does not charge an entrance fee. However, within the garden is the National Orchid Garden, which charges an entrance fee of SING$5 per adult, with concessions for students and senior citizens. The Botanic Gardens services a Public Reference Centre that is open daily (10 am - 4 pm on Mondays to Fridays; 9 am – 1 pm on Saturdays and Sundays). It also organizes public lectures and other public activities throughout the year. Other major attractions are a specially designed Ginger Garden, an air-conditioned Cool House for tropical montane plants, and a Children's Garden. The Botanic Gardens attracts 3.2 million visitors a year (counted by infrared sensors) and is one of the major tourist attractions of Singapore,

as well as a major recreational centre for residents. The National Orchid Garden attracts 500,000 visitors a year.

Governance and Management

The National Parks Board is a statutory board of the Ministry of National Development. It is overseen by a Board of 10 members currently headed by Mrs Christina Loh, who comes from the corporate world. She succeeds Prof. Leo Tan, an academic scientist. The CEO of the NParks is a member of the Board. The other members are drawn from the corporate world and from the Government. The Board endorses broad directions, policies and strategies, oversees operating and financial performance, provides guidance on development, and approves tenders.

The Botanic Gardens is headed by a Director, assisted by a Deputy Director,

Tree House

Giant Mushrooms

and six Assistant Directors assigned to the following six areas of responsibility: Research, Living Collections, Visitors, Singapore Garden Festival (held at two-yearly intervals), Physical Facilities, and Education.

Collections and Research

The Herbarium was founded in 1875. Administratively, the Herbarium comes under the Gardens' Assistant Director for Research. The head of the Herbarium is titled 'Keeper of the Herbarium'. The Herbarium houses 650,000 specimens, including over 7,000 type specimens. The average rate of growth is 200 – 300 specimens per month. The collections are kept under 24-hour air conditioning (with alternate air conditioners operating) and 55% RH (maintained by three dehumidifiers), and the specimens are protected from insect pests (especially beetles) by treatment with mercuric chloride. The Herbarium is fumigated annually with methyl bromide and there is a continuous programme of monitoring and trapping of herbarium beetles. The collections are managed by a Collections Manager.

The Herbarium building is part of a new building complex completed in 2007. The Herbarium section has a floor area of about 1,000 sq m. The number of visiting scientists using the Herbarium in 2007 was 37. Local visitors using the Herbarium for reference work accounted for 164 visits.

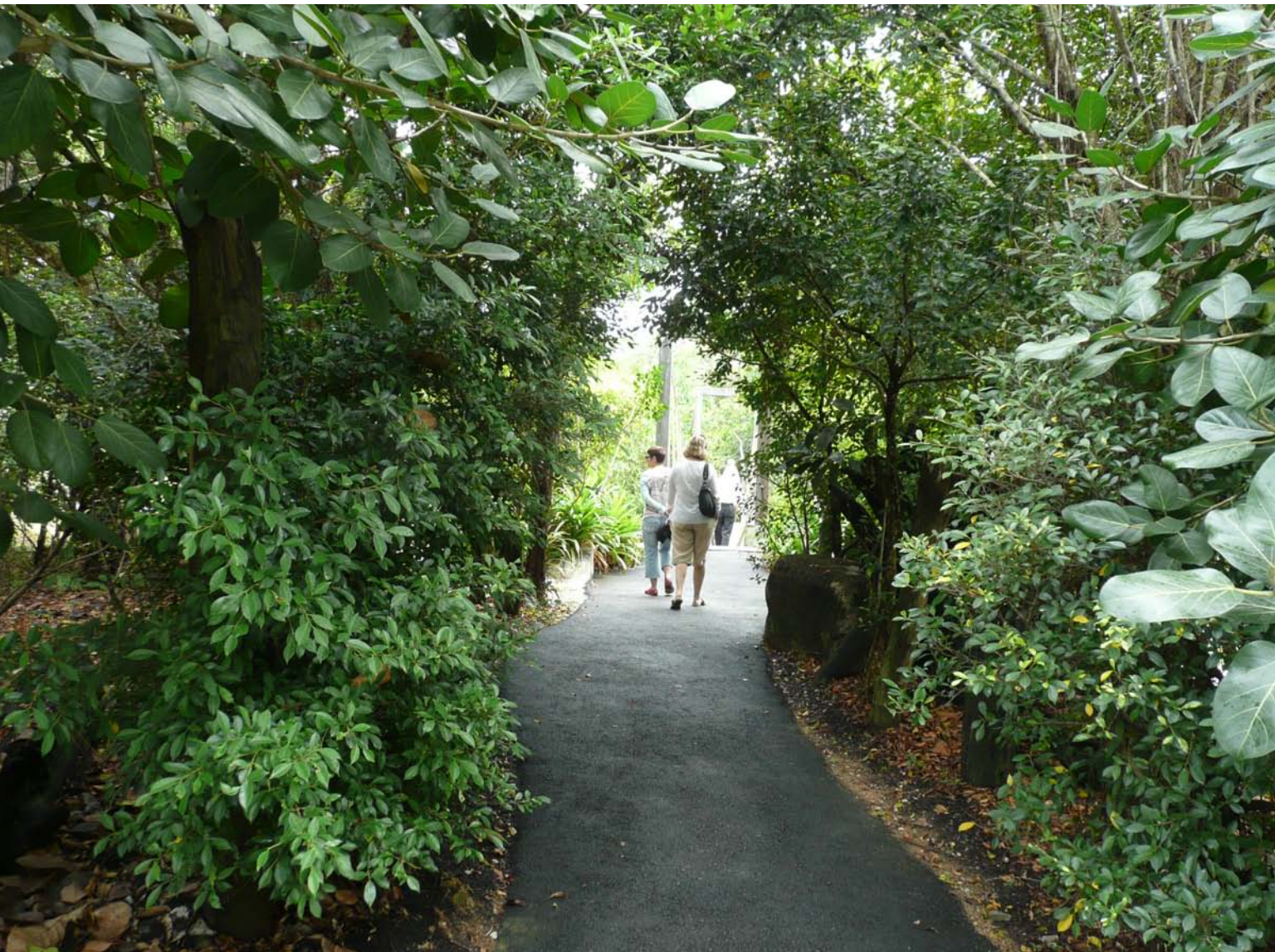
There are seven scientists employed in botanical research, covering bryophytes, Convolvulaceae, Orchidaceae, Begoniaceae, Memycylaceae, Zingiberaceae, orchid breeding and tissue culture. Five of the scientists are taxonomists who built their reputations elsewhere before they were recruited by the Botanic Gardens Singapore; their current research covers Southeast Asia.

Library and Publication

The Library has 26,500 volumes of books and 300 periodicals. The Gardens publishes the Gardens' Bulletin Singapore. First published in 1912, the Gardens' Bulletin is probably the oldest extant scientific journal in the region.

Exhibitions, Outreach and Education

The exhibitions of the Botanic Gardens are in the form of living plant collections, which are arranged in various ways, e.g. by taxonomy, ecology or usage. There are orchid, ginger, palm and bromeliad gardens, which are examples of grouping by taxonomy. The cool house and aquatic



Mysterious Forest

Secret Cave

gardens group plants that require similar ecological conditions. Spice and fruit gardens represent grouping by usage.

Of particular interest is the Jacob Ballas Childrens' Garden, designed to introduce children to nature in a safe and controlled play environment. This garden was built with a SING$7 m donation from Singapore philanthropist Jacob Ballas. It has turned out to be a very popular garden for families with young children.

There are several other gardens in the Botanic Gardens which are identified by the names of their sponsors.

Costs and benefits

The annual budget for salaries and maintenance of the Botanic Gardens is about SING$8 million. The funds are provided by the Government, but the Botanic Gardens is permitted to retain part of its earned income. The earned income is now approaching SING$4 million per annum. The main sources of income are

- leases for the Food Court, restaurant and café
- entrance fees to the National Orchid Garden
- rental and commission from souvenir and book shops
- commission from the car park operator

The National Orchid Centre attracts 500,000 visitors a years with tickets at SING$5 per adult entry. A visit to the Botanic Gardens requires a half-day stay in Singapore, which contributes to the economy in terms of money spent on accommodation, travel, food and other expenditures.

In addition, the Gardens provides society with a beautiful recreational resource and a competent educational and reference facility.

THE RAFFLES MUSEUM OF BIODIVERSITY RESEARCH

Date of visit: 27 February 2008

Foundation, Location and Public Significance

The Raffles Museum is named for Sir Stamford Raffles, founder of modern Singapore, who had first mooted the idea. The original museum was founded in 1849 and located in what was at that time a large building in Stamford Road. It had galleries for anthropology and natural history, but it was the whale hanging from the ceiling that all visitors remember. In 1969 the Raffles Museum became the National Museum of Singapore and its natural history division was abolished. The collection of 126,000 zoological specimens, the most comprehensive in Southeast Asia at that time, was put into crates and moved to the newly established Singapore Science Centre. The Science Centre had no room for it, so after one year, the collection was moved to the then University of Singapore. Over the next 14 years, the crates were moved from place to place, at one time to the library of Nanyang University at Jurong. Each move took several months and required at least 40 lorries. The specimens suffered from neglect during this period. In 1989, the collection, known as

Model of the dodo, icon of extinction

the 'Zoological Reference Collection' was finally given a proper home, in a three-storey building in the new campus of the National University of Singapore at Kent Ridge. In 1998, the University decided to establish a research centre for biodiversity, with a mandate for research, publication and public education. The 'Zoological Reference Collection' was united with the herbarium of the former Department of Botany of the University to constitute the Raffles Museum of Biodiversity Research.

Governance and Management

The Museum is now part of the Faculty of Science of the National University of Singapore and gets its funding from the University. Its scientists are appointed as university teaching staff. The museum is managed by a Director, Dr Peter Ng, and an Assistant Director. Among the staff are two Research Officers, one Education Officer, one Outreach officer and three Curators (for fish and reptiles, corals and insects, and crustaceans) and one Administrator.

Gallery of Singapore wildlife

Collection and Research

The collections occupy three floors. The rooms are maintained at a temperature of 20ºC and 60-70% RH round the clock.

The old Raffles Museum carried out many expeditions, notably to Christmas Island, Pulau Tioman and Taman Negara. After its re-establishment, new expeditions have been organized, at the rate of one or two per annum to various parts of Southeast Asia, and as far away as Yunnan in

China. The collections now total 500,000 specimens, growing at the rate of 10,000 specimens per annum. With collections spanning 150 years and including 6,000 types specimens, the Raffles Museum has again become attractive to visiting scientists. In 2007, about 100 scientists came to refer to its collections. The Museum also sponsors selected scientists by paying air fares and a daily stipend for 3 – 4 weeks per scientist. In 2007 it sponsored 14 scientists at a cost of SING$30,000. In 2007, the Museum also sent out loans of specimens for study to 388 scientists overseas. All this activity results in scientific papers, published mostly in the Museum's own journal, which raises the University's profile as a centre of excellence for Southeast Asian biodiversity.

Director Dr Peter Ng with theme for 2008

One of the interesting design features of the Museum is a laboratory for visiting scientists, with an internal door to the Collections and an external door to the outside. The internal door is locked at closing time, but visiting scientists are provided with a key to the external door. They can have specimens moved to the visitors' laboratory, to be worked on after closing time and during weekends. Since visitors have only a short stay of 3 – 4 weeks, most of them would want to maximise their time by working longer hours than resident scientists. Visiting scientists have been extremely good value for money!

Library and Publication

The natural history library of the old Raffles Museum is housed in the new Museum. The Bulletin of the Raffles Museum, first published in 1934, was revived in 1987 as the Raffles Bulletin of Zoology. It is a peer-reviewed, citation-indexed journal now considered the premier journal for Southeast Asian biodiversity research.

Exhibition, Outreach and Education

The museum maintains a gallery for exhibitions, small by international standards but with permanent as well as seasonal displays. The current seasonal display is on rats, to mark the Year of the Rat. Entrance is free.

Specimen preparation room

Laboratory for visiting scientists

Every museum needs an iconic exhibit. For its icon, the Museum commissioned a special model of a dodo (the most famous extinct bird) for USD20,000 two years ago. This spectacular bird now stands in a glass case and is the first specimen one sees as one enters the Exhibition Gallery.

The Museum joined with the Singapore Science Centre to hire a travelling exhibition, *A T. rex named Sue* from the Field Museum of Chicago. This exhibition ran for three months and not only paid for itself but also made a good profit for its co-sponsors.

Future development

There is no room for expansion of the Museum in its present location and the present facilities also do not conform to modern fire-safety regulations. Also, its location within a university campus conveys the wrong message—that it is a university facility rather than a general public facility. A new modern museum is being planned, to be located in a more central part of Singapore.

Appendix 4
ROSTER OF NATURAL HISTORY SCIENTISTS IN MALAYSIA 2008

('T' symbolises taxonomy; 'E' ecology; 'B' both taxonomy and ecology)

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
1	Mr.	Affendi, Y.A.	Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur. affendi@um.edu.my	•										E										Scleractinian hard corals, coral reef
2	Dr.	Andrew, A.T.	Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, Kota Samarahan, 94300 Sarawak. aatuen@ibec.unimas.my			•								B			B							
3	Dr.	Ani, S.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. anis@frim.gov.my	•					B															
4	Ms	Asmah , A.	Quarantine Section, Department of Agriculture, Jalan Gallagher, 50480 Kuala Lumpur. asmah8419@yahoo.com	•							E							E						
5	Ms	Avelinah, J.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. avelinah@frim.gov.my	•	•				T															
6	Mr.	Aziz, I.	Entomology Unit, Infectious Diseases Research Centre (IDRC), Institute for Medical Research, Jalan Pahang, 50588 Kuala Lumpur. aziz@imr.gov.my	•														B						
7	Ms	Azlina, Z.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. azlinaz@frim.gov.my	•														B						

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
8	Haji	Azmi, C.A.	Lembaga Koko Malaysia, PO Box 36307, Sungai Sumun, Perak. haca@koko.gov.my	•	•	•					B													
9	Dr.	Badrul, M.M.Z.	School of Environmental and Natural Resource Sciences, Faculty of Science & Technology, 43600 Bangi, Selangor. abgbadd@ukm.my	•	•	•								T										
10	Dr.	Bakhtiar, E.Y.	Institute for Tropical Biology & Conservation (IBTP), Universiti Malaysia Sabah, 88999 Kota Kinabalu, Sabah. bakhtiareffendi@yahoo.co.uk	•	•	•												T						
11	Dato'	Barlow, H.S.	Southdene Sdn. Bhd., PO Box 10139, 50704 Kuala Lumpur. hsbar@pc.jaring.my	•	•													E						
12	Dr.	Chang, Y.S.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. changys@frim.gov.my	•				•			T													
13	Ms	Chew, M. Y.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. chew@frim.gov.my	•	•	•			B															
14	Ms	Chew, P.C.	Freshwater Fisheries Research Centre, Department of Fisheries Malaysia, Glami Lemi, Titi, Jelebu, 71650, Negeri Sembilan. chew@pppat.gov.my	•	•	•															B			
15	Dr.	Chey, V.K.	Forest Research Centre, Sabah Forestry Department, PO Box 1407, 90715 Sandakan, Sabah. VunKhen.Chey@sabah.gov. my		•													B						
16	Dr.	Chong, J.L.	Dept of Biological Sciences, Faculty of Science & Technology, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu. julian@umt.edu.my	•	•	•	•	•	E					E										Population genetics

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
17	Ms	Chong, L.	Forest Research Centre, Sarawak Forestry Corporation, Km 10, Jalan Datuk Amar Kalong Ningkan, 93250 Kuching, Sarawak. chongl@tm.net.my			•					T													
18	Mr.	Chong, M.H.N.	Asian Raptor Research & Conservation Network, 208, Jalan H-8, Taman Melawati, 53100 Kuala Lumpur. mikechn@pc.jaring.my	•	•	•	•	•									B							
19	Prof.	Chong, V.C.	Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur. chong@um.edu.my	•	•														B			E		
20	Dr.	Chung, A.Y.C.	Forest Research Centre, Sabah Forestry Department, PO Box 1407, 90715 Sandakan, Sabah. Arthur.Chung@sabah.gov.my		•													B						
21	Dr.	Chung, R.C.K.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. richard@frim.gov.my	•	•	•			T															
22	Mr.	Daud, A.	Fisheries Research Institute, Sarawak Branch, Department of Fisheries Malaysia, Jalan Perbadanan, Bintawa, PS 2243, 93744 Kuching, Sarawak. daudawang@dof.gov.my		•	•													B			B		Jelly fish
23	Ms	Endela, T.	Forest Research Centre, Sarawak Forestry Corporation, Km 10, Jalan Datuk Amar Kalong Ningkan, 93250 Kuching, Sarawak. endela@sarawakforestry.com			•			B															
24	Mr.	Faisal, A.A.K.	Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, 94300 Sarawak. faisal69@hotmail.com	•	•	•	•							B										Bats and rodents

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
25	Prof.	Fatimah, A.	Faculty of Resource Science andTechnology, Universiti Malaysia Sarawak, Kota Samarahan, 94300 Sarawak. fatim@frst.unimas.my		•	•												B						
26	Dr.	Fauziah, A.	Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur. fauziah@um.edu.my	•	•	•	•											B						
27	Mr.	Gary, K.Z.A.	EDUTREE, 2, Jalan Anggerik Aranda 31/12, Kota Kemuning, 40460 Shah Alam, Selangor. edu3_ services@yahoo.co.uk	•												B		B						
28	Mr.	Gonzaga, A.D.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. adgonzaga@ hotmail.com	•	•	•	•	•										B						
29	Dr.	Han, K.H.	Faculty of Science and Engineering, Universiti Tunku Abdul Rahman, Jalan Universiti, Bandar Banat, 31900 Kampar, Perak. hankwai@hotmail. com	•	•	•								B	E									Molecular taxonomy
30	Mr.	Het, K.	Forest Research Centre, Sarawak Forestry Corporation, Km 10, Jalan Datuk Amar Kalong Ningkan, 93250 Kuching, Sarawak. hetk@sarawakforestry.com			•												B						
31	Prof.	Idris, A.G.	School of Environmental and Natural Resource Sciences, Faculty of Science & Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor. idrisgh@ukm.my	•	•	•	•	•										B						
32	Dr.	Japar, S.B.	Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus, 97008 Bintulu, Sarawak. japar@science. upm.edu.my	•	•	•	•		B				B											

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
33	Mr.	John, B.S.	Sandakan Herbarium, Forest Research Centre, Sabah Forestry Department, PO Box 1407, 90715 Sandakan, Sabah. John.Sugau@sabah.gov.my		•	•			T															
34	Ms	Julia, A.S.	Forest Research Centre, Sarawak Forestry Corporation, Km 10, Jalan Datuk Amar Kalong Ningkan, 93250 Kuching, Sarawak. juliasang@ sarawakforestry. com	•	•	•			T															
35	Mr.	Kennedy, A.A.	Borneo Marine Research Institute, Locked Bag No 2073, Universiti Malaysia Sabah, 88999 Kota Kinabalu, Sabah. kennedy1@ums.edu.my		•								B											
36	Mr.	Khairul, N.K.	Biodiversity Institute, Department of Wildlife and National Parks, Bukit Rengit, 28500 Lanchang, Pahang. knizam@wildlife. gov.my	•														B						
37	Ms	Khoo, V.S.I.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. veronica@frim. gov.my	•														T						
38	Dr.	Kirton, L.G.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. laurence@frim. gov.my	•	•	•	•											B						
39	Mr.	Lau, K.H.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. laukh@frim.gov.my	•	•	•	•		B															
40	Dr.	Lee, S.S.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. leess@frim.gov.my	•		•					T													
41	Dr.	Leh, M.U.	Sarawak Museum, Jalan Tun Abang Haji Openg, 93566 Kuching, Sarawak. charllmu@sarawaknet. gov.my			•								B	T	T	T	T	T	T	T	T	T	

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
42	Dr.	Lim, C.K.	Sarawak Forestry Corporation, Level 11, Office Tower, Hock Lee Centre, Jalan Datuk Abang Abdul Rahim, 93450 Kuching, Sarawak. lck@sarawakforestry.com			•											E							
43	Mr.	Lim, C.L.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. limchunglu@frim.gov.my	•					T															
44	Dr.	Lim, G.T.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. grace@frim.gov.my	•														B						
45	Dr.	Lim, P.E.	Algae Research Laboratory, Universiti Malaya, 50603 phaikeem@yahoo.com	•	•	•	•	•					T											
46	Mr.	Lim, T.T.	Resource Stewardship Consultants Sdn. Bhd., 94, Jalan Maarof, 59000 Kuala Lumpur. limtzetshen@rescu.com.my	•	•	•								T				T						
47	Prof.	Mahani, M.C.	Faculty of Science & Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor. mahani@ukm.my	•	•	•			B															
48	Mr.	Maklarin, L.	Sabah Parks, PO Box 10626, 88806 Kota Kinabalu, Sabah. maklarin@yahoo.com		•									E	E	E	E							
49	Mr.	Marfaisal,M.	Forest Research Centre, Sarawak Forestry Corporation, Km 10, Jalan Datuk Amar Kalong Ningkan, 93250 Kuching, Sarawak. marfaisal@sarawakforestry. com			•																		
50	Dr.	Mariana, H.A.	Acarology Unit, Infectious Diseases Research Centre (IDRC), Institute for Medical Research, Jalan Pahang, 50588 Kuala Lumpur. mariana@imr.gov.my	•																				Acarine (ticks & mites)

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
51	Ms	Meriam, M.Y.	Pusat Penyelidikan dan Pembangunan Koko, Lembaga Koko Malaysia, Batu 10, Jalan Apas, Peti Surat 60237, 91012 Tawau, Sabah. meriam@koko.gov.my	•	•	•												B						Weeds
52	Prof.	Mohamed, A.M.	Biology Department, Universiti Brunei Darussalam, Gadong BE1410, Brunei. binabdulmajid@gmail.com	•	•	•	•			B														
53	Mr.	Mohammad, S.A.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. shahfiz@frim.gov.my	•	•	•	•	•						E										
54	Tunku	Mohammad, N.Y.	82, Jalan Ampang Hilir, 55000 Kuala Lumpur. tnazim@tm.net.my	•	•	•	•	•						B	B	B	B				B	B		
55	Dr.	Mohd, T.A.	Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, 94300 Sarawak. tabdullahmt@gmail.com	•	•	•								B										
56	Dr.	Mustafa, A.R.	Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, 94300 Sarawak. rmustafa@frst.unimas.my	•	•	•	•										B							
57	Dr.	Muta, H.Z.	Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus, 97008 Bintulu, Sarawak. drmuta@btu.upm.edu.my	•	•	•	•		B				B											Sea-grasses, aquatic plants, macroalgae
58	Ms	Nada, B.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. nada@frim.gov.my	•														E						
59	Ms	Nadiah, I.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. nadiahidris@frim.gov.my		•	•			T															
60	Dr	Ng, F.S.P.	A-9-5 Menara Menjalara, Bandar Menjalara, 52200 Kuala Lumpur. fng@pc.jaring.my	•	•	•	•	•	B															

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
61	Dr .	Ng, Y.F.	Centre for Insect Systematics, School of Environmental and Natural Resource Sciences, Faculty of Science & Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor. ng_yf@ukm.my	•	•	•												B						Parasitic wasps, thrips, dragonflies
62	Ms	Noorainie, A.A.	TRAFFIC Southeast Asia, Unit 9-3A, 3rd Floor, Jalan SS23/11, Taman SEA, 47400 PJ Selangor. naatsea@po.jaring.my	•	•	•	•	•	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	Trade monitoring
63	Dr.	Noorma, W.H.	Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur. noorma@um.edu.my	•	•	•			T															
64	Ms	Noraswati, M.N.R.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. noraswati@frim.gov.my	•							B													Polypora-ceae
65	Dr.	Norela, S.	School of Environmental and Natural Resource Sciences, Faculty of Science & Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor. vozela@pkrisc.cc.ukm.my	•	•													T						Acari
66	Mr.	Norhanizan, S.	Freshwater Fisheries Research Centre, Department of Fisheries Malaysia, Glami Lemi, Titi, Jelebu, 71650 Negeri Sembilan. norhanizans@yahoo.com					•																Aquatic plants
67	Ms	Norhayati, A.S.	Forest Research Centre, Sarawak Forestry Corporation, Km 10, Jalan Datuk Amar Kalong Ningkan, 93250 Kuching, Sarawak. norhayatias@sarawakforestry. com			•					T													
68	Ms.	Nur, Z.A.M.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. nurzatiakma@frim.gov.my	•														E						

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
69	Mr.	Ong, P.T.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. ongpohteck@frim.gov.my	•					T															
70	Ms	Ong, S.P.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. ongsuping@frim.gov.my	•														T						
71	Ms	Ooi, L.S.	Department of Geography, Faculty of Arts & Social Sciences, Universiti Malaya, 50603 Kuala Lumpur. gongdive@yahoo.com	•	•								E											
72	Mr.	Oswald, B.T.	Protected Areas & Biodiversity Conservation Unit (PABC), Sarawak Forestry Corporation, Level 11, Office Tower, Hock Lee Centre, Jalan Datuk Abang Abdul Rahim, 93450 Kuching, Sarawak. oswaldtisen@sarawakforestry. com			•								E	E									
73	Ms	Patahayah, M.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. patahayah@frim.gov.my	•							B													
74	Ms	Pereira, J.T.	Sandakan Herbarium, Forest Research Centre, Sabah Forestry Department, PO Box 1407, 90715 Sandakan, Sabah. Joan.Pereira@sabah.gov.my		•	•			T															
75	Ms	Petherine, J.	Institute for Tropical Biology & Conservation (IBTP), Universiti Malaysia Sabah, 88999 Kota Kinabalu, Sabah. ethrine@ums.edu.my		•													E						
76	Prof.	Phang,	Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur. phang@um.edu.my	•	•	•	•						B											Sea-grasses
77	Ms	Phon, C.K.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. phonchooikhim@frim.gov.my	•														E						

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
78	Ms	Phoon,	Forest Research Institute Malaysia, 52109 Kepong, Selangor. phoon@frim.gov.my	•					T															
79	Ms	Rafidah, A.R.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. rafidahar@frim.gov.my	•					T															
80	Mr.	Rahmat, M.S.	Institute for Medical Research, Jalan Pahang, 50588 Kuala Lumpur. rahmat@imr.gov.my	•	•	•								E										
81	Dr.	Rhett, H.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. rhett@bio.miami.edu	•	•	•	•		E					E			E	E						
82	Ms	Roziah, A.	Division of Genetics & Molecular Biology, Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur. salmiah@frim.gov.my	•																				
83	Dr.	Ruhana, H.	Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, 94300 Sarawak. hruhana@frst.unimas.my			•							B										B	
84	Dr.	Salmiah, U.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. salmiah@frim.gov.my	•							B													Wood deterioration
85	Ms	Sam, Y.Y.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. samyen@frim.gov.my	•		•			T															
86	Dr.	Saw, L.G.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. sawlg@frim.gov.my	•	•	•	•		B															
87	Dr.	Sepiah, M.	Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, 94300 Sarawak. msepiah@frst.unimas.my	•	•	•					B													

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
88	Ms	Shahlinney, L.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. shahlinney@frim.gov.my	•														B						
89	Mr.	Shawn, C.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. shawn@frim.gov.my	•	•	•	•	•										B						
90	Dr.	Siti Aishah, A. @ Orosco, C.A.	Dept of Marine Science, Faculty of Maritime Studies and Marine Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu. aishah@umt.edu.my	•	•	•	•		B				B												Vascular plants, sea-grasses
91	Dr.	Siti Akmar Khadijah, A.R.	Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, 94300 Sarawak. arakmar@frst.unimas.my			•							E										B	Echino-dermata
92	Ms	Siti Ariza, A.	Institut Akuakultur Tropika (AkuaTrop), Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu. sitiariza@yahoo.com	•	•	•															E			
93	Ms	Siti Munirah, M.Y.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. sitimunirah@frim.gov.my	•					T															
94	Ms	Siti Tafzil-meriam, S.A.K.	Institute of Oceanography, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu. sititafzil@umt.edu.my	•	•	•													B		B	B	B	Corals & sponges
95	Dr.	Soepadmo, E.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. soepadmo@frim.gov.my	•	•	•	•		B															
96	Dr.	Subha, B.	Freshwater Fisheries Research Centre, Department of Fisheries Malaysia, Glami Lemi, Titi, Jelebu, 71650 Negeri Sembilan. subhabhassu@yahoo.com	•																	B			

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
97	Ms	Suhaida, M.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. suhaida@frim.gov.my	•					E															
98	Mr.	Sundai, S.	Protected Areas and Biodiversity Conservation Unit (PABC), Regional Office Kuching, Sarawak Forestry Corporation, Sama Jaya Forest Park, Lot 554 & 8177, Block 11, Jalan Setia Raja, 93350 Kuching, Sarawak. sundai@sarawakforestry.com	•		•								E										Primates
99	Ms	Syahida Emiza, S.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. syahida@frim.gov.my	•	•	•		B																
100	Mr.	Taha, W.	Protected Area & Biodiversity Conservation Unit (PABC), Sarawak Forestry Corporation, Level 11, Office Tower, Hock Lee Centre, Jalan Datuk Abang Abdul Rahim, 93450 Kuching, Sarawak. tahaw2@sarawakforestry.com			•									E	E								
101	Ms	Tan, H.S.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. tanhuisin@frim.gov.my		•	•			T															
102	Ms	Tan, S.H.	Division of Genetics & Molecular Biology, Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur. hwatanum2@yahoo.com	•		•												T						
103	Ms	Thi, B.K.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. thibeekin@frim.gov.my	•							T													
104	Ms	Ummul Nazrah, A.R.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. ummul@frim.gov.my	•					T															

No	Title	Name	Postal & E-mail Address	Peninsular Malaysia	Sabah	Sarawak	Southeast Asia	World	Vascular Plants	Bryophytes	Fungi	Lichens	Algae	Mammals	Reptiles	Amphibians	Birds	Insects	Crustaceans	Spiders	Freshwater fishes	Marine fishes	Molluscs	Others
105	Ms	Wan Norafikah, O.	Institute for Medical Research, Jalan Pahang, 50588 Kuala Lumpur. wan_norafikah@imr.gov.my	•	•	•												B						
106	Ms	Wan Norjuliana, W.M.	Institute for Medical Research, Jalan Pahang, 50588 Kuala Lumpur. wnjulia23@yahoo.com.my	•														B						
107	Dr.	Wee, S.L.	School of Environmental and Natural Resource Sciences, Faculty of Science & Technology, 43600 Bangi, Selangor. slwee@ukm.my	•	•	•												E						
108	Mr.	Yao, T.L.	Forest Research Institute Malaysia, 52109 Kepong, Selangor. yaotzeleong@frim.gov.my	•					T															
109	Mr.	Yusri, Y.	Institute of Oceanography, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu. yusriyusuf@umt.edu.my	•	•	•															B	B		Corals, echino-derms, sponges
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