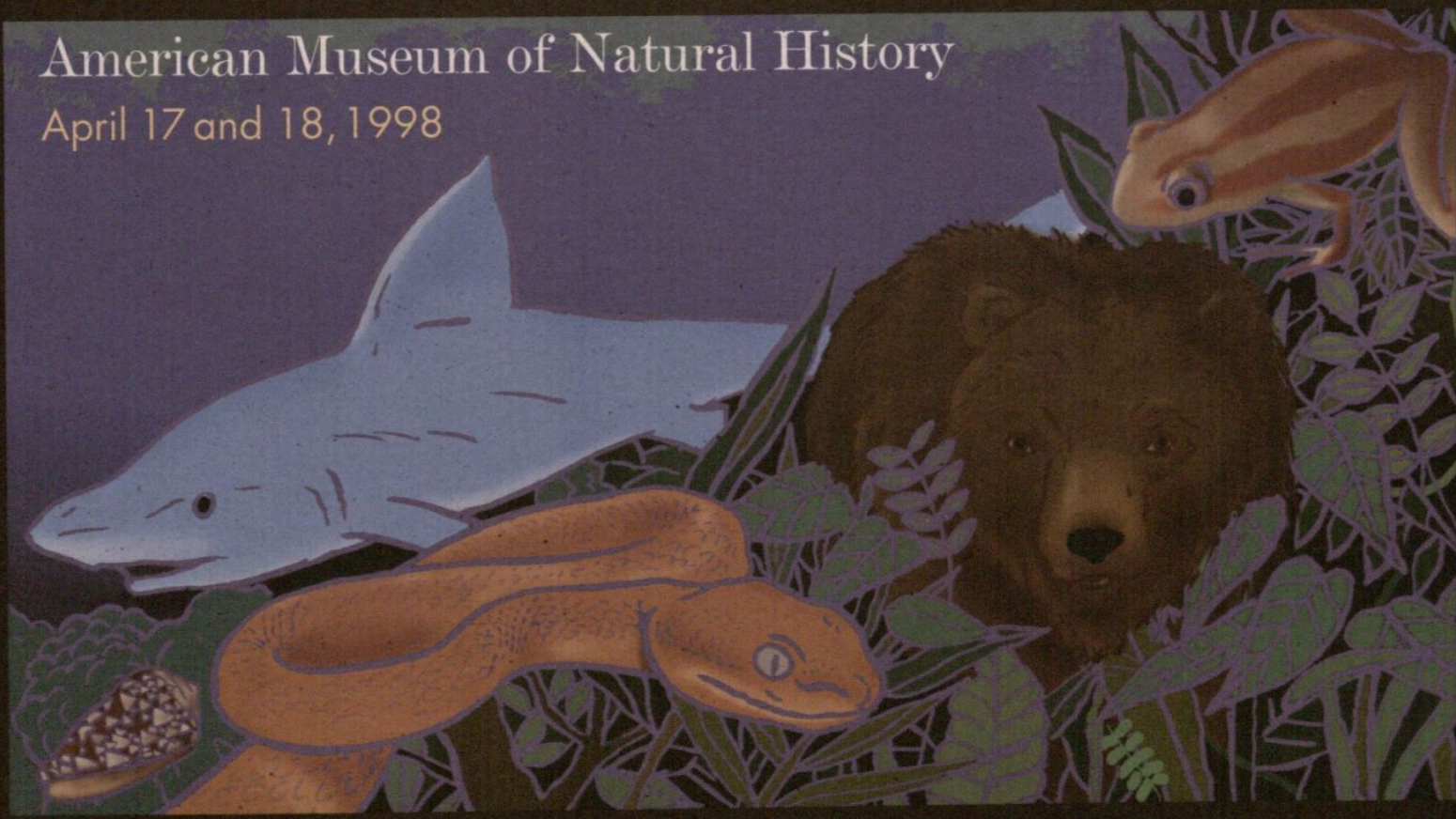
The Value of Plants, Animals, and Microbes to Human Health

American Museum of Natural History

April 17 and 18, 1998



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SPRING SYMPOSIUM

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CENTER FOR BIODIVERSITY AND CONSERVATION

SPRING SYMPOSIUM

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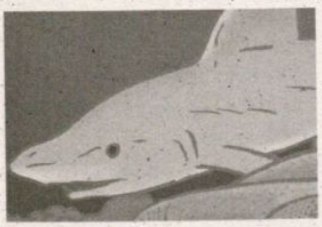
American Museum of Natural History

SPRING SYMPOSIUM

All life on Earth, from vast ecosystems to microscopic organisms, is connected and interdependent. Yet that basic fact has been largely overlooked by our own species. We have modified ecosystems to suit our own needs, altering their functions in the process. This and the resultant loss of biodiversity now threatens us with a health crisis of global proportions.

Plants, animals, and microbes offer the key to a greater understanding of human health and disease, both as medical models and as sources of new medicines for presently untreatable conditions. As much as 80 percent of the world's human population relies on traditional medicines made from natural ingredients, and a significant proportion of pharmaceutical products are derived from plants and other natural sources. Biomedical research has also led to the development of treatments for certain cancers, heart disease, and other debilitating and deadly illnesses. Yet only a fraction of the world's biological wealth has been studied for this purpose.



In order to utilize these resources, we must first protect them. Alarmingly, species are disappearing faster than they can be identified. The cause is our non-sustainable consumption of resources, which leads to habitat destruction and transformation, overexploitation, pollution, the introduction of alien species, and the alteration of global climate. Our destructive reach is global, affecting terrestrial, marine, and aquatic ecosystems.

Disruption of specific ecosystems has been linked to the emergence and spread of human infectious diseases, including the AIDS pandemic, malaria, and hemorrhagic fevers. The health implications for protecting biodiversity also extend to the vital role that plants, animals, and microbes play in maintaining the quantity and quality of our air, food, and water supplies.

Many of the earliest casualties within an ecosystem are species that are especially vulnerable to environmental assaults and that indicate future problems. They may serve as our "canaries," warning us of future human health problems, if we are willing to recognize their signals.

The state of human health is inseparable from the health of the natural world. This fundamental relationship has gone largely unnoticed by policy makers and the public. The connection can no longer be ignored.

CENTER FOR BIODIVERSITY AND CONSERVATION

SPRING SYMPOSIUM SCHEDULE

Friday, April 17, 1998

THE VALUE OF PLANTS, ANIMALS, AND MICROBES TO HUMAN HEALTH

8:00 a.m. REGISTRATION and Coffee

9:00 WELCOME
Ellen V. Futter, *President, American Museum of Natural History*

INTRODUCTION
Eric Chivian, *Center for Health and the Global Environment, Harvard Medical School*
Joanne Fox-Przeworski, *United Nations Environment Programme*
Francesca T. Grifo, *Center for Biodiversity and Conservation, American Museum of Natural History*
Joshua Rosenthal, *Fogarty International Center, National Institutes of Health*

I. Keynote Address

9:15 The Biodiversity Crisis: A Status Report
Stuart L. Pimm, University of Tennessee

II. Species as Sources of New Medicines

9:45 OVERVIEW AND MODERATOR
Francesca T. Grifo

10:00 Biodiversity and Traditional Medicines
Maurice M. Iwu, *Bioresources Development and Conservation Programme*

10:20 Natural Sources for Prescription and Over-the-Counter Drugs
David J. Newman, *National Cancer Institute*

10:40 **Coffee Break**

11:00 Development of Taxoid Anticancer Agents and MDR Reversal Agents from Yew Trees
Iwao Ojima, *State University of New York at Stony Brook*

11:20 **Panel Discussion: Case Studies**

- Animal Sources for Medicines: Anti-platelet Agents and Snake Venoms
  Robert J. Gould, *Merck Research Laboratories*
- Microbes and Antibiotics
  Dennis M. Schmatz, *Merck Research Laboratories*
- Drugs from Marine Species
  William Fenical, *Scripps Institution of Oceanography*

American Museum of Natural History

SPRING SYMPOSIUM SCHEDULE

12:10 p.m. **Questions from the Audience**

12:30 **Lunch**

III. The Importance of Species to Medical Research

2:00 OVERVIEW AND MODERATOR
Eric Chivian

2:15 **Panel Discussion: Neurotoxins, Neurophysiological Research, and Drug Development**
MODERATOR
Bruce P. Bean, *Harvard Medical School*

- Novel Alkaloids from Amphibian Skin: Pharmacological and Clinical Implications
  Edson X. Albuquerque, *University of Maryland*
- Converging Pathways: From the Frog Alkaloid, Epibatidine, to the Synthetic Cholinergic Channel Modulator, ABT-594, a Novel Potent Analgesic
  Michael Williams, *Abbott Laboratories*
- Learning Drug Design from Marine Snails
  Baldomero M. Olivera, *University of Utah*
- From Killing to Curing: Venom Peptides as Medicine
  George P. Miljanich, *Neurex Corporation*

3:30 Human Diseases: Help from Denning Bears
Ralph A. Nelson, *Carle Foundation Hospital*

3:50 **Coffee Break**

4:10 Immunity in Sharks: Origins of the Combinatorial Immune System of Jawed Vertebrates
John J. Marchalonis, *University of Arizona*

4:30 The Ancient and Ubiquitous Insulin Signaling Pathway: Implications for Screening Natural Products for Diabetes Pharmaceuticals Development
Gary Ruvkun, *Harvard Medical School*

4:50 Novel Enzymes from Thermophilic Bacteria
Stephen C. Nold, *Michigan State University*

5:10 **Questions from the Audience**

American Museum of Natural History

SPRING SYMPOSIUM SCHEDULE

Saturday, April 18, 1998

8:00 a.m. **Coffee**

IV. Ecosystems and the Control of Infectious Disease

8:45 OVERVIEW AND MODERATOR
Paul R. Epstein, *Harvard Medical School*

9:00 Ecology and Lyme Disease
Richard S. Ostfeld, *Institute of Ecosystem Studies*

9:20 Deforestation and Insect-borne Infection: Trends and Patterns
David H. Molyneux, *Liverpool School of Tropical Medicine*

9:40 The Real Cause of the AIDS/HIV Epidemic: Destruction of Monkey and Ape Habitats in the African Rainforest
Jaap Goudsmit, *University of Amsterdam*

10:00 Hantaviruses, Hemorrhagic Fevers, and the Emergence of Infectious Diseases
Stephen S. Morse, *Columbia University*

10:20 **Coffee Break**

10:40 Nutrient Discharge and *Pfiesteria piscicida*
JoAnn M. Burkholder, *North Carolina State University*

11:00 Global Change and Human Health: The Cholera Paradigm
Rita R. Colwell, *University of Maryland*

11:20 **Questions from the Audience**

11:45 **Lunch**

American Museum of Natural History

SPRING SYMPOSIUM SCHEDULE

V. Ecosystem Services and Life Support Systems

1:15 p.m. OVERVIEW AND MODERATOR
Joshua Rosenthal

1:30 Biodiversity and Agriculture
Alison G. Power, *Cornell University*

1:50 Freshwater and Health
Sylvia M. Le Blancq, *Columbia University*

2:10 Status and Trends in the World's Fisheries
Carl Safina, *National Audubon Society*

2:30 Climate Change and Ecosystem Services
Stephen H. Schneider, *Stanford University*

2:50 **Questions from the Audience**

3:10 **Coffee Break**

VI. Where Do We Go From Here?

3:30 OVERVIEW AND MODERATOR
Joanne Fox-Przeworski

3:45 Demographic Winter Solstice: Implications for Biodiversity and Health
Robert Engelman, *Population Action International*

4:05 The Global Biodiversity Assessment and Human Health
Per Wramner, *Swedish National Board of Fisheries*

4:25 **Questions from the Audience**

VII. Concluding Keynote Address

4:45 Towards a New Millennium: Rediscovering Our Place in the Natural World
David T. Suzuki, *David Suzuki Foundation*

American Museum of Natural History

Novel Alkaloids from Amphibian Skin: Pharmacological and Clinical Implications

Edson X. Albuquerque
University of Maryland

Co-author:
J.W. Daly

The skin secretions of amphibians have a wide range of biologically active alkaloids, many of which are toxic and have unique profiles of pharmacological activity. Over 500 alkaloids have been detected and structures of 20 different classes of alkaloids have been elucidated. The initial studies of such novel toxins made possible the cloning and molecular biology of the sodium channels and formed the basis for gene therapy for diseases where the sodium channel may be involved. Current understanding of the interactions of neurotransmitters with their receptors, leading to channel activation, inactivation, and desensitization of receptors, owes much to the discovery of these highly-specific toxins. These alkaloids were originally thought to be synthesized by the amphibians; but it is now realized that most, if not all, are merely accumulated unchanged from invertebrate dietary sources. Discovery of arthropod sources of the alkaloids found in amphibian skin may provide a treasure-trove of further alkaloids. Many genera of amphibians remain to be investigated as sources for alkaloids and other active substances, which most certainly will benefit molecular understanding and treatment of major degenerative processes such as Parkinson's and Alzheimer's diseases.

Global Change and Human Health: The Cholera Paradigm

Rita R. Colwell
University of Maryland

An environmental source of cholera was hypothesized as early as the late 19th century by Robert Koch, but not proven because of the ability of Vibrio cholerae, *the causative agent of cholera, to enter a dormant phase between epidemics. The association of* Vibrio cholerae *with plankton was established only recently, allowing analysis of epidemic patterns of cholera. The sporadicity and erraticity of cholera epidemics can now be related to climate and climate events, such as El Niño. Since zooplankton have been shown to harbor the bacterium and zooplankton blooms follow phytoplankton blooms, remote sensing can be employed to determine the relationship of cases of cholera with chlorophyll, sea surface temperature, ocean height, and turbidity. Recent satellite images have been used to show that cholera cases are more numerous when the ocean is high and sea surface temperature is elevated. Prospective investigations of sea surface temperature, phytoplankton, and zooplankton relationships with incidence of cholera are in progress. Results indicate that select climatological factors and cholera appear to be significantly interrelated, bringing the potential of predicting conditions conducive to cholera outbreaks closer to reality.*

Demographic Winter Solstice: Implications for Biodiversity and Health

Robert Engelman
Population Action International

The more we learn about the value of the Earth's wealth of living organisms to human health, the more we face a paradox. Our near vanquishing of infant and child mortality in the 20th century has resulted in a surge in the number of people that inhabit the planet. It is in large part impacts related to this population surge that threaten the biodiversity that sustains us. In recent years, however, an unexpectedly rapid human fertility decline has slowed population growth, opening up new possibilities for the natural world. We may be approaching a peak in human numbers—a kind of demographic winter solstice—that will brighten the prospects for species conservation in the coming millennium.

Drugs from Marine Species

William Fenical
Scripps Institution of Oceanography

Over 50 percent of the drugs on the market are derived from natural products. While traditional sources for natural drugs are terrestrial microorganisms and plants, the marine environment may become the most important natural drug resource for the next century. It is now recognized that marine organisms are genetically unique in comparison with their terrestrial relatives and have the capabilities of producing structurally-novel and pharmacologically-unique secondary metabolites. Already more than 5,000 novel compounds have been isolated from marine sources. The important drug targets are cancer, infectious diseases and diseases involving inflammation and pain. Because large amounts of marine plants and animals would be needed for drug development, there are significant problems with this approach to marine drug discovery. Recent studies explore microorganisms found in the world's oceans. Initial results indicate that the oceans are at least as biologically diverse as soil. Given these recent successes, marine microorganisms represent a significant resource for natural drug discovery.

The Real Cause of the AIDS/HIV Epidemic: Destruction of Monkey and Ape Habitats in the African Rainforest

Jaap Goudsmit
University of Amsterdam

The current worldwide AIDS epidemic is less than 20 years old, but its history is much older. AIDS is the unfortunate by-product of a virus's survival needs. The three known AIDS viruses are all retroviruses of the lentivirus family. Two of them, HIV-0 and HIV-2, remain fairly confined to their original African ecological niches, but the virus that became HIV-1 jumped from its original host and found foothold in humans. Within a century, this foothold has become a stranglehold. Environmental instability caused by humans was a major factor in the rise of today's AIDS epidemic. As humans decimated the monkey and ape populations that had sustained the SIV ancestor of HIV-1, the virus found a new host in humans, on which it now depends for its survival. Our increasing intrusion on monkey and ape habitats has convinced some scientists that monkeys could vanish from the wild by the end of the 21st century. Monkey retroviruses will likely jump to new hosts, probably humans. To survive and spread, they will adapt and cause disease. While scientists race to tame the AIDS virus, we must all work toward one important goal: to protect the monkey and ape populations still extant in the wild. We must consider their survival needs along with our own and create more preserves and sanctuaries.

Animal Sources for Medicines: Anti-platelet Agents and Snake Venoms

Robert J. Gould
Merck Research Laboratories

Aggrastat™ is a potent blocker of platelet aggregation that prevents refractory ischemia, myocardial infarction, and death in patients with unstable angina. The discovery and development of Aggrastat built on observations that the venom of vipers contains proteins that potently inhibit platelet aggregation by blocking a specific receptor, GP IIb/IIIa, on the platelet surface. Contained within the amino acid sequence of this family of proteins, named disintegrins, was a three amino acid sequence; arginin-glycine-aspartic acid. This motif is also found in fibrinogen which is the natural ligand for GP IIb/IIIa molecules on adjoining platelets and thus holds platelets together in a forming thrombus. If this thrombus forms within a cardiac blood vessel as a consequence of damage to atherosclerotic plaques, blood flow to the cardiac muscle can be impaired. This may result in unstable angina or non-Q-wave myocardial infarction. Therefore, Aggrastat was designed to mimic the naturally-occurring sequence found in disintegrins and fibrinogen and prevent the formation of the thrombus.

Biodiversity and Traditional Medicines

Maurice M. Iwu
Bioresources Development and Conservation Programme

Traditional medicine is multi-factorial both in the methods of treatment and in the choice of ingredients used for the preparation of remedies. It incorporates rational and analytical elements with those that are religious or psychosomatic. To the traditional healer, the natural environment is intrinsically bound to humans. It has helped to shape human cultures, and thus, represents not only material resources, but is a cultural heirloom that underpins our life on Earth. Conservation of biodiversity is therefore vitally important in the lives of the many peoples who depend on traditional medicine for their physical health and spiritual well-being. Conservation must involve not only maintaining genetic diversity within a given taxa or ecosystem, but supporting the human populations who use these natural resources as well. Knowledge of healing in any particular society is both a product of individually-acquired experience and the wisdom passed on by previous generations. Thus, the globalization of traditional medicine raises concerns about access to cultural information, ownership, and equitable distribution of benefits derived from commercialization of traditional knowledge.

Freshwater and Health

Sylvia M. Le Blancq
Columbia University

In the United States, copious amounts of clean water are available from the faucets in our homes, work places and recreation centers and there are flush toilets for the disposal of our waste. Most people barely give freshwater and sewage a second thought. Adequate water quality, quantity and sanitation, however, are crucial for public health because many disease-causing microorganisms are water-borne. When water supplies are limited and/or contaminated with human and animal waste, disease is rife. Where does freshwater come from? Where does sewage go? What keeps them separate? These questions will be the focus of this presentation.

Immunity in Sharks: Origins of the Combinatorial Immune System of Jawed Vertebrates

John J. Marchalonis
University of Arizona

Chondrichthytians, the most primitive extant class of jawed vertebrates, are the lowest group of animals to demonstrate the entire set of cellular, molecular, and genetic elements of the combinatorial immune response. Sharks have one predominant antibody class that resembles the earliest produced IgM macroglobulins of fetal humans. The arrangement of immunoglobulin and T-cell receptor gene segments is distinct in sharks from that of mammals, but sharks have an unexpectedly great diversity in these recognition molecules. Naturally-occurring anti-microbial antibodies and innate recognition molecules of sharks present a virtually untapped resource of therapeutic agents. The shark immune system is relevant to natural immunity, to inducible antigen specific immunity, to autoimmunity and to the molecular basis of the rapid emergence of combinatorial immunity in an evolutionary "big bang."

From Killing to Curing: Venom Peptides as Medicine

George P. Miljanich
Neurex Corporation

Ziconotide (SNX-111), a promising new analgesic derived from the venom of a sea snail, is in the final stages of clinical trials. It has been shown to effectively—and often dramatically—reduce or eliminate many manifestations of chronic and otherwise intractable pain. Animal venoms contain extremely potent and selective compounds directed against essential molecular components of the nervous, muscular, or circulatory systems of prey animals. As exemplified by ziconotide, these same properties make many of these compounds promising candidates for effective human therapeutics. New methods of separation, characterization, and production place us at the threshold of fully exploiting this source of novel medicines.

Deforestation and Insect-borne Infection: Trends and Patterns

David H. Molyneux
Liverpool School of Tropical Medicine

Deforestation continues to affect global and local health. The interface of forests and populations is highly variable and the outcomes of exposure to infectious agents depends on factors such as the immune status of populations, types of settlement patterns, the nature of agricultural development, types of reforestation, and changes in insect vector populations, as well as the role of any animal reservoir hosts. This presentation will analyze the impact of deforestation on malaria, leishmaniasis, river blindness and trypanosomiasis—particularly the status of vector populations and the changed levels of exposure of populations—and compare the impact on insects with different biological cycles. The importance of using modern identification methods to detect the diversity of vectors and parasites will be emphasized.

Hantaviruses, Hemorrhagic Fevers, and the Emergence of Infectious Diseases

Stephen S. Morse
Columbia University

Emerging infectious diseases are those that are newly appeared in the population, or are rapidly increasing their incidence or geographic range (e.g., HIV/AIDS, cholera in South America and Africa, Ebola in Africa, Hantavirus pulmonary syndrome and Lyme disease in the U.S.). A reflection of the great, and largely uncatalogued, microbial biodiversity that exists in nature, many emerging infections are caused by pathogens that are present in the environment but are newly introduced into humans, often from another species as a result of changing ecological or environmental conditions that increase the chance of human contact. Ecological changes such as deforestation, habitat fragmentation, or climatic effects can increase the population of a natural host carrying a previously unfamiliar pathogen, with a corresponding increase in risk of human contact. Well known examples include Ebola and monkeypox in Africa, Argentine hemorrhagic fever in South America, and Hantaan (Korean hemorrhagic fever) in Asia. After introduction, human population movements can transfer remote infections to a larger population (as probably happened with HIV). Environmental changes that decrease productivity of the local food supply can potentially accelerate this migration.

Human Diseases: Help from Denning Bears

Ralph A. Nelson
Carle Foundation Hospital

Alert and reactive, the denning bear is unequaled as the only mammal that can fast for 150 days or more at a normal body temperature, burning 4,000 calories per day. Not eating, drinking, urinating, or defecating, the bear stands alone in its ability to emerge healthy in spring. The circumstances of denning should produce early death. But the bear survives over winter by producing substances that, when developed as drugs, should treat serious human disorders of osteoporosis, kidney failure, obesity, diabetes, mellitus, and anxiety. A biological extract from bears, developed by the Carle Foundation Department of Research, has been able to reproduce the phenomena of denning in non-denning and non-hibernating mammals and shows promise for treating osteoporosis and kidney disease.

Natural Sources for Prescription and Over-the-Counter Drugs

David J. Newman
National Cancer Institute

Analyses of the new chemical entities that have been approved between 1983 and 1994, together with selective extensions into more recent years, will be presented, thus demonstrating how investigations of nature have led to the development of very significant numbers of agents in cancer, infective diseases, and other diseases areas. Some examples will also be given of compounds from nature that have been used as, or led to, effective over-the-counter drugs.

Novel Enzymes from Thermophilic Bacteria

Stephen C. Nold
Michigan State University

Thermal habitats, such as the hot springs found in Yellowstone National Park, support a vast diversity of microbial life forms. During the 1960s, Dr. Thomas Brock of the University of Wisconsin cultivated and characterized an organism from a Yellowstone hot spring that he named Thermus aquaticus. *Now, the thermostable DNA polymerase from* T. aquaticus *is central to the polymerase chain reaction, a revolutionary molecular technique used in genetic disease diagnosis, pathogen detection, and genome sequencing efforts. Other enzymes from thermophilic microorganisms have been used in biotechnology, pharmaceutical, and industrial applications. Future progress may rely on studies of thermophilic viruses and cultivation-independent sampling of microbial enzymatic diversity.*

Development of Taxoid Anticancer Agents and MDR Reversal Agents from Yew Trees

Iwao Ojima
State University of New York at Stony Brook

This presentation will describe the development of highly efficient and practical methods for the production of the anti-cancer drug, Taxol, by semi-synthesis using a baccatin isolated from the leaves of European yew trees, Taxus baccata. *It will also examine the development of second generation taxoid anti-cancer agents that possess exceptional activity against cancers with multi-drug-resistance (MDR). Finally, the lecture will address the highly efficient taxane MDR reversal agents that enable anti-cancer drugs, like Taxol and doxorubicin, to recover their activity against MDR cancers through co-administration of the agent with the anti-cancer drug. These latter two agents are also based on baccatins isolated from the leaves of European and Himalayan yew trees.*

Learning Drug Design from Marine Snails

Baldomero M. Olivera
University of Utah

The venomous Cone snails (genus Conus*) are an extremely successful group of over 500 species that have evolved highly sophisticated, diverse neuropharmacological strategies. Each Cone snail has between 50 to 200 pharmacologically active peptides in its venom. Several of these are being developed as drugs. The Cone snails appear to have evolved a new paradigm of drug design that delivers highly-refined target specificity. The Cone snail strategy may be a key to developing drugs without side effects. An overview of the biological diversity, endogenous functions, and potential for drug development of the pharmacological agents in Cone snail venoms will be presented.*

Ecology and Lyme Disease

Richard S. Ostfeld
Institute of Ecosystem Studies

Many agents of infectious disease, including Lyme disease, live primarily in natural communities where they infect mammals and birds, and are only incidentally transmitted to humans. Prevention of such zoonotic diseases requires knowledge of the interactions between the pathogen, its natural hosts, vectors (e.g., ticks, mosquitoes), and humans. Recent studies have revealed that risk of exposure to Lyme disease is determined by a set of intricate interactions among trees, ticks, white-footed mice, and white-tailed deer. Oak trees periodically produce bumper crops of acorns, which attract deer to oak-dominated forests and cause dramatic increases in populations of mice. Deer and mice are critical hosts in the life cycle of the tick vector of Lyme disease. Our studies show that it may be possible to predict risk of Lyme disease nearly two years in advance, based on acorn production. Moreover, computer simulation models suggest that the higher the species diversity in the vertebrate community, the lower the risk of Lyme disease. I conclude that preserving biodiversity may have tangible benefits in reducing the risk of infectious disease; ecological understanding may promote the prediction of disease risk and aid in prevention; and the science of ecology should be considered a critical ally, and indeed, a necessary component, of the health sciences.

The Biodiversity Crisis: A Status Report

Stuart L. Pimm
University of Tennessee

What are we doing to the planet as this century comes to an end? On land, humans consume about half the annual plant growth—which amounts to the interest on the principal of life's bank account. We dip into that principal extensively, destroying forests and drylands together with their potential to support us. In the oceans, about one third of the annual plant production goes to support our fisheries, the majority of which are already damaged. Though these changes may be reversible, the loss of species is not. How fast are species becoming extinct worldwide? Although extinction is a naturally-occurring process, we are now faced with a greatly increased extinction rate. Compared with background rates of extinction, as calculated from the fossil record, we estimate that over the last century extinction rates have increased by between 100 and 1000 times. If current rates of habitat destruction continue, and evidence suggests they are in fact accelerating, then within 50 years nearly half of the planet's species would face extinction.

Biodiversity and Agriculture

Alison G. Power
Cornell University

Biodiversity at multiple trophic levels plays an essential role in the productivity of agroecosystems. Conservation of genetic resources in wild relatives of crop species can help increase crop resistance to pests and diseases, increase resistance to drought and other abiotic stresses, and improve crop productivity. Genetic and species diversity among crops can increase the productivity and stability of agroecosystems. Diversity of natural enemies such as predators and parasites can decrease losses to insects and diseases through natural pest regulation. A wide range of pollinators can lead to higher crop productivity. Below ground, variation of the soil biota can contribute to pathogen regulation and the acquisition and retention of nutrients in the agroecosystem. For example, conserving the diversity of mycorrhyzal fungi aids in phosphorus acquisition by crop plants, as well as in water regulation. Humans benefit from all types of biological diversity in agroecosystems and we must conserve and manage this diversity through the thoughtful design of cropping systems and the careful selection of appropriate management practices.

The Ancient and Ubiquitous Insulin Signaling Pathway: Implications for Screening Natural Products for Diabetes Pharmaceutical Development

Gary Ruvkun
Harvard Medical School

Co-authors:
S. Ogg, S. Paradis, G.I. Patterson, K. Kimura, H. Tissenbaum

The metabolism of both humans and the nematode C. elegans *is regulated by an insulin signaling pathway that uses many common elements. Insulin regulation of metabolism may be quite general to all animals. As in* C. elegans, *insulin may also regulate hibernation in other animals. It is reasonable to assume that some of these organisms defend themselves from predation by producing drugs that target the insulin signaling system. Any drug that perturbs conserved proteins in the pathway would be expected to affect metabolism and hibernation in many insect and nematode (and mammalian) predators. The* C. elegans *genetics suggests that insulin signaling may inactivate the human FKHR, AFX, or AF6 transcription factor activities. These proteins may represent key targets for drug screening from natural product libraries.* C. elegans *can be genetically engineered to carry only a human version of this key transcription factor, and screened in microtitre plates for drugs that inactivate that human version, allowing reproduction in the absence of insulin signaling. Drugs detected in this manner would be expected to treat both juvenile and adult onset forms of diabetes.*

Status and Trends in the World's Fisheries

Carl Safina
National Audubon Society

Oceans mediate climate, making life possible on Earth. Phytoplankton produce much of the Earth's breathable oxygen. But the most effective way in which humans benefit and affect the oceans' services is through fisheries. After exponential rises in world fish landings earlier in the 20th century, catches leveled off in the 1990s. Modern fisheries have adapted military technologies to the task of fishing; and excess capacity has brought fishing power to twice that necessary to take the annual catch. This overcapacity has brought down the profitability of fishing: to catch $70 billion worth of fish, $124 billion is spent. Government subsidies largely pay the deficits. The reduced profitability is exemplified in the U.S. where depletions cost the gross national product $8 billion annually, and 300,000 jobs. In addition to overfishing, depletion of living marine resources is caused by habitat loss and the capture of non-target fishes (bycatch) and other biota.

Microbes and Antibiotics

Dennis M. Schmatz
Merck Research Laboratories

Since Alexander Fleming's discovery of a contaminating mold on a petri dish that lysed neighboring bacteria in 1929 and the demonstration of penicillin's therapeutic properties in the early 1940s, the power of microorganisms as a source of novel anti-infective agents has been the mainstay of antibiotic discovery. Despite major advances in chemistry and the discovery of many unique metabolic targets in bacteria, fungi, and protozoa, microbe-produced natural products continue to lead the way as a source of novel anti-infectives and validated drug targets. Since drug resistance is an ongoing problem, the continuous search for new antibiotics is vital for maintaining the current standards of human health and for controlling newly emerging diseases. In an effort to increase the potential for discovering new molecules, many have focused on expanding the biodiversity of their microbe collections. Several examples of new natural products from these efforts and their elucidated targets will be discussed.

Climate Change and Ecosystem Services

Stephen H. Schneider
Stanford University

It is a scientific truism that climate determines ecological niches and it is increasingly obvious that life also modifies climate. This mutual interaction—the coevolution of climate and life—has taken on particular poignancy in the past several decades as human use of the atmosphere as an unpriced sewer is a likely cause of modification of the atmosphere's chemical composition with potentially significant consequences on both climate and life. Moreover, the fragmentation of habitats combined with unprecedented rapid human-induced climate change raises the prospect of disruption to biological communities that, in turn, are relevant to human welfare. Large uncertainties attend every link in the chain from human disturbances to the environment, to climatic responses, to impacts on nature and society, to the costs of mitigating human disturbances. Fortunately, the emerging meta-discipline of "integrated assessment" is beginning to approach this vast problem in a quantitative way. Some of the conclusions from such studies will be presented.

Towards a New Millennium: Rediscovering Our Place in the Natural World

David T. Suzuki
David Suzuki Foundation

Most people today live in the biologically poor habitat of cities where it is easy to forget that we remain deeply immersed in and dependent on nature. Our need for the diverse species that share this planet with us goes far beyond their utility as resources for food, drugs, and materials. They are our biological kin, related to us through our evolutionary history and necessary to satisfy our innate need for them (which E.O. Wilson calls "biophilia"). Biodiversity is the means whereby air, water, and soil are cleansed and replenished, and clean energy from the sun is captured and made available.

Converging Pathways: From the Frog Alkaloid, Epibatidine, to the Synthetic Cholinergic Channel Modulator, ABT-594, a Novel Potent Analgesic

Michael Williams
Abbott Laboratories

Co-authors:
M.W. Holladay, A.W. Bannon, J.W. Daly

Epibatidine is a frog alkaloid discovered by Daly's group at NIH that is an analgesic 200-fold more potent than morphine which produces its effects by activation of neuronal nicotinic receptors (nAChRs) in the spinal cord and brain. However, due to its interactions with non-neuronal nAChRs the compound is toxic at doses close to its analgesic range. Building on published structural data from the Daly group and utilizing existing synthetic compounds[1], approximately 500 new compounds were made at Abbott to identify those that retained the analgesic effects of epibatidine while reducing or eliminating the toxic side effects of the alkaloid. From these, ABT-594 was selected as a novel, non-opoid, non-NSAID analgesic, 30 to 70 times more potent than morphine with similar efficacy in models of acute and chronic pain and with reduced side effect liabilities as compared with epibatidine[2]. Unlike morphine, ABT-594 did not appear to produce opoid-like withdrawal or physical dependence upon repeated administration nor did it cause respiratory depression or effects on GI motility. Daly's long-term research interest in arthropod alkaloids[3] (supported by the American Museum of Natural History) and Abbott's ongoing investment in nAChR-based drug discovery provided a convergence of research interests, one basic and one applied, that led from the natural product, epibatidine, to the synthetic ligand, ABT-594, which is currently in early stage human trials as a novel analgesic.

1. M.W. Holladay et al. 1997. *J. Med Chem.* 40: 4169-4194.
2. A.W. Bannon et al. 1998. *Science.* 279: 77-81.
3. J.W. Daly. 1998. *J. Nat. Prod.* 61: 162-172.

Microbes and Antibiotics

Dennis M. Schmatz
Merck Research Laboratories

Since Alexander Fleming's discovery of a contaminating mold on a petri dish that lysed neighboring bacteria in 1929 and the demonstration of penicillin's therapeutic properties in the early 1940s, the power of microorganisms as a source of novel anti-infective agents has been the mainstay of antibiotic discovery. Despite major advances in chemistry and the discovery of many unique metabolic targets in bacteria, fungi, and protozoa, microbe-produced natural products continue to lead the way as a source of novel anti-infectives and validated drug targets. Since drug resistance is an ongoing problem, the continuous search for new antibiotics is vital for maintaining the current standards of human health and for controlling newly emerging diseases. In an effort to increase the potential for discovering new molecules, many have focused on expanding the biodiversity of their microbe collections. Several examples of new natural products from these efforts and their elucidated targets will be discussed.

Climate Change and Ecosystem Services

Stephen H. Schneider
Stanford University

It is a scientific truism that climate determines ecological niches and it is increasingly obvious that life also modifies climate. This mutual interaction—the coevolution of climate and life—has taken on particular poignancy in the past several decades as human use of the atmosphere as an unpriced sewer is a likely cause of modification of the atmosphere's chemical composition with potentially significant consequences on both climate and life. Moreover, the fragmentation of habitats combined with unprecedented rapid human-induced climate change raises the prospect of disruption to biological communities that, in turn, are relevant to human welfare. Large uncertainties attend every link in the chain from human disturbances to the environment, to climatic responses, to impacts on nature and society, to the costs of mitigating human disturbances. Fortunately, the emerging meta-discipline of "integrated assessment" is beginning to approach this vast problem in a quantitative way. Some of the conclusions from such studies will be presented.

Towards a New Millennium: Rediscovering Our Place in the Natural World

David T. Suzuki
David Suzuki Foundation

Most people today live in the biologically poor habitat of cities where it is easy to forget that we remain deeply immersed in and dependent on nature. Our need for the diverse species that share this planet with us goes far beyond their utility as resources for food, drugs, and materials. They are our biological kin, related to us through our evolutionary history and necessary to satisfy our innate need for them (which E.O. Wilson calls "biophilia"). Biodiversity is the means whereby air, water, and soil are cleansed and replenished, and clean energy from the sun is captured and made available.

Converging Pathways: From the Frog Alkaloid, Epibatidine, to the Synthetic Cholinergic Channel Modulator, ABT-594, a Novel Potent Analgesic

Michael Williams
Abbott Laboratories

Co-authors:
M.W. Holladay, A.W. Bannon, J.W. Daly

Epibatidine is a frog alkaloid discovered by Daly's group at NIH that is an analgesic 200-fold more potent than morphine which produces its effects by activation of neuronal nicotinic receptors (nAChRs) in the spinal cord and brain. However, due to its interactions with non-neuronal nAChRs the compound is toxic at doses close to its analgesic range. Building on published structural data from the Daly group and utilizing existing synthetic compounds[1], approximately 500 new compounds were made at Abbott to identify those that retained the analgesic effects of epibatidine while reducing or eliminating the toxic side effects of the alkaloid. From these, ABT-594 was selected as a novel, non-opoid, non-NSAID analgesic, 30 to 70 times more potent than morphine with similar efficacy in models of acute and chronic pain and with reduced side effect liabilities as compared with epibatidine[2]. Unlike morphine, ABT-594 did not appear to produce opoid-like withdrawal or physical dependence upon repeated administration nor did it cause respiratory depression or effects on GI motility. Daly's long-term research interest in arthropod alkaloids[3] (supported by the American Museum of Natural History) and Abbott's ongoing investment in nAChR-based drug discovery provided a convergence of research interests, one basic and one applied, that led from the natural product, epibatidine, to the synthetic ligand, ABT-594, which is currently in early stage human trials as a novel analgesic.

1. M.W. Holladay et al. 1997. *J. Med Chem.* 40: 4169-4194.
2. A.W. Bannon et al. 1998. *Science.* 279: 77-81.
3. J.W. Daly. 1998. *J. Nat. Prod.* 61: 162-172.

Edson X. Albuquerque, M.D., Ph.D.

Edson Albuquerque is Professor and Chairman of the Department of Pharmacology and Experimental Therapeutics and Professor of Medicine at the School of Medicine, University of Maryland. He is also Titular Professor of Biophysics at the Federal University of Rio de Janeiro in Brazil and Director of the Molecular Pharmacology Training Program, a joint program between the Federal University and the University of Maryland. His scientific interests relate to neurotoxicology and the wide range of biologically active alkaloids and other substances, many of which are toxic. He has received numerous awards and honors, and has been the recipient of the Jacob K. Javits Neurobiology Investigator Award for eight years (1991-1998). Dr. Albuquerque has published extensively in the field of animal neurotoxicology.

RELEVANT PUBLICATIONS

Albuquerque, E.X., M. Alkondon, E.F.R. Pereira, N.G. Castro, A. Schrattenholz, et al. 1997. Properties of neuronal nicotine acetylcholine receptors: Pharmacological characterization and modulation of synaptic function. *Journal of Pharmacology and Experimental Therapeutics* 280: 1117-1136 (Otto Krayer Award Lecture).

Albuquerque, E.X., E.F.R. Pereira, N.G. Castro, et al. 1995. Nicotinic receptor function in the mammalian central nervous system. *Annals of the New York Academy of Sciences 757*: 48-72.

Bruce P. Bean, Ph.D.

Bruce Bean is Professor of Neurobiology at Harvard Medical School. His research seeks to elucidate the electrical behavior of neurons and its modulation by neurotransmitters and pharmacological agents. Current research in his laboratory includes studies on gating and drug block of sodium channels in central neurons, the pharmacology of calcium channels, and neurotransmitter modulation of ion channels in neurons and cardiac muscle. The ultimate goal of the research is to understand electrical signalling in the nervous system in terms of the operation of ion channels. An immediate goal is to identify drugs or naturally-occurring compounds that can selectively block individual types of channels.

RELEVANT PUBLICATIONS

McDonough S.I., K.J. Swartz, I.M. Mintz, L.M. Boland and B.P. Bean. 1996. Inhibition of calcium channels in rat central and peripheral neurons by w-conotoxin MVIIC. *Journal of Neuroscience* 16: 2612-2623.

McDonough S.I., I.M. Mintz and B.P. Bean. 1997. Alteration of P-type calcium channel gating by the spider toxin w-Aga-IVA. *Biophysical Journal* 72: 2117-2128.

JoAnn M. Burkholder, Ph.D.

JoAnn Burkholder is Associate Professor of Aquatic Botany and Marine Sciences at North Carolina State University, and a Pew Fellow. Over the past 25 years, Dr. Burkholder's research has emphasized the nutritional ecology of algae, dinoflagellates, and seagrasses, especially the effects of cultural eutrophication on algal blooms and seagrass disappearance. Since co-discovering the toxic dinoflagellate, *Pfiesteria piscicida*, in 1991, she has worked to characterize its complex life cycle and behavior, its stimulation by sewage and other forms of nutrient over-enrichment, and its chronic/sublethal, as well as lethal, impacts on commercially important finfish and shellfish in estuaries and aquaculture facilities. Dr. Burkholder has held policy-advising positions on North Carolina's Coastal Futures Committee and Marine Fisheries Commission. Recently, she served as science advisor on a Governor-appointed *Pfiesteria* Commission in Maryland, and received an *Admiral of the Chesapeake* award from the Governor for her assistance. Dr. Burkholder is also active in environmental education and has worked to raise public awareness of the critical need for ethics and accountability among scientists working in the environmental field.

Eric Chivian, M.D.

Eric Chivian is Director of the Center for Global Health and the Environment and Assistant Clinical Professor of Psychiatry at Harvard Medical School. He is also Staff Psychiatrist at the Massachusetts Institute of Technology. He has worked to involve physicians around the world in efforts to protect the environment and increase understanding of the health implications of global environmental change. In 1996, he founded the Center he now directs, the first Center at a medical school in the United States to focus specifically on these critical issues. He has been a consultant to the White House Office of Science and Technology Policy and the Office on Environmental Quality, and a reviewer of the second assessment report of the Intergovernmental Panel on Climate Change. Dr. Chivian co-founded the International Physicians for the Prevention of Nuclear War, recipient of the 1985 Nobel Peace Prize. His primary interests are the human health consequences of habitat degradation, species extinction, and biodiversity loss.

RELEVANT PUBLICATIONS

Chivian, E. 1997. Global environmental degradation and biodiversity loss: Implications for human health. In: *Biodiversity and Human Health*. F.T. Grifo and J. Rosenthal, (eds.). Washington D.C.: Island Press.

Chivian, E., M. McCally, H. Hu, and A. Haines (eds.).1993. *Critical Condition: Human Health and the Environment*. Cambridge, MA: MIT Press.

Rita R. Colwell, Ph.D.

Rita Colwell is President of the Biotechnology Institute and Professor of Microbiology and Biotechnology at the University of Maryland. Dr. Colwell has served as president of numerous organizations, including the American Society for Microbiology, International Union of Microbiological Societies, Sigma Xi National Science Honorary Society, American Association for the Advancement of Science, and Washington Academy of Sciences. She is currently Chair of the Board of Governors of the American Academy of Microbiology. She is the recipient of Honorary Doctorate degrees conferred by several universities and is Honorary Professor of the University of Queensland, Australia and University of Qingdao, Peoples Republic of China. Author of over 16 books and 500 scientific publications, she has served on the National Science Board and is a member of federal and state advisory committees and boards.

Robert Engelman, M.S.

Robert Engelman is the Director of the Population and Environment Program at Population Action International (PAI). A research-based advocacy organization in Washington, D.C., PAI works to slow population growth through universal access to family planning services and increasing the well-being of women and families. He also serves as vice chair of the Center for a New American Dream, a nonprofit organization committed to enhancing the quality of life while reducing the consumption of natural resources. He is author or co-author of reports on population and economic growth, renewable freshwater, cropland, fisheries, and climate and has written numerous articles, journal papers and book chapters on population and the environment. A former newspaper reporter, his work has appeared in *The Washington Post*, *The Wall Street Journal*, and *The Boston Globe*.

RELEVANT PUBLICATIONS

Engelman, R. 1997. Earthly dominion: Population growth, biodiversity, and health. In: *Biodiversity and Human Health*. F. T. Grifo and J. Rosenthal (eds.). Washington D.C.: Island Press.

Engelman, R. and R.P. Cincotta. 1997. Economic growth and rapid change: The influence of population growth. Washington D.C.: Population Action International.

Paul R. Epstein, M.D., M.P.H.

Paul Epstein is on the faculty of Harvard Medical School and the Harvard School of Public Health (HSPH), and is Associate Director of the Harvard Center for Health and the Global Environment. He has worked in medical, teaching, and research capacities in Africa, Asia, and Latin America. A member of the HSPH Working Group on Emerging Diseases, he also serves on the Human Dimensions Panel of the National Academy of Sciences/National Research Council. He is a member of the Health of the Oceans module of the Global Ocean Observing System. Dr. Epstein is coordinating a project funded by the National Aeronautics and Space Agency (NASA) and the National Oceanic and Atmospheric Administration (NOAA) to conduct an integrated assessment of disease events along the east coast of North America, the Gulf of Mexico, and the Caribbean. This project will examine the health, ecological, and economic dimensions of global change in marine environments.

RELEVANT PUBLICATIONS

Epstein, P.R., H.F. Diaz, S. Elias, G. Grabherr, N.E. Graham, W.J.M. Martens, E. Mosley-Thompson, and J. Susskind. 1998. Biological and physical signs of climate change: Focus on mosquito-borne disease. *Bulletin of the American Meteorological Society* 78: 409-417.

Epstein, P.R., A. Dobson, and J. Vandermeer. 1997. Biodiversity and emerging infectious diseases: Integrating health and ecosystem monitoring. In: *Biodiversity and Human Health*. F. T. Grifo and J. Rosenthal (eds.). Washington D.C.: Island Press.

William Fenical, Ph.D.

William Fenical is Professor of Oceanography and Director of the Center for Marine Biotechnology and Biomedicine at the Scripps Institution of Oceanography, University of California, San Diego. From 1989 to 1996, Dr. Fenical was the Director of the Marine Research Division at Scripps. He is also the coordinator of the University's Sea Grant College Program. Dr. Fenical has received numerous awards and honors including the Silver Medal Award from the International Society for Chemical Ecology in 1997 and the Paul J. Scheuer Award in Marine Natural Products Chemistry in 1996. He has published 280 works and is on the editorial boards of the *Journal of Natural Products*, *Molecular Marine Biology and Biotechnology* and the *Journal of Marine Biotechnology*.

RELEVANT PUBLICATIONS

Jenkins, K.M., P. R. Jensen, and W. Fenical. In press. Marine microbial chemical ecology, bioassays with marine organisms: Part II. In: *Methods in Chemical Ecology*, K.F. Haynes et al. (eds.).

Fenical, W. In press. New pharmaceuticals from marine organisms. *Trends in Biotechnology* 15(9): 339-341.

Joanne Fox-Przeworski, Ph.D.

Joanne Fox-Przeworski has been Director of the Regional Office for North America, United Nations Environment Programme since 1995. Previously, she was special advisor to two Deputy Secretary-Generals on environment and development and represented the Organization of Economic Development at the UN. She was director of the work on aid and the environment, on urban policies for economic revitalization, and on aging societies and technological change. Author of several books, she has published numerous articles on these subjects, as well as on the copper industry in Chile, the subject of her doctorate research. Dr. Fox-Przeworski, received her Ph.D. from Washington University and her masters degree from Harvard University. She has worked in Poland, Chile, India and France.

RELEVANT PUBLICATIONS

Fox-Przeworski, J., ed. 1992. *Urban Policies for Ageing Societies*. Paris: Organization for Economic Cooperation and Development.

Fox-Przeworski, J. 1991. *Urban Regeneration in a Changing Economy*. Oxford, U.K.: Clarendon Press.

Ellen V. Futter, J.D.

Ellen Futter has been President of the American Museum of Natural History since November 1993. She previously served for 13 years as president of Barnard College. She is Director of a number of organizations and has a strong record of public service, including having served as chairman of the Federal Reserve Bank of New York. Ms. Futter is also a fellow of the American Academy of Arts and Sciences, and a member of the Council on Foreign Relations. She is widely recognized as a dynamic voice for education. She has been awarded numerous honorary degrees, and is the recipient of the National Institute of Social Science's Gold Medal Award and the National Organization of Women's Eleanor Roosevelt Leadership Award. Ms. Futter was graduated Phi Beta Kappa, magna cum laude, from Barnard College in 1971. She earned her J.D. degree from Columbia University's Law School in 1974.

Jaap Goudsmit, M.D.

Jaap Goudsmit is Professor of Virology and Chairman of the Department of Human Retrovirology at the University of Amsterdam, the Netherlands. He is universally recognized as one of the leading scientists working on HIV and AIDS. Dr. Goudsmit recently became chairman of the Scientific Advisory Committee of the International AIDS Vaccine Initiative.

RELEVANT PUBLICATIONS

Goudsmit, J. 1997. *Viral Sex: The Nature of AIDS*. New York: Oxford University Press.

Robert J. Gould, Ph.D.

Robert Gould is Executive Director of Pharmacology at Merck Research Laboratories in Pennsylvania. He received his Ph.D. in biochemistry from the University of Iowa in 1981. He then accepted a postdoctoral research fellowship in the Department of Neuroscience at Johns Hopkins University. In 1984, Dr. Gould was employed at Merck Research Laboratories as a Senior Research Pharmacologist. He became interested in the components of animal venom that disrupt blood coagulation as an approach to identifying novel antithrombotic therapies.

Francesca T. Grifo, Ph.D.

Francesca Grifo is Director of the Center for Biodiversity and Conservation at the American Museum of Natural History. Her interests center around the conservation of biodiversity, including how scientific results are best integrated into conservation projects, policy, and education. She currently oversees projects that demonstrate how this integration is possible. She has focused on intellectual property rights and benefits-sharing issues related to the commercialization of biodiversity, including how these and other issues relevant to scientists are interpreted through the Convention on Biological Diversity. Additionally, she has worked closely with an array of institutions in Eastern Europe on national-level biodiversity management and planning. Her recent work has examined the relationships between biodiversity and human health.

RELEVANT PUBLICATIONS

Grifo, F.T., D. Newman, et al. 1997. The origins of prescription drugs. In: *Biodiversity and Human Health*. F. T. Grifo and J. Rosenthal (eds.). Washington D.C.: Island Press.

Grifo, F.T. 1996. The role of chemical prospecting in sustainable development. In: *Emerging Connections Among Biodiversity, Biotechnology, and Sustainable Development in Health and Agriculture*. Julie Feinsilver (ed.). Washington D.C.: Pan American Health Organization.

Maurice M. Iwu, Ph.D.

Maurice Iwu is Executive Director of Bioresources Development and Conservation Programme, a private, non-profit organization that seeks to develop strategies for sustainable utilization of biological resources. He was formerly Professor of Pharmacognosy at the University of Nigeria at Nsukka and is currently Adjunct Professor at the College of Medicine, Enugu State University of Science and Technology in Nigeria. He is a visiting Senior Research Associate at Walter Reed Army Institute of Research, a Scientific Adviser at Shaman Pharmaceuticals, Inc., and until recently, was Vice-President of Research and Development at Tom's of Maine (a personal care manufacturing company). Dr. Iwu earned a Master of Pharmacy degree in 1976 and a Ph.D. in 1978 from the University of Bradford in England. He was a WHO Visiting Scholar to the Dyson Perrins Laboratory, University of Oxford and a Fulbright Scholar to Ohio State University and Columbia University. Dr. Iwu has published over 100 research papers and has given many public lectures on African traditional medicine, industrial utilization of medicinal plants, and the conservation of biodiversity.

RELEVANT PUBLICATIONS

Iwu, M.M. 1993. *Handbook of African Medicinal Plants*. Boca Raton, FL: CRC Press.

Iwu, M.M., et al. 1997. *Commercial Production of Indigenous Plants as Phytomedicines and Cosmetics*. Nsukka, Nigeria: BDCP Press.

Sylvia M. Le Blancq, Ph.D.

Sylvia Le Blancq is Assistant Professor in the Division of Environmental Health Sciences, School of Public Health and the Center for Environmental Research and Conservation at Columbia University. Her research interests include environmental and human health, particularly parasites and parasitism. She is currently studying the protozoan parasites *Giardia lamblia* and *Cryptosporidium parvum*. Dr. Le Blancq is conducting an epidemiological study of *C. parvum* in pristine and populated habitats, and analyzing the sources of *C. parvum* oocysts in New York City drinking water. Her teaching activities focus on the role that water plays in the life cycles of many infectious diseases throughout the world, considering the ecology, transmission cycles, epidemiology, etiologic agents, pathogenesis and prevention strategies, as well as how water resource development and urbanization alters patterns of disease.

RELEVANT PUBLICATIONS

Perz, J.F., F.K. Ennever, and S.M. Le Blancq. 1998. *Cryptosporidium* in tap water: Comparison of predicted risks to observed levels of disease. *American Journal of Epidemiology* 147: 289-301.

Le Blancq, S.M., N.V. Khramtsov, F. Zamani, S.J. Upton, and T.W. Wu. 1997. Ribosomal RNA gene organization in *Cryptosporidium parvum*. *Molecular and Biochemical Parasitology* 90: 463-478.

John J. Marchalonis, Ph.D.

John Marchalonis is Professor and Chairman of the Department of Microbiology and Immunology at University of Arizona College of Medicine. He has a long-term interest in the structure of antibodies and the molecular evolution of the immune system. As a graduate student, he was the first to isolate and characterize antibodies of primitive vertebrates, including the shark, and non-antibody recognition molecules including the C-reactive protein-like lectin of the horseshoe crab. He and his colleagues studied the evolution of the immune system by analyzing genes specifying immunoglobulins, antigen receptors of T lymphocytes, and systems responsible for recombination of immunoglobulin gene segments. Much of his work continues to focus on sharks because these represent the most primitive extant vertebrates to have a set of cellular, molecular, and genetic elements characteristic of the "combinatorial immune response" best studied in mammals.

RELEVANT PUBLICATIONS

Schluter, S.F., R.M. Bernstein, and J.J. Marchalonis. 1997. Molecular origins and evolution of immunoglobulin heavy chain genes of jawed vertebrates. *Immunology Today* 18(11): 543-548.

Marchalonis, J.J., R.M. Bernstein, S.X. Shen, and S.F. Schluter. 1996. Emergence of the immunoglobulin family: Conservation in protein sequence and plasticity in gene organization. *Glycobiology* 6: 657-663.

George P. Miljanich, Ph.D.

George Miljanich is Senior Director of Biochemistry and Assay Development at Neurex Corporation. He joined Neurex in 1988 in order to work full-time on research and development of drugs to treat neurological disorders, including the cone snail venom peptide, ziconotide (SNX-111). He began studying peptidic calcium blockers from cone snail venoms and their inhibitory effects on synaptic transmission at the University of Southern California, where he was a faculty member from 1982-1988. He received a doctorate in chemistry from the University of California, Santa Cruz, and conducted post-doctoral research at the University of California, San Francisco, where he studied the molecular mechanisms of synaptic transmission.

RELEVANT PUBLICATIONS

Miljanich, G.P. 1997. Venom peptides as human pharmaceuticals. *Science and Medicine* 4(5): 6-15.

Miljanich, G.P., and J. Ramachandran. 1995. Antagonists of neuronal calcium channels: Structure, function, and therapeutic implications. *Annual Reviews of Pharmacology and Toxicology* 35: 707-737.

David H. Molyneux, Ph.D.

David Molyneux has been Director of the Liverpool School of Tropical Medicine since 1991. He received his Ph.D. in Parasitology from Cambridge University. His doctoral and earlier work in Nigeria were on trypanosomes, the organisms that cause sleeping sickness. After two years in Nigeria, he returned to the School to work on Leishmania parasites in sandflies. In 1975, he went back to Africa to work with the World Health Organization (WHO) on sleeping sickness diagnosis and control in Burkina Faso. Dr. Molyneux has acted as a consultant to many international organizations on parasitic diseases. Currently, he is Chairman of the WHO Expert Advisory Committee of the Onchocerciasis Control Programme, a member of the International Commission for Dracunculiasis Eradication, Chairman of the WHO Technical Advisory Group of the Division of Control of Tropical Diseases, and Vice President of the Royal Society of Tropical Medicine.

RELEVANT PUBLICATIONS

Molyneux, D.H. 1997. Current public health status of trypanosomiases and leishmaniases. In: Trypanosomiasis and Leishmaniasis. G. Hide, J.C. Mottram, G.H. Coombs, and P.H. Holmes (eds.). *CAB International*, pp. 39-50.

Molyneux, D.H. 1977. Patterns of change in vector-borne diseases. *Annals of Tropical Medicine and Parisitology* 91: 827-39.

Stephen S. Morse, Ph.D.

Stephen Morse is Director, Program in Emerging Diseases and Assistant Professor of Epidemiology at Columbia University's School of Public Health, and an adjunct faculty member at The Rockefeller University. He is currently serving as a Program Manager at the Defense Advanced Research Projects Agency in Washington D.C. Dr. Morse is an editor of the journals *Emerging Infectious Diseases* (CDC) and *Research in Virology* (Pasteur Institute). He chaired the 1989 NIH/NIAID Conference on Emerging Viruses, was a member of the Institute of Medicine's Committee on Emerging Microbial Threats to Health, and is currently a member of the Steering Committee of the Institute of Medicine's Forum on Emerging Infections, and Chair of ProMED (the Program for Monitoring Emerging Diseases). He has served as an adviser to WHO, the Pan-American Health Organization, and other agencies.

RELEVANT PUBLICATIONS

Morse, S.S., ed. 1994. *The Evolutionary Biology of Viruses*. New York: Raven Press.

Morse, S.S., ed. 1993. *Emerging Viruses*. New York: Oxford University Press.

Ralph A. Nelson, M.D., Ph.D., F.A.C.P.

Ralph Nelson is the Director of Research at the Carle Foundation and holds several positions at the University of Illinois: Executive Head of the Department of Medicine, Head of the Department of Internal Medicine, and Professor of Nutritional Science, College of Medicine and Professor of Food Science, College of Agriculture. His research interests have focused on the metabolism of bears, before, during and after winter sleep. By studying their protein and fat metabolism, Dr. Nelson is exploring possible links to the treatment of osteoporosis and kidney failure, as well as stress management during long-term flights into space.

RELEVANT PUBLICATIONS

Nelson, R.A. 1989. Nitrogen turnover and its conservation in hibernation. *Living in the Cold, 2nd International Symposium* 193: 299-307.

Nelson, R.A. 1987. Black bears and polar bears: Still metabolic marvels. *Mayo Clinic Proceedings* 62: 850-53.

David J. Newman, Ph.D.

David Newman is with the Natural Products Branch of the National Cancer Institute, where for the last seven years, he has been responsible for marine and microbial collection programs. Originally trained as an organic chemist, he received a doctorate in microbial chemistry from the University of Sussex, U.K. for work on nitrogen-fixing *Desulfovibrio*. He has worked in the U.K. agricultural and chemical industries and the U.S. biotechnology, chemical, and pharmaceutical industries for over thirty years, dealing predominantly with microbial natural products.

RELEVANT PUBLICATIONS

Cragg, G.M., M.R. Boyd, M.A. Christini, R. Kneller, T.D. Mays, K.D. Mazan, D. J. Newman, and E.A. Sausville. 1997. Screening of natural products of plant, microbial and marine origin: The NCI experience. In: *Proceedings of the Symposium on Phytochemical Diversity: A Source of New Industrial Products*. London, U.K.: The Royal Society of Chemistry.

Cragg, G. M., D. J. Newman and K. M. Snader. 1997. Natural products in drug discovery and development. *J. Nat. Prod.* 60: 52.

Stephen C. Nold, Ph.D.

Stephen Nold recently joined the Center for Microbial Ecology at Michigan State University, a National Science Foundation Science and Technology Center. He is studying the key processes controlling nitrogen release from coastal marine sediments. Throughout his career, he has been applying the tools of molecular biology to investigate the evolution and ecology of aquatic microbial communities. His graduate studies at Montana State University focused on the biodiversity and activity of microorganisms inhabiting the hot springs in Yellowstone National Park. During this time he characterized the distribution and abundance of organisms similar to *Thermus aquaticus* and investigated carbon cycling between primary producers and consumers inhabiting thermophilic microbial mat communities. Although his future research will concentrate on the patterns of distribution, abundance, and activity of mesophilic aquatic microorganisms, his heart remains with the thermophiles living in the bubbling hot pools of Yellowstone National Park.

RELEVANT PUBLICATIONS

Nold, S.C., and G. Zwart. In press. Patterns and governing forces in aquatic microbial communities. *Aquatic Ecology.*

Nold, S.C., and D.M. Ward. 1996. Photosynthate partitioning and fermentation in hot spring microbial mat communities. *Applied and Environmental Microbiology* 62: 4598-4607.

Iwao Ojima, Ph.D.

Iwao Ojima is Distinguished Professor and Chairman of the Department of Chemistry, the State University of New York at Stony Brook, where he has been a faculty member since 1983. Previously, he was Senior Research Fellow at the Sagami Institute of Chemical Research in Tokyo. He has a wide range of research interests in synthetic organic and medicinal chemistry. These include asymmetric synthesis, organic syntheses by means of organometallic reagents and catalysts, anticancer agents, enzyme inhibitors, antithrombotic agents, peptides and peptide mimetics, beta-lactam and organofluorine chemistry. He is Guggenheim Fellow and Fellow of the American Association for the Advancement of Science. He has served as advisory committee member for the National Institutes of Health, National Science Foundation, and the U.S. Department of Energy.

RELEVANT PUBLICATIONS

Ojima, I., P.-Y. Bounaud, C.Takeuchi, P..Pera, and R.J. Bernacki. 1998. New taxanes as highly efficient reversal agents for multi-drug resistance in cancer cells. *Bioorg. Med. Chem. Lett.* 8: 189-194.

Ojima, I., J.C. Slater, E. Michaud, S.D. Kuduk, P.Y. Bounaud, P. Vrignaud, M.C. Bissery, J.M. Veith, P. Pera, and R.J. Bernacki. 1997. Syntheses and structure-activity relationships of the second generation antitumor taxoids: Exceptional activity against drug-resistant cancer cells. *Journal of Medical Chemistry* 39: 3889-3896.

Baldomero M. Olivera, Ph.D.

Baldomero Olivera is Distinguished Professor of Biology at the University of Utah. His doctorate from California Institute of Technology is in chemistry and his research has focused on the neuropharmacology of the venomous Cone snail and the potential for drug development of the active peptides in its venom. Among his many awards and honors is the Utah Governor's Medal for Science and Technology, which he was awarded in 1991. He currently serves on the Advisory Committee to the Director of the National Institutes of Health and the Editorial Board of *Molecular Diversity*.

RELEVANT PUBLICATIONS

Terlau, H., K. Shon, M. Grilley, M. Stocker, W. Stuhmer, and B.M. Olivera. 1996. Strategy for rapid immobilization of prey by a fish-hunting cone snail. *Nature* 381: 148-51.

Olivera, B.M., D.R. Hillyard, M. Marsh, and D. Yoshikami. 1995. Combinatorial peptide libraries in drug design: Lessons from venomous Cone snails. *Trends in Biotechnology* 13: 422-26.

Richard S. Ostfeld, Ph.D.

Richard Ostfeld is Associate Scientist at the Institute of Ecosystem Studies, adjunct Associate Professor of Ecology and Evolutionary Biology at the University of Connecticut, and associate member of the Graduate Faculty in Ecology at Rutgers University. His primary research interests concern the relationships between population dynamics of mammals, forest dynamics, and disease risk. He also studies territoriality, social behavior, and foraging strategies of small mammals. Dr. Ostfeld is a member of the American Society of Mammalogists, where he was elected to the Board of Directors, and of the Ecological Society of America, for which he serves on the Board of Editors. He has published two books and approximately 60 papers for peer-reviewed journals.

RELEVANT PUBLICATIONS

Jones, C.G., R.S. Ostfeld, M.P. Richard, E.M. Schauber, and J.O. Wolff. 1998. Chain reactions linking acorns to gypsy moth outbreaks and Lyme disease risk. *Science* 279: 1023-1026.

Ostfeld, R.S. 1997. The ecology of Lyme-disease risk. *American Scientist* 85: 338-346.

Stuart L. Pimm, Ph.D.

Stuart L. Pimm is Professor of Ecology in the Department of Ecology and Evolutionary Biology at the University of Tennessee. His research focuses on the question: How fast are species becoming extinct worldwide? He argues that their high rates of extinction on Pacific islands also typify a wide range of mainland situations that share equally high levels of endemism. The second argument addresses how long individual species last. He has explored how species numbers vary from year to year—a critical component of this question—and documented the empirical patterns of time-to-extinction of small populations on islands. Finally, he has considered how useful the species-area-relationship is in predicting how many endemic species are lost following habitat fragmentation. Applied to areas of high endemism in Brazil and insular Southeast Asia, his predictions based on deforestation closely match the numbers of species known to be on the brink of extinction.

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Pimm, S.L., G.J. Russell, J.L. Gittleman, and T.M. Brooks. 1995. The future of biodiversity. *Science* 269: 347-350.

Pimm, S.L., M.P. Moulton, and J. Justice. 1994. Bird extinctions in the central Pacific. *Philosophical Transactions of the Royal Society* 344: 27-33.

Alison G. Power, Ph.D.

Alison Power is Professor in the Section of Ecology and Systematics, Cornell University. She received her Ph.D. in Zoology in 1985 from the University of Washington. Her research has focused on the ecology of agricultural systems in the United States, Latin America, and Thailand. Particular research interests include: ecological interactions between natural and agricultural ecosystems; biodiversity in agricultural systems, the ecology of plant viruses and their insect vectors; and biological methods of pest management in agroecosystems.

Joshua Rosenthal, Ph.D.

Joshua Rosenthal is Program Director for Biodiversity and Medical Informatics at the Fogarty International Center of the National Institutes of Health and an Assistant Research Professor at Georgetown University. He received his doctorate in Botany from the University of California at Berkeley for ecological and ethnobotanical research on plant-insect interactions in Mexico. He has worked with a variety of conservation and development projects over the past 15 years, principally in Latin America. He currently manages the federal government's interagency biodiversity prospecting program, the International Cooperative Biodiversity Groups. He has authored a number of scholarly research publications as well as policy papers related to international technology transfer, sharing of the benefits of biodiversity, and economic incentives for conservation.

RELEVANT PUBLICATIONS

Rosenthal, J. 1997. Integrating drug discovery, biodiversity conservation and economic development: Early lessons from the International Cooperative Biodiversity Groups. In: *Biodiversity and Human Health*. F.T. Grifo and J. Rosenthal (eds.) Washington, D.C.: Island Press.

Rosenthal, J. 1997. Equitable sharing of biodiversity benefits: Agreements on genetic resources. In: *Investing in Biological Diversity: Proceedings of the International Conference on Biodiversity Incentive Measures*. Paris: Organization for Economic Cooperation and Development Press.

Gary Ruvkun, Ph.D.

Gary Ruvkun is Professor of Genetics at Harvard Medical School. He is a 1973 graduate of the University of California at Berkeley. After a few years of tree-planting in the Pacific Northwest and travel in Latin America, he studied bacterial/plant symbioses for his Ph.D. at Harvard in 1982. As a Junior Fellow at Harvard, he switched to the study of *C. elegans* developmental genetics. His lab at Harvard studies insulin control of metabolism, genetic control of neural development and function, and temporal pattern formation.

Carl Safina, Ph.D.

Carl Safina is Program Director of the National Audubon Society's Living Oceans Program, a program which he founded in 1990. For the last eight years, he has been engaged in major efforts to ban high seas driftnets, to overhaul federal fisheries law in the U.S., to use international agreements in restoring depleted marine populations, and to achieve passage of a new high seas fisheries treaty through the United Nations. His marine conservation work has also been featured in newspapers, radio, and television in the U.S., Europe, and Asia. Dr. Safina has been director of The Antarctica Project and deputy chair of the World Conservation Union's Shark Specialist Group, has served on the Mid-Atlantic Fisheries Management Council, and was a member of the Smithsonian Institution's Ocean Planet advisory board. He is a lecturer at Yale University and is a recipient of the Pew Charitable Trusts' Scholar's Award in Conservation and the Environment.

RELEVANT PUBLICATIONS

Safina, Carl. 1998. *Song for the Blue Ocean*. New York: Henry Holt.

Safina, Carl. 1997. World fisheries: Depletion and renewal. In: *Principles of Conservation Biology*, G. Meffe and R. Carroll, (eds.). Sunderland, MA: Sinauer Associates.

Dennis M. Schmatz, Ph.D.

Dennis Schmatz is Executive Director at Merck Research Laboratories in New Jersey where his major focus is on the discovery of new anti-infective agents for human and animal health. In 1989, his research team discovered that the fungal-produced pneumocandins were efficacious against *Pneumocystis carinii*, the major cause of fatal pneumonia in AIDS patients. The discovery initiated a medicinal chemistry effort on the pneumocandin molecule. This ultimately lead to MK-991, a new therapeutic agent for life-threatening fungal infections, currently in late Phase II clinical trails. Dr. Schmatz's research group has also identified a novel natural product with efficacy against medically important protozoan parasites including those that cause malaria, toxoplasmosis, cryptosporidiosis and coccidosis in man and/or animals. They have also very recently reported on a natural product that selectively inhibits protein synthesis in yeast, which may provide new insight toward the development of new antifungal agents.

RELEVANT PUBLICATIONS

Justice, M.C., M. Hsu, T. Bruno, T. Ku, J. Balkovec, D.M. Schmatz, and J. Nielsen. 1998. Elongation Factor 2 as a novel target for selective inhibition of fungal protein synthesis. *The Journal of Biological Chemistry* 273: 3148-3151.

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Stephen H. Schneider, Ph.D.

Stephen Schneider is Professor in the Department of Biological Sciences, Senior Fellow at the Institute for International Studies, and Professor by Courtesy in the Department of Civil Engineering at Stanford University. He was honored in 1992 with a MacArthur Fellowship for his ability to interpret the results of global climate research for a wide variety of audiences. Dr. Schneider has served as a consultant to federal agencies and White House staff under several U.S. presidential administrations. Author or co-author of over 200 scientific papers, he has also published proceedings, legislative testimonies, and newspaper and magazine interviews. In 1975, he founded the interdisciplinary journal, *Climatic Change*, and continues to serve as its editor. Dr. Schneider's current global change research interests include: climatic change, global warming, the ecological and economic implications of climatic change, the integrated assessment of global change, and climatic modeling of paleoclimates and human impacts on climate.

David T. Suzuki, Ph.D.

David Suzuki has been Professor of Zoology at the University of British Columbia in Vancouver since 1969 and is an Associate with the Sustainable Development Research Institute. A distinguished geneticist, he is also an award-winning journalist and broadcaster. Dr. Suzuki is familiar to television audiences as the host of the Canadian Broadcasting Corporation's "The Nature of Things" and "A Planet for the Taking." From 1969 to 1972, he was the recipient of the E.W. R. Steacie Memorial Fellowship Award as the "Outstanding Canadian Research Scientist under the age of 35." Dr. Suzuki is a past recipient of UNESCO's Kalinga Prize for Science, the United Nations Environmenalt medal and UNEP's Global 500. He is an officer of the Order of Canada, recipient of 12 honorary degrees in Canada, the United States, and Australia, and is known for his work in support of Canada's Native people.

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Suzuki, D.T. (with Amanda McConnell). 1998. *The Sacred Balance: Rediscovering Our Place in Nature*. Amherst, New York: Prometheus Books.

Suzuki, D.T., and P. Knudtson. 1992. *Wisdom of the Elders: Honoring Sacred Native Visions of Nature*. New York: Bantam Books.

Michael Williams, Ph.D., D.Sc.

Michael Williams is Divisional Vice President of Neurological and Urological Diseases Research at Abbott Laboratories. He received his Ph.D. and D.Sc. degrees from the University of London. Dr. Williams has had a long standing interest in the potential for drug discovery using natural sources. Following postdoctoral training at the University of North Carolina, he joined the pharmaceutical industry holding positions at Merck, Sharp and Dohme, Nova Pharmaceuticals, CIBA-Geigy, and Abbott Laboratories. While at Merck, he began working on the receptor binding profile of garlic and then spearheaded a relationship between CIBA-Geigy and the Harbor Branch Oceanographic Institute to identify new ligands from marine sources. The synthetic ligand ABT-594, developed from the frog alkaloid, epibatidine, is currently in early human trials as a novel analgesic.

Per Wramner, Ph.D., D.Sc.

Per Wramner is Director-General of the Swedish National Board of Fisheries, Chairman of the National Swedish Scientific Council for Biodiversity, and Chairman of the Board of Directors of the National Swedish Museum of National History. In the late 1970s and early 1980s, Dr. Wramner served as State Secretary of the Ministry of Agriculture, Fisheries and Environment and State Secretary of the Ministry of Housing and Physical Planning in Sweden. He chairs or vice chairs numerous governmental, intergovernmental and non-governmental committees and working groups on environmental conservation and fisheries. Dr. Wramner has authored over 100 scientific papers, consultancy reports and popular articles on physical geography, biology, environmental conservation, and fisheries management.

SUGGESTED READING LIST

Balick, M.J., E. Elisabetsky, and S. A. Laird (eds.). 1996. *Medicinal Resources of the Tropical Forest: Biodiversity and its Importance to Human Health*. New York: Columbia University Press.

Cartledge, Bryan (ed.). 1994. *Health and the Environment*. New York: Oxford University Press.

Cohen, Joel E. 1995. *How Many People Can the Earth Support?* New York: W.W. Norton & Company.

Chivian, Eric, Andrew Haines, Howard Hu, and Michael McCally (eds.). 1993. *Critical Condition: Human Health and the Environment*. Cambridge: MIT Press.

Daily, Gretchen (ed.). 1994. *Nature's Services: Societal Dependence on Natural Ecosystems*. Washington, D.C.: Island Press.

Garrett, Laurie. 1994. *The Coming Plague: Newly Emerging Diseases in a World Out of Balance*. New York: Farrar, Straus and Giroux.

Goudsmit, Jaap. 1997. *Viral Sex: The Nature of AIDS*. New York: Oxford University Press.

Grifo, Francesca T., and Joshua Rosenthal. 1997. *Biodiversity and Human Health*. Washington, D.C.: Island Press.

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McMichael, A.J. 1995. *Planetary Overload: Global Environmental Change and the Health of the Human Species*. Canto edition. Cambridge: Cambridge University Press.

Platt, Anne E. 1996. *Infecting Ourselves: How Environmental and Social Disruptions Trigger Disease*. Worldwatch Paper 129. Washington D.C.: Worldwatch Institute.

Ponting, Clive. 1991. *A Green History of the World: The Environment and the Collapse of Great Civilizations*. New York: Penguin Press.

Raeburn, Paul. 1996. *The Last Harvest: The Genetic Gamble that Threatens to Destroy American Agriculture*. 2nd ed. Lincoln, Nebraska: University of Nebraska Press.

Safina, Carl. 1998. *Song of the Blue Ocean*. New York: Henry Holt Co.

Suzuki, David (with Amanda McConnell). 1998. *The Sacred Balance: Rediscovering Our Place in Nature*. Amherst, New York: Prometheus Books.

Center for Biodiversity and Conservation American Museum of Natural History

The Center for Biodiversity and Conservation (CBC) at the American Museum of Natural History is dedicated to the study and conservation of biological diversity at all levels—from genetic diversity to species and ecosystems. The CBC draws on the strengths of the Museum's science, education, and exhibition departments to integrate scientific knowledge into the conservation process and to promote dialogue and collaboration on biodiversity conservation worldwide.

Center for Health and the Global Environment Harvard Medical School

The Center for Health and the Global Environment at Harvard Medical School, a "Collaborating Center" of the United Nations Environment Programme, is the first center at a medical school in the United States focusing on the human health dimensions of global environmental change. Through its interdisciplinary research, educational and policy programs, the Center seeks to promote a wider understanding of the potential human health consequences of population growth, global climate change, stratospheric ozone depletion, toxic pollution and the loss of habitats and species. It is guided by the conviction that people will work to preserve the global environment when they have begun to recognize the risks to their health and lives, and to those of their children.

United Nations Environment Programme

UNEP

The United Nations Environment Programme (UNEP) was established to provide leadership and encourage partnerships in caring for the environment by inspiring, informing and enabling nations and people to improve their quality of life without compromising that of future generations. UNEP's uniqueness lies in its advocacy of environmental concerns within the international system. Built on a heritage of service to the environment, UNEP has been creating a basis for coordinated action within the UN on the problems of the human environment. UNEP provides an integrative and interactive mechanism through which a large number of separate efforts by intergovernmental, non-governmental, national and regional bodies in the service of the environment are reinforced and interrelated.

Fogarty International Center
National Institutes of Health

The Fogarty International Center, National Institutes of Health, is dedicated to advancing the health of the people of the United States and other nations through international scientific cooperation. In pursuit of its mission, the Center fosters biomedical research partnerships between U.S. scientists and foreign counterparts through research and training grants, fellowships, and international agreements, and provides leadership in international science policy and research strategies.

The Hall of Biodiversity
American Museum of Natural History
Opening May 30, 1998

The issues addressed in this symposium will be explored in the new Hall of Biodiversity, a permanent exhibition opening at the Museum in May. This 11,000-square-foot exhibition displays the diversity of life, threats to its future, and actions required to stem the tide of destruction.

The awe-inspiring diversity of life on Earth is vividly conveyed with specimens, models, and videos of creatures ranging from microorganisms to terrestrial and aquatic giants. Visitors will be immersed in an ever-changing and severely-threatened environment as they walk through a 2,500 square foot diorama recreating a section of the Dzanga-Ndoki Rainforest in the Central African Republic. This multi-sensory experience–which includes sight, sound, and smell–offers a closer look at the complexity of the relationship between humans and their environment, a relationship that has a profound impact on the future of all life.

Throughout the exhibition, visitors will explore the challenges to biodiversity conservation around the globe. While critical threats to biodiversity are presented, visitors will also learn of areas where biodiversity loss is being slowed through protection and restoration, natural resources management, legal measures, research and educational efforts, and reduced resource consumption.

In a rapidly changing world, representing the current status of biodiversity presents a challenge. Frequent updates will appear in electronic "bio-bulletins" in the Hall, which will interpret news and events that affect global biodiversity–including new scientific discoveries and prospects for our future. In this way, the Hall of Biodiversity will make a significant contribution to the Museum's commitment to expand public understanding of Earth's diverse and often endangered forms of life.

Printed on 100% post-consumer unbleached paper
with soy based ink