YALE ENVIRONMENTAL NEWS

Yale Peabody Museum of Natural History, Yale School of Forestry & Environmental Studies, and Yale Institute for Biospheric Studies

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Peabody Curator Awarded MacArthur "Genius" Grant

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KROON HALL RECEIVES DESIGN AWARDS

Kroon Hall, the Yale School of Foresty & Environmental Studies' new ultra-green home, captured two awards this fall for "compelling" design from the American Institute of Architects.

"The way the building performs is essential to this beautiful, cathedral-like structure," the jurors noted. "Part of its performance is the creation of a destination on the campus. The long walls of its idiosyncratic, barn-like form define this compelling building."

Designed by Hopkins Architects of Great Britain, in partnership with Connecticut-based Centerbrook Architects and Planners, the $33.5 million Kroon Hall received an Honor Award from American Institute of Architects (AIA) New England and a Design Award from AIA Connecticut. The building is expected to achieve a platinum rating in the green-building certification program, Leadership in Energy and Environmental Design.

The architects used Briar Hill sandstone from Ohio for the building's exterior, which is used in many buildings on the main campus, and its pale yellow coloring makes a luminous contrast with the brownstone and maroon brick of other Science Hill buildings. Glass facades on the building's eastern and western ends are covered by Douglas fir louvers, which are positioned to deflect unwanted heat and glare. The building's tall, thin shape, combined with the glass facades, enables daylight to provide much of the interior's illumination. And the rounded line of the standing seam metal roof echoes the rolling whaleback roofline of architect Eero Saarinen's David S. Ingalls Rink across the street.

Inside, Kroon's use of exposed concrete surfaces consciously echoes architect Louis Kahn's two masterworks on the main campus, the Yale University Art Gallery and the Yale Center for British Art. To soften the concrete, the architects also employed red oak paneling from the 7,840-acre Yale-Myers Forest, which is managed by the school. Almost from the moment a visitor enters the building at ground level, the long open stairway carries the eye up toward the high barrel-vaulted ceiling and the big window high up on the third floor, with its view into Sachem's Wood.

Opened in January 2009, the 58,200-square-foot Kroon Hall is designed to use 50% less energy and emit 62% less carbon dioxide than a comparably sized modern academic building. A 100-kilowatt rooftop array of photovoltaic panels, funded in part by the Connecticut Clean Energy Fund, provides about 25% of the building's electricity. Four 1,500-foot-deep wells use the relatively constant 55°F temperature of underground water for heating and cooling. And four panels of evacuated tubes embedded in the southern facade use the sun to provide hot water.

In March of 2009, at the International Scientific Congress on Climate Change in Copenhagen, Yale's President Richard Levin announced the formation of the Yale Climate and Energy Institute (YCEI), and named as its first director Rajendra K. Pachauri, the head of the Intergovernmental Panel on Climate Change (IPCC), who shared the Nobel Peace Prize in 2007 with Al Gore.

The mission of YCEI is to bring the weight of Yale to bear on the most pressing climate and energy issues of our generation. YCEI was initiated by the Department of Geology & Geophysics (G&G), which hosted a Yale-wide workshop in March 2008 to inventory and share mutual progress in climate and energy research occurring at Yale, and to discuss how an interdisciplinary "umbrella" institute might be formed to foster practical solution-based research. Following this highly successful

View from Kroon Hall's Knobloch Environment Center. Photo: Robert Benson Photography.

workshop, a team of faculty spanning the natural sciences, engineering and social sciences developed a proposal for a new Yale institute to bring together Yale's talent and stature, and to address the global problems of climate change and renewable energy. President Levin received the proposal in the summer of 2008, and the Institute was created in early 2009. YCEI is a testament to President Levin's commitment to this issue, and he personally recruited Dr. Pachauri to be the YCEI's first director.

At present, YCEI is promoting its first activities through interdisciplinary grants, workshops, postdoctoral fellowships and symposia, and participated at the COP15 International Climate Congress in Copenhagen in December 2009.

Seed-funding for the first round of proposals was committed in fall of 2009, with projects ranging from the development and marketing of more efficient cook-stoves for developing nations, to the study of carbon dioxide sequestration in ultramafic rocks. YCEI is also supporting several one to two-day interdisciplinary workshops that cover focused topics in climate and energy. For example, workshops in 2010 will explore ancient cultural collapse to abrupt climate variability, and the propagation of vector-borne pathogens in response to climate change.

In addition to Director Pachauri, the Institute's governance includes a faculty deputy director (formerly G&G Chair David Bercovici, and currently Professor Gary Brudvig from the Yale Department of Chemistry) and an assistant director, Juliana Wang, who oversees day-to-day operations of the Institute. The deputy director also chairs the YCEI Executive Committee, which is composed of Yale faculty from across the University.

YCEI puts Yale on the international stage as an important player in these monumental challenges, with the intention that its future contributions will be lasting and profound.

For more information on YCEI, visit their Web site at *www.climate.yale.edu/*

CONFERENCES, SEMINARS, SYMPOSIA

YIBS PRESENTS FOUR CLIMATE AND ENERGY SEMINARS DURING ITS FALL 2009 SCHEDULE

The Yale Institute for Biopsheric Studies (YIBS) continues its sponsorship of the weekly YIBS/ESC Friday Luncheon Seminars held in the Class of 1954 Environmental Science Center (ESC) during the fall and spring semesters, a popular offering for students and faculty.

This fall, YIBS Director Jeffrey Park was pleased to incorporate four seminars sponsored by the new Yale Climate and Energy Institute (YCEI) that specifically addressed issues relating to climate and energy. YCEI seminars were held in Burke Auditorium in the School of Forestry & Environmental Studies (F&ES) Kroon Hall on Prospect Street, with Dr. Rajendra Pachauri, director of the YCEI, as the first presenter.

The Fall 2009 list of YIBS and YCEI speakers and their topics were:

Nicholas Longrich, Gaylord Donnelley Postdoctoral Environmental Associate, Yale Department of Geology & Geophysics: *Diversity of Dinosaurs and Other Vertebrates from the Late Cretaceous of Western North America: Implications for the Patterns and Processes of the End Cretaceous Mass Extinction* ■ **Linda Thomas**, Artist/Muralist: *Art on the Wild Side* ■ **Rajendra Pachauri**, Director, YCEI; Director General of the Energy Resources Institute, YCEI Seminar: *Climate Change and Copenhagen: Scientific and Ethical Imperatives* ■ **John Wettlaufer**, Batemann Professor, Yale Department of Geology & Geophysics, YCEI Seminar: *Whither Arctic Sea Ice?* ■ **Allessandro Gomez**, Professor of Mechanical Engineering at Yale University, YCEI Seminar: *Evolution of a Fossil-Fueled Civilization: The Next Few Decades* ■ **Robert Stavins**, Albert Pratt Professor of Business and Government, Environment and Natural Resources Program, Belfer Center for Science and International Affairs, YCEI Seminar: *Getting Serious About Global Climate Change in the Post-Kyoto World* ■ **Scott A. Strobel**, Henry Ford II Professor of Molecular Biophysics & Biochemistry and Chemistry, Yale University, YCEI Seminar*: Rainforest Microbes*

YIBS CENTER FOR THE STUDY OF GLOBAL CHANGE — TOPICS IN GLOBAL CHANGE SEMINARS

The YIBS Center for the Study of Global Change presented its weekly seminar series, Topics in Global Change, during the Fall 2009 semester. Center Director Karl K. Turekian, Sterling Professor in the Department of Geology & Geophysics, organized the seminars with an emphasis on climate change consequences.

Speakers and topics for the Fall 2009 seminars were:

■ **John Wettlaufer**, Professor in the Department of Geology & Geophysics, Yale University: *Whither Arctic Sea Ice?* ■ **Inez Fung**, Professor at the University of California, Berkeley, and Bass Distinguished Visiting Environmental Scholar at Yale: *What Don't We Know About Global Warming?* and *Can the Carbon Budget Be Managed?* ■ **Robert Adair**, Sterling Professor Emeritus and Senior Research Scientist, Department of Physics, Yale University: *Stochastic Contributions to Global Temperature Changes* ■ **Dr. Richard Feely**, National Oceanic and Atmospheric Administration (NOAA): *Ocean Acidification: The Other CO_2 Problem* ■ **Taro Takahashi**, Doherty Senior Scholar, Lamont-Doherty Earth Oberservatory, Columbia University: *Uptake of Atmospheric CO_2 by the Global Oceans: How Is It Changing in Recent Decades?* ■ **Paul Halloran**, Meteorology Office Hadley Centre, UK: *Ocean Acidification and the Carbonate Pump* ■ **Peter Brewer**, Senior Scientist at the Monterey Bay Aquarium Research Institute (MBARI): *Limits to Marine Life Posed by CO_2 and O_2 Levels* ■ **Richard Seager**, Doherty Senior Research Scientist, Lamont-Doherty Earth Observatory, Columbia University: *Global Warming Impacts on Drought Around the World* ■ **Nancy Knowlton,** Adjunct Professor of Marine Biology/Director of CMBC, Smithsonian Institution: *Global Change and the Future of Coral Reefs* ■ **Sydney Levitus**, National Oceanic and Atmospheric Administration (NOAA): *Global Ocean Heat Content 1955-2008 and Earth's Heat Balance*.

For the Winter/Spring 2010 seminar schedule, please visit the YIBS Web site at *www.yale.edu/yibs/research/csgc.html*.

and Their Applications ■ **Karen Seto**, Associate Professor, F&ES: *Cities and Climate Change: Impacts, Risks, and Adaptation* ■ **Paul Sabin**, Assistant Professor, History Department: Yale University, *The Climate Crisis and Energy Transition: Lessons from History* ■ **Durland Fish**, Professor of Epidemiology, Yale School of Medicine: *Lyme Disease and Other Infections from the Environment* ■ **Matthew Walsh**, Gaylord Donnelley Environmental Postdoctoral Associate, Yale Department of Ecology & Evolutionary Biology: *Impacts of the Direct and Indirect Effects of Predators on Evolutionary Change in Trinidadian Killifish* ■ **Melinda Smith**, Assistant Professor, Yale Department of Ecology & Evolutionary Biology: *Convergence and Contingencies in Grassland Responses to Fire and Grazing: An Inter-hemispheric Comparison*

For the Winter/Spring 2010 seminar schedule, please visit the YIBS Web site at *www.yale.edu/yibs/events_yibsesc.html*

Government of Japan Honors Yale Professor William W. Kelly

On November 19, 2009 the Japanese government conferred the Order of the Rising Sun, Gold Rays with Neck Ribbon, on Professor William W. Kelly of Yale University, acknowledging his contributions to the study of Japanese society and culture in the United States, and for his promotion of scholarly and educational exchange between Japan and the United States. The Order of the Rising Sun was the first national decoration to be created by the Japanese government in 1875, and it is the country's second most prestigious decoration after the Order of the Chrysanthemum. The Japanese government recognized Professor Kelly as a most worthy recipient of this distinguished award.

Professor Kelly joined the Yale faculty in 1980 and has been dedicated to research and teaching about Japan for 30 years. As Professor of Anthropology and Sumitomo Professor of Japanese Studies, he has been a major figure in the development of Japanese studies at Yale and in the United States, and has fostered many younger researchers in Japanese studies. He is a noted authority on the anthropology of contemporary and historical Japan, and for two decades much of his research has been focused on the place of regional society within modern Japan based on extensive fieldwork on farming, families, and festivals in the Shônai area of Yamagata Prefecture. For the last 15 years, he has turned to sport and body culture in Japan, conducting long-term research on professional baseball in the cities of Osaka and Kobe and on Japan's Olympic experiences. He has published widely in English and Japanese, and is particularly known for his writings on the importance of baseball for modern Japan and on the place of Japanese sports in global sports history.

Throughout his career, Kelly has worked tirelessly to promote United States-Japan educational exchange, serving many years on the Governing Board of the Kyoto Center for Japanese Studies and on the Advisory Board of the Japan-United States Student Conference. He also served on the Japan Committee of the Social Science Research Council and the Northeast Asia Council of the Association for Asian Studies. He was a four-term member of the American Advisory Committee of the Japan Foundation and a long-time associate editor of the *Journal of Japanese Studies*.

Professor Kelly has introduced generations of Yale undergraduates to Japanese society through his popular lecture courses, and has nurtured many Japanese anthropologists in his long-running graduate research seminar. Many of his students now fill academic posts in major universities such as the Massachusetts Institute of Technology, Waseda University, International Christian University, the Chinese University of Hong Kong, and Yale itself.


BOOS


STORELVMO


TIMMERMANS

Three Join Faculty in the Department of Geology & Geophysics

WILLIAM BOOS

William Boos joins the faculty in the Department of Geology & Geophysics as an assistant professor in July 2010. He received his doctorate in Atmospheric Science from the Massachusetts Institute of Technology in 2008, and then worked at Harvard University as a Daly Fellow in the Department of Earth and Planetary Sciences, and as a Fellow in Harvard's Center for the Environment. Dr. Boos studies the processes responsible for variations in tropical climate over a broad range of time scales, using theory, numerical models, and observational analyses.

He has worked most extensively in monsoon dynamics, attempting to improve the understanding and prediction of these tropical circulations that deliver water to billions of people. Such planetary-scale circulations in the tropical atmosphere are poorly understood because they depend strongly on the heat released when water vapor condenses and falls out as precipitation, a process that occurs on short length scales that are extremely difficult to resolve in global models of climate. To address this problem, Dr. Boos uses high resolution computer models of the atmosphere in limited domains to represent the transfer of energy between moist convective scales and idealized planetary-scale circulations. He employs these models, together with data from satellites and in-situ measurements, to verify and guide development of theories for the variability of the tropical atmosphere.

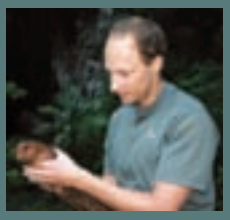
Dr. Boos recently advanced a theory to explain the repeated poleward migration of elongated bands of cloudiness and precipitation that occur several times each summer in Asia and the eastern Pacific. He has examined the role that topography plays in the climate of South Asia, using observations and numerical simulations to show that, contrary to previous thinking, the Himalayas and adjacent mountain ranges may be more important than the Tibetan Plateau for creating a strong summer monsoon. He has also studied the abrupt onset of monsoon circulations, in which the circulation undergoes rapid, nonlinear shifts when subject to the smooth seasonal cycle of solar radiation. Dr. Boos is currently working to understand how precipitation distributions over land in the tropics might change as the climate warms in coming decades. Since understanding the past may improve our ability to predict the future, he also seeks to understand how and why tropical land precipitation responded to changes in solar radiation, glaciation, and topography thousands to millions of years in the past.

NEW JOINT APPOINTMENT AT THE SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES AND IN THE DEPARTMENT OF ANTHROPOLOGY

Karen Hébert joins faculty in the School of Forestry & Environmental Studies and the Department of Anthropology as an assistant professor.

Professor Hébert is a cultural anthropologist whose research examines the development and implications of changing forms of natural resource production and consumption. Her work is situated in resource-dependent communities in the subarctic north. She has conducted long-term ethnographic fieldwork in southwest Alaska, where she has analyzed historical and recent transformations in the region's salmon industry. Her research and teaching interests focus on issues of globalization and economic restructuring; the rise of market-driven policy paradigms and new modes of consumerism; the regulation of fisheries and agro-food systems; the production and experience of ecological risk and vulnerability; human-environment relations and sustainable livelihoods; and the sociocultural theory of environment and economy.

NEW APPOINTMENT IN EEB



Walter Jetz joined the faculty of the Department of Ecology & Evolutionary Biology as an associate professor in July 2009. He received his D.Phil. in Zoology from Oxford University in 2002. After postdoctoral work at the University of New Mexico and Princeton University, he served as an assistant professor and associate professor in the Division of Biological Sciences at the University of California, San Diego, where he received tenure.

Dr. Jetz uses theory, simulations and large ecological, biogeographic and phylogenetic datasets to address basic and applied ques-

TRUDE STORELVMO

Trude Storelvmo joined the faculty in the Department of Geology & Geophysics as an assistant professor in January 2010. Dr. Storelvmo received her doctorate in 2006 from the University of Oslo, Norway, and has spent three years in Switzerland working as a postdoctoral fellow at the Swiss Federal Institute of Technology (ETH) in Zurich. Dr. Storelvmo is a climate scientist and studies how aerosol particles affect climate, in particular via their effect on clouds. Her main research tools so far have been global climate models (GCMs) often combined with satellite data. Dr. Storelvmo works on incorporating aerosol-cloud interactions into GCMs with the goal of understanding how aerosol particles influence climate.

The global aerosol burden has increased substantially since pre-industrial times due to human activity. Anthropogenic aerosols affect the radiative balance of the earth-atmosphere system in two ways: directly, by scattering and absorbing solar and terrestrial radiation, and indirectly, by acting as nuclei required for the formation of clouds and changing their optical and microphysical properties. Both aerosol direct and indirect effects are believed to cool the current climate, thereby partly counteracting the current warming due to increased greenhouse gas concentrations. However, the uncertainties associated with aerosol effects on climate are high and simulations of such effects in global climate models are extremely challenging. In fact, aerosols and clouds have been characterized as the biggest source of uncertainty in model predictions of future climate, a topic characterized as one of the biggest puzzles driving climate research today.

Dr. Storelvmo's research focuses on the aerosol effects on clouds, that is, the aerosol indirect effects. The development of new models describing aerosol-cloud interactions for use in numerical simulations requires reliable and extensive laboratory and field measurements. To tackle the monumental challenge of treating aerosol effects in climate, one must integrate computer models with remote sensing and in-situ and laboratory experiments. This will be Dr. Storelvmo's approach when she continues her research at Yale.

MARY-LOUISE TIMMERMANS

Mary-Louise Timmermans joined the faculty in the Department of Geology & Geophysics in July 2009 as an assistant professor. She received her doctorate in Fluid Mechanics from Cambridge University, England, after which she was a postdoctoral fellow at the University of Victoria in British Columbia, Canada. Following this, she was a postdoctoral scholar at the Woods Hole Oceanographic Institution in Massachusetts, where she was most recently an assistant scientist in the Physical Oceanography Department. Her principal research focus is the dynamics and variability of the Arctic Ocean to better understand how the ocean impacts Arctic sea ice and climate.

Dr. Timmermans' approach is to apply fundamental theoretical models to geophysical observations. She uses measurements from an ice-based network of drifting automated ocean-profiling instruments, moored instrument systems, hydrographic measurements from icebreaker surveys, satellite measurements, and atmospheric and ice-thickness data. Her research includes investigations of ocean mixing, eddies, double-diffusive heat transport, and freshwater and heat content in the upper Arctic Ocean. Dr. Timmermans is also conducting research to understand waves and density intrusions in the deepest Arctic Ocean, as well as the exchange of deep water between Arctic basins, how changes in the shallow and intermediate waters are manifest in the deep ocean, and the importance of Arctic deep water in understanding Arctic climate transitions.

tions in ecology, biogeography, and biodiversity science, and has worked extensively on documenting and understanding regional to global patterns of biodiversity in terrestrial vertebrates and plants. Knowledge of the determinants of species geographic distributions at broad scales is still limited, and Dr. Jetz' work has helped to significantly advance and integrate the field of global biodiversity science. In related research, Dr. Jetz has tackled long-standing questions about community structure and the variation of animal life histories along environmental gradients. This research is characterized by an attempt to integrate ecological and evolutionary explanations of ecological variation across geographic scales. For this work, Dr. Jetz employs bio- and geoinformatic techniques, modeled and remotely sensed environmental information, spatial modeling, phylogenetic tree analysis, and biodiversity data collected at different spatial scales.

One large component of Dr. Jetz' work is applied biodiversity science and conservation. He has helped advance methods to assess how future global change may affect the distribution of species and the composition of animal communities. Where are the hotspots of future species extinction risk? Using birds as a model system, Dr. Jetz performed several regional, continental and global analyses of expected impacts of climate change on biodiversity. Working with projections from the Intergovernmental Panel on Climate Change and the Millennium Ecosystem Assessment, he has provided a first baseline assessment of potential impacts of land use and climate change on each of the 9,000 terrestrial bird species worldwide. Relating the geography of projected change to species distributions has reaffirmed the high extinction risk posed by continuing tropical land use change above and beyond looming changes to the climate.

Dr. Jetz is currently extending this work to include all terrestrial vertebrates. Using novel functional and phylogenetic data, he is developing new ways to quantify, understand and predict the structure of species assemblages at different geographic scales. Extending these analyses to the species level, he hopes to quantify the functional and evolutionary uniqueness of vertebrate species to provide advanced metrics of species' global significance that may assist conservation decision-makers in our rapidly changing world.

YALE PEABODY MUSEUM OF NATURAL HISTORY

EVENTS

14TH ANNUAL CELEBRATION OF MARTIN LUTHER KING, JR. DAY
January 17 & 18, 2010

The Yale Peabody Museum's renowned two-day festival in honor of Dr. Martin Luther King, Jr., and his efforts to ensure environmental and social justice among all people.

DINOSAUR DAYS
February 15–20, 2010

Join us during the February school holidays for our yearly celebration of paleontology and everything dinosaurs.

A DIORAMA TAKES SHAPE: BRINGING THE GENIUS OF JAMES PERRY WILSON TO LIFE
On view February 27 to April 25, 2010

Visitors will have a unique "behind the scenes" opportunity to see how dioramas are made as Preparator Michael Anderson, sculptor of the Peabody's *Torosaurus* statue, and trained volunteers prepare the foreground elements for the Museum's newest acquisition, a James Perry Wilson diorama painting of the famed warbler migration at Point Pelee in southwestern Ontario, Canada.

SKELETONS IN THE CLOSET: IT'S ID DAY AT THE PEABODY
April 15, 2010

Have you found something interesting that you'd like to have identified? Come to the Great Hall! Our experts will be on hand to identify your finds or give you their best guess. Or come to see what others bring. Living creatures must be safely secured in breathable containers and promptly returned to their native environment.

BACKYARD BLOODSUCKERS: BIODIVERSITY BITES BACK!
April 17, 2010

The Yale Peabody Museum's teacher professional development program presents activities that look at how we are changing environments in ways that bring people into closer contact with organisms that transmit disease from one species to another, including changes in Connecticut. Learn from experts about predictions for West Nile virus and Lyme disease at this fun and engaging program for the whole family.

EARTH DAY CELEBRATION
April 22, 2010

The first national Earth Day celebration on April 22, 1970 raised environmental awareness and encouraged citizens of our planet to strive for healthy, sustainable surroundings. Enjoy fun activities for the whole family, including a presentation on bats, and learn from local organizations about simple actions that can protect the planet.

Information and updates at (203) 432-5050 and *www.peabody.yale.edu*

Art on the Wild Side: A Showcase of Interpretive Mural Art

The latest exhibition in Yale's Class of 1954 Environmental Science Center, *Art on the Wild Side,* was on view from September through December 2009, and highlighted a variety of client-based natural history art projects by muralist and artist Linda Thomas commissioned by public environmental centers in New York and Connecticut.

The exhibition featured original oil, acrylic and watercolor paintings as well as reproductions and descriptive panels of commissioned interpretative signage and murals that showed the process of creating and installing the mural displays. Featured in the show were the two

The Peabody Museum Joins Facebook, YouTube and Twitter

By Shae Trewin, Collections Manager, Division of Historical Scientific Instruments

Fans of the Yale Peabody Museum of Natural History (YPM) can now follow regular updates online through YPM's newly launched Facebook page and Twitter feed (visit *www.peabody.yale.edu* for links to both).

Created in early fall 2008, YPM's Facebook page features regularly updated information on events, links to current and future exhibits, behind-the-scenes photographs, an active wall with posts from staff and fans and links to collection blogs, and media releases. Facebook is a social utility Web site that allows easy access to online communication among friends, family and coworkers.

The Facebook page also has a link to YPM's new YouTube channel (*www.youtube.com/user/yalepeabodymuseum*) on the popular online video-sharing Web site. Fans of YPM's Facebook page, who now number more than 1,150, are actively encouraged to post feedback and comments about the Museum and to upload their own photographs. Also planned

canvases of the "Maritime Oak Forest" mural at the newly renovated Mashomack Preserve Visitor Center on Shelter Island, New York. Installed on curved walls in an interactive space and integrated with hands-on displays to enhance the viewing experience of the visitor, the mural depicts 28 species of the local flora, including native and invasive plants, along with 17 bird species, 6 mammals and 3 reptiles, all researched by Thomas. One of three murals, each represented in the exhibition, that show the interaction of species and their life cycles in eastern Long Island Sound—along with "Salt Marsh" and "Freshwater Kettle"—these works were commissioned to express the values and objectives of the conservation management programs at the Preserve.

According to Thomas, the tradition of natural history art has an essential role in scientific documentation and in interpreting and communicating natural science concepts and discoveries to the public. Creating natural history art is a collaborative process, and this exhibition featured step-by-step explanations of the planning and creation of serial educational displays. Preparatory on-site research—field sketching, photography and species identification—provides crucial information needed to create the art. Scientists and educators review work in progress for accuracy and relevance to program content. The artist's inspiration completes the pictures by representing the awesome beauty and power of the natural world. A hallmark of Thomas's work is showing the human influence on natural habitats in all her work, whether it be a discarded can, a fencepost, or a ferry crossing a bay.

Other works in the exhibition included: a scaled-down reproduction of 16-by-40-foot mural depicting 90 species in their montane habitats and an identification panel for the migrating raptors of the Shawangunk Flyway, done for the Nature Conservancy at the Sam's Point Conservation Center in Cragsmoor, New York; four of the six original paintings created for the Connecticut's Beardsley Zoo's new Wolf Center; "Life at the Edge of the Goodlife Pond" for the Sheldrake Environmental Center in Larchmont, New York; "Quassaick Creek Estuary" for the Quassiaick Creek Coalition and the City of Newburgh, New York; and six original wildlife and African paintings.

Linda Thomas is a muralist, fine artist, and illustrator. She graduated Washington University in St. Louis with a BFA in Illustration and began her career in interpretive art, publishing and advertising. Her award-winning works include murals, portraits, landscape and wildlife paintings and illustrations represented in museums, nature centers, galleries and private collections. Linda recently served as president of the Greater New York Chapter of the Guild of Natural Science Illustrators.

"Maritime Oak Forest," Mashomack Preserve, Shelter Island, New York (detail), acrylic on canvas. © 2008 Linda Thomas. The full mural shows the oak forest of the Preserve through various seasons.

for the page is a "Specimen of the Day" box with a photograph and caption highlighting a randomly selected specimen direct from the collections catalog.

The YPM's new Youtube channel, launched in conjunction with its Facebook page, features the Museum's latest short documentary, which accompanied the recent exhibition *Darwin: 150 Years of Evolutionary Thinking.* Other clips include interviews with curators and related documentaries from the Peabody's previous exhibition *Travels in the Great Tree of Life.* Fans interested in the current move out to West Campus can also watch several short films of anthropology specimens in transit. Most impressive is the sequence of clips featuring the Division of Anthropology's longest object, a 23-foot canoe, being delicately moved out of the building where it was stored, navigated through the foyer of its new West Campus home, and finally installed in the collection room.

Twitter is an online service that lets people keep in touch through the exchange of quick, frequent messages. Twitter fans can now follow the activities of YPM staff through the regularly updated Twitter feed, listed under yalepeabody (*http://twitter.com/yalepeabody*).

A selection of nymphalid butterflies from the YPM Division of Entomology.

How Butterflies Got Their Spots

For more than a year now, a small army of Yale undergraduates has been furiously photographing and annotating butterflies in the Yale Peabody Museum of Natural History's (YPM) entomology collections. Under the guidance of YPM's Division of Entomology Informatics Manager Larry Gall, this effort has so far produced a collection of some 10,000 images of a broad-spectrum of species in the Nymphalidae, a large family that includes many charismatic species such as monarchs, morphos, and painted ladies. These images document the full extent of wing pattern diversity and will be used to study how wing patterns in this family have evolved throughout their 90-million-year history.

This research, funded by a National Science Foundation grant to YPM Division of Entomology Assistant Curator Antónia Monteiro, an assistant professor in the Yale Department of Ecology & Evolutionary Biology, and YPM Associate Director for Evolutionary Informatics William Piel, seeks to discover critical moments in evolution when important novel pattern elements first arose. Using a custom-made database, student researchers score the location and types of wing pattern elements. These thousands of data points will be analyzed over an enormous phylogenetic tree by Yale postdoctoral fellow Jeff Oliver. This analysis will also allow Oliver to target key species for detailed molecular analysis of the gene networks responsible for wing pattern development, and in this way discover how changes in gene networks have led to the splendid diversity of butterfly wing patterns in nature.

Aside from the anticipated scientific insights, the photographic collection itself is a pleasure to behold and peruse: a dazzling array of bright and iridescent colors, spots, chevrons, stripes and bars. The researchers hope to make the images publicly available to offer a glimpse into YPM's vast and rich research collections.

Dominic Colosi

Vertebrate Zoology Welcomes New Staff

JORDAN COLOSI

Thanks to a recent three-year grant from the National Science Foundation, Jordan Colosi joined the staff of the Yale Peabody Museum of Natural History (YPM) in July 2009 as a museum assistant in the Division of Vertebrate Zoology.

A graduate of Yale, Jordan received her bachelor of science degree in ecology and evolutionary biology in 2009. As a junior she was a student assistant in the Vertebrate Zoology Division and spent much of her senior year working with YPM Curator of Ichthyology and Assistant Professor Thomas J. Near, Yale Department of Ecology & Evolutionary Biology, researching fish systematics and morphology, specifically looking at species diversity within a clade of darters. In Summer 2008 she was awarded a YPM undergraduate internship, which helped fund her research on *Etheostoma* morphologic variation.

Jordan will be primarily working with the fluid-preserved specimens in the Division of Vertebrate Zoology's broad collection of amphibians, birds, fishes, mammals and reptiles. Among her tasks under the grant will be to identify unknown specimens, verify the identification of specimens, update the collection data and re-house specimens into new jars with new archival labels. With a collection covering a time span of nearly 160 years, she will be very busy.

Grant to Support Recuration of Peabody Vertebrate Zoology Fluid-preserved Collections

By Greg Watkins-Colwell, Museum Assistant, Division of Vertebrate Zoology

Jordan Colosi

A

Greg Watkins-Colwell (2)

B

C

A. The jars in the collection, such as these eel specimens, will receive new labels (shown on the right), which will be printed with a thermal printer onto alcohol-proof print stock and placed inside all the jars, replacing the exterior labels (on left).

B. The type of fluid used to store fluid-preserved specimens depends on the developmental stage of the animal and the desired research use of the specimen. Specimens maintained as "wet" are useful to several different types of research, such as in studies of feeding ecology, reproductive biology, developmental biology, parasitology, conservation genetics and systematics.

C. Vertebrate Zoology Museum Assistant Greg Watkins-Colwell holds a jar of a snake specimen, a racer, in the fluid-preserved collection that will receive a new label. In the background are specimens in old mason jars that will go into new jars with better seals.

The Yale Peabody Museum of Natural History (YPM) Division of Vertebrate Zoology has been awarded a $350,000 grant from the National Science Foundation's Improvements to Biological Research Collections (BRC) program for the recuration of the Division's fluid-preserved specimens. The BRC program supports improvements to specimen curation and collection management for established natural history collections, including computerization of specimen-related data, to increase accessibility to specimens for the biological research community.

Amassed over more than 160 years by faculty and researchers from Yale, other institutions, and government agencies, the Division of Vertebrate Zoology's fluid-preserved collections include more than 248,000 individual specimens. The ichthyology collection includes important materials from the broad 19th century surveys of the United States Fish Commission and has among the highest ratio of type specimens to total specimens for any fish collection of its size. The ornithological collection of spirit specimens is among the three or four largest and most diverse in the world. Although comparatively more modest, the herpetology and mammalogy spirit specimen collections include world class research materials. By recurating the entire fluid-preserved vertebrate zoology collection the Division hopes to facilitate greater accessibility to these holdings, and to promote its use in research and education.

During the next three years the grant will enable the Division to provide new jars, fluids and archival specimen labels for the fluid-preserved collections. Additionally, funding provides for staff to verify identifications and update electronic records for these specimens, including incorporating object locations and any supplementary data that accompanies the materials (such as body size and time of collection, among others).

The BRC grant will support not only zoological curation and specimen identification, but also database training for undergraduate students in a dynamic museum setting. In addition, the Division of Vertebrate Zoology will recruit high school interns through YPM's Evolutions After School Program to work on the specimen curation portion of the project.

This ambitious project will ensure that YPM's fluid-preserved vertebrate collection continues to be scientifically and educationally valuable, keeping YPM at the forefront of specimen curation and data management.

Peabody Evolutionary Biologist and Ornithologist Richard Prum Receives MacArthur Foundation "Genius" Grant

Dr. Richard O. Prum, the William Robertson Coe Professor of Ornithology in Yale's Department of Ecology & Evolutionary Biology (EEB), and head curator in the Peabody Museum of Natural History (YPM) Division of Vertebrate Zoology, has been named a MacArthur Foundation Fellow for 2009. Known as a "genius" grant, the five-year $500,000 unrestricted fellowship is awarded annually by the John D. and Catherine T. MacArthur Foundation to creative individuals who have shown extraordinary originality and dedication in their pursuits and a marked capacity for self-direction. Fellows are chosen for their exceptional creativity and the future promise of their accomplishments, and for the potential for the fellowship to facilitate subsequent creative endeavors.

Professor Prum, who serves as EEB chair, is best known for his research on the evolution of feathers and its support of the idea that birds evolved from dinosaurs. His theory of a five-step sequence of genetic adaptations that accounts for the evolution of modern feathers has been supported by discoveries in the fossil record. Professor Prum's interdisciplinary work encompasses several areas of study, including developmental biology, optical physics, molecular genetics, phylogenetics, paleontology and behavior ecology. For example, with evidence gathered through careful fieldwork, Professor Prum's research suggests that comparative behavioral studies can be used to infer phylogenetic relationships among bird species.

He has also studied the mechanisms of color production in feathers. Collaborating with applied mathematicians, Professor Prum showed that the color of blue feathers is attributable not to a pigment but to the scattering of light, as also occurs with some butterflies and reptiles. And with his Yale colleagues, Professor Prum recently discovered evidence of color in the 47-million-year-old fossilized feathers of a bird. (See "Dinosaurs in Technicolor," page 22.)

Whatever the focus of his research, Professor Prum regularly synthesizes ideas from other fields along surprising paths to reach carefully reasoned conclusions, and he continues to open new frontiers with each new project. Currently, Professor Prum is collaborating with the Yale School of Engineering and Department of Physics to explore how the mechanisms of color-producing nanostructures in bird feathers and butterfly scales can be applied to new photonic technologies.

Richard Prum received his AB (1982) from Harvard University and a PhD (1989) from the University of Michigan at Ann Arbor. He joined Yale in 2004.

A. Professor Richad Prum in the YPM ornithology collections in Yale's Class of 1954 Environmental Science Center.

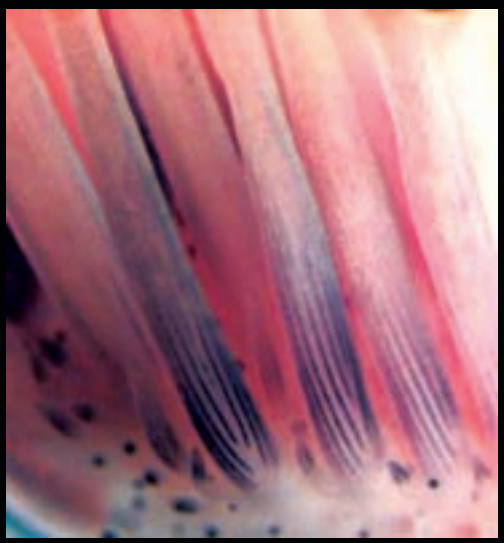
B. Developing tail feathers of an embryonic duckling, stained for expression of the gene Sonic Hedgehog (blue). The feathers reveal the role of the interbarb epithelium in the control of barb ridge morphogenesis, helical growth, and barb fusion to form the rachis of the feather.

C. The Plum-throated Cotinga *(Cotinga maynana)* is an Amazonian bird with a non-iridescent structural color produced by spongy air and beta-keratin nanostructures in its feather barbs.

Michael Marsland/Yale University.

A

Matthew Harris



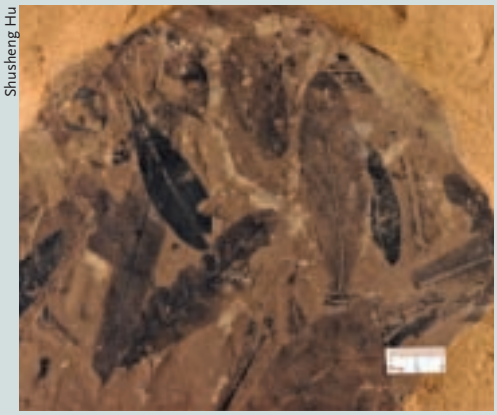
B

C

The Peabody *Glossopteris* Collection

By Shusheng Hu, Collections Manager, Division of Paleobotany

Shusheng Hu



Foliage of a *Glossopteris* tree (*G. browniana* Brongniart, YPM 8008) from the Permian of Australia, collected by James Dwight Dana in 1839 in New South Wales, Australia.

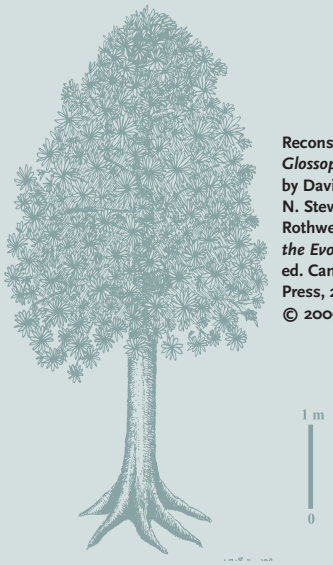
The Yale Peabody Museum of Natural History (YPM) is world-renowned for its holdings of historically significant collections. One of these is the *Glossopteris* collection gathered by James Dwight Dana, Yale's eminent geology professor, during the United States Exploring Expedition of 1838–1842. Commanded by Lieutenant Charles Wilkes, this expedition endured countless hardships and dangers from both man and nature.

During the four-year voyage, Dana stayed for two months in New South Wales, Australia, and collected plant fossils from coal formations dating to the Permian period, around 290 to 250 million years ago. Nearly 100 of these fossil plant specimens are currently stored in the YPM Division of Paleobotany. Most belong to the genus *Glossopteris*, a member of an extinct group of plants called "seed ferns" that grew only in the Southern Hemisphere from around 290 to 240 million years ago. The abundance of *Glossopteris* in Australia, India, Antarctica, Africa and South America, and its complete absence from the northern continents, support the hypothesis that these regions were once part of a supercontinent, "Gonwana," during the Permian and early Mesozoic.

James Dwight Dana reported six species of *Glossopteris* from New South Wales in 1849. Four are new species and the type specimens of *Glossopteris ampla*, *G. reticulum* and *G. cordata* are currently housed in the Yale Peabody Museum. The name *Glossopteris* was established by the French paleobotanist Adolphe Brongniart in 1828 in allusion to its tongue-shaped leaves. Later, other parts of *Glossopteris,* such as reproductive structures, trunks and roots, were found. Paleobotanists had to piece these isolated fossil organs together to reconstruct the complete *Glossopteris* plant.

Glossopteris was a sturdy tree that was probably similar to a modern conifer. It grew up to six meters high (almost 20 feet) with leaves in spirals or whorls. However, its position in plant phylogeny is still problematic. *Glossopteris* was probably very diverse in the past, numbering more than 50 species. Its frequent occurrence in coal-bearing sediments and the presence of aerating tissue in its roots indicate that it probably lived in swamps. This important tree of the temperate regions of the Southern Hemisphere suffered a massive decline at the end of the Permian period and became extinct a few million years later.

Dana's *Glossopteris* collection not only gives us a glimpse of a fascinating period in earth history, but also into the exploits of intrepid natural historians during the age of scientific exploration more than 170 years ago.



Reconstruction of a *Glossopteris* tree (drawing by David Hu after Wilson N. Stewart and Gar W. Rothwell, *Paleobotany and the Evolution of Plants*, 2nd ed. Cambridge University Press, 2001). © 2009 David Hu

J. Yépez

Expedition team members (*left to right*) Dr. Wendy Clement, Dr. Michael Donoghue, Dr. Erika Edwards and Dr. Patrick Sweeney in an upper montane rain forest near San Gabriel, Ecuador.

A Peabody Botanical Expedition through the Ecuadorian Andes

By Patrick Sweeney, Collections Manager, Division of Botany and Yale University Herbarium

The northern Andes Mountains extend from Venezuela to northern Peru. This region, with a remarkable range of habitats, is of great botanical interest because of its extensive diversity and endemism; more than half of the plant species within some ecosystems are native to the area. During June and July of 2009, botanists from the Yale Peabody Museum of Natural History's Division of Botany and the Yale Department of Ecology & Evolutionary Biology conducted a collecting expedition to the Ecuadorian Andes, an exceptional area within this northern Andes region. The high Andes of Ecuador encompasses about 45,000 square kilometers (more than 11 million acres). By some estimates it is home to more than 4,500 species, or 50% more than the Amazonian lowlands of Ecuador, an area almost twice as large.

Patrick Sweeney (6)

A

B

C

D

E

A. & B. Andean native plants *Columellia oblonga* (Columelliaceae) and *Desfontainia spinosa* (Desfontaineaceae). Photos: Patrick Sweeney

C., D. & E. Species of Ecuadorian *Viburnum*: *V. jamesonii* (with fruits), *V. hallii*, and *V. stipitatum*.

Large photo: Andean native plant *Axinaea* cf. *scutigera* (Melastomataceae).

Patrick Sweeney (7)


F


G


H

F., G. & H. Montane rain forest plants. *Psammisia* (Ericaceae), *Bomarea* (Alstroemeriaceae) and *Telipogon* (Orchidaceae). By some accounts there are more than 3,000 species of orchids in Ecuador, of which almost half are endemic.

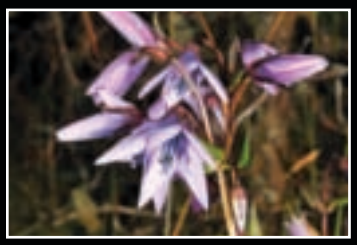
I. A species of lupine (the genus *Lupinus*, Fabaceae), a group with North American representatives that has experienced a recent, rapid radiation in the Andes.

J., K. & L. Some of the variety of herbaceous plants and scattered shrubs that occur among the tussocks in grass páramos include *(left to right) Halenia* (Gentianaceae), *Chuquiraga jussieui* (Asteraceae), and *Gentianella rapunculoides* (Gentianaceae).


I


J


K

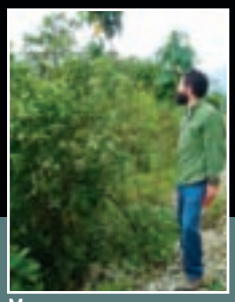

L

The main focus of our expedition was to collect plants in the genus *Viburnum*, a group that has been a long-term focus of study for Dr. Michael Donoghue, Division of Botany Curator and G. Evelyn Hutchinson Professor of Ecology & Evolutionary Biology, his students and post doctoral researchers. The approximately 160 species of shrubs and small trees in this genus are distributed broadly in the Northern Hemisphere and their range extends into the mountains of Asia and Central and South America. In the Andes they are almost wholly confined to areas above 1,200 meters (almost 4,000 feet). The Andean species are among some of the least studied within the genus.

Recent molecular studies of *Viburnum* suggest that most of the Latin American species form a single lineage that may have originated in the Northern Hemisphere and then moved into the high elevation areas of Central and South America, where it subsequently diversified. This is a pattern seen in many other North American genera also found in the tropical Andes, where their species diversity is much greater relative to that on the northern continent. Some think that geologically recent mountain building events in the northern Andes were a major factor spurring this diversification. This uplift would have provided a dispersal route for the movement of Northern Hemisphere groups into the Andes, where a combination of diverse habitats and lack of competition drove diversification.

The main goal of our collecting trip was to achieve population-level sampling of all Ecuadorian *Viburnum* species. This will allow us to investigate more deeply the processes that have contributed to shaping the biogeographic distribution and diversification of Latin American *Viburnum*, and also to address taxonomic issues involving the group. We chose to target our initial field work in Ecuador because of the many *Viburnum* species there and because of the excellent support network available to visiting botanists through the Herbario Nacional del Ecuador in Quito and the Missouri Botanical Garden. Along with Professor Donoghue, our team also included Dr. Wendy L. Clement, an post doctoral researcher in the Yale Department of Ecology & Evolutionary Biology, Dr. Erika Edwards, Assistant Professor in the Department of Ecology & Evolutionary Biology at Brown University, and Juan Yépez Cadena, a graduate student at Universidad Central de Ecuador in Quito affiliated with Herbario Nacional del Ecuador.

Our trip was a great success. We collected more than 550 specimens from almost 90 populations and covered an area of Ecuador stretching from the Columbian border south to Peru. Driving more than 2,500 kilometers (1,500 miles), we visited habitats in the Eastern and Western Cordilleras, including grass páramo, shrub páramo, Polylepis forest, lower and upper montane rainforests, and secondary vegetation. Our efforts are now focused on incorporating this newly collected material into our ongoing systematic investigations of Viburnum and on planning our next major expedition—to Southeast Asia, another major center of diversity for *Viburnum*.


M


N


O


P

M. *Viburnum* is common in disturbed habitats such as forest edges and roadsides. Here Botany Collections Manager Patrick Sweeney views a specimen of *V. divaricatum*, an Ecuadorian endemic, along a road near Pacca. Photo: Wendy Clement

N. Mount Chimborazo. This mountain was climbed by Alexander von Humbolt in 1802. His observations at the time played a central role in the development of his ideas about plant biogeography. Photo: Patrick Sweeney

O. The páramo is a northern Andean ecosystem between the upper tree line and permanent snow line. More than 60% of the species in this ecosystem are native. Grass páramos vegetation is dominated by tussock grasses and giant stem-rosette plants such as *Espeletia* (Asteraceae) and *Puya* (Bromeliaceae). Pictured is a grass páramo near the town of El Ángel on the Columbian border. The tall stem-rosette plants in the foreground are *Espeletia pycnophylla*. Photo: Wendy Clement

P. Plant preparation along the road near San Gabriel. *Left to right:* Dr. Wendy Clement, Dr. Michael Donoghue, Universidad Central de Ecuador graduate student Juan Yépez Cadena, and Dr. Erika Edwards. Photo: Patrick Sweeney

Undergraduate Summer Internships at the Yale Peabody Museum: Student Reports

The Yale Peabody Museum of Natural History (YPM) was delighted to offer an expanded internship program for Yale undergraduate students in the summer of 2009. Interns participated in the rich variety of research taking place in the Yale Science Hill community, working with a mentor on semi-independent projects using the YPM's diverse collections. Projects often also included valuable experience in the field. Interns had the opportunity to choose to work with a host scientist as part of an ongoing research program, or to design a project that investigated a topic of interest. As part of the fulfillment of the internship, at its completion students are expected to give a short presentation on their summer research project and to submit an essay on their research experience to the *Yale Environmental News*.

The 2009 undergraduate interns included: Jacob Berv (Yale '10), who worked with YPM Division of Vertebrate Zoology Collections Manager Kristof Zyskowski on field and ecological research on the birds of Suriname; Shan Kuang (Yale '11), who studied the evolutionary biology of Antarctic fishes with Assistant Professor Thomas J. Near, Yale Department of Ecology & Evolutionary Biology, and Assistant Curator of Ichthyology in the YPM Division of Vertebrate Zoology; and Adrianne Smits (Yale '10), whose study of sexual deformity in Connecticut's green frogs was hosted by David Skelly, Professor of Ecology, Yale School of Forestry & Environmental Studies and Curator of Herpetology in the YPM Division of Vertebrate Zoology. The internship program is coordinated by YPM Division of Invertebrate Zoology Senior Collections Manager Eric Lazo-Wasem.

The Ancestry and Genetic Differentiation of Surinamese Savanna Bird Populations

By Jacob Berv (Yale EEB '10)

Kristof Zyskowski (3)

A

B

Jacob Berva

C

D

A. Jacob Berv poses with a freshly excavated Tawny-throated Leaftosser (*Sclerurus mexicanus*) nest, found using radio telemetry. Although not new to science, finding this nest is an important proof of concept for the technique.

B. A Green and Rufus Kingfisher (*Chloroceryle inda*) fights back.

C. Jacob Berv tracks birds to their nests using radio telemetry.

D. This baby Crested Bobwhite (*Colinus cristatus*) was captured by hand on the ground near Zanderij International Airport.

I participated in the Yale Peabody Museum of Natural History (YPM) Undergraduate Internship Program as part of a 12-week summer research project in collaboration with four Yale advisors: Dr. Gisella Caccone, Senior Research Scientist and Lecturer, Yale Department of Ecology & Evolutionary Biology (EEB) and Director, Yale Institute for Biospheric Studies Molecular Systematics and Conservation Genetics Laboratory, and EEB postdoctoral fellow Dr. Jon Beadell guided my molecular research; and ornithologists Dr. Richard Prum, EEB William Robertson Coe Professor of Ornithology and YPM Curator of Vertebrate Zoology, and Dr. Kristof Zyskowski, Collections Manager in the YPM Division of Vertebrate Zoology, who guided field and ecological research. Additional funding came from the Yale College Dean's Research Fellowship in the Sciences, the Environmental Fellowship for Study and Research, the Yale Science and Engineering Association Fellowship, the Alan S. Tetelman '58 Fellowship for Study Abroad, and the Richter Summer Fellowship.

Studying the South American tropics, the world's apex of biodiversity, is an essential part of answering the question, "What determines patterns of species diversity?" Hypotheses explaining the incredible abundance of life in tropical rain forests have been debated for centuries. The Pleistocene refuge hypothesis, first proposed by Ernst Mayr, argues that climate change towards the beginning of the Pleistocene divided a continuous rain forest into isolated patches separated by dry savanna habitats. These gaps allopatrically split populations and fueled speciation. Subsequently, increased rainfall at the end of the Pleistocene reconnected some of these areas and created the modern Amazonian rain forests, though several savannas still remain throughout the region.

Recent YPM ornithological surveys of Suriname's Sipaliwini savanna have discovered that the open-habitat species living there are shared predominantly with the geographically far Brazilian Cerrado, rather than with other northern savannas. Generally, the savanna species that occur in the northern Surinamese

savannas are shared predominantly with the Venezuelan Llanos and Roraima–Rupununi savannas. The decoupling of species ancestry observed in Sipaliwini implies that there were once geographic connections between South America's current islands of savanna. Perhaps today's isolated Sipaliwini savanna was once connected to the Brazilian Cerrado by a coastal corridor. Dramatic changes in the South American landscape since the Pleistocene must have occurred for this to be possible, so answering the question of where the Sipaliwini birds came from could not only shed light on the evolutionary history of neotropical savanna avifauna—it may help explain the history of the forest itself.

Voucher tissue specimens collected by the YPM expeditions provide the unique opportunity to test the species-sharing hypotheses with genetics, and I began a study of several representative avian taxa collected in Sipaliwni. We began with eight target species that have populations both in the Brazilian Cerrado and the savannas of northern Suriname and Venezuela. Using DNA sequence data, our goal was to determine the actual genetic relationships between the different savanna populations. Statistical analysis of sequence data would then either corroborate or contradict the hypothesis: If the genetic data reveal that the species-sharing hypothesis is correct, it will be important to understand what has prevented the northern and southern Surinamese savanna populations from mixing; if not correct, then we will need to reexamine the contradictory evidence to figure out how such a scenario could arise.

Working with Dr. Beadell, I learned to extract DNA from different tissue sources (blood, liver, muscle, toe clippings), to amplify DNA using the polymerase chain reaction and to prepare amplified DNA for sequencing. I chose to use mitochondrial DNA (CR, ND2) for this project because mitochondrial loci are generally a more sensitive indicator of population structure than are nuclear loci. MtDNA's susceptibility to free radicals, oxygen ions and peroxides generated by the electron transport chain speed up the formation of informative mutations, which are less likely to be repaired than nuclear DNA mutations because of mtDNA's reduced DNA repair capacity. Mitochondrial DNA has been a workhorse of avian genetic studies for the last two decades because of this high relative mutation rate. Many of these mutations become fixed and are passed matrilineally to offspring, resulting in rapid sequence change highly useful for studies of population structure.

In my work over the summer, I successfully amplified and sequenced tissues collected by YPM's previous expeditions. To complete the data set, I needed tissue samples from all over South America, so I also researched and requested samples that ranged in origin from Venezuela to as far south as Argentina and Bolivia (analog of Brazil) from several major collecting institutions. These will provide a wide sampling for studying our genetic question, which will be the focus of my senior research project.

Another goal of this project was the integration of molecular work with a field study. In August Dr. Zyskowski and I led an expedition to Suriname to collect additional samples, this time focusing on northern savanna habitats where there had been no collecting by YPM or partner institutions. I identified in advance potential sampling areas using satellite image data, incorporating GIS data to field collection of DNA samples. We chose the Zanderij savanna region for its accessibility and the presence of target species. The nearby Boven–Cosewijne nature reserve was ultimately the best site for our project. During our 12 days in the field we collected 115 individuals; 14 of these (three species) are relevant to my project and should provide enough data to say something about their relationships with the other savanna populations. On this trip, Dr. Zyskowski and I also successfully demonstrated the first (to our knowledge) use of radio telemetry to localize an avian nest in South America. Using my prior experience tracking large predators on a South African game reserve in the summer of 2008, and Dr. Zyskowski's expertise in nest searching, we were able to combine forces to develop a novel method of nest discovery. We are both convinced that it has great potential to create new science, and once we have another opportunity to experiment (planned for Ecuador over Thanksgiving), we plan to write a methodological paper for publication in a scientific journal.

Ancestral Dynamics of Antarctic Fishes

By Shan Kuang (Yale '11)

Kristen Kuhn

A

Thomas Near (2)

B

C

A. Peabody undergraduate intern Shan Kuang with a *L. nudifrons* specimen in YPM's vertebrate zoology collection in the Class of 1954 Environmental Science Center.

B. & C. *Lepidonotothen nudifrons* specimens collected on the 2009 Antarctic Marine Living Resources–Yale Peabody Antarctic expedition to the South Orkney Islands.

Like any other kid who grew up watching countless nature programs on PBS and the Discovery Channel, I always had a special fascination with evolutionary biology and natural history. Ichthyology especially captured my interest, ever since I first started to go on regular East Coast fishing trips with my dad. Even though I am currently studying physical chemistry, I was thrilled to take part in the Yale Peabody Museum of Natural History (YPM) undergraduate internship program, which afforded me the opportunity I had been hoping for to be involved with evolutionary biology while at Yale. I put aside for a time what was familiar—chemistry, physics, politics—for the chance to explore a field that had long fascinated me. In the process, I gained invaluable research experience for my future work, whether in evolutionary biology, chemistry, or any other area.

My independent research project this summer involved the study of *Lepidonotothen nudifrons* under the guidance of Dr. Thomas J. Near, Assistant Professor in the Yale Department of Ecology & Evolutionary Biology (EEB) and Assistant Curator for Ichthyology in the YPM Division of Vertebrate Zoology, and EEB postdoctoral researcher Dr. Kristen Kuhn. *L. nudifrons* is a species of the Notothenioidei suborder, which is unique and fascinating for its unrivaled domination of the fish fauna of the Southern Ocean that surrounds Antarctica. The notothenioid clade is the only example of adaptive radiation observed among teleost fishes in marine habitats.

My main goal was to study the pattern of genetic differentiation of *L. nudifrons* among the different populations within the Antarctic Peninsula and the Scotia Arc. Because *L. nudifrons* is benthic with a depth distribution of 5 to 350 meters (from about 16 to 1,150 feet), breaks of up to 3,000 meters deep (almost 10,000 feet) between the island archipelagos of the Scotia Arc and Antarctic Peninsula present clear geographical barriers to dispersal between these areas. Demographic and phylogenetic analyses allowed me to determine whether deep water habitats between these shelf habitats have provided long-standing barriers to gene flow. The timing was perfect for this project because with the recent Antarctic Marine Living Resources–Yale Peabody Antarctic expedition to the South Orkney Islands in 2009 a comprehensive collection of *L. nudifrons* tissue biopsies was available for this research.

I extracted DNA from about 100 specimens and collected gene sequences from the mitochondrial encoded ND2 gene, as well as the nuclear encoded S7 and RAG genes. The *L. nudifrons* specimens were sampled from near-shore shelf habitats of South Georgia Island, the South Sandwich Islands, the South Orkney Islands, Elephant Island, and the South Shetland Islands. I then analyzed the gene sequences to determine the genetic relationships between haplotypes (the sets of alleles found in the gene), the relative prevalence of each haplotype, and the locations where they were found. Using this data it was possible to infer the extent of genetic differentiation between different geographical populations, the ancestral population dynamics of the species, and the effect of geographical obstacles between the islands on these dynamics.

There was significant genetic differentiation among the *L. nudifrons* populations of the Antarctic Peninsula and Scotia Arc islands. This provided a fascinating contrast to results published in June 2009 ("Gene flow by larval dispersal in the Antarctic notothenioid fish *Gobionotothen gibberifrons,*" by Michael Matschiner, Reinhold Hanel and Walter Salzburger, *Molecular Ecology* 18(12):2574–2587). The species *Gobionotothen gibberifrons* is also in the suborder Notothenioidei and has a population distribution nearly identical to that of *L. nudifrons*; however, there was no genetic differentiation among populations in that study.

This research is currently ongoing. I am now working with Dr. Near to analyze the data in the context of various evolutionary models. The analyses will provide further insights on geographic isolation, ancestral dynamics, and speciation in near-shore Southern Ocean marine habitats.

Frogs in the Backyard: Wastewater and Sexual Deformity

By Adrianne Smits (Yale '10)

Susan Bolden (2)

A

B

A. Adrianne Smits netting a green frog at one of the field sites in her study.

B. A female green frog (*Rana clamitans*) from a pond in Avon, CT.

This summer, as an intern at the Yale Peabody Museum of Natural History working with Dr. David Skelly, professor in the Department of Ecology & Evolutionary Biology in the Yale School of Forestry & Environmental Studies, I conducted a field survey in the greater Hartford area of Connecticut to investigate the relationship between urban proximity and rates of sexual deformity in green frogs (*Rana clamitans*).

Amphibians are currently in decline worldwide, for a myriad of reasons. Current research has linked pharmaceuticals in human wastewater, especially estrogenic compounds found in contraceptive pills, with sexual deformities and hermaphroditism in fish and amphibians. That trace concentrations of these compounds

fundamentally alter the sexual development of these vertebrate groups is important on a conservation level and as a public health concern. Their effects on humans are still unknown. Widely-spread amphibians, such as green frogs on the east coast of the United States, inhabit the same water that is eventually used by humans for drinking and for agriculture; they are therefore an ideal model organism to study the effects of this contamination—a modern "canary in a coal mine." Levels of estrogenic compounds in surface water and groundwater are often higher in urban and suburban areas, and a field study by Professor Skelly's amphibian ecology lab confirmed that rates of sexual deformity, specifically the presence of eggs developing in the testes of male green frogs, correspond with proximity to urban and suburban land use.

Because the compounds that might be responsible for abnormal sexual development in green frogs probably infiltrate their habitat through leaky sewers and backyard septic systems, I set out to measure the level of wastewater contamination in suburban and urban ponds. I specifically measured the concentration of caffeine, a chemical routinely ingested and excreted by humans, to gauge the level of human waste in each pond. I then collected adult male green frogs from ponds with different degrees of contamination, taking note of surrounding land use and water quality indicators such as pH, dissolved oxygen content, salinity and temperature.

In the coming year I will dissect the male frogs I collected this summer to look for testicular oocytes (eggs growing in the testes). I will also test all the ponds I visited for estrogenic compounds, natural and artificial, as well as for herbicides and pesticides. This data will allow me to discern the relationship, if any, between amphibian sexual deformities and habitat contamination by chemicals from human wastewater. The widespread presence of the pharmaceuticals in surface and groundwater is an issue that, so far, laws and regulations have failed to address. I hope that my research will help clarify what is happening in the water, for the frogs' sake and for our own.

Unique Peabody After School Science Careers Program Receives Grant Support

"I'm a parent, and I just want to say that I'm very grateful for the astounding experience that you provided for these students; it's amazing... I hope you realize what a huge life-changing experience this was."

— Evolutions Parent

The Yale Peabody Museum of Natural History (YPM) has received two new federal grants to support its Evolutions After School Program for the 2009–2010 and 2010–2011 academic years. Established in 2005, this academically rigorous (but fun!) program has continued to grow, providing unique opportunities for high school students to learn about science. It now serves 125 New Haven and West Haven teens and their families with a comprehensive

Jamie Alonzo (5)

"It's educational and it's fun. It's kind of a club that's science and college-prep based. It informs you about science careers, how to apply for college, the tests and applications, financial aid."

— Evolutions Student

year-long curriculum that includes hands-on projects, field trips, internship opportunities, college preparation, and career awareness activities.

A new National Science Foundation grant to YPM Director and Principal Investigator Derek Briggs, the Frederick William Beinecke Professor of Geology & Geophysics, from NSF's geosciences directorate enables YPM to implement GeoCORPS, a program that focuses on exploration of the geosciences and geoscience careers. Other collaborators on this grant include professors Ruth Blake, Leo Hickey and Mark Pagani from the Yale Department of Geology & Geophysics, and Associate Professor of Ecosystem Ecology Peter Raymond from the Yale School of Forestry & Environmental Studies. GeoCORPS also includes a new partnership with the Louis Stokes Alliances for Minority Participation (LSAMP) program and geology faculty at the University of Connecticut that will bring UConn and Evolutions students together on both campuses. The program is also receiving substantial support from a Museums of America grant from the Institute of Museum and Library Services to Principal Investigator Jane Pickering, YPM Assistant Director for Public Programs and Deputy Director.

Along with internship opportunities, this summer high school students also served as interpreters of YPM exhibits for the first time. SciCORPS, the job-related extension of Evolutions, was rolled out in part last fall. By the summer the program had enough students that were trained and approved to run hands-on activities for visitors to have them work almost four days a week, as well as during YPM special events such as "Summer's Last Roar."

The program graduated its first set of seniors in the summer of 2009, including one student who is a member of the Yale class of 2013. During the last six years the Evolutions students have produced exhibitions, films and lesson plans, and worked with faculty from many different Yale departments. Feedback from participants has been almost uniformly positive. Most report that the experience has changed their perception of science and scientists and led them to seriously consider majoring in science. To quote one student: "Now I see people in the science labs—all the professors and students—they're [just] people and I'm a little more comfortable."

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Opposite: Evolutions students during construction of their exhibit *GEOWhiz: An Exploration of Careers in the Geosciences.*

A. Evolutions intern Kathleen Smith at work in Dr. Ruth Blake's lab.

B. Yale undergraduate Rafa Kern with Evolutions students Kayla Williams (Cooperative Arts & Humanities High School, currently enrolled at Yale) and Donald Walker (Metropolitan Business Academy High School) piloting a new interpretation for YPM's Southern New England diorama hall.

C. Evolutions intern Renee Beamon studying *Daphnia* (water fleas) in Dr. Stephen Stearns's lab.

D. Yale undergraduate Julia Blum with Evolutions student Christine Randall (Wilbur Cross High School) piloting a new interpretation cart for the North American diorama hall, part of YPM's new SciCORPS program.

Jakob Vinther (2)

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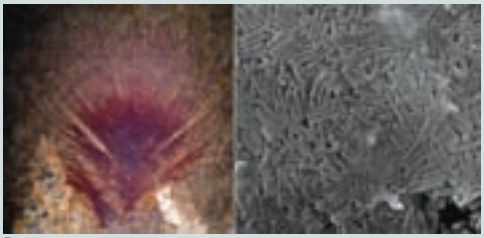

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Julia Clarke

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Dinosaurs in Technicolor

By Jakob Vinther (PhD '11), Department of Geology & Geophysics

Most people were captivated, when Spielberg's *Jurassic Park* was first released, to see that dinosaurs could be reconstructed and, using modern computer graphics, brought to life. Spielberg's team relied on advice from several paleontologists to make their dinosaurs as accurate and dynamic as possible. Since then, however, remarkably preserved fossils from China have shown that many dinosaurs were feathered like their modern descendants, the birds.

This discovery has profound implications for our understanding of dinosaurs and their evolution. Not only does the presence of feathers confirm that dinosaurs were warm-blooded, active animals, but suddenly dinosaurs morphed from dull creatures with scaly skin to fully plumaged animals displaying all sorts of colors. Why?

Birds use a plethora of colors for camouflage and, more than anything else, for sexual display. Dinosaurs might have interacted like modern birds, with spectacularly colored male dinosaurs making courtship displays, but how would we ever know? Coloring the past has always been limited mainly by the artist's imagination, qualified by suggestions from the scientist.

This may now change. A recent discovery shows that colors can actually be fossilized. About two years ago, as part of my work on early animal evolution and fossil preservation, I was studying fossil squid ink sacs and saw with a scanning electron microscope that the small granules of the fossilized ink, or melanin, were identical in shape and size to those of modern squid ink. That made me think that it should be possible to recognize melanin pigments in other fossils. Looking at feathers was an obvious next step.

I first studied a fossil bird with preserved feathers from rocks about 50 million years old from Denmark. To my surprise, the feather imprints are made solely of the melanin structures called melanosomes. They look like little sausages that are aligned in densely packed layers inside the feather.

A team consisting of myself, Yale paleontologist Derek Briggs, the Frederick William Beinecke Professor of Geology & Geophysics and director of the Yale Peabody Museum of Natural History, William Robertson Coe Professor of Ornithology Richard Prum, chair of the Yale Department of Ecology & Evolutionary Biology and Peabody Curator of Vertebrate Zoology, and Yale alumna Julia Clarke (PhD '02), an associate professor in the Department of Geological Sciences at the University of Texas at Austin, is now working on interpreting colors in fossil birds and dinosaurs. The research is funded by the National Science Foundation, the National Geographic Society and the Yale University William Robertson Coe Fund. Last year we showed that the preservation of melanosomes accounts for the color banding in a 100-million-year-old feather from Brazil. This year we identified iridescence in a 47-million-year-old feather from the famous Messel Oil Shale near Frankfurt in Germany. This feather was originally a metallic blue-green or copper color, although it now looks red and white. A scanning electron microscope clearly shows swaths of melanosomes arranged in the white areas of the feather to form a thin film that would have scattered incoming light and given the feather a metallic appearance.

The discovery that evidence of color can be fossilized has tantalizing implications. Soon we could see dinosaur reconstructions in hues that owe more to science than speculation.

A. A Cretaceous fossil feather from Brazil with preservation of color bands (the feather is about half an inch long).

B. On the left is the recently described fossil feather that preserves evidence of iridescence. The distal parts of the feather, which appear almost white, would have been iridescent blue, green or coppery (the feather is about an inch long). To the right is a scanning electron micrograph showing the layer of sausage-shaped melanosomes that would have made the feather iridescent (the melanosomes are about one micrometer in length).

C. Jakob Vinther (at the microscope) and Derek Briggs taking samples of a feathered dinosaur fossil in China last summer.

Peabody Museum Reaches GBIF Milestone

By Larry Gall, Systems Office

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The Yale Peabody Museum of Natural History (YPM) has been engaged for more than a decade in a concerted mission to electronically catalogue all its specimens and artifacts and to make that information available as broadly as possible to researchers and other audiences. This is a continually evolving saga, given that YPM's current holdings are estimated at around 12 million items, with new materials regularly acquired through field work, donations, and other means.

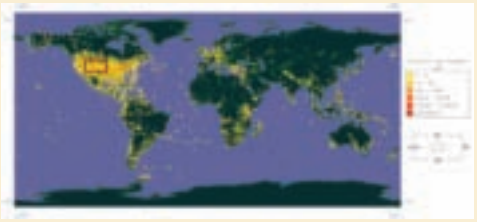
During the last several years, museum specimens like these have helped catalyze a rapid expansion in biodiversity studies. Advances in internet infrastructure now allow biodiversity data to be accessed and mined from anywhere. At the same time, the Global Biodiversity Information Facility (GBIF), an international organization based in Copenhagen, Denmark, has emerged as a primary clearinghouse for biodiversity data, offering free and open access to this data online.

Through its web portal, GBIF aggregates and serves nearly 200 million biodiversity data records worldwide from more than 300 data providers, or "nodes," which typically are museums and similar institutions (*http://data.gbif.org/welcome.htm*). In early summer 2009, YPM reached a new milestone by climbing to 19th overall globally in the GBIF rankings, with over 1.5 million records registered and available over the internet. At that time only the nodes for the Missouri Botanical Garden and the Smithsonian Institution among organizations in the United States were serving more records.

The GBIF portal offers intuitive "one-stop browsing" of biodiversity data using species names, geography and related attributes, with search results summarized and displayed on a global map and available in downloadable formats. Users can often drill down farther into GBIF nodes, since most nodes are composed of more than one networked dataset. For example, YPM's node (*http://data.gbif.org/datasets/provider/207*) consists of 14 datasets that closely mirror the curatorial divisions that steward YPM's collections. These divisions in turn mirror their underlying disciplines (such as vertebrate zoology and entomology).

Many of the data providers registered with GBIF serve their data simultaneously to discipline-specific portals, and some were active before the ascendance of GBIF. Among these earlier portals were those for birds (ORNIS, at *http://olla.berkeley.net/ornisnet/*), mammals (MaNIS, at *http://manisnet.org*), reptiles and amphibians (HerpNet, at *http://www.herpnet.net*), and fish (FishNet, at *http://www.fishnet2.net*). This vertebrate flush was soon followed by others, such as the Paleontology Portal (*http://www.paleoportal.org*), which aggregated fossil data for invertebrate paleontology, vertebrate paleontology and paleobotany, and which also introduced a substantial online outreach component for science educators, K-12 students and the public.

GBIF and similar portal services are able to cross-walk biodiversity information successfully by using community standards that govern both the description of biological data and methods for distributing it easily. Most GBIF nodes use the Darwin Core (*http://wiki.tdwg.org/twiki/bin/view/DarwinCore/WebHome*) data standard for the exchange of information about collections and the geographic distribution of species, paired with a Distributed Generic Information Retrieval (DiGIR) provider (*http://digir.sourceforge.net*) to handle the actual data dissemination. The Darwin Core has several published variants in use, but each is fundamentally a one-dimensional ("flat file") model. While such a straightforward model presents a helpful low barrier to establishing provider nodes, it also constrains the expression of more complex relationships inherent in biological data (like part-whole concepts), and is not particularly well suited to the evolving semantic web (such as the markup and tagging of specimen records). To address this, a multi-dimensional Darwin Core model that harmonizes the existing variants has been developed and is in the late stages of ratification as a new data standard. YPM is already reworking its GBIF node in eager anticipation of this event!



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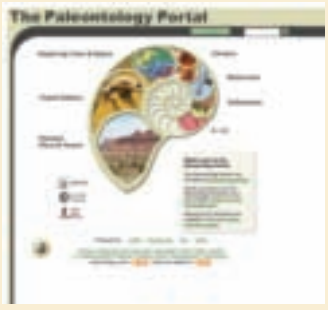

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A. GBIF home page.

B. Geographic distribution of Yale Peabody Museum invertebrate specimen records with latitude and longitude coordinates, from the GBIF portal.

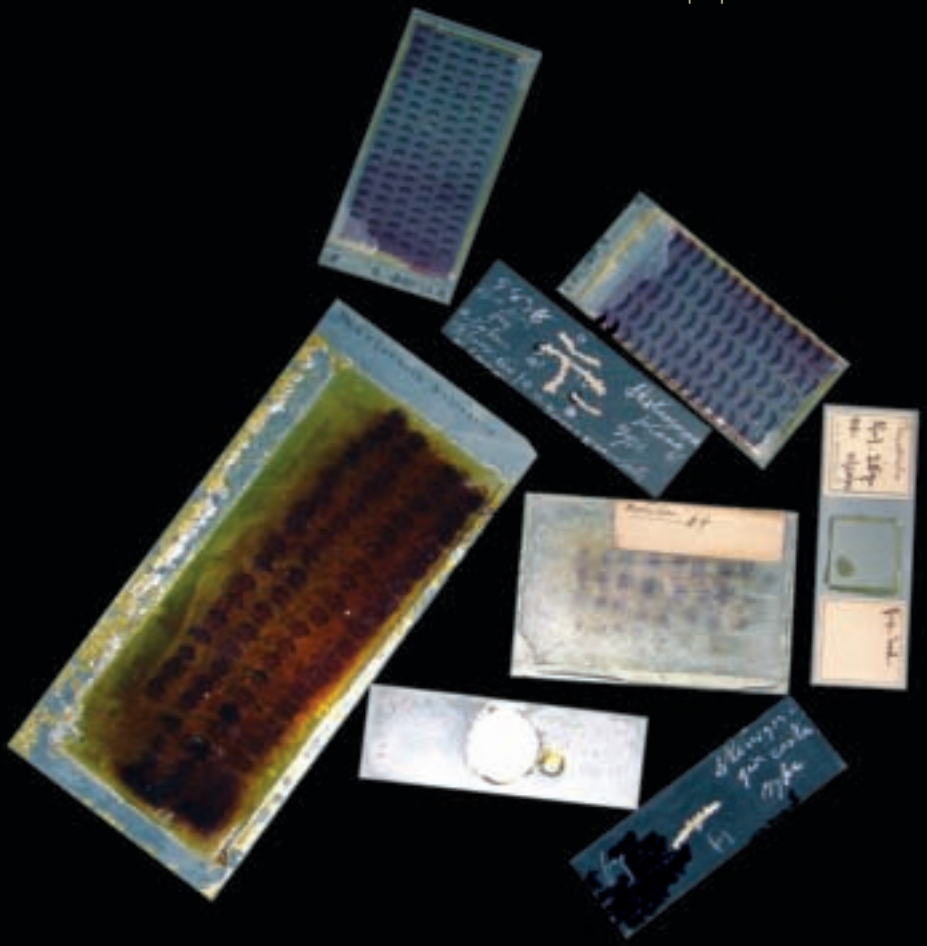
C. The Paleontology Portal, a web service that aggregates information about North American paleontological collections.

Peabody Museum Project Conserves Collections Microscope Slides

By Catherine Sease, Senior Conservator

Since September 2007, staff at the Yale Peabody Museum of Natural History (YPM) have been working on a project funded by the Institute for Museum and Library Services to conserve, catalogue and rehouse microscope slides that are part of the collections in YPM's divisions of Vertebrate Zoology and Invertebrate Zoology. Under the overall supervision of Senior Conservator and Principal Investigator Catherine Sease, joined by Invertebrate Zoology Senior Collections Manager Eric Lazo-Wasem and Vertebrate Zoology Museum Assistant Greg Watkins-Colwell, the project has used a cadre of Yale undergraduate and graduate students and casual workers.

Most of the slides in this project are historically as well as scientifically important: some represent type specimens, while others are up to 150 years old. A portion of the holdings in the Division of Invertebrate Zoology date to the late 19th century, when curator Addison Emery Verrill was responsible for tremendous growth of the collections. Most of the slides in both divisions were created as part of the ongoing research of faculty, graduate students and other researchers. This material therefore has considerable scientific and historical value as vouchers of science conducted at Yale and other institutions. Furthermore, nearly half of the microscope slides represent specimens that have been prepared but studied only provisionally, undoubtedly an important resource for future research.



These slides had been kept in sometimes substandard storage in the Peabody Museum, Kline Geology Laboratory and Class of 1954 Environmental Science Center buildings. Most were physically inaccessible. In addition, roughly half of the slide boxes were cryptically marked and, because no inventory existed, their exact contents were unknown.

First the slides were cleaned in batches in the YPM Conservation Lab by a team of undergraduate and graduate students. During the summers, summer school students and casual workers augmented the work force. Most of the cleaning was quite straightforward, done with damp swabs and cloths. The Verrill slides, however, required more attention because they were dirtier than most of the others and the brittleness of their mounting media required handling with considerable care. Some slides were broken and many had loose cover slips and mounting rings. Paper adhesive labels, in some instances the only accompanying documentation, were also loose. All Verrill slides were cleaned and repaired by Sease.

Once clean, the slides were returned to the divisions where, under the supervision of Lazo-Wasem and Watkins-Colwell, students catalogued and entered each one into YPM's collections database. The cataloguing and capture of the Verrill collection slide information is being done by Lazo-Wasem. Many of the Verrill slides contain specimen fragments, such as small branches of soft coral colonies, mounted on cardboard slides. These will be digitally photographed to minimize future handling of the delicate slides.

The final step is to rehouse the slides in museum quality cabinets. In advance of this project Sease and other YPM staff spent considerable time working with Delta Designs, Ltd., the premier museum cabinetmaker in the United States, to design special archival storage cabinets and trays made of inert materials specifically for microscope slides. As a result of this YPM project, Delta Designs now manufactures a line of microscope cabinets available to other institutions.

The cleaning, cataloguing and rehousing of the Division of Vertebrate Zoology microscope slide collection—a total of 7,356 slides—was

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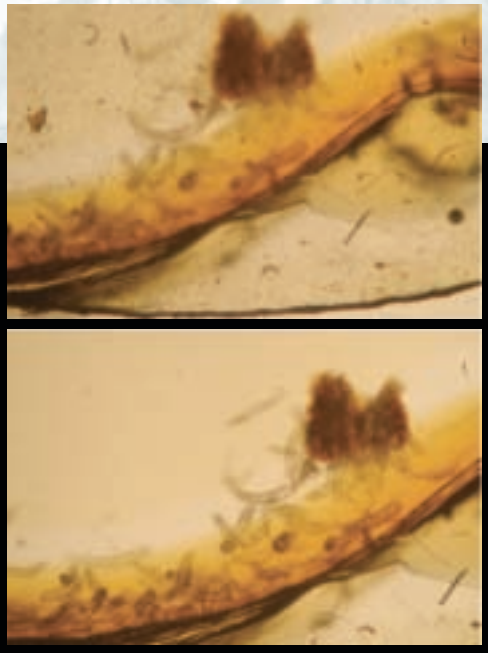

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completed in the fall of 2008. The cleaning and repair phase for the Division of Invertebrate Zoology slides was finished at the end of July 2009, and involved 51,359 slides, of which 2,660 were Verrill slides. The cataloguing and rehousing of the Invertebrate Zoology miscroscope slides was projected to continue until the end of 2009.

Two other YPM collections benefited from this project. The Division of Paleobotany received three cabinets, and the Division of Mineralogy two cabinets, to rehouse their own collections of microscope slides. Stored under better conditions, these slides did not require cleaning and were just rehoused and added to the collections database. Microscope slides in the Division of Invertebrate Paleontology will be the focus of a future project.

This project resulted in several discoveries. In the Division of Vertebrate Zoology, we have made connections between the microscope slides and existing specimens in the collections, especially for the *Latimeria* (coelacanth) slides and for the slides of blenniid pectoral fins. This is a major accomplishment, because it attaches considerably more documentation to the specimens on the slides and thereby greatly increases their scientific value. We also discovered that most of the older fish microscope slides were used in a research project on teleost brain morphology by R. G. Meader in the 1930s. These slides can now be referenced to Meader's publications, increasing the value of the slides for students and researchers.

In the Division of Invertebrate Zoology, we discovered we unknowingly had many slides of type specimens. For example, we found type slides of *Paragorgia pacifica,* a species described by Verrill, that we were not aware of, even though there is a specimen in alcohol in our collections. We have also uncovered slides of extremely rare material, including preparations of giant squid mouthparts and of foraminifera collected in the 1870s at nearly 2,925 fathoms (a depth of 18,000 feet, or 5.5 kilometers) by the H.M.S. *Challenger* Expedition. The existence of this material in our collections was unknown before our project. No doubt as we finish cataloguing, more treasures will be uncovered. These discoveries have greatly enhanced the significance of our collections and will be of great interest to researchers.

This project has significantly improved the storage conditions of a major portion of the YPM's microscope slide collections, ensuring their long-term preservation. The most important scientific benefit will be providing access to this material. For the first time these now inventoried slides will be housed together in appropriate storage conditions and be searchable in YPM's collections database, instantly available both to researchers at YPM and on the YPM Web site.

A. Original microscope labels. Photo: Eric Lazo-Wasem

B. Slide, of a gorgonian polyp collected by A. E. Verrill, before *(top)* and after *(bottom)* cleaning. 100x magnification. Photo: Eric Lazo-Wasem

C. Typically some of the slides were stored on end in a variety of boxes. Photo: Catherine Sease

D. Slides are stored flat in the new Delta Designs cabinets. Photo: Catherine Sease

Opposite: The collection includes slides made of glass, cardboard and wood in several different sizes. Photo: Greg Watkins-Colwell

RESEARCH AND PROGRAM HIGHLIGHTS

Amphibians as Environmental Omen Disputed

Amphibians, for years considered a leading indicator of environmental degradation, are not uniquely susceptible to pollution, according to a meta-analysis that has been published in *Ecology Letters*.

After a review of over 28,000 toxicological tests, researchers from the University of South Dakota, Yale University and Washington State University are challenging the prevailing view that amphibians, with their permeable skin and aquatic environment, are particularly sensitive to environmental threats and, as such, are "canaries," or predictors of environmental decline.

"The very simple message is that for most of the classes of chemical compounds we looked at, frogs range from being moderately susceptible to being bullet-proof," said David Skelly, professor of ecology at the Yale School of Forestry & Environmental Studies and a member of the research team. "There are lots of other kinds of environmental threats that have led to their decline, including habitat conversion, harvesting for food and the global spread of the Chytrid fungus, which is mowing down these species in its path."

The team, led by Jacob Kerby, an assistant professor at the University of South Dakota, based its analysis on information gleaned from the US Environmental Protection Agency's (EPA) Aquatic Toxicity Information Retrieval database, examining 1,279 species, among them segmented worms, fish, bivalves such as clams, insects and snails. Those species were exposed in water to various concentrations of 107 chemical agents, including inorganic chemicals, pesticides, heavy metals and phenols, a class of chemical compound.

"What our results suggest is that all animals are susceptible to chemical stressors and that amphibians are potentially good indicators," said Kerby. "There isn't any evidence that they're a uniquely leading indicator. We tried to be comprehensive in the types of chemicals and organisms that we examined."

In light of the findings, Skelly said, scientists should evaluate the absence, presence or abundance of amphibians in wild populations as "signals" of potential exposure to different chemicals in the environment. "If we have such an understanding for several species, we may be able to use their responses, collectively, as a means of narrowing potential causes of environmental degradation," he said.

The EPA, according to the paper, uses African clawed frogs as a proxy for biological diversity when determining a species' sensitivity to chemical exposures, even though that particular species does not occur naturally in North America. "Our knowledge of amphibians' sensitivity to particular chemicals or classes of chemicals has not been used to design assays for effects in nature," Skelly said.

The paper, "An examination of amphibian sensitivity to environmental contaminants: are amphibians poor canaries?," is now available at *http://www3.interscience.wiley.com/cgi-bin/fulltext/122658158/PDFSTART.*

Grant to Aid F&ES Research on Frog Deformities

A Yale ecology professor will investigate why male frogs living in Greater Hartford ponds are exhibiting female sex traits, with a grant from the Hartford Foundation for Public Giving.

The two-year, $30,000 grant from the foundation's Richard P. Garmany Fund will allow David Skelly, professor of ecology at the Yale School of Forestry & Environmental Studies, to continue his research on hermaphrodites, which are proliferating in Connecticut ponds. In a previous study, Skelly found that frogs in suburban areas are more likely than their rural counterparts to grow female eggs in their testes.

"Amphibians living in and around Connecticut neighborhoods show abnormal sexual development at very high frequencies," says Skelly. "Something about these environments is causing these vertebrates to develop an illness that is otherwise uncommon."

The grant will help fund a study of suburban and urban neighborhoods in the Hartford area. The research will include the physical examination of the common green frog, *Rana clamitans*, and water testing for pharmaceuticals and pesticides, including atrazine. Area homeowners will also be surveyed about their use of chemicals.

In preliminary research in Hartford, Skelly found that 21% of male frogs from suburban ponds and 18% from urban ponds had immature eggs growing in their testes, compared to 7% from agricultural ponds. The research was conducted at 23 ponds in 14 towns—Avon, Berlin, Bristol, Cromwell, East Windsor, Ellington, Hebron, Middlefield, Somers, South Windsor, Suffield, West Hartford, Wethersfield and Windsor.

While Skelly has not found a direct link between illness in amphibians and human health, he said, "The fact remains that they are vertebrates like us and share similar physiological and developmental pathways. Such animals can serve as sentinels for human health risks."

The fund supporting Skelly's research was named after the late Richard Garmany, an executive at Aetna. Before his death in July 2008, he created a donor-advised fund at the Hartford Foundation through his will, naming a close friend as the official fund advisor and two other friends to be involved in recommending grants. Hartford Foundation for Public Giving is the community foundation for the 29-town Greater Hartford region, dedicated to improving the quality of life for area residents. The Foundation receives gifts from thousands of generous individuals and families, and last year, awarded grants of more than $27 million to a broad range of area nonprofit organizations.

For more information about the Hartford Foundation, visit *www.hfpg.org* or call 860-548-1888.

Carbon Dioxide and Climate Change

The world's oceans are absorbing less carbon dioxide (CO_2), a Yale geophysicist has found after pooling data taken over the past 50 years. With the oceans currently absorbing over 40% of the CO_2 emitted by human activity, this could quicken the pace of climate change, according to the study, which appeared in the November 25, 2009 issue of *Geophysical Research Letters*.

Jeffrey Park, professor of geology and geophysics and director of the Yale Institute for Biospheric Studies, used data collected from atmospheric observing stations in Hawaii, Alaska and Antarctica to study the relationship between fluctuations in global temperatures and the global abundance of atmospheric CO_2 on interannual (one to 10 years) time scales. A similar study from 20 years ago found a five-month lag between interannual temperature changes and the resulting changes in CO_2 levels. Park has now found that this lag has increased from five to at least 15 months.

"No one had updated the analysis from 20 years ago," Park said. "I expected to find some change in the lag time, but the shift was surprisingly large. This is a big change."

With a longer lag time, atmospheric CO_2 can no longer adjust fully to cyclical temperature fluctuations before the next cycle begins, suggesting that the oceans have lost some of their ability to absorb CO_2 from the atmosphere. Weaker CO_2 absorption could be caused by a change in ocean circulation or just an overall increase in the surface temperature. "Think of the oceans like soda," Park said. "Warm cola holds less fizz," Park said. "The same thing happens as the oceans warm up."

Increases in CO_2 levels have tended to precede increases in temperature over the past century, with the human influence on climate accumulating over many decades of burning fossil fuels and clearing forests. However, this relationship is reversed on interannual time scales, with multiyear temperature cycles leading multiyear cycles in CO_2 levels.

Park found particularly strong correlations between sea-surface temperatures and CO_2 levels in tropical ocean areas. Conversely, in places with a lot of trees and other biomass to soak up much of the atmospheric CO_2, there was little or no correlation between temperature and CO_2 on interannual time scales. In those places, such as the vast forests of North America and Eurasia, a large annual CO_2 cycle synchronizes with the seasonal growth and decay of plants.

"Researchers have used climate models that suggest the oceans have been absorbing less CO_2, but this is the first study to quantify the change directly using observations," Park said. "It strengthens the projection that the oceans will not absorb as much of our future CO_2 emissions, and that the pace of future climate change will quicken."

Carbon Monoxide Linked to Heart Problems in Elderly

Exposure to carbon monoxide, even at levels well below national limits, is associated with an increased risk of hospitalization for the elderly with heart problems, according to a study published August 31, 2009 in *Circulation: Journal of the American Heart Association*.

The nationwide study of 126 urban communities, funded by the US Environmental Protection Agency (EPA) and the National Institute of Environmental Health Sciences, found that an increase in carbon monoxide of one part per million in the maximum daily one-hour exposure is associated with a 0.96% increase in the risk of hospitalization from cardiovascular disease among people over the age of 65.

This link holds true even when carbon monoxide levels are less than one part per million, which is well below the EPA's National Ambient Air Quality Standard of 35 parts per million. This finding suggests an under-recognized health risk to seniors. Currently, the EPA is evaluating the scientific evidence on the link between carbon monoxide and health to determine whether the health-based standard should be modified.

"This evidence indicates that exposure to current carbon monoxide levels may still pose a public health threat," said Michelle Bell, the study's lead investigator and associate professor of environmental health at the Yale School of Forestry & Environmental Studies. "Higher levels of carbon monoxide were associated with higher risk of hospitalizations for cardiovascular heart disease."

Bell and researchers from the Johns Hopkins Bloomberg School of Public Health and the University of Southern California's Keck School of Medicine based their findings on an analysis of hospital records for 9.3 million Medicare recipients and data on air pollution levels and weather gathered between 1999 and 2005. Their analysis took into account the health effects of other traffic-related pollutants, including nitrogen dioxide, fine particles and elemental carbon.

"We found a positive and statistically significant association between same-day carbon monoxide levels and an increased risk of hospitalization for cardiovascular disease in general, as well as for multiple, specific cardiovascular disease outcomes, including ischemic heart disease, heart rhythm disturbances, heart failure and cerebrovascular disease," Bell said.

Carbon monoxide is a tasteless, odorless gas that is a component of automobile exhaust. The researchers acknowledged that additional research is needed to investigate whether carbon monoxide or a combination of it and other traffic-related pollutants are the cause of the increased risk of cardiovascular hospitalizations in seniors.

F&ES Study: Most Polluted Ecosystems Recoverable

Most polluted or damaged ecosystems worldwide can recover within a lifetime if societies commit to their cleanup or restoration, according to an analysis of 240 independent studies by researchers at the Yale School of Forestry & Environmental Studies (F&ES). Their findings appear in the journal *PLoS ONE*.

The Yale researchers found that forest ecosystems recovered in 42 years on average, while ocean bottoms recovered in less than 10 years. When examined by disturbance type, ecosystems undergoing multiple, interacting disturbances recovered in 56 years, and those affected by either invasive species, mining, oil spills or trawling recovered in as little as five years. Most ecosystems took longer to recover from human-induced disturbances than from natural events, such as hurricanes.

"The damages to these ecosystems are pretty serious," said Oswald Schmitz, Oastler Professor of Population and Community Ecology and co-author of the meta-analysis with F&ES doctoral student Holly Jones. "But the message is that if societies choose to become sustainable, ecosystems will recover. It isn't hopeless."

The Yale analysis focuses on seven ecosystem types, including marine, forest, terrestrial, freshwater and brackish, and addresses recovery from major anthropogenic disturbances—agriculture, deforestation, eutrophication, invasive species, logging, mining, oil spills, overfishing, power plants and trawling—and from the interactions of those disturbances. Major natural disturbances, including hurricanes and cyclones, are also accounted for in the analysis.

Schmitz and Jones analyzed data derived from peer-reviewed studies conducted over the past century that examined the recovery of large ecosystems following the cessation of a disturbance. The studies measured 94 variables that were grouped into three categories: ecosystem function, animal community and plant community.

The F&ES researchers quantified the recovery of each of the variables in terms of the time it took for them to return to their pre-disturbance state as determined by the expert judgment of each study's author. The Yale analysis found that 83 studies demonstrated recovery for all variables; 90 reported a mixture of recovered and non-recovered variables; and 67 reported no recovery for any variable. Schmitz said 15% of all the ecosystems in the analysis are beyond recovery. Also, 54% of the studies that reported no recovery likely did not run long enough to draw definitive conclusions.

In addition, the analysis suggests that an ecosystem's recovery may be independent of its degraded condition. Aquatic systems, noted Schmitz and Jones, may recover more quickly because species and organisms that inhabit them turn over more rapidly than, for example, forests whose habitats take longer to regenerate after logging or clear-cutting.

The researchers point out that a potential "pitfall" of the analysis is that the ecosystems may have already been in a disturbed state when they were originally examined. Many ecosystems across the globe that have experienced extinctions and other fundamental changes as a result of human activities, combined with the ongoing effects of climate change and pollution, are far removed from their historical, natural pristine state. Thus ecologists measured recovery on the basis of an ecosystem's more recent condition. The analysis points out the need for the development of objective criteria to decide when a system has fully recovered.

The researchers said the analysis rebuts speculation that it will take centuries or millennia for degraded ecosystems to recover and justifies an increased effort to restore degraded areas for the benefit of future generations. "Restoration could become a more important tool in the management portfolio of conservation organizations that are entrusted to protect habitats on landscapes," said Schmitz.

Jones added: "We recognize that humankind has and will continue to actively domesticate nature to meet its own needs. The message of our paper is that recovery is possible and can be rapid for many ecosystems, giving much hope for a transition to sustainable management of global ecosystems."

The analysis, "Rapid Recovery of Damaged Ecosystems," is available online at *http://dx.plos.org/10.1371/journal.pone.0005653*.

Earth Systems Center for Stable Isotopic Studies Welcomes New Staff

In March 2009, Dominic Colosi joined the staff in the Earth Systems Center for Stable Isotopic Studies. He received his BS in Chemistry from the University of Florida in 2008, where he worked in Rick Yost's laboratory doing undergraduate research in mass spectrometry.

Colosi will be helping to maintain the Center's mass spectrometers, including its two new stable-isotope mass spectrometers, as well as associated peripherals. He will also be working with Center users, doing standards and method development, and work on specific projects as needed. With Colosi on staff, the Center will be able to take on more projects and develop new techniques in the area of light stable-isotope analyis.

BASS SCHOLARS

FOX

FUNG

DAVID L. FOX

Yale Institute for Biospheric Studies (YIBS) Director Jeffrey Park is pleased to announce the appointment of David L. Fox, Professor in the Department of Geology & Geophysics at the University of Minnesota, as an Edward P. Bass Distinguished Visiting Environmental Scholar. Professor Fox will serve in the Department of Anthropology during the Winter/Spring 2010 semester, working with Professor Eric Sargis.

Professor Fox received his AB in Biological Anthropology from Harvard University with an emphasis in hominid paleontology. He then moved to the Midwest for graduate studies in vertebrate paleontology in the Department of Geological Sciences and Museum of Paleontology at the University of Michigan. Under the guidance of Dan Fisher and Catherine Badgley, he developed a range of research interests in graduate school that includes the evolution and ecology of elephants from the point of view of their tusks, applications of stable isotopes in paleoecology, ecological changes and extinctions among late Cenozoic mammals in North America, the ecological structure of the modern mammal fauna of North America, and stratocladistics.

Professor Fox completed his PhD in 1999 and did postdoctoral work with Paul Koch at the Department of Earth Sciences at the University of California, Santa Cruz, and in 2001 became an associate professor in the Department of Geology and Geophysics at the University of Minnesota in Minneapolis where his first focus is investigating the chemical isotopes in ancient animal teeth and bones, namely carbon, nitrogen, and oxygen. These isotopes record paleoclimate signals that tell what the environment was like 40 million years ago. By tracking those signals through time, patterns emerge in the ecosystem of herbivore animals due to a changing climate.

His second focus explores how species evolved by creating computer simulated evolutionary histories. The anatomical "gaps" that exist in the evolution of different species can be filled with stratigraphic data. In other words, geologic time-keeping is applied. On-going simulation studies help visualize the evolutionary tree of life.

And, his third focus is research on the ecological biogeography of animals. The body size and dietary categories of modern mammals show striking correlations with climatic variables. Continuing work will include comparisons between continents with quite different faunal and climatic histories over the last several million years.

INEZ FUNG

Yale Institute for Biospheric Studies (YIBS) Director Jeffrey Park is pleased to announce the appointment of Professor Inez Fung as an Edward P. Bass Distinguished Visiting Environmental Scholar during the 2009/10 academic year. Fung, a professor of atmospheric science and co-director of the Berkeley Institute of the Environment, was born in Hong Kong, where she completed her high school education. She received her SB in Applied Mathematics (fluid dynamics) at the Massachusetts Institute of Technology (MIT). She notes that the fact that the equations could explain the movement of continents and the fact that there were toys (the first Lorenz water wheel) associated with fluid dynamics brought her to the graduate program in meteorology at MIT. Since then she has enjoyed her research on the physics of climate change, ecosystem dynamics, and biogeochemical cycles. Building on that work, she and her colleagues are using global carbon-climate models to project future co-evolution of climate and atmospheric carbon dioxide.

Professor Fung is internationally known and well respected in her field, and is one of 10 women scientists featured in the series Women Adventures in Science written for middle school students. Her biography is *Forecast Earth* by Renee Skelton.

She served during the fall 2009 in the Yale Department of Geology & Geophysics, presenting two talks as part of the Topics in Global Change Fall Seminars: *What Don't We Know About Global Warming?* and *Can the Carbon Budget Be Managed?* She will return to Yale in the spring of 2010 to continue her appointment as a Bass Scholar in the Department of Geology & Geophysics.

Professor Fung notes that the climate of the earth is intimately tied to the composition of the atmosphere and the dynamics of the underlying surface. The atmosphere and land surface exchange energy, water and other trace substances on all space and time scales. The exchange is dependent on, and in turn determines, the states of the atmosphere and biosphere themselves. Her research in the past decade has focused on the processes that maintain and alter climate, as well as on the biogeochemical cycling of carbon dioxide, methane and dust. The goal is to gain predictive capability of how atmospheric composition and climate have evolved in the past and may co-evolve in the future. The present and past variations in atmospheric composition contain information about how sensitive the atmosphere and biosphere are, separately and together, to natural climate fluctuations. This sets the stage for detecting and evaluating the extent to which the systems have been and will be altered by human action.

DONNELLEY FELLOWS

DONALD WORSTER COMES TO YALE

Donald Worster, historian and Professor of History at the University of Kansas, will serve as the Dr. Strachan Donnelley Distinguished Visiting Environmental Scholar during the Winter/Spring 2010 semester. Professor Worster is considered one of the founders of, and leading figures in, the field of environmental history. In 2009 he was named to the American Academy of Arts and Sciences.

Professor Worster has been at the University of Kansas since 1989 and occupies the Hall Chair in American History, thus returning to his undergraduate institution and his home region. His most recent book, *A River Running West: The Life of John Wesley Powell*, was published by Oxford in 2001. Earlier books include *The Wealth of Nature, Under Western Skies, Rivers of Empire, Dust Bowl,* and *Nature's Economy* (now available in

five languages). He is former president of the American Society for Environmental History and a member of the Western History Association, the Organization of American Historians, and the American Historical Association. Over the past two decades he has lectured extensively in Europe, Africa, Asia, and Latin America, as well as throughout North America.

Professor Worster is primarily interested in the emerging field of environmental history; the changing perception of nature, the rise of conservation and environmentalism, but especially the ways that the natural world has impinged on human society and provided the context for human life over time. He also has strong interests in comparative history (especially of the United States and Canada), in American regionalism (particularly the West), in agriculture, and in science and technology.

He has said, "Whatever terrain the environmental historian chooses to investigate, he has to address the age-old predicament of how humankind can feed itself without degrading the primal source of life. Today as ever, that problem is the fundamental challenge in human ecology, and meeting it will require knowing the earth well—knowing its history and knowing its limits."

Dr. Worster will occupy an office in the School of Forestry & Environmental Studies, and will be available for the entire semester to faculty and students who wish to explore this and other environmental challenges that we face today.

POSTDOCTORAL ASSOCIATES

YIBS ANNOUNCES APPOINTMENTS OF SEVEN POSTDOCTORAL ASSOCIATES

YIBS Director Jeffrey Park is pleased to announce the two-year appointments of three Gaylord Donnelley Environmental Postdoctoral Associates and four Yale Institute for Biospheric Studies (YIBS) Postdoctoral Associates in 2009.

The three Gaylord Donnelley Environmental Postdoctoral Associates are:

Dr. Andrea Gloria-Soria is working in the Yale Peabody Museum of Natural History and the Department of Ecology & Evolutionary Biology with Professor Leo W. Buss. Andrea's research focuses on the characterization of the allelic variation on the allorecognition complex of *Hydractinia symbiolongicarpus.*

Dr. Nicholas Longrich is working with Professor Jacques Gauthier in the Department of Geology & Geophysics. Nicholas's research focuses on dinosaur diversity trends in the late Cretaceous of western North America and understanding the influence of global climate change and sea levels.

Dr. Matthew Walsh is working with Associate Professor David Post in the Department of Ecology & Evolutionary Biology. Matt's research focuses on the link between environmental heterogeneity and evolutionary change in coastal lake ecosystems.

The four YIBS Environmental Postdoctoral Associates are:

Dr. Christopher Clark is working with Richard Prum, William Coe Robinson Professor of Ecology & Evolutionary Biology. Chris's research focuses on the mechanics and diversity of feather-generated sounds in birds.

Dr. Li-Quing Jiang is working with Associate Professor Peter Raymond at the School of Forestry & Environmental Studies. Li-Quing's research focuses on the impact of seasonal hypoxia on carbon dioxide in large estuarine systems—a case study of the Long Island Sound.

Dr. Philip Larese-Casanova is working with Professor Ruth Blake in the Department of Geology & Geophysics. Philip's research is focused on improving bioremediation of groundwater contamination using 18o stable isotope signatures.

Dr. Henry Wilson is working with James Saiers, Professor of Hydrology and Associate Dean of Academic Affairs at the School of Forestry & Environmental Studies, and Professor of Chemical Engineering. Henry's research focuses on determining the role played by hydrological events in mediating dissolved organic matter (DOM) dynamics and related in-stream processes.

Yale Environment 360 Honored in International Online Journalism Awards

The Online News Association has honored Yale Environment 360 with its best "specialty site journalism" award at its annual Online Journalism Awards ceremony, citing content that is "taking debate to a higher level and is so needed in the journalism community now." In recognizing Yale Environment 360 *http://e360.yale.edu/* as the best small website in a specialized category, the judges praised its mix of reporting, commentary and discussion, as well as the quality of its writing, the attractiveness of its design and the level of debate on its interactive reader forum.

"Such a well-done site," the judges wrote. "When you read the comments, you know the incredibly knowledgeable audience is totally engaged with the site. It's a nice place to be and learn."

Other news organizations honored by Online News Association for online excellence included *The New York Times*, BBC News, ProPublica and NPR.org. The winners were announced in October at an awards ceremony in San Francisco.

Published by the Yale School of Forestry & Environmental Studies, Yale Environment 360 was launched in 2008 as an online source for in-depth environmental journalism, commentary and debate from a global perspective. Major funding is provided by grants from the William and Flora Hewlett Foundation and the John D. and Catherine T. MacArthur Foundation.

Earlier this year, TreeHugger named Yale Environment 360 as the Best New Science Site.

The Online Journalism Awards were launched in 2000 by the Online News Association, which works in collaboration with the University of Miami's School of Communications. A link to the announcement can be found at *http://journalists.org/news/31016/Publish2-My-Ballard-and-Gotham-Gazette-recognized-with-inaugural-Online-Journalism-Awards.htm*.

Green Intelligence: Creating Environments that Protect Human Health

by John Wargo

We live in a world awash in manmade chemicals, from the pesticides on our front lawns to the diesel exhaust in the air we breathe.

Although experts are beginning to understand the potential dangers of these substances, there are still more than 80,000 synthetic compounds that have not been sufficiently tested to interpret their effects on human health. John Wargo has spent much of his career researching the impact of chemical exposures on women and children. In his new book from Yale University Press, Professor Wargo explains the origins of society's profound misunderstanding of everyday chemical hazards, and offers a practical path toward developing greater "green intelligence."

Despite the rising trend in environmental awareness, information about synthetic substances is often unavailable, distorted, kept secret, or presented in a way that prevents citizens from acting to reduce threats to their health and the environment. By examining the histories of five hazardous technologies and practices, Wargo finds remarkable patterns in the delayed discovery of dangers and explains governments' failures to manage them effectively. Sobering, yet eminently readable, Wargo's book ultimately offers a clear vision for a safer future through prevention, transparency, and awareness.

John Wargo, professor of environmental policy, risk analysis, and political science at the Yale School of Forestry & Environmental Studies and the Department of Political Science at Yale University, has also authored *Our Children's Toxic Legacy: How Science and Law Fail to Protect Us from Pesticides.*

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We welcome submissions from faculty, staff and students.

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