

The Yale Institute
for
Biospheric Studies

Progress Report
1991 – 2003

**THE YALE INSTITUTE FOR BIOSPHERIC STUDIES
PROGRESS REPORT
1991 – 2003**

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The Yale Institute for Biospheric Studies
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INTRODUCTION AND OVERVIEW:

The Yale Institute for Biospheric Studies (YIBS) was founded in 1991 with an extraordinary gift from Edward P. Bass, '72 Art A, with a purpose of building on the strong foundation of University resources to advance the understanding of the biosphere and develop relevant approaches to environmental issues of national and global importance.

Biology Professor Leo W. Buss served as the first Director of YIBS from 1991-1996. Geology & Geophysics Professor Elisabeth Vrba was appointed YIBS' Director in 1996. Sterling Professor of Geology & Geophysics Karl Turekian became the Director of YIBS in January 1999, and ends his term on December 31, 2003, with Geology & Geophysics Professor Derek Briggs assuming the YIBS Directorship on January 1, 2004.

The Institute was established to bring together a community of scholars and utilize the strengths of the University in the basic sciences which inform environmental issues; to draw on the knowledge embodied in the Faculty of Arts and Sciences and in the graduate and professional schools of the University, particularly the School of Forestry & Environmental Studies; and to encourage the reintegration of the natural history collections of the Peabody Museum of Natural History into faculty and student research, thus drawing on the past to inform the present and enlighten the future.

In the past twelve years, the Institute has succeeded in cultivating a standard for university-based environmental research and education. It has established itself as a catalyst for interdisciplinary collaboration through its research centers and most recently through its weekly seminar series held in the Class of 1954 Environmental Science Center, the hub of this interdisciplinary activity.

In addition to specific advances in research and education, a principal achievement has been in fostering a shared vision among multiple academic units. As a result, Yale's considerable intellectual resources continue to be most effectively brought to bear in solving environmental problems.

Among its notable achievements, the Institute has:

- Worked with the University to make the Class of 1954 Environmental Science Center a reality. The Environmental Science Center is a unique space conducive to interdisciplinary interaction. It houses faculty from Anthropology, the Department of Ecology & Evolutionary Biology, the School of Forestry & Environmental Studies, the Department of Geology & Geophysics, as well as the YIBS ECOSAVE Conservation Genetics Laboratory, two teaching laboratories, collections from the Peabody Museum of Natural History, and state-of-the-art teaching facilities.

- Recruited and encourages the active involvement of an External Advisory Board of notable prominence. The Board meets twice a year and its members play an active role in addressing issues that reach beyond the Institute and encompass the broader concerns that are shared by the Institute, the School of Forestry & Environmental Studies, and the Peabody Museum of Natural History.
- Catalyzed an institutional examination of the structure of biological sciences at Yale, giving new institutional emphasis and prominence to fields crucial to the environmental sciences – ecology, evolution, and organismal biology.
- Secured a permanent faculty base and program financing for the Environmental Studies Program (formerly the Studies in the Environment Program), one of the oldest undergraduate programs of its kind among US universities offering an environmental studies major. The program has evolved from a double-major undergraduate offering, and is now offered as a single major to undergraduates.
- Called for proposals from faculty to create interdisciplinary research centers and has established and offers support to them.
- Established separate endowments to ensure continued funding in specific areas that allows YIBS continued presence to act as a catalyst for various initiatives in promoting interdisciplinary environmental research and education at Yale. Endowments that were established are: The Directorship of the Peabody Museum of Natural History (PM) Endowment (\$2 million); Faculty Support Fund (\$7 million)¹; YIBS Program Support Fund (\$4 million); Graduate Fellowship Fund (\$2 million); Edward P. Bass Distinguished Visiting Scholars Program (\$2 million)
- Administered income from endowments set up to support the Environmental Studies Program (formerly Studies in the Environment): Gaylord Donnelley Studies in the Environment Endowment (\$500K); Montgomery Family Fund (\$82K); William Bingham Studies in the Environment Fund (\$250K)²
- Administered income from the Gaylord Donnelley Environmental Fellowship Endowment (\$2,478,601) and oversees the selection process for the Gaylord Donnelley Post-Doctoral Environmental Fellowships.
- Organized a weekly seminar series in the Class of 1954 Environmental Science Center (ESC) classroom featuring talks by faculty and researchers from the various departments who occupy space in the ESC, Gaylord Donnelley Fellows, YIBS Research Center Directors and others who are involved in environmental research and teaching at Yale.

¹ YIBS has assigned the income from the \$4 million representing the Edward P. Bass and G. Evelyn Hutchinson Chairs Endowments, to the new Department of Ecology & Evolutionary Biology for a period of about 5 years.

² The funds are administered through the Yale College Dean's Office as agreed by a letter of understanding with YIBS.

STUDENT PROGRAMS:

UNDERGRADUATE PROGRAMS

The Yale Institute for Biospheric Studies provided support for two undergraduate degree-granting programs: Studies in the Environment (now the Environmental Studies Program) and the Program in Organismal Biology.

The Studies in the Environment Program (SE) was established in 1984 as a second major and was designed to engage Yale College students in the interdisciplinary study of environmental issues and to encourage students to integrate a broad range of economic, political, ethical, and scientific approaches to environmental problem solving. When the Institute was established, it was only natural that the SE program would be administered by YIBS and thus enabling students, faculty, and program administrators to become a more integral part of the University's broader efforts to enhance the environmental sciences. YIBS also provided the program with the stability needed to attract internal and external support, both financial and conceptual, and to benefit from a targeted development. Working through YIBS and its development team, the program attracted a total of \$750,000 in endowment from the William Bingham Foundation, the Gaylord and Dorothy Donnelley Foundation, and friends of the University including an External Advisory Board member, to offer the program growth and stability.

The Environmental Studies Program was established in the spring of 2001. With the growing interest among faculty and students at Yale to offer a single major addressing specific environmental issues on an interdisciplinary scale, the SE double major program was transformed into a stand alone major, and the Environmental Studies Program (EVST) was established. EVST will graduate its first round of students in 2004.

The Program in Organismal Biology (OB) was created in 1991 to serve as a vehicle for students pursuing careers in environmental sciences, particularly in the evolutionary and ecological sciences, enabling them to earn a second major in conjunction with a degree in Anthropology, Biology, Geology & Geophysics, or Molecular Biophysics and Biochemistry. The focus of this major was to prepare students as natural scientists who could work in such fields as conservation biology. Organismal Biology was eliminated as a double major offering in Yale College in the fall of 1998, it was incorporated into the Department of Ecology & Evolutionary Biology.

UNDERGRADUATE SUMMER INTERNSHIP PROGRAM

In 1992 Hitachi America and one of the Institute's External Advisory Board members established the Hitachi Summer Internship Program, offering small grants from \$500 to \$2,000 to students wishing to augment their studies with research projects that would not be feasible within an academic year. In 1999, Hitachi America no longer offered funding for this effort and so in the summer of 1999, income from the various endowments that supported the SE program, along with a supplemental contribution from the Department of Ecology & Evolutionary Biology, were combined and the Environmental Studies Undergraduate Environmental Summer Internship Program was established and continues to be funded in this way. A grant from the Henry David Thoreau Foundation supplied funding for summer internships in 2001.

YALE INSTITUTE FOR BIOSPHERIC STUDIES GRADUATE STUDENT SUPPORT

Income from the Graduate Student Support Endowment Fund gives yearly support for Graduate students designated as Yale Institute for Biospheric Studies Graduate Students, in the following areas:

The Department of Ecology & Evolutionary Biology
(formerly the Department of Biology)

Environmental Engineering (beginning in 1998)

School of Forestry & Environmental Studies

Department of Geology & Geophysics

GAYLORD DONNELLEY ENVIRONMENTAL POST DOCTORAL FELLOWSHIPS

The following is a list of past and present Donnelley Environmental Post Doctoral Fellows

YEAR	NAME	SPONSOR/S
1997 – 1999	Dr. Joseph Kiesecker Assistant Professor of Biology Pennsylvania State University Eberly College of Science	Professor David Skelly, School of Forestry & Environmental Studies
1999 – 2001	Dr. Ofer Ovadia Post Doctoral Associate Yale School of Forestry & Environmental Studies	Professor Oswald Schmitz School of Forestry & Environmental Studies
1999 – 2001	Dr. Douglas Gollin Assistant Professor of Economics Williams College Center for Environmental Studies Maintains affiliation with Yale Economic Growth Center	Professor Robert Evenson Economic Growth Center
2000 –2002	Dr. Claudio Ciofi Post-Doctoral Fellow Department of Ecology & Evolutionary Biology Yale University	Dr. Gisella Caccone ECOSAVE Conservation Genetics Laboratory Professor Jeffrey Powell Ecology & Evolutionary Biology
2000 –2002	Dr. Campbell Webb Associate Research Scientist Department of Ecology & Evolutionary Biology Yale University	Professor Mark Ashton School of Forestry & Environmental Studies Professor Michael Donoghue Ecology & Evolutionary Biology
2001 – 2003	Dr. Luciano Beheregaray	Dr. Gisella Caccone ECOSAVE Conservation Genetics Laboratory
2001 – 2003	Dr. Jeremy Redman	Professor Menachem Elimelech Environmental Engineering
2002-2004	Dr. Jenney Hall	Professor Karl K. Turekian Geology & Geophysics
2003-2004	Dr. Klaus Meiners	Professor John Wettlaufer Geology & Geophysics
2002-2004	Dr. Susanna Remold	Professor Paul Turner Ecology & Evolutionary Biology
2003-2005	Dr. Stephen Meyers	Professor Mark Pagani Geology & Geophysics
2003-2005	Dr. Amy Russell	Professor Anne Yoder Ecology & Evolutionary Biology
2003-2005	Dr. Benjamin Twining	Professor Gaboury Benoit School of Forestry & Environmental Studies Chemical Engineering

YIBS POST DOCTORAL FELLOWS (SHARED FUNDING)

2002-2004	Dr. Linda Puth	Professor David Skelly, School of Forestry & Environmental Studies
2003-2004	Dr. Neung Oh	Professor Peter Raymond School of Forestry & Environmental Studies

YIBS AFFILIATES

CENTER FOR BIODIVERSITY, CONSERVATION AND SCIENCE

Director, Oswald Schmitz

Professor & Director of Doctoral Studies at the School of Forestry & Environmental Studies and Professor of Ecology & Evolutionary Biology

GENOCIDE STUDIES PROGRAM

Director, Benedict Kiernan

A. Whitney Griswold Professor of History

Requested and granted support in 1998/1999

Requested and granted additional support in 2002

CENTER FOR SOLAR AND SPACE SCIENCE

Director, Sabatino Sofia

Professor of Astronomy

Support for Post Doctoral Student, Dr. Linghuai Li

Center for Solar & Space Science

Four-month support – 2002

Underwriting support in anticipation of grant

Special Topics in Astrobiology Seminar Series

Fall 2000

(co-sponsored by the YIBS Center for the Study of Global Change)

SPONSORED ACTIVITIES

Yale Environmental News (YEN)

Ongoing support for Newsletter

Yale Student Environmental Coalition (YSEC)

Since 1993, YIBS has given support each spring to fund various YSEC initiatives, including:

- Yale Green Plan
- Yearly Earth Day Activities
- Yearly Speakers Series
- Fees to attend conferences

YIBS/ESC Friday Seminar Series

2002/2003 – Fall Semester/Spring Semester

2003/2004 – Fall Semester/Spring Semester

Special Requests for Support:

Support for Martin Hanczyc to complete PhD work with Professor Robert Dorit,
Department of Ecology & Evolutionary Biology
Fall 1998 through March 1999

Support for Dr. Joseph Ryan, visiting faculty in Environmental Engineering from
the University of Colorado
Spring Semester 2001

Support for EEB Graduate Student Erika Edwards
Tuition and Travel Expenses to participate in the Organization for Tropical
Studies Summer Field Camp
Summer 2002

Support for Dr. James Greenwood
Department of Geology & Geophysics
Two months support – Fall 2002
Underwriting support in anticipation of grant

YIBS Sponsored Seminars/Symposiums/Speakers

Sponsor of the 1993 *Yale In the Environment Conference*, February 1993. This two-day conference brought Yale faculty together with environmental leaders to discuss current environmental issues and explore Yale's role in addressing them. A total of 96 faculty, students, External Advisory Board members, and invited guests attended the two-day sessions.

Ecorealism: Toward the Next Generation of Environmental Policy, was sponsored by the Yale Student Environmental Coalition (YSEC) and the Yale Center for Environmental Law and Policy with support from YIBS.

The UN Conference on demographic policy, held in Cairo in September 1994, is typically followed by local conferences aimed at national implementation. One such follow-up conference was held at Yale under the joint sponsorship of the Institute and a variety of other Yale and non-Yale groups.

Population Seminar Series – Fall, 1997

Global Change: The Broad View Symposium
70th Birthday Celebration for Professor Karl K. Turekian
October 24 and October 25, 1997

Society for Conservation Biology Distinguished Guest Lecture Series
Fall Semester – 1997
Spring Semester - 1998

World Population and Environmental Issues Course Lecturers
Spring, 1998

F&ES Climate Change Conference
April 2 and April 3, 1998

Global Change Policy Project
December 1998

Ecology of Invasive Species Symposium
F&ES
February 27, 1999

Society for Conservation Biology Seminars
Spring 1999

Society for Conservation Biology Seminar Series
Fall 1999 through Spring 2000

Society for Molecular Biology & Evolution Conference
June 17 and June 18, 2000

G. Evelyn Hutchinson Day of Commemoration Symposium
October 25, 2003

RESEARCH CENTERS:

Through a competitive proposal process, the Yale Institute for Biospheric Studies Faculty Council established seven synergistic research and teaching Centers focused on three major areas of concern: global change; the evolution and diversity of life; and the engagement of people with their planet and its other forms of life. The first two areas encompass important environmental issues, including changes in the earth's climates, atmosphere, terrestrial ecosystems, and oceans, and the rapid reduction of terrestrial and marine biodiversity at all latitudes. The third area focus is on the ways in which people contribute to and attempt to manage the broad changes underway in their environment. Three of the original YIBS Centers, The Center for Earth Observation; the ECOSAVE Center, and the Center for the Study of Global Change, are still in operation today, with three new Centers formed in 2001 – The Center for Field Ecology; the Center for Microbial Diversity; and the Center for Stable Isotopic Studies of the Environment.

ACTIVE RESEARCH CENTERS:

YIBS CENTER FOR EARTH OBSERVATION (1992–Present)

Ronald Smith, Director

The Yale Center for Earth Observation (CEO) was created in 1992 to consolidate and promote the use of satellite remote sensing throughout the Yale Campus. It is one of the original centers of the Yale Institute for Biospheric Studies (YIBS). Four academic units provide academic guidance and direction to CEO; the Departments of Geology & Geophysics, Anthropology, and Epidemiology and Public Health, and the School of Forestry and Environmental Studies. Each unit engages in research projects for which satellite remote sensing and geographic information systems are essential.

In 1997 the Center was designated a NASA Center of Excellence and was awarded an \$180,000 grant for new equipment. In its tenth year, 2002, the CEO upgraded its equipment again and moved into the new Class of 1954 Environmental Science Center on Sachem Street. This recent upgrade, supported by several environmental organizations on and off campus, allows CEO to expand its activities to meet the growing needs of the students and faculty at Yale, and their research partners. The image archive at CEO has grown exponentially since its founding. This archive, together with our online access to government depositories, give CEO users global reach and the ability to look back at the earth's landscape to about 1975.

A key annual activity at CEO is the support of the course "Observing the Earth from Space". This course is an intensive introduction to the techniques and applications of satellite remote sensing. The enrollment includes both undergraduates and graduate students from a variety of academic departments. In lecture and in the laboratory, students learn the fundamentals of statistical image analysis and physical interpretation. The central theme of the course is the detection of change in the earth's land surface, atmosphere and ocean. Every student completes a research project of their own design and presents the results in a public forum. Several other courses in Yale College and the professional schools receive assistance from CEO.

The primary ongoing role of CEO is to support the research activities of Yale students, faculty and staff. At any one time, approximately twenty-five projects are active at CEO including a wide variety of disciplines and objectives. The two largest current projects are the SouthWest Asia Project (SWAP), investigating rapid landscape changes in the Middle East, and the Characterization of Eco-Regions in Africa project (CERA). These NASA supported projects involve faculty members from Geology and Geophysics, Anthropology and the School of Forestry and Environmental Studies, as well as foreign institutional partners. Local Connecticut projects include the epidemiology of Lyme disease, Woolly Adelgid infestation, urban encroachment on marshland, heat buildup in inner cities, and management of the Yale-Myers forest.

Additional information about CEO is available online at <http://www.yale.edu/ceo/index.html>

In 2001/2002 CEO moved from temporary quarters in KGL to new facilities in the Class of 1954 Environmental Science Center (ESC). The complex in Room 119 ESC was specifically designed for CEO and includes two small offices, a computer server room

and a large computer lab with space for about 15 workstations. This room also holds the CEO image archive comprising about 1000 Landsat images and other data types. The ESC location is proving to be well suited to the Center's needs.

While moving to new quarters, the CEO completely replaced its old UNIX-based computer system with a new Windows-based system. The switch to a new operating system, including the rewriting of much of the research and teaching support materials, was completed in time for the spring semester 2003 (see below).

The new Dell computer system at CEO includes 10 workstations and a server hosting about 1 terabyte of RAID disk storage. Communication between workstations and server is accomplished with a 1 Gigabyte per second Ethernet hub. These upgrades have kept YCEO at the forefront of technology in regard to the display and analysis of huge image data sets.

The support for the computer upgrade was contributed by four on-campus units: YIBS, the Environmental Studies Program (EVST), the School of Forestry & Environmental Studies (F&ES), and the Department of Geology & Geophysics (G&G).

1. Base funding; changing sources

During the last year, CEO base funding transitioned from a "YIBS alone" model to a "diversified source" model. Contributions for base funding were provided from F&ES (\$25,000), YIBS (\$25,000), EVST (\$20,000), and partial matching by the Provost's Office of Yale College (\$45,000). This new scheme is more cumbersome to administer but it more accurately reflects the diverse clientele of the Center. The matching arrangement from the Provost continues through 2007, so with stable help from the other units, this scheme may be sustainable over a five-year period at least.

"Base" funding includes the basic staff, hardware and software costs to allow the CEO to support teaching and unfunded research. "Non-base" funding includes staff support, data costs, travel etc. associated with specific agency-supported research projects. Non-base funding is supported entirely by grant funds from outside the university. The university charges overhead on these grants.

2. Teaching: "Observing the Earth from Space"

Our premier annual teaching support activity is the course "Observing the Earth from Space". This course was not taught in the academic year 2001-2002 due to the physical disruption during the move of the Center to ESC and because of a scheduled faculty leave. The course was taught again last spring with good response from the students. As in past years, this challenging course put the students in a position to carry out significant projects by the end of the term. A list of the project titles is attached. The diversity in this list is characteristic of the broad applications found today for satellite monitoring of the earth system. One new feature of the course last spring was the analysis of MODIS images. MODIS is the new sensor on the NASA Terra and Aqua satellites that will soon become the primary tool for broad scale earth monitoring.

The CEO also supported the Junior Seminar in the EVST major.

3. Ongoing support for research projects

The CEO continues to support large and small research projects. A partial list of current projects is attached. The Middle East project continues to be our largest project, although the existing grant is expiring next spring. New grant funds have been applied for from NASA.

4. GIS at Yale University

The CEO is part of the rapidly growing cross-campus program in Geographic Information Systems (GIS) at Yale. Other units contributing to this effort are the Science Library, Map library, F&ES, EPH and the Statistics Lab. CEO's role in this joint effort relates to the combined use of remote sensing and GIS, and to specific applications of GIS to the earth sciences. We envision a "seamless" network of GIS resources across campus comprising a virtual "Geography Center" at Yale.

CEO participates in a regional working group on satellite remote sensing and GIS. This CT based user group recently held a full day workshop on remote sensing at UConn. This was supported by NASA with funding. The workshop was attended by approximately 80 members of State and municipal government agencies, private industry, and a few academics. The goal of the workshop was to introduce GIS users to this technology, and let them know that there are a variety of locations within the state that they could turn to for assistance.

5. Governance

The current steering committee for CEO includes Frank Hole (Anthropology), Mark Aston (F&ES), Durland Fish (E&PH) and Ronald Smith (G&G). Prof. Smith continues to serve as Director. Larry Bonneau is the full-time CEO lab manager. We also seek advice from faculty and staff in E&EB, History, the Peabody Museum and other units.

6. New directions for the Center

a. Expanding the scope of research support

The primary focus of CEO activities is the support of research using satellites to monitor the changing earth. In the past, most of the students, staff and faculty using the CEO have been carrying out remote sensing activities. This user profile is shifting slightly now. We are increasingly supporting advanced users whose primary focus is GIS, rather than remote sensing. These users have secondary interests in remote sensing, earth science and environmental science. Both our computer systems and our staff expertise allow us to offer high quality support in these new areas.

Some students/staff have a basic knowledge of GIS but no experience with remote sensing image analysis software. To make YCEO accessible to these potential users, we will offer a short workshop on ArcView Image Analyst, a new low level package providing some raster capability to the usual GIS functions.

b. Support for undergraduates

Undergraduate students in G&G, EVST, EEB and Anthropology often require assistance in those courses, seminars and senior projects that involve earth resource mapping. We are beginning to offer some support to these students, even if they are not yet familiar with image analysis methods. Additional support is provided by the Sterling Map Library.

c. New course in geoscience mapping

G&G Professor Mark Brandon, working with CEO, is designing a new course offering in the general area of “Geoscience Mapping”. Such a course could be strongly and effectively supported by our Center, using our existing GIS tools and other special geoscience software packages. Funds from NSF may be sought for this initiative.

d. Biodiversity and Human Health

The CEO has offered to support a Yale cross-campus program on biodiversity and human health being discussed by faculty from E&EB, E&PH and F&ES. The Center could provide substantial support in mapping natural landscapes, human impacts and degradation.

e. Advanced course in satellite remote sensing

Work has begun on an advanced course in remote sensing. We hope the availability of an advanced course will encourage students to begin their study of remote sensing earlier. The advanced course will cover new data types and statistical interpretation methods. The course will include talks by external experts; including faculty from NASA, BU, Brown and UConn.

f. New data types

The science of remote sensing is advancing very rapidly. Several new environmental satellites and sensors are launched each year generating data sets requiring new types of interpretation. A goal of the Center is to keep abreast of these developments so that we can offer useful advice to Yale researchers. Over the past year we have gained experience with the new MODIS sensor. We are now undertaking similar initiatives with regard to SEAWIFS data for ocean mapping, ICONOS data for high resolution mapping, AVIRIS hyperspectral imagery and SAR data for ocean/ice mapping and monitoring cloud covered tropical forests and agriculture.

7. Resources for CEO

The new “diversified source” model for the Center funding provides base support at the level of about \$100,000 per year. Additional funds would allow new initiatives and improved research support:

- \$20,000 per year for a half-time staff position to assist users
- \$15,000 for 5 additional work stations
- \$2000 per year for an additional software license (MATLAB)
- \$3000 per year for staff training
- \$1200 for a new video projector
- \$5000 per year for images for student projects
- \$6000 per year for summer internships

Further information about these projects is available from Prof. Smith/

Appendix I: OEFS Class Projects

Land Cover Change Detection

Charles Brunton	Vegetation change analysis – Jigme Dorji National Park, Bhutan
Nathaniel Carroll	Land cover change in and around Piedras Blancas National Park, Costa Rica
Hoang Huu Dinh	Land use dynamics in the Central Highlands of Vietnam
Nataliya Plesha	Vegetation change at Chernobyl, Ukraine after the accident
Theresa Silla	Land cover changes in the border region of southern Cameroon
Karina Yager	Developing methods to assess land cover change in the Sacred Valley, Peru
Anne Blis	Land cover change in the Mississippi River Valley
Jen Molnar	Detection of vegetation changes in aerial photographs of the Quinnipiac Marsh
Rich Callan	Lyme disease response to land use change in Hunterdon County, NJ

Urban and Suburban Sprawl

Dani Simons	Detecting urban sprawl in arid regions: A remote sensing and GIS approach
Ruth Baker	Using entropy as a measure of agricultural conversion in CT
Beth Owen	Observing land use changes in New Haven County watersheds and their impact on water quality
Kirsten Spainhower	Adirondack NYC Watershed cover loss

Landscape Analysis Techniques

Helen Mills	Analysis of vegetation mapping techniques using remotely sensed images
Richard Chavez	Comparing land use classification methods in La Cordillera Los Maribios, Nicaragua

Climate and Landscape

Vladimir Vladimirov	Spatial and temporal patterns of snow distribution in the Caucasus Mountain Range
Kabir Peay	Monitoring tropical ENSO phenology using MODIS
Hanan Karam	Time series classification of a lower basin of the Khabur River
Arcady Kropov	Timberline processes

Tara O'Donnell	Examining factors that correlate to land surface temperatures
Astronomy	
Erik Brudvig	Analyzing star forming gases in galaxy NGC 3469
Forest Issues	
David Affleck	Multi-temporal forest cover classification of the Yale Meyers forest
Nancy Cothran	Relating land cover of Yale Meyers Forest to wood frog abundance patterns
Daniela Cusack	Identifying changes in forest type across topographic and edaphic gradients
Kyla Dahlin	Distinguishing between young and old growth kauri stands in New Zealand

Appendix II: Selected CEO supported projects

Student projects

Theresa Daniels – Tectonics and geobiology of the paleo and mesoproterozoic

Tim Raub – Neoproterozoic paleobiology, paleogeography, and geodynamics

Diana Karwin – Interface of a hydrologic model with landscape management

Beth Owen – Comparing southern CT landcover change with social/environmental demographics

Christian Palmer – Land use change in extractive reserves in Acre, Brazil

David Gershkoff – Temperature and altitude over the Sierra Nevadas

Kyla Dahlin – Crotona park forest management plan

Helen Mills – Quantify fire regime parameters and plant population trends in west TX and northern Mexico

Jennifer Balch – Landcover change in the Henri Pittier Park, Venezuela

John Brownstein and Maria Diuk-Wasser – a health project in Fairfield County

Ben Zaitchik – Water resources in the Middle East

Karina Yager - Land use in the Andes

Faculty projects

Peter Raymond, (Eden Enclona and post-doc Neung-Hwan Oh). Watershed and river mapping

Frank Hole/Ron Smith - Middle East climate and landscape

David Post – Integrating imagery of Horse Island into GIS

John Wargo – Locate and acquire aerial photographs of Vieques for GIS and image processing

Ben Kiernan – Genocide Studies Program

Ron Smith – The Oregon climate transition

Others

Peabody Museum – Reed Beaman –Phylogeography and ecophysiology of cretan plants and also developing location maps and GIS locations of museum collections

YIBS EARTH SYSTEM CENTER FOR STABLE ISOTOPE STUDIES (2001-Present)

Danny Rye, Director

The YIBS Center for Stable Isotopic Studies of the Environment was established with the completion of the stable isotope facility in ESC. The Center is devoted to the study of the environment, using the latest technology and ideas in light stable isotope research. The Center also serves as a meeting point for both Yale and external scientist to exchange ideas and develop new approaches to the study of the environment.

Given that stable isotopes of oxygen, hydrogen, carbon, sulfur, and nitrogen all show large variations depending on climatic and local conditions, it is clear that most aspects of the environment can be studied using light stable isotopes. Every living thing on this planet is, to a large extent, “what it eats, drinks and breaths”. The isotopic compositions of animals and plants reflect the environment in which they live. Isotopic records of many fossils document environmental change, while living flora and fauna carry isotopic information on animal migration, metabolic pathways and environmental influences.

Light stable isotopes can also be used to study long-term cycles that influence Earth’s climate. Isotopic data reveal aspects of CO₂ cycling within the Earth’s interior, and to place constraints on the flux of volatiles through the Earth’s crust.

There have been a number of contributors to the Center for Stable Isotopic Studies of the Environment in the last year. Ruth Blake (Geology and Geophysics) and her lab members, Alexandr Soukov, and Yuhong Liang have studied the oxygen isotopes of phosphates as environmental indicators. They have also studied isotopically labeled water to determine where the oxygen comes from in phosphates and sulfates. Further work by Jim Greenwood and Alexandr Soukov has established a protocol to analyze oxygen isotopes in sulfates using a TC/EA connected to the Delta XP spectrometer. Work by Darren Dagru and Yuhong Laing has established a protocol to analyze oxygen isotopes in phosphates using a TC/EA. Gaku Takimoto from David Post’s lab (Ecology and Evolutionary biology) have been doing ecological studies analyzing C and N isotope ratios of plant samples from the Bahamas using the Costech Elemental analyzer connected to the Delta XP mass spectrometer. Mark Pagani (Geology and Geophysics) and his student Brett Tipple have been analyzing alkenones using the Gas Chromatograph connected the MAT 253 via the GCC. Hongyu Chen from Gary Brudvig’s (Chemistry) lab has been using the Gas Bench attached to the Delta XP to analyze the isotope ratio of molecular oxygen evolved from their Photosystem II model system. Danny Rye (Geology and Geophysics) has used the lab for the analysis of carbonates in rock samples to study fluid flow and reaction in thrust ramps. The samples were prepared offline by Ephraim Taylor (undergraduate from Dartmouth) and analyzed via the tube cracker on the MAT 251. Ruth Blake and Elizabeth Donald (Stanford University, and Yale undergraduate) have demonstrated the usefulness of oxygen isotopes in phosphates in metamorphic rocks as indicators of previous life. Other contributors include Cathy Skinner and Ellen Thomas.

Infrastructure:

The center is housed in a 2000 square foot facility in the basement of ESC. Last year at the time there was one mass spectrometer operating. A twelve year old MAT 251 was moved into the center from the KGL stable isotope facility. That instrument remains an important part of the center. It is used to test new techniques on the new instruments and

to do standard routine analyzes of the isotopes of carbonates, silicates and sulfides. In the last year two new spectrometers have been installed and are producing data daily. The instruments include a Delta XP and a MAT 253. In addition all of the peripherals have been installed to allow us to measure, on line, the stable isotope ratios of O, H, C, S and N to a very high precision on extremely small samples of essentially every compound that occurs in the environment, including the isotopic ratios of specific organic compounds. The workload on the Delta XP was so large that we added a Delta Advantage that is currently being installed. Several of the peripherals on the Delta XP will be moved onto the Delta Advantage. This instrument should serve the need for elemental analyses by a number of users within and out side of the university and will greatly enhance the research efforts of both David Post (EEB), and Peter Raymond (Forestry and Environmental Studies).

At the present time the Finnigan MAT 251 is the workhorse for rock analysis. Long-term plans call for the replacement of the Finnigan 251 with a state of the art MAT 253 or its equivalent.

Members:

The strength of the Center also includes the expertise of the individuals who operate the instruments. The mission of the Center is to bring together a group of scientists with stable isotope expertise that encompass a broad spectrum of environmental science disciplines. Our current group includes: Danny Rye, Mark Pagani, Ruth Blake, David Post, Gerald Olack, Gabory Benoit, Peter Raymand and Karl Turekian. Our range of expertise provides representation of geochemistry, bio-geochemistry, paleo-ecology, ecology, micro biology, chemistry, and forestry. We also will have close ties to anthropology, and engineering.

It is our desire to make the center a hot bed of research that not only will interact with the other inhabitants of ESC, but also with the rest of the Yale community. We hope also to have a steady flux of visitors to the laboratory. These visitors will come both for the state of the art equipment, and for intellectual exchange.

Staff:

The Center has one full time PhD level staff member. Dr. Gerald Olack provides day-to-day management of the Center, assists users and instructors, and works with others from both within and from outside of Yale who wish to use the facility. He also has his own projects within the center Dr. Olack has brought a high standard of professionalism and scientific knowledge to the Center.

Some Current initiatives:

Ruth Blake:

1) *Enzyme reaction mechanisms and microbial metabolic pathways*

2) *Detecting life and metabolic activity in the sub-seafloor biosphere and in extraterrestrial systems*

3) *Oxygen isotope ratios of Phosphate in fish Teeth as a Sediment dating Tool: Application to Marine Red Clays*

Mark Pagani:

The evolution of atmospheric carbon dioxide: Causes and effects of long-and short-term climate change

The Cenozoic character of terrestrial photosynthesis

Peter Raymond:

1) *Isotope geochemistry of riverine, and estuarine organic carbon*

2) *Organic Carbon cycling in marshes, rivers, estuaries and oceans,*

3) *Inorganic carbon cycling and air-sea exchange*

Danny Rye

1) *The fate of CO₂ in metamorphic rocks, are they a source or a sink of CO₂*

2) *The nature of water and condensate transport in the atmosphere*

Future Needs:

Future needs include a Finnegan MAT 253 with peripherals to replace the MAT 251. As the operation grows we will also need to add staff. We will need to add at least one and probably 2 staff members to run instruments on a daily basis. The Finnegan Mat 253 with peripherals, including a laser system for analyzing very small silicate samples presently cost \$413, 500. At present the staff is supported through fees, and G&G department resources. We hope to with the recent addition of the Delta Advantage elemental analyzer to eventually support the present staff and one operator from fees for analyses. In the short term we will require funding for staff. With our present recovery fees, grant support, and G&G department support we will require \$40,000 for each of the next two years to support our technical staff.

We are now in the position to have scientist from other universities and institutions visit the laboratory. We will be continuously looking for funding and opportunities to have world-class visitors.

YIBS ECOSAVE CENTER (1992-Present)

Elisabeth Vrba, Director

ECOSAVE CONSERVATION GENETICS LABORATORY (1998-Present)

Dr. Gisella Caccone, Director

The Yale Institute for Biospheric Studies ECOSAVE Center was founded in 1992, and in 1998 added the Conservation Genetics Laboratory as part of the Center. Our six faculty members associated with the Center, Adalgisa Caccone, Michael Donoghue, Jacques Gauthier, Jeffrey Powell, Elisabeth Vrba who is the Director of the Center, and Anne Yoder, represent a diverse spectrum in terms of the organisms studied, analytical methods, and global field locations. Yet we all share the central focus of ECOSAVE, which is to add new knowledge on global biodiversity and on the processes that produced it. Included within this focus is understanding the historical pattern of phylogenetic relationships among living and extinct organisms, and the distribution in time and over geography of the elements of that pattern (from molecules and morphology to speciation and extinction) in the context of earth's physical dynamics. Such compound patterns are a powerful substrate for innovation on evolutionary processes and conservation strategy. The interaction in EC of specialists on living organisms with paleontologists is a special strength because understanding the present or predicting the future - requires understanding the past.

Our goals for the future fit in well with the renaissance over the past decade in environmental science at Yale. ECOSAVE support will emphasize exploration and discovery of new living and fossil forms - the *naissance* or birth of new information on hitherto unknown species in present and past ecosystems from the far-flung corners of the earth - because we envision that this is where the cutting edge will be in the future. International and especially third-world collaborations in research and exchange of scientists and students will feature prominently. Third-world countries contain a large proportion of Earth's undescribed species. Yet their poverty, high population growth, and low level of education imply a greater risk of future extinction. Thus we are motivated not only by the will to serve the educational and research efforts of those countries, but also by Yale's interests. These partnerships will be equal ones with benefits for us, ranging from access to foreign sites, collection programs, and specimens, through the newsworthiness of scientific announcements on exotic biota, to influence on policy. In our view the globalization of science is on the march at Yale and elsewhere, and EC should be a part of that globalization.

ECOSAVE's past and ongoing achievements, in science, teaching, and worldwide collaborations have positioned it well to succeed in these goals. The places involved range from the southwestern U.S, through Ecuador, Brazil, Europe, Russia, China, Laos and Vietnam, to Ethiopia, Mali, Burkina Faso and Madagascar. The launching in 1998 of the Molecular Systematics and Conservation Genetics Laboratory (MSCGL), and recruitment of its director Gisella Caccone, is one of ECOSAVE's seminal successes. The MSCGL has established flourishing teaching programs, and is also the exceptionally productive site of a wide range of integrative programs with foreign collaborators. Two Gaylord Donnelley Postdoctoral Fellows, Claudio Ciofi from Italy, who completed a two year fellowship heading MSCGL projects, and Luciano Beheregaray from Brazil, who completed working on projects in the MSCGL. The diversity of the numerous collaborative MSCGL researches, on animals ranging from mosquito malaria vectors and cave crickets to prairie chickens and Siberian tigers, is illustrated by the few examples below.

Study of the Galapagos tortoises by Gisella Caccone and Jeff Powell with collaborators is a long-term ECOSAVE project. The tortoises are the largest terrestrial ectothermic herbivores still alive and represent a unique radiation that was an inspiration to Charles Darwin. Through support from ECOSAVE, National Science Foundation, and National Geographic Society, the team has amassed a collection of about 2400 blood samples from the remaining natural populations as well as captive animals. Analyses of these samples has resulted in the most complete and solid phylogenetic analysis of the eleven extant species, identification of the effects of recent movement of tortoises (likely by whalers and buccaneers in the last 300 years), and confirmation of a heretofore unrecognized second conservation unit on the island of Santa Cruz. These studies are becoming a classic case of conservation genetics and widely recognized. For example, Gisella has been invited to the International Congress of Genetics in Australia specifically to present this work.

A project on fishes in Amazonia is headed by Luciano Beheregaray in collaboration with Gisella and others. They are studying evolutionary patterns in fishes from the floodplains of the Rio Negro, the largest dark water river in the world located in the middle of the Amazonian forest. The project aims to compare population genealogies, based on DNA sequences, of four co-distributed fish species to evaluate the influence of historical events in shaping evolutionary diversification in Amazonia. An expedition explored over 1,200 miles of rivers and streams, collected around 1,300 fishes and taught principles of conservation biology for fishermen and Amazonian students.

The Komodo Dragon research, headed by Claudio Ciofi, exemplifies how conservation of endangered species benefits from multidisciplinary collaboration. Claudio is currently collecting a comprehensive data set on the genetics, reproductive biology, demography, distribution, and sustainable use of natural habitats, of the Komodo dragon *Varanus komodoensis*, an endangered giant monitor lizard in Indonesia. These data will be integrated in setting management priorities for extant populations. Ciofi is also supervising a collaboration with U.S. institutions (Zoological Society of San Diego, The Nature Conservancy) and Indonesian ones (Department of Forestry, and Udayana University, Bali) which has established a research laboratory for molecular biology and endocrinology at Udayana University, and supported the training in wildlife management techniques of Indonesian graduate students and staff of Komodo National Park.

Where did the Aldabra tortoises come from, and are the native Seychelles tortoises really extinct? Gisella Caccone and coworkers were able to solve these questions thanks to collaboration with Nature Protection Trust of Seychelles and a generous gift to ECOSAVE from Mr. Coleman Burke. Aldabra, an isolated atoll in the Indian Ocean, is the only location where wild populations of these giant tortoises survive. Giant tortoises once inhabited islands throughout the western Indian Ocean. Madagascar, Africa and India have all been suggested as possible sources of colonization for these islands. Using mitochondrial DNA sequences the team showed that the Aldabra tortoises came from Madagascar, probably by floating on ocean currents flowing northward from the east coast of Madagascar. In a second study Gisella's group addressed the question whether native Seychelles tortoises are extinct, as was long thought likely, or whether their lineage may survive in captivity as suggested by a recent morphological study. The latter claim has been controversial since the morphological characters of the carapace used to identify these species can be sensitive to captive conditions. The potential survival of a giant tortoise species previously thought extinct is an exciting prospect for conservation.

Unfortunately the present genetic studies indicated that the morphotypes suspected to represent the Seychelles species do not show levels of variation and genetic structuring consistent with this hypothesis.

A systematic analysis of Xantusiid "Night lizards" by Gisella Caccone and Jacques Gauthier has just been completed. These sedentary and secretive lizards live in confined spaces such as rock crevices in isolated populations ranging from the American Southwest southwards into Central America, with one island endemic on Cuba, *Cricosaura typica*, and another on the Channel Islands off Southern California, *Xantusia riversiana*. They include species with dramatic differences in body size and peculiar habitat preferences. An integrative approach based on molecular, morphological, biogeographic, and paleontological data resulted in a pattern that resolves several persistent controversies in lizard evolution: Night lizards are not close to the gekkoes which they resemble but are scincomorph lizards related to the cosmopolitan skinks and African cordyliforms. Similarities in morphological and ecological specializations in rock-dwelling *Xantusia* are not the result of common ancestry, but instead are convergences related to similar environmental pressures. For instance, the "island giant," *X. riversiana*, is embedded within the dwarf *Xantusia* on the mainland, rather than being sister to them or close to *Lepidophyma smithii* the other giant in the analysis. The Cuban outlier, *Cricosaura*, previously thought to be closest to *Lepidophyma*, is actually the most basal branch, or sister to all other xantusiids. Another exciting conclusion concerns how the two island species came to be on their respective islands and the putative influence of the end Cretaceous asteroid impact on the Cuban *Cricosaura*.

Research on the causal linkages between paleoclimate and evolution in Elisabeth Vrba's laboratory resulted in an ECOSAVE-sponsored international conference and volume (edited by Vrba and others), which continues to be widely cited. This research continues with analyses of the macroevolutionary patterns of all the larger African mammals of the past 25 million years (my). Collaboration with George Schaller, Wildlife Conservation International, included the conference and volume *Deer, Antelopes, Giraffes, and Relatives: Past, Present and Future*, and analyses with colleagues of gene sequences, morphology, behavior, ecology, and phylogeny of Bovidae, with emphasis on rare and endangered high-altitude species from Tibet, Vietnam and Laos. Collaboration with other American and Ethiopian members of the Middle Awash Research Program continues. Excavation of eastern Ethiopian six to one-half million years old strata has yielded hundreds of mammalian fossils, and many new species and genera including early hominids, that have resulted in a series of papers in *Nature* and *Science*. The record shows patterns of large-scale episodes of speciation, extinction and migratory exchange with Eurasia in relation to major environmental changes. For example, while the Awash area is very arid today, at some past times when our early relatives lived there, lush well-vegetated inland deltas and river margins were present that resembled the modern Okavango Delta in Botswana in terms of the presence and relative abundances of mammalian genera.

The research of Michael Donoghue, one of our two new members, is focused on understanding biological diversity, especially from the perspective of evolutionary history. Much of his work has focused on the phylogeny and of plants, and especially on the flowering plants, but he is also interested in fungi. Within the context of ECOSAVE he and his students are actively extending their research on the biogeography of the Northern Hemisphere, especially on the evolution of the alpine flora of the eastern

Himalayas in China. Here the ultimate goal is to discover why so many new species have been generated within this "biodiversity hotspot" -- by far the most diverse temperate-zone flora on Earth -- and how and when the alpine flora of this region has served as a source for the colonization of other high-elevation areas around the Northern Hemisphere, and even the Andes of South America. Additional field studies are being planned to explore the Hengduan Mountain region of Yunnan and the Qinghai-Tibetan Plateau, focused especially on a diverse group of high-elevation plants known as the Dipsacales. Collections from these and related field trips will be deposited in Chinese institutions and in the Peabody Museum of Natural History, and materials for genetic and biogeographic studies will be databased and made widely accessible to the scientific community.

Anne Yoder, our second new member, is currently involved with multiple projects relating to the evolutionary history, phylogeography, species diversity, and conservation of Madagascar's vertebrates. Among the many vertebrate groups being investigated are lemurs, carnivores, rodents, tenrecs, chameleons, and plated lizards. For several of these groups, Anne also has samples of extinct taxa for which she is attempting to extract and sequence ancient DNA. Her collaborations with numerous Malagasy scholars are vital to her research program in that they allow her unprecedented access to rare biological specimens. At the same time, she is concentrating on training her collaborators in modern methods of phylogenetic and conservation genetic methods. The eventual goal is to initiate a self-sustaining conservation genetics program in Madagascar, to be run and operated by Malagasy scientists.

YIBS CENTER FOR FIELD ECOLOGY (2002-Present)

Stephen Stearns, Director

The YIBS Center for Field Ecology (CFE) was founded in 2002 to support field based research and teaching in the environmental sciences. Comprised of faculty from departments and schools across the University, its goal is to help make Yale a world leader in ecology by supporting faculty development, student research, and infrastructure projects to enhance field-based research and teaching. To do so it awards grants to graduate students for pilot projects leading towards a PhD and to undergraduates for summer internships on field ecology projects with Yale faculty. It has inventoried field studies being done at Yale and field sites available to Yale faculty and students; the results are now available on a web site. Its future goals include endowed faculty chairs, substantially upgraded field sites, additional graduate and undergraduate support, and undergraduate curricular offerings that enable Yale students to engage seriously with field ecology.

The Faculty Advisory Council of the CFE:

Director

Stephen C. Stearns

Edward P. Bass Professor of Ecology and Evolutionary Biology
Chair, Department of Ecology and Evolutionary Biology

Department of Anthropology

Richard Bribiescas, Andrew Hill, Alison Richard, David Watts

Department of Ecology and Evolutionary Biology Michael Donoghue, David Post,
Melinda Smith, Steve Stearns, Anne Yoder

Environmental Studies Major

Jeffrey Park

School of Epidemiology and Public Health

Durland Fish, Leonard Mustermann

School of Forestry & Environmental Studies

Mark Ashton, Gaboury Benoit, Lisa Curran, Michael Dove, Peter Raymond

PhD Pilot Grants

These grants allow beginning graduate students to develop their own ideas independently. They are highly sought after and very competitive. Demand greatly exceeds supply. In 2002 the following awards were made:

Brandon Brei, School of Epidemiology and Public Health

The maintenance of Lyme Disease in nature

Mr. Brei is investigating the natural reservoirs of Lyme Disease in Connecticut by combining landscape ecology with molecular analysis of pathogens collected from the blood of small mammals.

Casey Dunn, Department of Ecology and Evolutionary Biology

The colony structure of Siphonophores

Mr. Dunn is tracing the evolutionary origins of functional specialization using colonial pelagic hydrozoans as a model system. These animals are particularly appropriate because of the dramatic division of labor among parts of the colonies.

Erika Edwards, Department of Ecology and Evolutionary Biology

How plants tolerate drought

Ms. Edwards is studying the evolutionary origins and physiological basis of drought tolerance in plants by conducting a comparative physiological and morphological investigation of the group most closely related to the ancestors of the cacti.

Jane Halvorson, Departments of Geology and Geophysics and Chemical Engineering

How fungi degrade wood in the tropics

Ms. Halvorson is probing the diversity of white rot fungi that break down lignin in the dead wood of tropical forests. Lignin composes 5-30% of the dry mass of woody plants, and its degradation plays an important part in the global carbon cycle.

M. Anders Halverson, School of Forestry and Environmental Studies

The impact of kinship on population ecology

Mr. Halverson is using genetic fingerprinting to evaluate the importance of kinship to the population ecology of wood frogs in the wild. Wood frogs are an ideal model system in which to pose this question because of their short generation time and discrete breeding habitat – small woodland ponds.

Nathan Havill, Department of Ecology and Evolutionary Biology

The impact of history and selection on sexual reproduction in adelgids

Mr. Havill is studying the life cycle of one of the most important pests of forest trees in North America to ask what determines the switch from sexual to asexual reproduction and thus the evolutionary potential of the insect.

Michael Muehlenbein, Department of Anthropology

Hormones and parasites in wild male chimpanzees

Mr. Muehlenbein is analyzing the determinants of parasite infection in our closest relatives, chimpanzees, at a field site in Uganda, with particular emphasis on the interaction between male sex hormones and susceptibility to infection.

Heather Peckman, School of Forestry and Environmental Studies

Rehabilitating dry tropical forests

Ms. Peckman is working with small landholders in Central America to develop economically viable agricultural systems that protect natural areas and rehabilitate degraded ones. Her particular focus is on the sustainable simultaneous exploitation of forests and cattle.

Saverio Vicario, Department of Ecology and Evolutionary Biology

Adaptation to cave environments

Mr. Vicario is using a promising model, cave beetles and their relatives that live outside caves, to study how repeatable evolutionary change can be. He is working in Italy, Croatia, France, and Spain.

Monica Wakefield, Department of Anthropology

Costs and benefits of gregariousness in female chimpanzees

Ms. Wakefield is studying the chimpanzees of Kibale National Park, Uganda, to determine why females spend more time off by themselves with their infants than do males. She suspects that the pattern results from the avoidance by females of feeding competition with males.

Undergraduate Summer Internships

David Call, supervised by Dr. Luciano Beheregaray, Gaylord Donnelly Environmental Post Doctoral Fellow working in the YIBS ECOSAVE Conservation Genetics Laboratory

Erik Crew, supervised by Professor Oswald Schmitz, School of Forestry & Environmental Studies

Michael Morita, supervised by Professor David Skelly, School of Forestry & Environmental Studies

Matthew Shirley, supervised by Professor Ruth Blake, Department of Geology & Geophysics

In 2003 the Yale Institute for Biospheric Studies (YIBS) Center for Field Ecology (CFE) distributed \$19,962 to support independent pilot PhD projects in the following departments and schools:

Department or School	Students Supported	Amount (total)
Ecology & Evolutionary Biology	5	\$4,760
Forestry & Environmental Studies	7	\$6,650
Geology & Geophysics	6	\$5,202
Anthropology	2	\$3,350

Demand for this kind of support during the first two years of graduate school remains high; the YIBS CFE is one of the few sources providing it; students report that it makes a substantial difference in their development as scientists.

The procedure used to decide which applicants should get the rewards needs to be adjusted. To make sure that the faculty with the best knowledge of the students made the decisions, I have in the past allocated a fixed amount to each department or school, then asked the mentors of the students involved to decide who should be supported. This led to the unfortunate decision in some departments to divide the money equally among all applicants to avoid conflict among the faculty, rather than giving the more promising students more support and the less promising less support.

Next year – funding permitting - I shall try the following procedure:

Each department or school will get a lump sum allocation. The awards will be fixed at \$2000 per student and will only be made to students in their first or second year. The local allocation will be done by the DGS in consultation with the faculty mentors of the students involved. The DGS shall recuse herself if she is the mentor of a student

submitting a proposal and shall arrange for a neutral replacement. Students will write proposals and submit them to their DGS. No letters of recommendation from faculty will be required; the faculty involved will discuss the proposals at a meeting. I will be informed of the awards via a copy of an email to Rose Rita Riccitelli at YIBS (Rose Rita disburses the money and keeps track of the account). When the projects are finished, I will get a brief report on the work and a digital photo of the student taken in the context of the project (for the web site), with a copy of that email to Peter Schrader (who maintains the site).

The allocations, based on the experience of the first 2 years, will be:

Anthropology	\$4000 (2 students)
EEB	\$4000 (2 students)
FES	\$4000 (2 students)
G&G	\$4000 (2 students)
EPH	\$2000 (1 student)
Env. Engineering	\$2000 (1 student)

2003 Awards:

Balmer, Oliver	EEB	\$1,360
Glaberman, Scott	EEB	\$680
Hanley, Torrie	EEB	\$680
Lynch, Vinnie	EEB	\$680
Palkovacs, Eric	EEB	<u>\$1,360</u>
EEB Total:		\$4,760

SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES

Ardoin, Nicole	F&ES	\$1,000
Goodale, Uromi Manage	F&ES	\$1,600
Hamilton, Alissa	F&ES	\$1,000
Jones, Elizabeth	F&ES	\$350
Mills, Helen	F&ES	\$350
Ponette, Alexandra	F&ES	\$350
Urban, Mark	F&ES	<u>\$2,000</u>
F&ES Total:		\$6,650

ANTHROPOLOGY

Yager, Karina	Anthropology	\$1,500
Binetti, Katie	Anthropology	<u>\$1,850</u>
Anthropology Total:		\$3,350

DEPARTMENT OF GEOLOGY & GEOPHYSICS

Downs, Jason	G&G	867
Jerome Neufeld	G&G	867
Ian Miller	G&G	867
Matthew Benoit	G&G	867
Megan Andrews	G&G	867
Benjamin Zaitchik	G&G	<u>867</u>
Geology & Geophysics total:		\$5,202

YIBS Center for the Study of Global Change (1992-present)

Karl K. Turekian, Director

In 1989, Sabatino Sofia of the Astronomy Department and Karl Turekian of the Department of Geology & Geophysics asked Robert Watson, then of NASA, for help in starting discussions on global change research at Yale. He responded by encouraging various investigators supported by his office to come to Yale for a series of seminars on global change. Among these visitors were F. Sherwood Rowland, Ralph Cicerone and Michael McElroy. This set of seminars was the beginning of the Center for the Study of Global Change.

The Center was formed before the existence of the Yale Institute for Biospheric Studies (YIBS) and became a part of YIBS as it was established. Its goal has been to maintain a presence in the area of global change studies. Global change in the Center has been defined broadly to include aspects of the changes that have led to the Earth that we now inhabit. The reason for this broad view is that we can only understand changes that are taking place now both natural and anthropogenic that we can put in a larger context.

We have had three Visiting Scholars in the Center using funds not obtained from YIBS. They were Thure Cerling of the University of Utah, Ellen Thomas then of Cambridge University and S. Krishnaswami of the Physical Research Institute in Ahmedabad, India. This initial program has set the pattern for the newly endowed Visiting Scholar program in YIBS.

To assist in this enterprise an informal group of advisors to the Center has been put into place. At present this group includes Ruth Blake, Steve Sherwood, Robert Berner, Ronald Smith, Leo Hickey, Mark Pagani, John Wettlaufer and Danny Rye from the Department of Geology & Geophysics (G&G). These people have regularly been involved with the seminar entitled "Topics in Global Change" in attendance and in making suggestions for speakers. Other Yale participants have been Frank Hole of Anthropology, Sabatino Sofia of Astronomy, Harvey Weiss of Near East Studies, Robert Mendlesohn of the School of Forestry & Environmental Studies (F&ES) and Robert Evenson of Economics.

As an example of the activities of the Center for the past 13 years the seminar schedule for the 2003 Fall Schedule is shown below:

Monday	2 - 3:30 PM	Room 102 Kline Geology Laboratory
9/15/03	David Rind , Goddard Institute for Space Studies of NASA: "Solar effects on climate and the Maunder Minimum: Minimum certainty".	
9/22/03	James R. Holton , University of Washington: "The global transport circulation of the middle atmosphere and its possible role in constituent trends"	
9/29/03	William F. Ruddiman , University of Virginia: "The anthropogenic greenhouse era began thousands of years ago"	

- 10/6/03 **Dorothy Koch**, Goddard Institute for Space Studies of NASA and Department of Geology and Geophysics, Yale University: "Do Clouds Cleanse or Clutter the Atmosphere with Sulfate?"
- 10/13/03 **Thomas M. Cronin**, U.S. Geological Survey: "The Holocene climate record of the eastern U.S."
- 10/20/03 **Stephen Leatherman**, Florida International University: " Sea level rise and coastal impacts"
- 10/25/03 Symposium remembering G.E. Hutchinson on his 100th birthday.
- 10/27/03 **V. Ramanathan**, Scripps Institution of Oceanography: "Aerosols and greenhouse gases: Emerging issues in regional and global climate change
- 11/3/03 *No seminar Geological Society of America meeting*
- 11/10/03 **David Hodell**, University of Florida: "Human-climate-environment Interactions in the Maya Lowlands (Yucatan Peninsula) inferred from lake sediment cores"
- 11/17/03 **John Wettlaufer**, Department of Geology and Geophysics, Yale University: "Life on the edge: Interfaces, melting, and the survival of life in ice"
- 12/1/03 **Gus Speth**, School of Forestry and Environmental Studies, Yale University: "Governing the global environment: Anatomy of a policy failure -- and where do we go from here"
- 12/8/03 *No seminar: American Geophysical Union meeting*

YIBS CENTER FOR MICROBIAL DIVERSITY (2002-Present)

Margaret Riley, Director

In the spring of 2002, the Yale Institute for Biospheric Studies announced the creation of a new Center for Microbial Diversity. The mission of this center is to apply our understanding of microbial ecology, evolution and diversity to address human health and ecological concerns. To this end the Microbial Diversity Center is coordinating the efforts of the wealth of existing Yale microbial-minded faculty to address such concerns in a synthetic and cross-disciplinary way. The first concern the Center will tackle poses a truly a life-threatening challenge. Can we apply microbial evolutionary and ecological information to address one of the primary and increasing threats to human health; the emergence of multiply-resistant pathogenic bacteria?

Within the next 15 years, the death toll due to bacterial infection will skyrocket and no new 'magic bullet' is on the horizon. Every new antimicrobial we find, design or develop will encourage the emergence of already existing resistant microbes. The spread of this resistance to human pathogens is then simply a matter of time and intensity of human-mediated selection (by over-use and misuse of antibiotics). To address this concern will require more than simply developing a larger arsenal of antibiotics. It will take more than reinforcing to the medical community (and the public) the importance of following rationale guidelines for proper antibiotic use. Long-term solutions demand the coordinated efforts of epidemiologists, population geneticists, microbial physiologists and ecologists as well as engineers, physicians and clinicians. Proposed solutions must gain acceptance from the pharmaceutical and agricultural companies and politicians. Physicians and other health workers must be convinced to employ these novel solutions and society at large must be willing to accommodate and accept the changes in current health practices required. There are no existing programs at NIH or NSF, no national centers or even university departments that have attempted to coordinate such a multidisciplinary effort to tackle this challenging and critical concern.

The Center for Microbial Diversity will take a first step towards addressing this challenge by bringing together Yale researchers as well as representatives from Connecticut-based pharmaceutical companies and physicians and clinicians from the Yale-New Haven hospital to define the existing problem, to view the problem from a variety of perspectives and to generate research strategies aimed at novel, long-term solutions. What we require are truly novel approaches to solving this critical national and worldwide need. One such solution involves the development and use of narrow spectrum, rather than the traditional broad spectrum, antibiotics. Such a switch would ensure a longer shelf life per drug, reduce the intensity of selection for any particular resistance mechanism and allow the patient to retain her healthy microbial communities and therefore reduce the rate of nosocomial infections. This solution makes perfect sense from an ecological and evolutionary perspective. However, implementing such a solution creates an extraordinary challenge. First, narrow spectrum drugs must be discovered or developed (*which Yale researchers are actively pursuing*). Second, appropriate diagnostics are required for rapid and specific pathogen diagnosis in the hospital (*a procedure currently avoided with the use of broad spectrum antibiotics*). Third, application of evolutionary and ecological theory is required to design the most effective strategy of administration to avoid or delay the emergence of resistance. Fourth, the pharmaceutical companies must be convinced that production of such drugs is

in their long-term financial interests. I will stop short of including the steps involved in the regulation and enforcement of such an approach.

In this example, the role of the CMD is to focus its resources on enabling and coordinating these disparate stages of development. It will provide resources to aid in discovery and/or development of narrow spectrum antimicrobials and will initiate partnerships with pharmaceutical companies to explore the potential of such drugs in the market and the requirements for mass production. The Center will enable discussions between University and pharmaceutical researchers and clinicians to determine methods for rapid diagnosis to identify specific pathogens in real time in a hospital setting. This series of steps represents just the tip of the iceberg in achieving the desired long-term solutions, but clearly represent the cross-disciplinary nature and new pathways of communication required.

The CMD has an integrated educational mission. First, there is the traditional approach of developing courses to train our undergraduates, medical students and physicians about the seriousness of this health concern and the absolute requirement for a change in our current practices to achieve a long-term solution. One such graduate course already exists: Ecology and Evolution of Infectious Disease. However, it is critical that we target a broader audience. The center is currently developing a course for non-science majors that will address more generally the role of microorganisms in our modern world, from human health and bioterrorism to the health of the biosphere. A second, novel educational approach involves the development of a series of workshops to serve in the education of researchers and clinicians in pharmaceutical companies, hospitals and governmental agencies, such as the CDC or NIH, as well as the general public. These workshops will not only educate the participants about the problem and our proposed solution, but will also continuously supply the center with new perspectives from the field about alternative solutions to consider.

The newly created Center for Microbial Diversity has set for itself an extraordinary challenge. There are no existing solutions to the antibiotic resistance emergency. No magic bullets are in the pipeline. With the breadth of microbial-minded researchers at Yale and with the development of strong ties between Yale faculty and Connecticut-based pharmaceutical companies, health workers and legislatures we are poised to meet this critical challenge.

INACTIVE RESEARCH CENTERS:

YIBS CENTER FOR BIOLOGICAL TRANSFORMATION (1993–2001)

L. Nicholas Ornston, Director

Most chemicals introduced into the environment are rapidly removed by bacteria. Because the most abundantly produced chemicals are the products of plant metabolism, bacteria's lengthy evolutionary history has provided the genetic "repertoire" needed to effectively metabolize plant products. So through genetic means, it SHOULD be possible to alter microorganisms so that they convert some of the renewable resources produced by plants to socially benefit products. In addition, the genes used by bacteria to remove pollutants are variants of the genes used to remove plant products, so genetic modifications of the genes SHOULD allow the design of organisms with improved potential for environmental cleanup.

These "SHOULDs" represent just a few of the questions that inspired and challenged the Center for Biological Transformation (CBT) Director, Professor Nicholas Ornston, and co-director, Professor Margaret Riley. In its first five years, the CBT research team carried out a comprehensive research program to understand the biological processes underlying the bacterial transformation of chemicals to create useful products as well as those processes underlying successful biological removal of toxic chemicals from the environment. Building upon this basic research, scientists would be able to develop applications for removing and preventing pollution.

The Center's mission was to determine how microorganisms remove chemicals from the environment. At the onset, it is important to realize that this has been going on for a very long time. Before there were humans, indeed before there were animals, plants and microorganisms were engaged in complex chemical communication. As part of this, plants produced potentially toxic compounds, and successful microorganisms evolved to eat them. By analyzing such adaptations, it is possible to learn how microorganisms rise above biochemical hurdles imposed by chemicals that are difficult to digest. The lessons learned may gain broad application in removal of chemical pollutants caused by human activity, but first lessons must be learned.

The Center's work spawned a successful industrial/academic collaboration with DuPont and was recognized by the scientific community with Margaret Riley named as a Presidential Young Investigator. It also attracted support from General Reinsurance Corporation, the largest professional property/casualty reinsurer in the United States, which made it possible to learn some important lessons:

Lesson I: Harnessing the energy of oxygen for specific biochemical reactions.

We are aware of the chemical energy of oxygen when we watch chemicals burn. This nonspecific use of the energy is kept going by the heat of the ongoing flame. A more difficult challenge is the harnessing of the energy in oxygen for a specific biochemical reaction at normal environmental temperatures. Microorganisms have the ability to do this with enzymes named oxygenases. Using a novel genetic system we have been able to explore how oxygenases function. We have isolated mutant oxygenases with altered properties caused by subtle changes. The changes indicate how the enzymes harness the energy of oxygen.

Lesson II: Changing the control of enzyme synthesis.

Microorganisms control the synthesis of enzymes so that for the most part, they are made only when their activity is demanded. Sometimes it is useful to change this form of regulation. For example, if we have genetically designed an enzyme with a new activity, we might want to change the conditions that cause its synthesis. The novel genetic system allowed the isolation of mutants with altered biosynthetic control of enzymes, and characterization of the mutants showed how the changes were achieved.

Lesson III: Clustering of genes with related function.

Thus far we have analyzed about 50 genes that are clustered together in a bacterial chromosome. The genes have very different functions, but their overall selective value is that they allow bacteria to remove complex chemicals from the environment. SO why are the genes clustered? Recent evidence suggests that the clustering allows the full set of genes to increase its activity by tandem duplication when their functions are called into play. This is important because it suggests a mechanism whereby the dosage of a gene with a desired function could be increased in response to environmental demand.

Lesson IV: Physical separation of potentially destructive activities.

Sometimes microorganisms can convert a toxic chemical into something that supports growth. One way to do this is to detoxify the chemical by enzyme reactions that take place on the cell surface and then to transport the nontoxic product of the reactions into the cell. Genetic approaches have revealed such a system and demonstrated how it works.

Lesson V. Controlling passage of a chemical into cells with a genetic switch.

Some chemicals prevent growth when presented at high concentrations and foster growth when available at low concentrations. We have identified a genetic switch that allows a single bacterial cell line to maintain two populations. When the switch is off the bacteria are protected from high concentrations of a chemical because they do not pump it into the cell. When the switch is on, bacteria pump low concentrations of the chemical into the cell so that growth can be supported. Thus the bacterial are prepared for either contingency, low or high supply.. When the chemical is absent, the genetic switch flips back and forth providing a mixture of cells to be called upon by future selective demand.

In addition to conducting research, CBT advanced the study of biological transformation beyond the Yale community, hosting visitors from universities in the US, Korea, Germany, the Netherlands, and France, and CBT researchers participated in lectures, seminars and workshops at universities and professional meetings throughout the US, Spain and Scotland.

Publications:

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YIBS CENTER FOR COMPUTATIONAL ECOLOGY (1992–2002)

Directors, Günter Wagner and then Oswald Schmitz

What would happen to our country's wildlife population if atmospheric carbon dioxide were doubled? How do we discover the population genetic processes that enable a species to adapt to environmental disturbances or changes? By using mathematical models, scientists will be able to develop theories about fundamental behavior that will in turn explain the relationships between environmental impacts and ecological patterns.

The Center for Computational Ecology's (CCE) research goal was to understand how complexity in ecological systems emerges and is sustained, further enabling researchers to:

- Understand the dynamics of multi-scale, self-organizing ecological systems;
- Predict the effects of perturbations on ecosystem dynamics and organization structure; and
- Gauge the potential to restore perturbed ecological systems.

By 1996, CCE's research projects were structured around three simulation platforms, evolving as related research unfolded; each of these platforms contributed to the computational keys by which researchers began to unlock the understanding of complexity:

Gecko, School of Forestry and Environmental Studies Professor Oswald Schmitz' extension of the Santa Fe Institute's "ECHO" model, simulating behavior such as species competition in highly structured environments. The most immediate applications of this development would be in examining rock intertidal shoreline communities and old field food web structures.

The Mult locus population genetic simulator enabled scientists to study the dynamics of mutation, selection, recombination and drift. This model, developed by then CCE Director and Professor of Biology, Günter Wagner, was to be applied to the problem of how the adaptive versatility of a population changes under environmental change.

The λ -grammar model was designed by Biology and Geology Professor Leo Buss, and Walter Fontana, Institute of Theoretical Chemistry, University of Vienna. This model was designed to enable scientists to study the emergence of stable, self-maintaining networks of interactions by generating specifications for systems which, if satisfied, will be self-sustaining.

In 1997, Forestry & Environmental Studies Professor Oswald Schmitz served as the Director of CCE and the Center's maintained a high level of research productivity.

Some of the products of research (e.g. Gecko Simulator for complex ecological systems) became available to researchers outside of Yale University to assist in their endeavors to model dynamics in their own specific systems.

CCE also moved forward to satisfy its teaching mission and was awarded three separate grants (Howard Hughes, NECUSE and Yale ITS) to develop and implement teaching

software to support existing science courses at Yale. CCE programmer Ginger Booth designed and programmed CourseWare, a generic software platform that facilitates the implementation of simulation programs for specific class assignments. CourseWare not only runs specific simulations, it also produces graphical output to display data from the simulations.

Given that many of CCE's initiatives, aimed at linking computational modeling with field experimentation, are well underway, CCE was able to shift more emphasis toward its teaching mission, and in 1998, CCE programmer Ginger Booth developed software (called CourseWare) that would facilitate creating interactive science labs that could be served over the Internet. A prototype lab course was developed for FES 563b/EEB 340b, *Community Ecology*, taught by Oswald Schmitz. The intent was to offer students a way of learning mathematical principles taught in lecture, in a setting in which they could interact with computational-based exercises that could be accessed at their leisure outside of normal lab meeting times. There were five electronic labs designed to complement various themes presented in lectures. The electronic labs appeared to serve a valuable role - student grades improved by 10-15% on the first mid-term exam relative to years when such teaching software was unavailable.

Building on the success of this pilot project, CCE applied for and received funding from Yale ITS and from Howard Hughes to develop course modules for other undergraduate courses. CCE is now actively developing computer-based learning modules for EEB 110, *Introduction to Environmental Science* (R. Dorit, enrollment 300 students). These modules will again complement lecture material and allow students the freedom to explore different lecture concepts (e.g., human population growth, risk and spread of infectious diseases, biodiversity and the stability of ecosystems) within and outside of normal weekly discussion sections. These modules will be designed to be completely interactive such that students can explore concepts in far greater depth than can be covered during lecture. We have also developed several modules for EEB *Conservation Biology* (J. Powell, O. Schmitz and A. Caccone, enrollment 50 students), which aids students in understanding the concepts and measures of biodiversity.

In the 2000, CCE activities focused on the teaching and research mission.

Teaching Support

Based on our success with CourseWare, CCE was asked by Yale ITS to move into distance education. They accomplished this with their new Mortal Stakes initiative, which was supported by a \$50,000 Yale Center for Media Initiatives grant. Mortal Stakes is a Foodweb game for use in both on-campus and distance learning courses. This new line of simulators features more deluxe, goal-oriented user interfaces in order to better hold the attention of the non-captive audience of adult learners.

In the year 2000, CCE had 28 CourseWare Java web-based scientific simulators in use in courses both inside and outside Yale, including 6 full-blown Gecko-based ecosystem models. CourseWare was now a required part of Yale's courses in Conservation Biology, Environmental Science, Community Ecology, Landscape Ecology, and Human Creation and Destruction of Environments.

New CourseWare developed included Human Demographics and Ricker Diagrams modules for Environmental Science, funded with a \$10,000 continuing grant from

Howard Hughes Medical Informatics. The new Environmental Studies program provided \$10,000 to program ArchaeoSim for their new core course, *Human Creation and Destruction of Environments*. This simulator explores the agricultural system and a climate change based collapse in ancient Subir in northern Mesopotamia. CourseWare was also updated to use the latest Java user interface improvements. New Gecko models were written to support research efforts.

The CCE programmer was also contracted at cost to develop new websites for the Environmental Studies program (\$5000) and the Doctoral Studies program at the Yale School of Forestry (\$4000).

Research

CCE members continued to develop, implement and calibrate the Gecko simulator to a real world field system. The intention is to explore emergent nonlinearities population level interactions and dynamics as a consequence of individual agents acting according to rules based on behavioral measurements made in the field. This work led to 2 publications:

Schmitz O.J 2001. From interesting details to dynamical relevance: on effective use of empirical insights in theory development. *Oikos* 94:39-50.

Ovadia, O., H. ZuDohna, O. Schmitz and G. Booth. Effect of variance in initial body size of agents on dynamics of old-field food webs. To be submitted to *The American Naturalist*.

Members of CCE also received a \$100,000 grant from the Noble Foundation to conduct a computational assessment of the predicted effects double-atmospheric CO₂ climate change on mammals' species in parks and protected areas in the continental USA. The aim of the project is to evaluate how well parks with fixed boundaries will protect species under changing climate.

CCE concluded its affiliation as a YIBS Research Center at the end of the academic year 2001-2002.

**YIBS CENTER FOR HUMAN ECOLOGY, ENVIRONMENT AND INFECTIOUS DISEASE
(1992-1997)**

Burton Singer, Director

As long as tropical forests are under the pressure of human incursion and development, there must be the ability to define the options for achieving sustainable use in terms of biological mechanisms and social costs and benefits, particularly those related to human health.

Tropical rainforest destruction has caused not only drastic economic, social and environmental changes in many countries in recent years, but has also exacted a heavy toll through the increase in infectious diseases such as malaria. The YIBS Center for Human Ecology, Environment and Infectious Disease (CHEEID) is charting the impact of social and economic factors and of environmental change, such a deforestation, on infectious diseases. This fundamental research will provide the basis for scientifically sound health and environmental policies.

Initial research activities in CHEEID focused on the Amazon River Basin of Brazil and on three insect-transmitted diseases-malaria, leishmaniasis, and yellow fever. The project Land Use and Health in the Amazon is the first intensive study to integrate health and environmental factors in an effort to guide settlement in the Amazon basin. Developed as a collaborative effort among Yale scientists and colleagues from Brazilian institutions, this project focuses on the relationship between insect transmitted diseases and deforestation, and on sustainable land-use for socioeconomic development. The multidisciplinary project is set in the frontier settlements of the state of Rondonia and in the floodplain communities of the Amazon estuary in Pará, Brazil. However, with the 1994 departure of Professor Burt Singer, CHEEID Director of Epidemiology & Public Health, the Center had to reassess its direction, and ultimately dissolved in 1997.

YIBS CENTER FOR MOLECULAR ECOLOGY AND SYSTEMATICS

The YIBS Center for Molecular Ecology and Systematics (CMES) had a goal of developing and utilizing the latest advances in molecular biology to rapidly survey the genetic status of natural populations. In addition to providing a focus for the development of new technology, the Center was created to serve the increasingly important demands of the community of ecologists, conservation biologists, and evolutionists for access to such tools. In carrying out their work, Center researchers would build a molecular collection destined to become a new division of the Peabody Museum of Natural History.

The goals of the Center for Molecular Ecology and Systematics have now been realized in the creation of the ECOSAVE Conservation Genetics Laboratory.

FACULTY SUPPORT

Faculty Support Fund representing seven Junior Faculty Equivalent (JFE) positions, each for a period of 5 years to then redistributed for another JFE position

Two JFE's to support the Edward P. Bass Professorship, currently held by Professor Stephen Stearns in EEB (2001-2006)

Two JFE's to support the G. Evelyn Hutchinson Professorship, currently held by Michael Donoghue in his position as Professor of Ecology & Evolutionary Biology

One JFE was used for a two-year period to support a fluid dynamics position in (G&G)

One JFE currently supporting Assistant Professor Mark Pagani in G&G (2002-2007)

One JFE currently supporting Assistant Professor William Mitch in Environmental Engineering (2003-2008)

One JFE currently being held to support a position in the area of population when the position is filled (search is being conducted by the Department of Epidemiology & Public Health (EPH))

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