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American Association for the Advancement of Science 2/15/91 [OA 6855] [4]

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SCIENCE

American Association for the Advancement of Science, 1333 H Street, N.W., Washington, D.C. 20005

BACKGROUND INFORMATION ON SCIENCE

Founded by Thomas Edison in 1880, **SCIENCE** has been, the official weekly journal of the American Association for the Advancement of Science (AAAS) since 1900. Each weekly issue contains original articles, research reports, book reviews by some of the world's leading scientists, the staff written "News and Comment" and "Research News" sections, and "This Week in **SCIENCE**" - a brief overview of the issue's highlights. Scientific articles cover all the disciplines, dealing with such diverse areas as health care, new energy sources, industrial research, and space exploration, among many others. An occasional "Perspectives" column by a well-known researcher describes exciting new work in his or her field.

The "News and Comment" section presents sophisticated and timely information on such topics as government funding for research, the slowdown of American innovation, and the federal scientific bureaucracy. The "Research News" section of **SCIENCE** gives readers in-depth and analytical reports on significant developments and innovations that will affect the scientific community for years to come.

SCIENCE also publishes special issues devoted to in-depth coverage of one topic. In the past, special issues have focused on such topics as Recombinant DNA, biotechnology, energy, computers and electronics, plate tectonics, the Voyager mission to Mars, and science in Japan.

In addition to the more than 134,000 individual scientists, engineers, and others interested in science and technology who receive an issue of **SCIENCE** each week as part of their AAAS membership, an estimated 500,000 additional people regularly read the journal in libraries, schools, and research institutions.

SCIENCE, one of the most widely quoted scientific journals in the world, has won a number of distinguished awards for science reporting, among them the Science-in-Society Journalism Award of the National Association of Science Writers (NASW), the Blakeslee Award of the American Heart Association, the Distinguished Medical Writing Award of the American Heart Association, and the George Polk Award in Journalism.

AAAS

American Association for the Advancement of Science, 1333 H Street, N.W., Washington, D.C. 20005

FOR IMMEDIATE RELEASE
(Mailed 6 December 1990)

CONTACT: Joan Wrather
(202) 326-6431

**EDUCATION ISSUES TO BE A MAJOR FOCUS AT AAAS ANNUAL MEETING
14-19 FEBRUARY 1991, WASHINGTON, D.C.**

Washington, D.C. -- The leaders, the innovators, the teachers, the scientists, and the citizens of the 21st century are today students. What is the quality of the education they are receiving? How are science and mathematics faring? Are the new projects aimed at improving science and mathematics education making a difference?

The nation's science and technology education will be broadly explored at the annual meeting of the American Association for the Advancement of Science (AAAS). The Association will meet at the Sheraton Washington and Omni Shoreham hotels in Washington, D.C., 14-19 February 1991.

Some of the symposia featuring science and technology education will be:

- Cross-national Perspectives on the Public Understanding of Science
- The Progress and Impact of Project 2061
- Science & Technology Education: Assessment/State Models of Reform/Curriculum Reform
- Animals in the K-12 Classroom

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- Minority Mathematics and Science: Successful Programs at Community Colleges
- Satellite Delivery of Education: From Elementary School to the Working World
- Conflict Between National and International Roles of Universities
- Science for the Nonscience Major
- Mathematics and Mathematics Education: Beyond Reports
- Science and Mathematics Curriculum Reforms: How Do They Relate?

In addition to these and other sessions on science and technology education, the meeting will include plenary lectures by John Brademas, president, New York University, and Donald N. Langenberg, chancellor, University of Maryland and president, AAAS.

The program also will include sessions covering physical, earth, and planetary sciences; medicine and health; mathematics and computing; environmental science and global change; behavioral science; science policy; science and international security; and more.

The program also will feature a series of free public lectures (including those by Brademas and Langenberg), a science film festival, and the AAAS Science and Technology Exhibition.

A special feature of the 1991 AAAS Annual Meeting will be a three-day seminar on "The Neurosciences: Challenges for the '90s." An additional fee will be required to attend this seminar.

Formed in 1848, the American Association for the Advancement of Science is the nation's leading general scientific organization. It currently has over 132,000 individual members and nearly 300 affiliated scientific and engineering societies and academies of science. The AAAS publishes the weekly journal Science.

#

NOTE TO MEDIA: Complete newsroom facilities will be maintained throughout the meeting at the Sheraton Washington Hotel. Several press conferences will be scheduled and many of the papers will be available. A preliminary program for the meeting is enclosed. Journalists planning to cover the meeting should fill out and return the enclosed press registration card. Please follow the hotel reservation instructions on page 15 of the preliminary program. Note that you must call the Housing Bureau (toll free) to make your room reservation.

AAAS

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FOR IMMEDIATE RELEASE
(Mailed 6 December 1990)

CONTACT: Joan Wrather
(202) 326-6431

**AAAS ANNUAL MEETING TO FEATURE HEALTH AND MEDICINE
14-19 FEBRUARY 1991, WASHINGTON, D.C.**

Washington, D.C. -- Gene therapy, RU486, dizziness, AIDS, cancer, animal research, immunocontraception, and cystic fibrosis will be among the many areas of health and medicine explored at the annual meeting of the American Association for the Advancement of Science (AAAS).

The AAAS will meet at the Sheraton Washington and Omni Shoreham hotels 14-19 February 1991.

Some of the symposia highlighting health and medicine will be:

- Gene Therapy: Scientific Prospects and Societal Implications
- AIDS: Scientific Research and Public Policy
- RU486
- Ethical and Clinical Issues in Carrier Screening for Cystic Fibrosis
- New Molecular Insights into "Old" Genetic Disorders
- The Drug Approval Process in the United States: Current and Future Considerations
- Balance and Dizziness: Assessment and Rehabilitation

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- Development of Medications for the Treatment of Brain/Behavior Disorders
- Alternative Approaches to Clinical Trials in AIDS: Ethics and Methodology
- Molecular Determinants in Human Cancers
- The Father and the Fetus: Facts and Fallacies
- Control of Infectious Diseases: New Aspects of Vaccines
- Scientific and Statistical Inferences in Modeling Animal Research
- Consequences of HIV/AIDS in Eastern Africa
- The Aging and Cancer Interface: Multidimensional Research Perspectives

In addition to these and other sessions on health and medicine, the meeting will include plenary lectures by Sir Walter Bodmer, president, Human Genome Organisation (HUGO) and director of research, Imperial Cancer Research Fund, on the Human Genome Project; and Louis W. Sullivan, secretary, U.S. Department of Health and Human Services, on biomedical research.

The program also will include sessions covering physical, earth, and planetary sciences; mathematics and computing; environmental science and global change; behavioral science; science policy; science and security; education; and more. In addition, there will be a series of public lectures (including those by Bodmer and Sullivan), a science film festival, and the AAAS Science and Technology Exhibition.

A special feature of the 1991 AAAS Annual Meeting will be a three-day seminar on "The Neurosciences: Challenges for the '90s." An additional fee will be required to attend this seminar.

Formed in 1848, the American Association for the Advancement of Science is the nation's leading general scientific organization. It currently has more than 132,000 individual members and nearly 300 affiliated scientific and engineering societies and academies of science. The AAAS publishes the weekly journal Science.

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What is AAAS?

Founded in 1848, the American Association for the Advancement of Science is the world's largest federation of scientific and engineering societies, with nearly 300 affiliates. In addition, AAAS counts more than 132,000 scientists, engineers, science educators, policy makers, and interested citizens among its individual members, making it the largest general scientific organization in the world.

AAAS is dedicated to the following objectives:

- * To further the work of scientists;
- * To facilitate cooperation among them;
- * To foster scientific freedom and responsibility;
- * To improve the effectiveness of science in the promotion of human welfare;
- * To advance education in science;
- * To increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

The Association's board of directors consists of the chairman, president, president-elect and eight others elected by the general membership. Two other officials--the executive officer and the treasurer--also sit on the 13-member board. In addition, members elect an 84-member council, which meets annually to establish general policies regarding AAAS programs.

A central staff of about 230 people work in the Association's headquarters in Washington, D.C. Among their activities are the editing and publishing of the weekly journal Science; the planning and support of annual meetings and symposia; and a range of special programs in science education, international cooperation, science and public policy, equal opportunity in science, and science communication to the general public.

AAAS maintains its multidisciplinary focus through members' participation in 22 sections embracing all the natural, physical, health, social, economic, and applied sciences, mathematics, technology, and engineering (see p.TK). Four independently run geographic divisions of AAAS--the Pacific, Southwestern and Rocky Mountain, Arctic, and Caribbean--carry out AAAS objectives on a regional level.

AAAS lends support to three "participating organizations," whose activities contribute to the Association's goals. They are the Commission on Professionals in Science and Technology in Washington, D.C., the Gordon Research Conferences, based in Kingston, Rhode Island, and the Chicago-based Illinois Science Lecture Association.

Individual membership in the Association, which includes the weekly journal, Science, is available for \$82 per year. Student, emeritus, spouse, postdoctoral, and foreign membership rates are also available. Contact the AAAS membership office for more information (202-326-6430).

PUBLICATIONS

Science

Founded by Thomas Edison in 1880, Science has been the official journal of AAAS since 1900. Each weekly issue contains original research reports, book reviews, editorials, research news and general news and comment about science and technology. Science is one of the most frequently cited scientific journals in the world.

In addition, Science co-sponsors an annual Human Genome Conference to explore advances in the effort to map the more than 100,000 genes making up the human genome. Topics include innovations in technique, applications for genome mapping, interesting

regions of the human genome, and the social and ethical issues raised by the project. (See Calendar p.tk for the date and location of the 1991 conference.)

Books

AAAS books arise from various sources including the activities of AAAS directorates and from AAAS annual meeting symposia. Other books are compilations of Science magazine articles that focus on a single topic, such as neuroscience and biological systems. Each book advances education in the sciences, contributes to the scientific and policymaking community, or increases the public understanding of science.

A complete catalog is available from the AAAS publications office (202-326-6446).

MEETINGS

Since it began, AAAS has held meetings throughout the United States, Canada, and Mexico. All AAAS meetings are held at sites accessible to participants who are disabled.

The Annual Meeting

Each year, the AAAS annual meeting offers its several thousand participants a stimulating, multidisciplinary look at the year's advances in science and technology. Scientists, engineers, and other interested professionals and citizens attend sessions that range from the highly technical to the broadly appealing.

Widely covered by national and local media, the annual meeting takes place in a different city each year:

- * 1991--Washington, D.C. (14-19 February)
- * 1992--Chicago (7-12 February)
- * 1993--Boston (11-16 February)
- * 1994--San Francisco (18-23 February)

Regional Meetings

Each of the four divisions holds an annual meeting with sessions geared to the specific interests of the region.

- * Southwestern and Rocky Mountain--
15-18 May 1991, Lubbock, Texas.
- * Arctic--22-24 May 1991, Fairbanks,
Alaska.
- * Pacific--23-27 June, 1991, Logan, Utah.
- * Caribbean--to be scheduled.

Others

For a listing of AAAS meetings, seminars, colloquia and workshops scheduled for 1991, see the Calendar, p.TK.

Education & Human Resources Programs

The Directorate for Education and Human Resources seeks to improve education in mathematics, science, and technology; foster equal access to these fields for women, minorities, and people with disabilities; and enhance the public's understanding of all areas of science.

Project 2061

Project 2061 is a long-term effort to fundamentally restructure the way science is taught in the United States. The project's 1989 report, Science for All Americans, defined goals for learning in mathematics, technology, and the sciences. Using the report as a springboard for change, six teams of educators around the country are now developing model curricula that can be adapted and used by schools nationwide. The project is supported by both foundation and industry sponsors.

Bell Atlantic/AAAS Institute

Originated in 1989 for science and technology teachers in the Bell Atlantic service area, the institute is a model program of in-service education and materials development in communications and information technology for middle and junior high school teachers.

Special Population Programs

These include the **Black Churches Project**, which helps black church groups establish science activities in their youth programs; training workshops with **Girl Scout** leaders on how to encourage scientific interest among the young women with whom they work; the **Hispanic Outreach Program**, which in 1991 is launching a new initiative called Proyecto

Futuro (Project Future) in eight Chicago schools; and the **Linkages** projects, funded primarily by the Carnegie Corporation of New York. These projects bring together community groups and science and technology professionals in order to help improve science education among women, minorities, and students with disabilities.

Public Understanding of Science

A variety of programs serve to enrich the public's appreciation for and understanding of science, including **Public Science Day** at each AAAS annual meeting site; "**Science Update**," the award-winning AAAS radio series; the annual **Franklin Lecture**; the **Science and Technology Centers Project**, which arranges for AAAS members to volunteer at science centers and museums; and an annual fellowship for scientists and engineers interested in working with the mass media (see AAAS Fellowships, p.tk).

Other Programs

Other activities include the **AAAS Forum for School Science** (see Calendar p.tk), an annual conference for scientists and science educators on teaching, curriculum, and learning in science and mathematics; **Math Power**, a series of prototypical mathematics activities for students; and the **AAAS Community Computer Learning Network** which, in partnership with Apple Computer, Inc., has provided hundreds of computers to community organizations.

International Programs

The Directorate for International Programs deals with four major areas: global change; international security; developing countries; and international scientific cooperation.

Global Change

This program helps coordinate the efforts of scientists and engineers worldwide who are working on such issues as climate change, environmental protection, and preservation of biological diversity. Among other activities, regional conferences are organized and symposia are developed for each annual meeting.

Program on Science and International Security

Formerly the Program on Science, Arms Control, and National Security, this program has since 1981 offered nonpartisan congressional seminars and briefings as well as a series of publications relating to security issues. See the Calendar (p.tk) for date and location of the program's annual colloquium on science and security.

Developing Countries

The **Sub-Saharan Africa Project** works to strengthen the research infrastructure of the African scientific community and to foster links between African scientists and their colleagues worldwide. Principal elements of the program are a journal distribution project, the sponsorship of a multidisciplinary malaria study, and the enhancement of electronic networking.

The **Western Hemisphere Cooperation (WHC) Project** convenes regional symposia, organizes short courses for faculty at Central American universities, and jointly conducts major

bilateral programs with Chilean scientists, among other activities. Since 1975, AAAS has also provided the executive secretariat for Interciencia Association, a federation of science organizations promoting closer ties among the scientific communities of the Americas and the Caribbean.

International Scientific Cooperation

The Consortium of Affiliates for International Programs (CAIP) acts as a clearinghouse for information of concern to AAAS affiliates and foreign scientific and engineering societies with shared international interests. CAIP also publishes an annual directory of its members as well as a newsletter, Consortium News.

Other activities include a series of seminars for science counselors and attachés posted to foreign embassies in Washington, D.C.; bilateral initiatives to foster links with Europe and the Soviet Union; and a new series of occasional lectures by distinguished members of foreign scientific and engineering communities who are visiting Washington, D.C.

Science and Policy Programs

The Directorate for Science and Policy Programs implements AAAS objectives in those areas where science, government, and society come together.

The staff is assisted by three entities: the board-appointed Committee on Science, Engineering, and Public Policy (COSEPP); the board- and council-appointed Committee on Scientific Freedom and Responsibility (CSFR); and the AAAS/American Bar Association National Conference of Lawyers and Scientists.

Science, Technology, and Government

The R&D Budget and Policy Program analyzes the research and development component of each year's federal budget; presents the results at the annual **Science and Technology Policy Colloquium** in April (see Calendar, p.TK); and publishes three reports covering federal R&D budgets as a whole. Recently the program also prepared a special report on the federal R&D budget trends during the Reagan years.

In addition, several fellowship programs serve to provide scientific and engineering expertise to federal and congressional offices (see AAAS Fellowships, p.tk).

Science and Human Rights

This program promotes the application of science to the protection of human rights. Program participants make regular appeals on behalf of hundreds of scientists around the world whose human rights are being violated. In addition, the program sponsors forensic missions and workshops to countries troubled by human rights abuses, including Argentina, West Bank/Israel, and most recently, Brazil.

New in 1991: A forensic fellowship for physicians from developing countries

concerned about human rights (see AAAS Fellowships, p.tk), and a project linking scientists with efforts to protect the rain forest and the human rights of indigenous peoples.

Scientific Freedom, Responsibility, & Law

Workshops, symposia, seminars, and publications stimulate discussion about scientific misconduct and fraud, professional ethics, and social issues such as computer abuse and the use of animals in research.

New in 1991: In July, the program will sponsor a workshop that will be the first systematic, national effort to recruit minorities into research on the values and ethical implications of science and technology (see Calendar, p.TK). Also newly launched is an exploration into the ethical and legal implications of genetic testing.

Among other ongoing projects, the results of a study on how national security controls affect unclassified science and engineering research will be available in 1991.

AAAS Sections and Their Secretaries

(A) Mathematics

Warren Page, 30 Amberson Ave., Yonkers, NY
10705

(B) Physics

Rolf M. Sinclair, National Science
Foundation, 1800 G St., N.W., Washington, DC
20550

(C) Chemistry

Blaine C. McKusick, 1212 Bruce Rd.,
Carrcroft, Wilmington, DE 19803

(D) Astronomy

Nancy Houk, Dept. of Astronomy, 1041 Dennison
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48109-1090

(E) Geology and Geography

Dana Isherwood, Lawrence Livermore National
Lab., P.O. Box 808, L-1, Livermore, CA 94550

(G) Biological Sciences

Judith P. Grassle, Institute of Marine and
Coastal Sciences, Cook College, P.O. Box 231,
Rutgers University, New Brunswick, NJ 08903

(H) Anthropology

Anna C. Roosevelt, c/o Weld, 28 Fayerweather
St., Cambridge, MA 02138

(J) Psychology

William N. Dember, Dept. of Psychology (ML
#376), University of Cincinnati, Cincinnati,
OH 45221-0376

(K) Social, Economic, & Political Sciences

William R. Freudenburg, Dept. of Rural
Sociology, University of Wisconsin, 1450
Linden Dr., Rm. 350, Madison, WI 53706

(L) History & Philosophy of Science

Edward Manier, Dept. of Philosophy,

University of Notre Dame, Notre Dame, IN
46556

(M) Engineering
W. Edward Lear, 5900 S.W. 35th Way,
Gainesville, FL 32608

(N) Medical Sciences
Lewis H. Kuller, A527 Crabtree Hall,
University of Pittsburgh, GSPH, 130 DeSoto
St., Pittsburgh, PA 15261

(O) Agriculture
Kenneth J. Frey, Dept. of Agronomy, Iowa
State University, Ames, IA 50010

(P) Industrial Science
Robert L. Stern, 2000 P St., N.W., #608,
Washington, DC 20036

(Q) Education
Ann C. Howe, 2311 Benjamin Bldg., University
of Maryland, College Park, MD 20742-1175

(R) Dentistry
Thomas R. Dirksen, School of Dentistry,
Medical College of Georgia, Augusta, GA
30912-1000

(S) Pharmaceutical Sciences
Betty-ann Hoener, School of Pharmacy,
University of California, San Francisco, CA
94143-0446

(T) Information, Computing & Communication
Elliot R. Siegel, National Library of
Medicine, 8600 Rockville Pike, Bethesda, MD
20894

(U) Statistics
R. Clifton Bailey, Health Standards and
Quality, ME 2-D-2, Health Care Financing
Administration, 6325 Security Blvd.,
Baltimore, MD 21207

(W) Atmospheric & Hydrospheric Sciences
William H. Beasley, Center for Analysis and
Prediction of Storms, University of Oklahoma,
401 E. Boyd, Norman, OK 73019-0515

(X) Societal Impacts of Science & Engineering
Rachelle D. Hollander, 616 E. 34th St.,
Baltimore, MD 21218

(Y) General Interest in Science & Engineering
James M. McCullough, National Science
Foundation, 1800 G St., N.W., Rm. 425,
Washington, DC 20550

AAAS Awards

The following awards are given each year to scientists, engineers, journalists, and public servants for their contributions to science and technology.

* **AAAS Hilliard Roderick Prize**, for an outstanding contribution to the understanding of issues related to arms control and international security, with an important scientific or technical dimension.
Contact: Thomas Wander 202-326-6496

* **AAAS Newcomb Cleveland Prize**, to the author(s) of the year's best article, research article, or report published in Science.
Contact: Sylvia Kihara 202-326-6507

* **AAAS Philip Hauge Abelson Prize**, to a public servant in recognition of sustained contributions to advancing science, or to a scientist whose career has been distinguished by scientific achievement as well as by notable service to the scientific community.
Contact: Mark Frankel 202-326-6793

* **AAAS Prize for Behavioral Science Research**, to the author(s) of a meritorious paper that furthers understanding of the psychological-social-cultural behavior of people.
Contact: Janice Merz 202-326-6621

* **AAAS Scientific Freedom and Responsibility Award**, to the scientist or engineer whose actions protected the public's welfare, furthered responsible public policy debates, carried out the social responsibility of scientists and engineers, or defended their professional freedom.
Contact: Mark Frankel 202-326-6793

* **AAAS Westinghouse Award for Public Understanding of Science and Technology**, to a scientist or engineer who has contributed to

the popularization of science and technology
and who is not a working journalist.
Contact: Patricia Curlin 202-326-6602

*** AAAS Westinghouse Science Journalism
Awards**, for outstanding science reporting on
the natural sciences for newspapers, general
magazines, radio, and television.
Contact: Joan Wrather 202-326-6431

AAAS Fellowships

The AAAS Congressional Science and Engineering Fellowship places two scientists for one year with members of Congress or congressional committees.

Application deadline: January 15

Contact: Science & Policy Programs 202-326-6600

The AAAS Environmental Science and Engineering Fellowship offers an opportunity for summer-long research at the Environmental Protection Agency on topics of agency interest.

Application deadline: March 1

Contact: Claudia Sturges 202-326-6600

The AAAS Mass Media, Science, and Engineering Fellowship provides science and engineering students with summer-long internships as science reporters for various media outlets.

Application deadline: February 1

Contact: Susan Sauer, 202-326-6605

The AAAS Science, Engineering, and Diplomacy Fellowship provides scientific expertise to the State Department and the Agency for International Development.

Application deadline: January 15

Contact: Science & Policy Programs 202-326-6600

The AAAS Sloan Executive Branch Science and Engineering Fellowship places industrial scientists and engineers at the White House Office of Science and Technology Policy to work on industrial competitiveness, technology transfer, manufacturing technology, and related issues.

Application deadline: February 1

Contact: Science & Policy Programs 202-326-6600

1991 AAAS Calendar At-a-Glance

February

14-19...AAAS annual meeting, Washington, D.C.

April

18-21..."Malaria Strategies for Africa."
Workshop in Lomé, Togo.

19.....Pacific Division West Coast
Conference on R&D in the 1992 Federal
Budget in Palo Alto, California.

11-12...Colloquium on Science and Technology
Policy in Washington, D.C.

May

15-18...Southwestern and Rocky Mountain
Division annual meeting in Lubbock,
Texas.

22-24...Arctic Division annual meeting in
Fairbanks, Alaska.

June

23-27...Pacific Division annual meeting in
Logan, Utah.

July

28-4 August...Workshop on Values and Ethical
Issues in Science and Technology for
Minority Scholars, location TBA.

October

11-12...Forum for School Science, Technology
and the Teacher, in Arlington, VA.

21-23...Human Genome Conference in San Diego,
CA.

December

12-13...Colloquium on Science and Security in
Washington, D.C.

AAAS Directory

American Association for
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1333 H St., NW
Washington, DC 20005
202-326-6400

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Ellis Rubinstein (Deputy Editor)
Monica Bradford (Managing Editor)
202-326-6500

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Subscriptions: (see Membership &
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Director: Shirley M. Malcom 202-326-6680

International Programs
Director: Richard W. Getzinger 202-326-6655

Science and Policy Programs
Director: Albert H. Teich 202-326-6600

Project 2061
Director: F. James Rutherford 202-326-6627

Communications
Director: Denise Graveline 202-326-6440

Development
Director: Jeannette Wedel 202-326-6636

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Director: Arthur Herschman 202-326-6450

Membership & Circulation
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Publications

Director: Patricia A. Morgan 202-326-6439

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STAFF LOCATIONS & TELEPHONE NUMBERS

during the

ANNUAL MEETING * WASHINGTON, DC * 14-19 FEBRUARY 1991

SHERATON WASHINGTON HOTEL: (202) 328-2000

<u>STATION</u>	<u>LOCATION/ROOM</u>	<u>PRIVATE PHONES</u> (outside calls)	<u>HOUSE PHONES</u> (in-house calls)	<u>PERSONNEL STATIONED</u>
Meeting Headquarters Office	Lanai Rm. #152	745-0346	7152 or 2605	Arthur Herschman / Robin Woo / Elisabeth Zeuschel / Rosita Johnson/ Michelle Games / CB staff
Meeting Registration	Atrium	None	None	Linda Sutton / Dottie Smith / CB staff
Information Desk	Atrium	745-0693	2611 or 2612	Gwen Huddle / CB staff
Message Center	Atrium	328-2000 (ask for ext. 2405)	2404 or 2405	CB staff
Exhibitor Registration	Atrium	328-2000 (ask for ext. 2610)	2610	CB staff / <u>Messages only for Ed Leonardo</u>
Resource Room for Disabled Registrants	Lanai Rm. #144	745-0747	7144	Judy Kass / Betty Ingraham
Session Aides Office	Lanai Rm. #156	745-0756	7156	Mystique Lassiter
Speakers' Ready Room & Meetings International	Lanai Rm. #148	328-2000 (ask for ext. 7148)	7148	Marty Nash / Bill Parker / projection crew
Employment Exchange	Exhibit Hall B	328-2000 (ask for ext. 3601)	3601	Jacque Roberts / Laurie Baker / CB staff
Poster Sessions	Exhibit Hall C	None	None	Michelle Games
MOBILTAPE Workroom	Lanai Rm. #160	328-2000 (ask for ext. 7160)	7160	Bruce Parker / Mike Zeilinger/ Mark Zeilinger / Steve Holloway
MOBILTAPE Sales Desk	Convention Desk A (Lobby Level)	None	None	MOBILTAPE staff
SB&F Science Film Festival	Atrium Room NO. 1	None	None	Maria Sosa

OVER.....

<u>STATION</u>	<u>LOCATION/ROOM</u>	<u>PRIVATE PHONES</u> (outside calls)	<u>HOUSE PHONES</u> (in-house calls)	<u>PERSONNEL STATIONED</u>
NEWSROOM::				
- Press Headquarters	Calvert Room	745-7585	2876	Denise Graveline / Joan Wrather / Shirlene Brooks / Mary Gannon / Eleanor Mohammed / CB staff
- Papers/Files	Johnson Room	328-2000 (ask for ext. 2879)	2879	Linda McDaniel / Scherraine Mack

AAAS BOOTHS — EXHIBIT HALL C:

STAFF IN CHARGE:

- SCIENCE Magazine	Booth #515	None	None	Arlene Ennis
- Science and Policy Programs	Booth #517	None	None	Elizabeth Broughman
- Project 2061	Booth #519	None	None	Gary Hammond
- Membership and Circulation	Booth #521	None	None	Marlene Zendell / Mary Curry
- Education and Human Resources Progs.	Booths #520/522	None	None	Barbara Walthall
- Publications Office	Booths #516/518	None	None	Roberta Wagner
- Senior Scientists and Engineers	Booth # 119	None	None	Laura Mann

OMNI SHOREHAM HOTEL: (202) 234-0700

AAAS Information Desk West Registration ... 234-0700 (ask 6791 CB personnel
Counter for ext. 6791)

MEDICAL EMERGENCY OR FIRE

1. Go to nearest house phone.
2. Dial "0" (Operator).
3. Report location & nature of emergency.

Program Changes

AAAS Annual Meeting
Washington, DC ❖ 14 - 19 February 1991

Open Forum with Fang Li Zhi

Scientific Collaboration with China and the Human Rights Issue

Monday, 18 February, 4:30-6:30 pm, Omni Shoreham/Empire Room

Chair: Walter Reich (*Woodrow Wilson International Center for Scholars, Smithsonian Institution Bldg., Washington, DC*)

Speakers: Fang Li Zhi (*Institute for Advanced Study, Princeton, NJ*), Li Shuxian (*Institute for Advanced Study, Princeton, NJ*), and Anne F. Thurston (*China specialist and writer*)

Dissident scientists Fang Li Zhi and his wife, Li Shuxian, were allowed to leave the People's Republic of China in June 1990 after a year in the U.S. Embassy in Beijing. They sought sanctuary there after learning of possible government retaliation following the Tiananmen Square massacre.

Focus on the Gulf War

Sessions of special interest in light of the war.

35T-1. Naval Forces and Arms Control: Implications for U.S. Security, Saturday, 16 February, 2:30 pm (Program page 83).

Featured speech: Eric H. Arnett on Sea-launched Cruise Missiles and Arms Control.

35-7. Scientific Approaches to the Study of International Conflict Resolution, Monday, 18 February, 2:30 pm (Program page 82).

New Topic: Richard W. Cottam on Nationalism as a Source of Conflict: An Iraqi Case Study

35-5. Chemical and Biological Weapons: Elimination or Proliferation?, Monday, 18 February, 2:30 pm (Program page 81).

35-4. Implications of Proliferating Advanced Weaponry: Nuclear, Chemical, Missile, and Naval Forces, Tuesday, 19 February, 8:30 am (Program page 81).

New Information for Sessions

36-1. Policy Issues in Science and Technology (Program page 83).

8:30 am / Fri / 15 Feb

Sheraton / Colorado

Resources for Scientific Research

Presiding: Ellis Rubinstein (*Deputy Editor, Science, AAAS, Washington, DC*)

Science: The End of the Frontier? A Perspective on Funding for Academic Science

Donald N. Langenberg (*Chancellor, Univ. of Maryland, Adelphi, MD, and President, AAAS, Washington, DC*)

Funding for Academic Science: Is There a Crisis?

Robert M. Rosenzweig (*President, Association of American Universities, Washington, DC*)

Support for University Research: A View from the Field
Raymond Orbach (*Provost, College of Letters and Science, Univ. of California, Los Angeles, CA*)

Their Most Productive Years: A Report on the American Physical Society's 1990 Survey of Young Faculty

Daniel Kleppner (*Lester Wolfe Professor of Physics, MIT, Cambridge, MA*)

Additional speaker to be announced.

2:30 pm / Fri / 15 Feb

Sheraton / Colorado

The Climate for Research

Presiding: Wil Lepkowski (*Senior Editor, Chemical and Engineering News, American Chemical Society, Washington, DC*)

An Industry Perspective on the Climate for Research

S. Allen Heininger (*Former Vice President for Resource Planning, Monsanto Co., St. Louis, MO*)

The Climate for Research: A Federal Agency Perspective
Alan I. Leshner (*Acting Director, National Institute of Mental Health, Rockville, MD*)

On Doing Research in Academia in the 1990s
Howard K. Schachman (*Professor of Molecular Biology, Univ. of California, Berkeley, CA*)

Additional speakers to be announced.

38W-3. Scientist-Teacher Partnerships in Middle School Science and Technology Education (Program page 97).

8:30 am / Fri / 15 Feb Sheraton / Woodley

Presiding: Gerald Kulm

Using Technology and a Hands-on Approach to Teach Science Objectives

Bruce T. Snyder (*Chairperson, Science Dept., Redland Middle School, Gaithersburg, MD*), Hannah Spalding (*Director of Purchasing, Bell Atlantic Corp., Arlington, VA*), and Brian Wienhold (*Hydrologist, U.S. Dept. of Agriculture, Beltsville, MD*)

Photons and Glass Can Be Fun in Your Class

Anthony A. Alastick (*Teacher, Timberlane Junior High School, Pennington, NJ*) and Clifford W. Draper (*Supervisor, AT&T Bell Labs, Princeton, NJ*)

Technology Across the Curriculum

Patricia Janas (*Teacher, East Amwell Elementary School, Ringoes, NJ*) and Clifford W. Draper.

Exploring Science and Technology Through Toys and Everyday Objects

Daisey R. Holley (*Teacher, Sissonville Junior High School, Sissonville, WV*), Gail Withrow (*Teacher, Sissonville Junior High School, Sissonville, WV*), and E.S. Hanrahan (*Dean, College of Science, Marshall Univ., Huntington, WV*)

Overview of the Bell Atlantic-AAAS Institute Summer Graduate Program

George W. Bynum (*Teacher, Brandywine High School, Wilmington, DE*)

Speaker and Room Changes

Saturday, 16 February

22-5. The Progesterone Antagonist RU-486: Science and Science Policy, 2:30 pm (Program page 41).

Change in Speaker: H. H. Sedlacek will be replaced by Andre Ullmann.

36-2. Science Advice to National Leaders, 8:30 am (Program page 84).

Change in Speaker: W. D. P. Stewart is being replaced by Lord Frederick S. Dainton (*Chairman, House of Lords Select Committee on International Scientific Programs, UK*)

Additional Speakers:

Advising the Government of India on Science and Technology
M. G. K. Menon (*Minister of Science and Technology, Government of India, and President, International Council of Scientific Unions, New Delhi, India*)

Science Advice in Brazil

José Goldemberg (*Secretary of State for Science and Technology, Government of Brazil, Brasília, Brazil*)

Sunday, 17 February

26-1. Alternative Approaches to Clinical Trials in AIDS: Ethics and Methodology, 8:30 am (Program page 56).

Change in Speaker: Ellen C. Cooper is being replaced by Paul R. Beninger (*Acting Deputy Director, Division of Antiviral Drug Products, Food and Drug Administration, Rockville, MD*).

35-1. Defense Technology and Policy After the Cold War, 2:30 pm (Program page 79).

Change in Topic and Speaker Order: Kosta Tsipis will be the last speaker in the afternoon session. *Topic:* Redeploying Research Resources from Military to Civilian Use

36-3. Organization for Science and Technology in the Executive, Legislature, and Judiciary, 8:30 am and 2:30 pm (Program page 84).

Speaker Order: David Z. Robinson will speak first followed by David Z. Beckler. In the afternoon session, H. Guyford Stever will be the last speaker.

Monday, 18 February

L-11. Plenary Lecture by Fang Li Zhi (Program page 3).

Affiliation Change: Fang Li Zhi is now at the Institute for Advanced Study, Princeton, NJ

Presider Change: Robert A. Frosch will be replaced as presider by Joseph G. Gavin (*Board of Directors, AAAS, Washington, DC*)

11-4. Can Electronic Publishing Solve the Science Library Crisis?, 8:30 am (Program page 13).

Change in Speaker: Stuart Rothenstein will be replaced by Theresa Murtha (*Director, Information Services, J. B. Lippincott Co.*)

35T-2. Fissile Materials from Nuclear Arms Reductions: A Question of Disposition, 8:30 am (Program page 83).

Speakers Cancelled: C. H. Bloomster, M. H. Killinger, P. L. Hendrickson, and Spartak T. Belyaev.

Speakers Added: Uri Gat, R. J. Engel, H. L. Dodds. *Topic:* Molten Salt Reactors: Versatile, Safe, Efficient, Flexible Fuel Utilizers.

Speaker Added: Aleksandr D. Sanin (*USSR Academy of Science*). *Topic:* Possible Procedures of Dismantlement and Verification of Nuclear Warheads.

Tuesday, 19 February

L-14. Plenary Lecture by James D. Watkins (*Secretary, U.S. Dept. of Energy, Washington, DC*) (Program page 3).

Room Change: Moved from Sheraton North Ballroom to Washington Ballroom.

11T-2. Stereo Computer Imaging and Analysis in Science, 8:30 am (Program page 15).

Speaker Order as Follows: Robert S. Ledley, Boyd MacNaughton, Michael W. Vannier, J. F. Greenleaf, James V. Jester, Lee D. Peachy.

AAAS★91

THE AAAS ANNUAL MEETING

SCIENCE ENCOUNTERS '91

*Plus a Student Guide to the
AAAS Annual Meeting*

WASHINGTON, DC

14-19 February 1991





Welcome to Science Encounters '91

A hearty welcome to each and every participant in the Youth Symposium of the 1991 AAAS Annual Meeting. Today's program is aimed at increasing your curiosity and stimulating your interest. We have an excellent group of scientists who are eager to share with you their enthusiasm and excitement about science and their joy and pride in doing science. It is part of the responsibility of scientists to communicate science to nonscientists; this Youth Symposium is a good example of carrying out that responsibility.

We live in a world full of scientific advances and technological achievements — a world that enjoys the tremendous benefits of those advances and achievements and a world that is at risk if the potential hazards of those same advances and achievements are not understood and controlled.

Each of us is naturally curious about the world. We ask questions and seek answers. Why is the sky blue? Why do tree leaves change color in the fall? Why do plants and flowers burst in the spring? Why are soap bubbles colorful, and why do they float? Why do we see colors when we look at a wet pavement where gasoline or oil has been spilled? Are the colors of the bubbles related to the colors on the wet pavement? Why do we see "white caps" when a strong wind is blowing on a body of water? Is the color of the "white caps" related to the color of clouds? How does a microwave oven work? How do microchips work, and how are they made? What are fractals? What are quasars? What are quarks and leptons? What is the superconducting supercollider? What is a black hole? Is there life elsewhere in the universe? How do we search for extraterrestrial intelligence? Why do some credit cards have a hologram? How does the laser printer work? What is a neurotransmitter, and what does it do? How do drugs treat illness? What is MRI (magnetic resonance imaging)? How does a nuclear power plant work? How do we dispose of nuclear

waste safely? Why is burning rain forests bad for the environment? What is "global warming" anyway? What are the consequences of depletion of the ozone layer, and how does it happen? What is the probability of winning a state lottery? Why does a firefly glow? Why are there four seasons? How do we know that the earth revolves around the sun (a recent study shows that 20% of Americans believe the sun revolves around the earth)? Why do we want to map the human genome? How will we do it? The list goes on and on! Science deals with such questions in disciplined and rational ways.

Today's program is part of a national strategy with a dual mission aimed at enhancing the quality of science education in America. The first part of the mission is to increase the flow of talented individuals — including women, minorities, and the disabled — to careers in science and careers of teaching science. We want to entice *you* to become a scientist. Ask any scientist and he or she will tell you science that is both intellectually stimulating and emotionally rewarding. Also, that science is fun! Fun in the true sense of the word and not in some cheap thrill fashion. As scientists tackle questions and are confronted with challenges, they encounter frustrations and often suffer setbacks, but if they persevere, they do, in due time, reach conclusions and achieve results.

The second part of the mission is to achieve science literacy among those who choose not to become scientists — the vast majority of the participants in today's program. It is essential for the well being of our society that *all* citizens develop an appreciation and understanding of science, the benefits of technology, and the potential risks associated with advances in both. We need a public at large that can distinguish between astronomy and astrology; we need to have our fellow citizens enjoy the benefits of the great advances in the nutritional sciences; we need an educated public that can deal successfully with the complex issues related to animal rights; we need to have our fellow citizens act in rational and responsible ways when dealing with environmental issues; in short, we need a scientifically literate society. Science literacy is a measure of what we value as a society, how we treat each other, how we treat the environment, and how we treat the other inhabitants of the planet.

Throughout the day — and when you go back to school — be alert and attentive. Allow your mind to be challenged and do not hesitate to ask questions. Be inquisitive and observant when you go to the National Zoo, the National Aquarium, any of the Smithsonian museums, a botanical garden, science centers, and just about everywhere. Think about what you see, smell, and hear. Formulate questions or explanations and discuss them with your friends, family, teachers, and neighbors. Collaborate with your friends, teachers, family members, and others to improve your understanding of the wonderful world we live in. Support the educational mission of your school and community. Remember, the ultimate purpose of education is to enable *you* to fulfill your human potential.

— BASSAM Z. SHAKHASHIRI
*Professor of Chemistry, University of Wisconsin–Madison
and Chair, Science Encounters '91*

Science Encounters '91

and a Student Guide to the AAAS Annual Meeting

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 **Bell Atlantic**
Charitable Foundation

AAAS wishes to acknowledge and thank the Bell Atlantic Charitable Foundation for its support of Science Encounters '91. This program is an important link in drawing students' interest to science and technology.

Student Notes

Standards of conduct: All who attend the AAAS Annual Meeting will conduct themselves with consideration for others and with particular consideration for those who generously give their time and thought to the sessions.

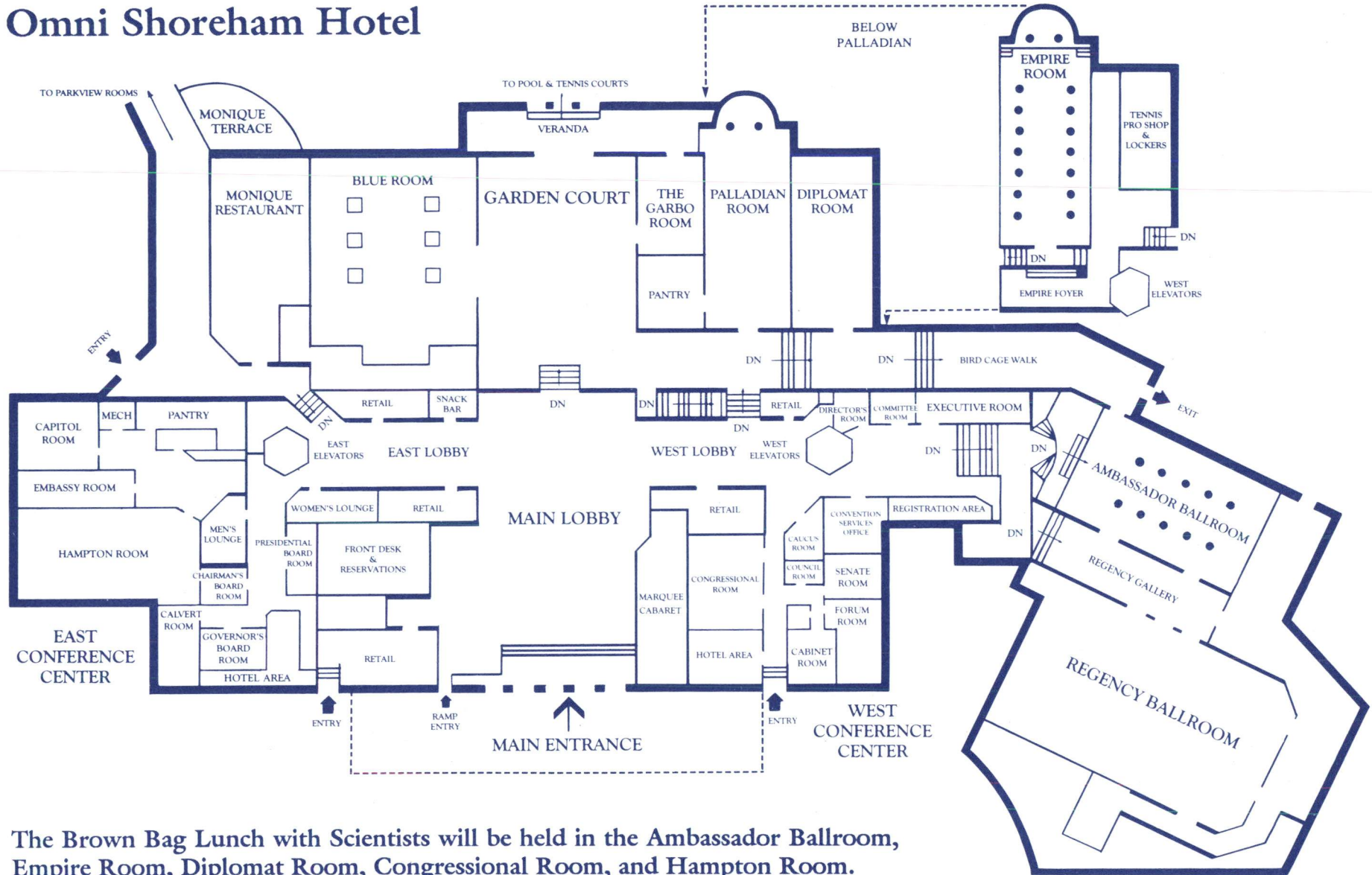
No smoking rule: All persons attending the Annual Meeting must refrain from smoking at scientific and public sessions.

Taping sessions: Video and/or audiotaping of any sessions or parts thereof for commercial purposes is not permitted without prior approval from the speakers and from the American Association for the Advancement of Science.

This program was compiled by Judy Kass, Barbara Walthall, and Betty Calinger of the AAAS Directorate for Education and Human Resources Programs and Sue O'Connell of the AAAS Publications Office. Cover design by Elisabeth Carroll.

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Omni Shoreham Hotel



The Brown Bag Lunch with Scientists will be held in the Ambassador Ballroom, Empire Room, Diplomat Room, Congressional Room, and Hampton Room.

All other sessions of Science Encounters '91 will be held in the Regency Ballroom.

Science Encounters '91

New Frontiers in Science and Technology

Regency Ballroom, Omni Shoreham Hotel

Presiding: David L. Crippens

(Senior Vice President, Educational Enterprises, KCET-TV, Los Angeles, CA, and Member, AAAS Committee on Public Understanding of Science and Technology)

REGISTRATION

9:00 am–9:45 am

WELCOME AND OPENING REMARKS

9:45 am–10:30 am

Welcome

James B. Walker (*Director, Public Affairs, C&P Telephone, A Bell Atlantic Company, Washington, DC*) and William Brown (*Acting Superintendent of Public Schools, Washington, DC*)

Opening Remarks

Leon M. Lederman (*Director Emeritus, Fermi National Accelerator Laboratory, Batavia, IL, and President-Elect, AAAS*)

PANEL DISCUSSION

“Cutting Edge Issues in Science”

10:30 am–11:30 am

Moderator: Bob Hirschon (*Producer/Host, “Science Update” Radio, Directorate for Education and Human Resources Programs, AAAS, Washington, DC*)

Panelists

Susan Forte (*U.S. Department of Agriculture National Agro-science Ambassador, Gulf Breeze, FL*)

Matthew George (*Assistant Professor, Department of Biochemistry, Howard University, Washington, DC*)

Jeff Goldstein (*Astrophysicist, Laboratory for Astrophysics, National Air and Space Museum, Smithsonian Institution, Washington, DC*)

Betty Mandel (*Engineer, Topography Laboratory, U.S. Army Corps of Engineers, Fort Belvoir, VA*)

Eileen L. Shea (*Deputy Director for Climate and Global Change Program, National Oceanic and Atmospheric Administration, Silver Spring, MD*)

BROWN BAG LUNCH WITH SCIENTISTS

11:45 am–12:45 pm

Small group discussions with over 100 scientists

Chemistry Is Fun!

1:00 pm–1:30 pm

Bassam Shakhshiri (*Professor of Chemistry, University of Wisconsin, Madison, WI, and Chair, Science Encounters '91*)

A Student Guide to AAAS☆91

Thursday, 14 February

Plenary Lecture

8:30 pm "Keynote Address"
 Invited Speaker: George H. W. Bush (*President of the United States of America*) [SW/Sheraton Ballroom]



Friday, 15 February

Plenary Lectures

1:00 pm "The Human Genome Project and HUGO"
 Speaker: Sir Walter Bodmer (*Director of Research, Imperial Cancer Research Fund, London, UK*) [SW/Washington Ballroom]

8:30 pm "Results from the Hubble Telescope"
 Speaker: Riccardo Giacconi (*Director, Space Technology Institute, Baltimore, MD*) [SW/Sheraton Ballroom]

Featured Symposia

10-1. Frontiers of the Physical Sciences: 1991

Organized by: Rolf M. Sinclair (*Program Director, Physics Division, National Science Foundation, Washington, DC*)

8:30 am / Fri / 15 Feb Omni Shoreham / Hampton

Presiding: Rolf M. Sinclair

Large Telescopes of the Future

J. Roger P. Angel (*Professor of Astronomy, Univ. of Arizona, Tucson, AZ*)

Enzyme Mimics

Ronald Breslow (*Professor of Chemistry, Columbia Univ., New York, NY*)

The Laser Interferometer Gravity Wave Observatory: Opening a New Frontier in Astrophysics

Rochus Vogt (*Director, L.I.G.O., California Institute of Technology, Pasadena, CA*)

2:30 pm / Fri / 15 Feb Omni Shoreham / Hampton

Presiding: Rolf M. Sinclair

Arranging Points on a Sphere

Neil J.A. Sloane (*Research Staff, AT&T Bell Laboratories, Murray Hill, NJ*)

Volcanoes Under the Sea: The Last Frontier of Global Vulcanology

Katharine V. Cashman (*Assistant Professor of Geology, Princeton Univ., Princeton, NJ*)

Toward a Science of Storm-scale Weather Prediction

Kelvin Droegemeier (*School of Meteorology, Univ. of Oklahoma, Norman, OK*)

This session will explore the limits of our current understanding of the physical sciences — where knowledge and speculation end — and will suggest what some of the next advances may be. The presentations are intended for a general audience.

[Sponsors: AAAS Sections A, B, C, D, E, and W.]

33-4. The Social Pathology of Large Cities

Organized by: Keith D. Harries (*Professor and Chair, Dept. of Geography, Univ. of Maryland-Baltimore County, Baltimore, MD*)

2:30 pm / Fri / 15 Feb Sheraton / Warren

Presiding: Keith D. Harries

Black Philadelphia Then and Now: The "Underclass" of the Late 20th Century Compared with the Poorer African-Americans of the Late 19th Century

Roger Lane (*Benjamin R. Collins Professor of Social Sciences, Haverford College, Haverford, PA*)

Emerging Settlement Patterns: Implications for the Inner City Poor

Mark Alan Hughes (*Assistant Professor, Woodrow Wilson School, Princeton Univ., Princeton, NJ*)

Does a Growing Underclass Threaten to Undermine Black Progress?

Sarah S. McLanahan (*Professor, Office of Population Research, Princeton Univ., Princeton, NJ*)

Why Homelessness Won't Go Away

Michael J. Dear (*Professor of Geography, Univ. of Southern California, Los Angeles, CA*)

Crimes in the Capital City: Case Study of Washington, DC

DeWitt Davis, Jr. (*Associate Professor, Dept. of Geography, Univ. of the District of Columbia, Washington, DC*)

Given that the AAAS meeting is located in Washington, DC, a city with extremely serious social problems, it is appropriate to focus on issues generically referred to as "social pathology." The first speaker will provide an historical perspective of urban pathology, a sense of how urban social problems have evolved and reached the stage that exists today in the typical U.S. city. The literature shows that a phenomenon that has come to be known as the underclass has attracted considerable attention in that many particular pathologies are found to reside overwhelmingly in underclass neighborhoods. Two of the speakers will touch on the underclass issue. One will provide an overview of the dimensions of the underclass; the other will focus more specifically on underclass demographics and address the question of whether the underclass is growing. The fourth speaker will address the critical issue of housing, and the final speaker will assess another critical problem:

Hotel Key

OS = Omni Shoreham SW = Sheraton Washington

street violence. The underclass, homelessness, and violence are all highly visible issues in Washington, DC, and other major metropolitan areas in the United States. Washington, however, has achieved singular notoriety as a result of its ranking as "the murder capital of the United States." A scholarly review of several of the principal issues surrounding urban pathology will be timely.

[Sponsors: AAAS Sections E and X. Cosponsor: AAAS Section H.]

Other Symposia

12-3. Scientific Advances in Emerging Solar Energy Technologies (Fri/pm, OS/Congressional). Photovoltaics, biomass. Org.: H.M. Hubbard (Midwest Research Inst.); Robert L. San Martin (DOE); Barbara Farhar (Solar Energy Research Inst.)

13-1. Seventy-five Years of General Relativity (Fri/am, OS/Diplomat). Gravitation, quantum theory. Org.: Arthur B. Komar (Yeshiva Univ.)

15-3. Impacts of the Climate During the 1980s in the United States (Fri/am, OS/Ambassador). Major events and surprises, socioeconomic impacts, effects on policy. Org.: Stanley A. Changnon (Illinois State Water Survey)

16-1. Making Informed Decisions for Planet Earth: Role of Satellite Measurements for a Safe Environment (Fri/pm; Sat/am-pm, OS/Ambassador). Space application data, environment policy, international concerns. Org.: Philip H. Abelson (AAAS); Gerald Soffen (NASA); Paul F. Uhlir (Natl. Academy of Sciences)

21-1. The Revolution in Developmental Biology (Fri/pm; Sat/am, SW/Sheraton South). Embryogenesis, animal models, gene conservation. Org.: Arthur S. Levine, Igor Dawid, Heiner Westphal (NICHD)

22-6. Prospects for Immunocontraception (Fri/pm, SW/Cotillion South). Vaccines, gamete antigens. Org.: John C. Herr (Univ. of Virginia)

22-8. Control of Infectious Diseases: New Aspects of Vaccines (Fri/am, SW/Cotillion South). Org.: Donald A. Henderson (Johns Hopkins Univ.)

22-9. Scientific and Statistical Inferences in Modeling Animal Research (Fri/am, SW/Baltimore). Animal models, biological references, alternatives, ethics. Org.: Ethel Tobach (Amer. Mus. Natural History)

26-3. DNA-based Identification Systems (Fri/am-pm, SW/Arlington). Statistical problems, impact on civil liberties. Org.: Paul Billings (Pacific Presbyterian Med. Ctr.); Nachama L. Wilker (Council for Responsible Genetics); Donald A. Berry (Univ. of Minnesota)

30-1. The Anthropology of Science and Scientists (Fri/pm; Sat/am-pm; Sun/am, SW/Sheraton North). Universality, knowledge formation, behavior, crosscultural traditions. Org.: Laura Nader (UC-Berkeley)

32-1. Scientific and Technical Personnel in the 1990s (Fri/am-pm, SW/Idaho). Pipeline issues — minorities/females, age and performance. Org.: Alan Fechter (Natl. Research Council)

37-4. Creative Couples and Gender Complementarity: Cross-disciplinary Perspectives (Fri/pm, SW/Kansas). Cooperation, conflict, career moves, publication strategies. Org.: Helena M. Pycior (Univ. of Wisconsin); Nancy G. Slack (Yale Univ.); Pnina G. Abir-Am (Northeastern Univ.)

SB&F Science Film Festival

[SW/Atrium Room 1]

10:00 am Why Can't I Fly Like a Bird

Why do birds fly? Why do turtles have a shell? Why do skunks smell? Why do we breathe? This production provides simple answers to these and other questions commonly asked by young children.

10:15 am Growing, Growing

Topics covered in this delightful and superb film include plant parts, what plants need to grow, the role and diversity of seeds, and how plants change with the seasons. This special film teaches in an open-ended context that makes possible further explorations by students and teachers.

10:30 am Push and Pull: Simple Machines at Work

Using examples relevant to the lives of young students, this video successfully introduces the concepts of work and simple machines to students in the primary grades. The real-life examples include playground equipment and toys, which help to make the learning fun.

10:55 am Life on Ice

White and various shades of blue, the predominant colors of this excellent film, help set the appropriate mood for the environment portrayed — the icy Arctic Ocean. The theme is the Arctic food chain, developed by focusing on the lifestyles and interactions of a variety of organisms.

11:30 am Volcano Scapes 3: Living on the Edge!

This timely and stunning video documents the recent activity of Kilauea, the world's most active volcano. The makers of this video have captured the devastation and splendor of Pele's most destructive eruption in this century as the beautiful coastal community of Kalapana is enveloped in the fiery flow.

12:30 pm The Immune System: Your Magic Doctor

This excellent and comprehensive project fully and successfully explains the actual workings of the cells — a complex and difficult task where the immune system is concerned. It accurately portrays the roles of macrophages, B-cells and suppressor cells, killer and helper T-cells, and the communication between these cells in times of health and disease.

12:55 pm Women in Science: Door to the Future

This video provides a realistic examination of the prerequisites for a career in science, prerequisites that have historically been less available to girls than to boys during the crucial high school years.

1:30 pm Greenhouse Crisis: The American Response

This brief video provides a useful introduction to the greenhouse effect and suggests some methods of ameliorating its potential dangers. The well-produced presentation provides a positive message and urges viewers to stop procrastinating and do something about the problem.

1:45 pm Clouded Land

In a very balanced presentation of the issues surrounding the attempt by the U.S. government to redress the loss of Indian reservation land, this video focuses on important cultural similarities and differences between those Chippewa affiliated with the White Earth Reservation in Minnesota and their non-Indian farming neighbors.

2:15 pm The Frontier of Biomedicine

This film explores several fascinating areas of marine biological research including the importance of the squid in nerve research and

the eye of the horseshoe crab in understanding vision. The film should stimulate interest in scientific research among students.

2:45 pm **Chico Mendes: Voice of the Amazon**

The photography of the rain forest is outstanding, while the message conveyed will inform and stimulate environmental activists worldwide. The production is a memorable and well-deserved tribute to Chico Mendes, the Amazon's "voice of reason," who successfully organized worldwide opposition to ongoing activities that eventually led to the creation of Brazil's first extractive reserve in June 1988. Six months later he was murdered.

3:45 pm **Finding Our Way: Men Talk About Their Sexuality**

This documentary features a weekend-long discussion of men's sexuality by 12 participants ranging in age from 27 to 71. The language is adult and candid, but should not present a problem for high school aged viewers and above.



Saturday, 16 February

Plenary Lectures

1:00 pm "Molecular Insights into the Function of Neurotransmitter Receptors and Ionic Channels"
Speaker: Shosaku Numa (*Professor, Depts. of Medical Chemistry and Molecular Genetics, Kyoto Univ. Faculty of Medicine, Kyoto, Japan*) [SW/Washington Ballroom]

1:00 pm "Molecular Robots"
Speaker: Elias J. Corey (*Professor, Dept. of Chemistry, Harvard Univ., Cambridge, MA*) [SW/Sheraton No. Ballroom]

8:30 pm "Science and Technology in Developing Countries"
Speaker: José Goldemberg (*Secretary of State for Science and Technology, Government of Brazil, Brasilia, Brazil*) [SW/Sheraton Ballroom]

Featured Symposia

25-6. Stakes in the Tropical Forest

Organized by: **Robert L. Randall** (*Director, RainForest ReGeneration, Washington, DC*)

8:30 am / Sat / 16 Feb Sheraton / Richmond

Tropical Forests and the Biogeophysiological Equilibrium

Presiding: Thomas E. Lovejoy (*Assistant Secretary for External Affairs, Smithsonian Institution, Washington, DC*)

Tropical Forests and the Global Carbon Cycle
Richard A. Houghton (*Senior Scientist, The Woods Hole Research Center, Woods Hole, MA*)

Atmospheric Chemistry
Peter S. Bakwin (*Postdoctoral Fellow, Division of Applied Sciences, Harvard Univ., Cambridge, MA*)

Climatic Impacts of Amazon Deforestation
Jagadish Shukla (*Director, Center for Ocean-Land-Atmosphere Interactions, Univ. of Maryland, College Park, MD*)

Soil Types and Productivity

Pedro A. Sanchez (*Professor and Director, Tropical Soils Program, Soil Science Dept., North Carolina State Univ., Raleigh, NC*)

Biohydrological Coupling

Helmut Eelsenbeer (*Research Scientist, Section Soil Science, Institute of Geography, Univ. of Berne, Berne, Switzerland*)

2:30 pm / Sat / 16 Feb

Sheraton / Richmond

Tropical Forests: Conservation and Development

Presiding: Thomas E. Lovejoy

The Urgent Transition to Sustainability: Policy Options
Robert Goodland (*The World Bank, Washington, DC*)

Tropical Forest Economics

Jan K. Lewandrowski (*Economist, Economic Research Service, U.S. Dept. of Agriculture, Washington, DC*)

Nonwood Forest Products

Robert O. Mendelsohn (*Associate Professor, Yale School of Forestry and Environmental Studies, Yale Univ., New Haven, CT*)

Debt-for-Nature Swaps

Thomas E. Lovejoy

Making Development and Conservation Compatible

Brian M. Boom (*Associate Curator, New York Botanical Garden, Bronx, NY*)

Roundtable Discussion: How Can We Create a Conservation/Development-compatible Future?

This symposium explores both the role of tropical forests in the global geophysiological equilibrium and the human manipulation of those forests. The first session addresses tropical forests' influence on the geophysiological equilibrium, a term coined by James Lovelock for terrestrial-scale interaction between physical and biological systems. To get a measure of the significance of tropical forests on the equilibrium, the speakers were asked to estimate the effects on the natural equilibrium of a hypothetical 50% reduction in tropical forests and of the complete disappearance of tropical forests. Tropical forests are diminishing principally as a result of human activities. The afternoon session searches for ways of encouraging economic development to relieve the deforestation pressures caused by poverty in the forested tropical countries while conserving natural bioresources. This session stresses political, economic, industrial, and cultural solutions, not simply analysis and interpretation of the present predicament.

[Cosponsors: AAAS Sections G, K, W, and X.]

33-2. Violence and Youth: Research and Prevention Programs

Organized by: Felton J. Earls (*Professor of Human Behavior and Development, Harvard School of Public Health, Boston, MA*)

8:30 am / Sat / 16 Feb

Sheraton / Warren

Presiding: Felton J. Earls

Predicting Teens' Violence Risk: A Developmental Taxonomy
Terrie E. Moffitt (*Associate Professor, Dept. of Psychology, Univ. of Wisconsin, Madison, WI*)

The Development of Violent and Assaultive Youth

Robert B. Cairns (*Professor of Psychology, Univ. of North Carolina, Chapel Hill, NC*) and Beverly D. Cairns (*Professor of Psychology, Univ. of North Carolina, Chapel Hill, NC*)

Developmental Epidemiology, Vulnerability, and Prevention Research on Early Risk Behaviors

Sheppard G. Kellam (*Professor and Chair, Dept. of Mental Hygiene, Johns Hopkins School of Public Health, Baltimore, MD*)

Community-based Skills Development Program as a Preventive Strategy

Dan R. Offord (*Professor of Psychiatry, McMaster Univ., Hamilton, Canada*) and M. B. Jones (*Pennsylvania State Univ. College of Medicine, Hershey, PA*)

This symposium will examine what is known about the risk mechanisms governing the development of aggressive and violent behavior in children and adolescents and critically evaluate the types of prevention efforts currently under way to reduce the incidence of these problems. The range of biological and psychosocial mechanisms explored operate throughout development. They include genetic contributions and biological risk factors affecting prenatal development, such as in utero drug exposures and alterations in the effect of gonadal steroids on brain differentiation. During early development, special consideration is given to the role of the parent-child relationship and other family influences. With the onset of puberty and the transition to early adolescence, concern again shifts to biological aspects of development as well as to peer influences, patterns of substance use, and school achievement. Several approaches to prevention will be discussed. Community and neighborhood programs to promote the development of physical and athletic skills will be presented. Preschool and elementary school programs to foster the development of academic and social skills provide a contrasting approach. The importance of teaching conflict resolution methods and other mediating techniques used to promote nonviolence in youth will also be considered.

[Sponsor: AAAS Section X. Cosponsor: AAAS Section J.]

Other Symposia

14-1. Cosmology: Our Knowledge of the Universe (Sat/am, OS/Diplomat). Past, present, and future observations. Org.: Martin Harwit (Nat. Air and Space Museum)

16-4. Science and Technology for the Development of the Third World (Sat/am-pm, OS/Palladian). Development plan, applications gap. Org.: Cyril Ponnampuruma (Univ. of Maryland)

17-5. Cleaning Up the Mess at the DOE Nuclear Weapons Complex (Sat/am, OS/Executive). Health impacts, citizen participation, status of effort. Org.: Peter A. Johnson (Office of Technology Assessment); Robert P. Morgan (Washington Univ.); Tara O'Toole (Office of Technology Assessment)

23-2. AIDS: Scientific Research and Public Policy (Sat/am, SW/Baltimore). Health care system, research in federal agencies, local and state governments. Org.: Andrew A. Sorensen (Johns Hopkins Univ.)

24-T1. The Economic Potential for Aquaculture in the United States (Sat/am, SW/Vermont). Clams, shrimp, salmon, catfish, bass. Org.: Morton M. Miller (Nat. Marine Fisheries Service); Douglas W. Lipton (Univ. of Maryland)

34-7. Systems Perspective for the Quality of Health Care (Sat/am, SW/Arlington). Optimization, Deming's philosophy of profound knowledge, epidemiologic oversight. Org.: R. Clifton

Bailey (Health Care Financing Admin.); W. Edwards Deming (Consultant in Statistical Studies)

SB&F Science Film Festival

[SW/Atrium Room 1]

10:00 am Backyard Bugs

This video emphasizes common names of several insects found around a house or garden using a musical format that is sure to be impressive from a child's point of view. There are several excellent close-up sequences of various insects, and the process of metamorphosis is clearly shown.

10:15 am Just Like Anyone Else: Living with Disabilities

This excellent video meets its objective of promoting an understanding of disabled teens. NBC News correspondent Bill Schechner introduces vignettes about five disabled teenagers who describe the ways they cope with deafness, cerebral palsy, neurofibromatosis, a brother's autism, and spinal cord injury.

10:45 am Icewalk

This video, the first in the *Icewalk* series, invites students and teachers to accompany an international expedition on its environmental research trek to the North Pole.

11:10 am Introducing Crystals and Lasers

The first in a series of Christmas lectures from Britain's Royal Institution, this video gives American audiences an excellent feeling for this classic lecture series, which makes use of all types of audiovisual media and at times is almost like a magic show.

12:10 pm The Problem Solving Film

Intended to stimulate critical thinking skills, this short, perky film presents a group of youngsters who try to solve the problem of a missing pet. Their actions are used to illustrate eight major principles of problem-solving behavior, which they apply to the mystery at hand.

12:30 pm Reducing, Reusing, and Recycling: Environmental Concerns

This excellent video introduces elementary school children to ways our society can control certain types of pollution by reducing, reusing, and recycling common solid waste materials. By making a clear distinction between nonrenewable and renewable resources, the video shows that some items disposed of as garbage have value and should not be covered over and forgotten in public landfills.

12:55 pm Kopjes: Islands in a Sea of Grass

Above the grasslands of East Africa rise the kopjes, islands of granitic rock. This beautifully photographed film focuses on the life cycle and behavior of two key species, the herbivorous rock hyrax and its major predator, the black eagle.

1:30 pm Smoking: Everything You and Your Family Need to Know

This antismoking video attempts to balance opposing viewpoints about smoking by presenting short narrations by a wide variety of smokers and nonsmokers. It makes extensive and effective use of an interview with former Surgeon General C. Everett Koop to answer questions related to smoking and health.

2:05 pm Drugs and Your Amazing Mind

This excellent film details the effects of various drugs on the brain and gives information on the nature of the drugs, where they come from, and what their effects are.

2:25 pm **The Last Word on Dinosaurs**

A firsthand look into the nature of scientific research is the centerpiece of this video in which noted researchers present a lively debate on dinosaur biology, behavior, and evolution.

2:55 pm **A World Alive**

This exhilarating film profiles the myriad creatures of the planet, their activities, and interactions. Its dramatic musical score and powerful narration are blended with some of the most spectacular wildlife footage ever assembled. Narrated by James Earl Jones.

3:20 pm **Futures: Aircraft Design**

An episode of the *Futures* series that features acclaimed mathematics teacher, Jaime Escalante. Using spectacular aerial photography, this video captures the thrill of flying while illustrating clearly how a knowledge of mathematics is the entry ticket into the field of aeronautics.

3:40 pm **The Truth About Teachers**

At a time when our schools are the target of much criticism, we need to be reminded occasionally that there is still a cadre of talented, dedicated, highly competent teachers who are working diligently to make a difference in the lives of the children they serve. This video program, hosted by Whoopi Goldberg, provides a vivid and stimulating reminder of that fact by letting us observe 10 exemplary teachers as they interact with their students.



Sunday, 17 February

Plenary Lectures

1:00 pm "The Grand Challenges of Computational Science"
Speaker: Larry L. Smarr (*Director, National Center for Supercomputing Applications, Univ. of Illinois, Champaign, IL*) [SW/Washington Ballroom]

1:00 pm "The Complexion of Scientific Communities"
Speaker: Kenneth Manning (*Professor of the History of Science, MIT, Cambridge, MA*) [SW/Sheraton No. Ballroom]

8:30 pm AAAS President's Lecture: "Science, Slogans, and Civic Duty"
Speaker: Donald N. Langenberg (*Chancellor, Univ. of Maryland, Adelphi, MD, and President, AAAS*) [SW/Sheraton Ballroom]

Featured Symposia

18-2. Science for the Naked Eye; or, The Physics of Everyday Experience, XVIII

Organized by: Rolf M. Sinclair (*Program Director, Physics Division, National Science Foundation, Washington, DC*)

8:30 am / Sun / 17 Feb **Sheraton / Sheraton So.**

Presiding: Rolf M. Sinclair

A Collection of Simple Physics Demonstrations
Robert Ehrlich (*Professor of Physics, George Mason Univ., Fairfax, VA*)

The Bird's-eye View

Jerry A. Waldvogel (*Assistant Professor of Biology, Clemson Univ., Clemson, SC*)

Movement and New Forms in Photography: Documentation and Measurement

Phillip Leonian (*Photographer, New York, NY*)

2:30 pm / Sun / 17 Feb

Sheraton / Sheraton So.

Presiding: Rolf M. Sinclair

Mozart's Starling

Meredith J. West (*Professor of Psychology, Indiana Univ., Bloomington, IN*)

Art and the Computer

Donna Cox (*Associate Director for Education, National Center for Supercomputer Applications, Urbana, IL*)

Lightning and How to Avoid It

Charles B. Moore (*Professor Emer. of Physics, New Mexico Institute of Mining and Technology, Socorro, NM*)

A number of phenomena in our daily lives can raise — and answer — quite profound questions, once our senses have been guided by the scientist or artist. This symposium will include presentations of the science behind everyday experience and will be replete with demonstrations and examples. It will include how simple demonstrations can yield surprising and counterintuitive results; the rich world that birds see, so different from ours; how photography can bring out both the details and beauty of motion; how birds can charm and mimic humans; how the computer gives the visual artist a whole new palette of expressions; and what lightning is, and how we now know ways to avoid it.

[Sponsor: AAAS Section B.]

13-7. Current Directions in Musical Acoustics

Organized by: Thomas D. Rossing (*Dept. of Physics, Northern Illinois Univ., DeKalb, IL*), Logan Hargrove (*Office of Naval Research, Washington, DC*), and Mark F. Hamilton (*Dept. of Mechanical Engineering, Univ. of Texas, Austin, TX*)

8:30 am / Sun / 17 Feb **Omni Shoreham / Congressional**

Presiding: Thomas D. Rossing

Perceptual Segregation and Integration of Musical Tones

William Morris Hartmann (*Dept. of Physics, Michigan State Univ., East Lansing, MI*)

Sound Production in the Piano

Anders Askenfelt (*Dept. of Speech Communication & Music Acoustics, Royal Institute of Technology, Stockholm, Sweden*)

Aperiodicity in Oscillations of Musical Instruments

Robert T. Schumacher (*Dept. of Physics, Carnegie Mellon Univ., Pittsburgh, PA*)

Brass Instruments

Klaus Wogram (*Physicalisch-Technische Bundesanstalt, Braunschweig, Germany*)

Wind Instruments and Chaotic Dynamics

Douglas H. Keefe (*Systematic Musicology Program, School of Music, Univ. of Washington, Seattle, WA*)

Current Directions in Computer Music

Max V. Mathews (*Dept. of Music, Stanford Univ., Stanford, CA*)

Modes of Vibration and Sound Production in Percussion Instruments

Thomas D. Rossing

Musical acoustics is a broad interdisciplinary field that deals with the production, transmission, and perception of musical sound. In percussion instruments and in certain string instruments, the player supplies energy by striking or plucking the primary oscillator (string, bar, membrane, or plate), which in turn transmits energy to other parts of the instrument. Wind instruments, on the other hand, depend upon nonlinear feedback from the air column to the input control valve in order to generate sustained oscillations. Similar feedback exists in a bowed string instrument and, to a lesser extent, in the singing voice. In recent years, electronic musical instruments have developed to a high degree of sophistication, thanks to the digital computer. Equally exciting have been advances in our understanding of the perception of musical sound, an important target of recent research in the field of psychoacoustics. This symposium, organized under the auspices of the Acoustical Society of America, attempts to illustrate principles of production, transmission, and perception of sound by focusing on one area in acoustics that is of wide general interest.

[Sponsors: AAAS Section B; Acoustical Society of America. Cosponsor: AAAS Section J.]

Other Symposia

12T-3. Changing Lives: New Technology for People with Disabilities (Sun/am, SW/Holmes). Reading systems, E-mail, speech processors, electroejaculation, orthotics, aging. Org.: Virginia W. Stern (AAAS); Jan Galvin (Natl. Rehab. Hospital)

22-1. New Molecular Insights into "Old" Genetic Disorders (Sun/pm, SW/Cotillion So.). Mendelian, mitochondrial. Org.: Victor A. McKusick (Johns Hopkins Hospital)

23-4. The Father and the Fetus: Facts and Fallacies (Sun/am, SW/Baltimore). Paternal influence, drugs/xenobiotics. Org.: Gladys Friedler (Boston Univ. School of Med.)

24-3. Biological and Biotechnological Alternatives to Chemical Insecticides (Sun/am-pm, SW/Annapolis). Policies and regulations, microbial insecticides, predators and parasites. Org.: Brian A. Federici (UC-Riverside); Ron Arp (Fleishman-Hillard); Richard A. Weinzierl (Univ. of Illinois)

24-T4. Value-added Products from Agriculture (Sun/am, SW/Vermont). Fermentation, process innovations, fibers, foods, Sterling Hendricks award. Org.: William H. Tallent (USDA)

25-5. Seeds Since Columbus: Crop Germplasm of the Americas (Sun/pm, SW/Richmond). Biodiversity, old/new world interchange, seed conservation. Org.: Douglas Boucher (AAAS)

27-4. Current Conceptions of Intelligence (Sun/pm, SW/Alexandria). Intelligences, individual differences, twin studies. Org.: Thomas J. Tighe (Univ. of Connecticut); Bert Moore (Univ. of Texas, Dallas)

32-T1. Science Policy for Women in Science: Lessons from Historical and Contemporary Case Studies (Sun/am, SW/Idaho). Gender and research productivity, developed vs. developing countries. Org.: Pnina G. Abir-Am (Northeastern Univ.)

34-2. Frontiers of Research in Experimental Economics (Sun/am, SW/Wisconsin). Experimental design, markets, regulation. Org.: Vernon L. Smith (Univ. of Arizona)

36-T2. Risk Perception and Public Policy (Sun/pm, OS/Cabinet). Radon, pesticides in food, global climate management, media impacts. Org.: Michael A. Kamrin, Daniel A. Bronstein (Michigan State Univ.)

SB&F Science Film Festival

[SW/Atrium Room 1]

10:00 am Fetal Development: A Nine-Month Journey

Excellent photography highlights this visual depiction of normal fetal development from fertilization through birth. A fiber optic camera is used to obtain remarkable images of the stages of embryonic growth.

10:15 am Stop Before You Drop

Using a music video format, this short presentation conveys a strong antismoking message to young people. Filmed as part of a community-wide effort to reduce cigarette smoking in the predominantly black community of Richmond, CA, the video features over 200 Richmond-area youngsters in the cast.

10:30 am The Fabulous Five: Our Senses

This colorful, lively video introduces the concepts of the different senses to young children. It begins by asking students to consider what it would be like to lack each sense and then goes on to present the five senses in a smooth, flowing sequence with excellent transitions.

10:55 am Garbage: The Movie—An Environmental Crisis

This movie opens with a summary of the six-month voyage of a garbage barge that traveled the seas looking for a place that would accept its cargo only to return to its point of origin. The film then goes on to provide a straightforward, no-nonsense presentation of a universal, current problem and its possible amelioration.

11:20 am Gilbane Gold

Although this video is fictitious (as clearly indicated in the introduction), it is based on actual situations and clearly presents the reality of the conflict between economics, public health, and human nature. The story revolves around the environmental engineer of a newly established high-tech company that is discharging toxic waste into a city's sewage system. The engineer must decide whether to report the dumping infractions or protect the company's interests by slanting his environmental reports.

11:45 am See Dick & Jane Lie, Cheat, & Steal: Teaching Morality to Kids

The 1990s look like dark times for America's children, but as this film shows, educators can be as imaginative and as passionate as poets. Statistics on crime, drugs, problems in schools, and teen pregnancy are used to buoy the focus here: educational efforts can help if they address the heart of the problem — the absence of morals in children.

12:35 pm The Search for Mind

This video takes on the formidable challenge of defining the human mind. The wide-ranging discussion is based largely on interviews with outstanding workers in the fields of biology, animal behavior, psychology, philosophy, and art.

1:40 pm Trigonometric Functions 1: Solving Triangles

This is the first part of a beautiful series of films that use animation to show how interesting and practical trigonometry is. Demonstrates the sine, cosine, and tangent functions for a right triangle.

1:55 pm **Water Baby: Experiences of Water Birth**

This beautiful film that enhances the premise that women instinctively know how to give birth presents an overview of the water birth process. Contains footage depicting actual water births.

2:55 pm **Hazardous Inheritance: Workplace Dangers to Reproductive Health**

Reproductive disorders rank among the 10 leading work-related diseases and injuries in this nation, but they can be prevented when reproductive health hazards are controlled. This video provides experience-based guides for identifying risks and instituting controls.

3:20 pm **AIDS: A Family Experience**

It is wrenching to watch these interviews with an AIDS patient and his family, but it is for this very reason that they should be seen. Not a clinical or factual presentation, but an utterly real human drama.

3:55 pm **The Greenhouse Effect**

This film focuses on the history, causes, and problems of the greenhouse effect. The impact of time on the greenhouse effect is very well documented, research techniques are depicted, and the complexities of weather forecasting are explained.



Monday, 18 February

Plenary Lectures

1:00 pm "Cosmology: Some New Developments and Problems"

Speaker: Fang Li Zhi (*Royal Society Guest Research Fellow, Institute of Astronomy, Cambridge Univ., Cambridge, UK*) [SW/Washington Ballroom]

1:00 pm William D. Carey Lecture: "American Science in the 21st Century: Prospects and Problems"

Speaker: John Brademas (*President, New York Univ., New York, NY*) [SW/Sheraton No. Ballroom]

8:00 pm "Biomedical Research"

Speaker: Louis W. Sullivan (*Secretary, U.S. Dept. of Health and Human Services, Washington, DC*) [SW/Sheraton Ballroom]

Featured Symposia

18-1. Chemistry Is Fun!

Organized by: Jean'ne M. Shreeve (*Professor of Chemistry, Univ. of Idaho, Moscow, ID*)

8:30 am / Mon / 18 Feb Sheraton / Sheraton So.

Presiding: Bassam Z. Shakhshiri (*Professor of Chemistry, Univ. of Wisconsin, Madison, WI, and National Science Foundation, Washington, DC*)

Chemistry Is Fun!

Bassam Z. Shakhshiri, Ethel Schultz (*Program Officer, Division of Teacher Preparation and Enhancement, National Science Foundation, Washington, DC*), and Lois Nicholson (*Program Officer, Division of Teacher Preparation and Enhancement, National Science Foundation, Washington, DC*)

Chemistry — the central science — must be communicated to audiences of all ages in effective ways. Throughout this session, experienced teachers will share their excitement and concerns about teaching chemistry at the elementary, secondary, and collegiate levels as well as in informal settings. Spectacular demonstrations will be presented and hands-on experiments will be displayed and discussed.

[Sponsor: AAAS Section C.]

25T-4. Advances in Zoo Biology and Conservation

Organized by: Benjamin B. Beck (*Associate Director for Biological Programs, National Zoological Park, Smithsonian Institution, Washington, DC*)

2:30 pm / Mon / 18 Feb Sheraton / Richmond

Presiding: Benjamin B. Beck

Species Survival Plans: Cooperative Efforts to Save Endangered Species

Michael Hutchins (*Director, Conservation and Science, American Association of Zoological Parks and Aquariums Conservation Center, Bethesda, MD*)

The Umwelt: Biologically Salient Features of Zoo Environments

Elizabeth F. Stevens (*Senior Research Associate, Dept. of Conservation and Research, Zoo Atlanta, Atlanta, GA*)

Causes of Death of Zoo-born Giant Pandas

Richard J. Montali (*Head, Dept. of Pathology, National Zoological Park, Smithsonian Institution, Washington, DC*)

Reproductive Endocrinology of Zoo and Wild Gorillas

Nancy Czekala (*Endocrinology Specialist, Center for Reproduction of Endangered Species, San Diego Zoo, San Diego, CA*)

Reintroducing Zoo-born Animals to the Wild

Benjamin B. Beck

Public Education and Professional Training in Conservation

Lou Ann Dietz (*Brazil Senior Program Officer, World Wildlife Fund, Washington, DC*)

Zoos continue to mature as educational, research, and conservation organizations. Ironically, as "the wild" shrinks, there is increased demand by wildlife ecologists for the knowledge and techniques that have been developed in zoos. This session will present a sampling of vital interdisciplinary research that is being conducted in zoos of the 1990s and remind nonzoo colleagues of the unique educational and scientific opportunities that zoos offer.

[Cosponsors: AAAS Sections G and X.]

Other Symposia

11-6. **Mathematics in the Public Policy Arena** (Mon/pm, SW/Colorado). Statistics, wavelets, fractals, invariant measures, convergence analysis. Org.: Mary Beth Ruskai (Univ. of Lowell); Mary W. Gray (American Univ.); Jill P. Mesirov (Thinking Machines Corp.)

14-4. **The Rationale for Human Exploration of Mars** (Mon/am, OS/Diplomat). Role of humans in space, political context. Org.: Louis Friedman (The Planetary Society)

20-1. **Consciousness in Life** (Mon/pm, SW/Sheraton So.). Psychosomatic networks, simple organisms, memories, beliefs.

Org.: Roger S. Payne (Whale and Dolphin Conservation Society); Lynn Margulis (Univ. of Massachusetts)

22-2. Gene Therapy: Scientific Prospects and Societal Implications (Mon/pm, SW/Cotillion So.). Cancer, ethics. Org.: W. F. Anderson (NIH)

25-3. Strategic Approaches to Conserving Genetic Resources in Natural Habitats (Mon/am, SW/Richmond). Pacific Northwest, Africa, Amazonia, Costa Rica. Org.: Joel I. Cohen, Christopher S. Potter (AID)

26-4. Scientists' Responsibilities When Research Is Socially Sensitive and Liable to Misinterpretation (Mon/am, SW/Arlington). Research responsibility, public understanding, founded/unfounded fears. Org.: Caroline Whitbeck (MIT)

31-4. Ethnography of Drug Use in Traditional and Modern Societies (Mon/am-pm, SW/Holmes). Psychoactive drug use, anthropology, political economy. Org.: Willett Kempton (Princeton Univ.)

35-7. Scientific Approaches to the Study of International Conflict Resolution (Mon/pm, SW/Vermont). Negotiation, nationalism, crisis management. Org.: Eric H. Arnett (AAAS); Richard W. Cottam (Univ. of Pittsburgh)

SB&F Science Film Festival

[SW/Atrium Room 1]

10:00 am **Invent It!**

Consisting almost entirely of interviews with children and adults who discuss and demonstrate their own inventions, this video effectively communicates to its audience that regardless of age, race, and gender, anyone can be a problem solver given enough self-confidence and the ability to follow a few simple guidelines.

10:30 am **Dinosaurs**

In this video we hear and see a lively group of primary school-aged children romping through the dinosaur exhibits in the Tyrrell Museum in Drumheller, Alberta, Canada. The children make observations and ask the kinds of questions young viewers would likely ask in the same circumstances.

10:45 am **The Bones and Muscles Get Rhythm**

Produced by Disney Educational Productions, this program blends superb animation with live action to present the basic anatomy and physiology of the musculoskeletal system to young viewers.

10:55 am **Animal Habitats**

This short introduction to six of the earth's habitats is designed for children in the elementary grades, although older groups will also enjoy it.

11:10 am **The Keepers of Eden**

An episode in *The Infinite Voyage* series, this program examines zoos throughout the world to discover how these educational habitats have evolved to help preserve diverse and nearly extinct species.

12:10 pm **Sex and the Scientist**

This film chronicles the transition of Alfred Kinsey from a long-time student of gall wasps to the pioneering researcher of human sexual behavior, giving clarity and engaging attention to both the human dimensions and underlying issues of science and academic freedom. Blends pictures, drawings, and old film footage with recent interviews with Kinsey's family, friends, co-workers, and former students.

1:40 pm **Face Value**

"We would not survive without faces," states a researcher in this excellent film that provides documentation of the importance of the face in providing a sense of identity and as the primary display system for emotions. Human faces depicted in art and in life illustrate this very interesting and aesthetic presentation.

2:25 pm **Acid Rain**

This British film gives the viewer a clear understanding of the causes of acid rain and possible steps to be taken on both a global and personal level to minimize the destructive effects of this phenomenon.

2:55 pm **A Season in the Sun**

This film follows the life cycles of many animal species throughout the wet or dry seasons of Africa. An excellent script complements the beautiful cinematography of renowned nature photographers Alan and Joan Root.

3:30 pm **The Power of Choice**

This video is designed to help teenagers make choices based upon their best vision of themselves and not out of fear, guilt, or spite. Michael Pritchard, an experienced teen counselor and stand-up comedian, is featured.



Tuesday, 19 February

Plenary Lecture

1:00 pm Topic to be announced

Speaker: James D. Watkins (*Secretary, U.S. Dept. of Energy, Washington, DC*) [SW/Sheraton No. Ballroom]

Featured Symposia

27-7. Fragrance Research: Effects of Fragrances on Behavior, Mood, and Physiology

Organized by: **William N. Dember** (*Professor of Psychology, Univ. of Cincinnati, Cincinnati, OH*)

8:30 am / Tue / 19 Feb

Sheraton / Alexandria

Presiding: Susan Schiffman (*Professor of Psychology, Duke Univ., Durham, NC*)

Development of Olfactory Perception in Infancy and Early Childhood

Hilary J. Schmidt (*Assistant Member, Monell Chemical Senses Center, and Assistant Professor, Dept. of Psychiatry, New Jersey Medical School, Newark, NJ*)

Effects of Fragrances on Performance and Mood in a Sustained-attention Task

William N. Dember

Effects of Fragrances on Sustained Attention and Visual-evoked Potentials

Raja Parasuraman (*Professor of Psychology, Catholic Univ. of America, Washington, DC*)

Fragrance as a Source of Environmentally Induced Positive Affect: Effects on Negotiation, Conflict, and Motivation

Robert A. Baron (*Professor of Psychology and Management, Rensselaer Polytechnic Institute, Troy, NY*)

Social Behavior and Fragrance Use

John B. Nezlek (*Associate Professor, Dept. of Psychology, College of William and Mary, Williamsburg, VA*)

In this symposium, recent efforts to investigate behavioral and physiological effects of fragrances will be reported by active researchers in this newly developing field. Following an overview by Schiffman, Schmidt will describe her research on the development of odor perception, including data indicating gender differences in infant sensitivity to fragrances. Dember will present the results of the first experiments to demonstrate enhancing effects of fragrances on performance in a sustained-attention (vigilance) task. That work has been replicated and extended by Parasuraman, who has also shown parallel fragrance effects on two components of the visual-evoked response that are known to reflect attentiveness, as well as effects on skin conductance suggestive of increased autonomic arousal. Effects of a pleasant fragrance on mood and consequent effects on self-efficacy and prosocial behavior in competitive situations will be discussed by Baron. Finally, Nezlek will present his research on the ways that wearing fragrances affect individuals' feelings about themselves and influence their social interactions.

[Sponsor: AAAS Section J.]

32W-1. Women of Science: Secrets to Success

Organized by: Margaret M. Lobnitz (*Director of Environmental Compliance Programs, ICF Kaiser Engineers, Universal City, CA*) and Harriet H. Kagiwada (*Rockwell International Professor of Systems Engineering, California State Univ., Fullerton, CA*)

8:30 am / Tue / 19 Feb

Sheraton / Wisconsin

Presiding: Margaret M. Lobnitz

Women of Science: A View from Academe and Industry
Harriet H. Kagiwada

Taste, Talent, and Tenacity
Ariel C. Hollinshead (*Distinguished Professor, Dept. of Medicine, George Washington Univ. Medical Center, Washington, DC*)

The Environmental Challenge
Suzanne L. Phinney (*Vice President, Environment, Aerojet, Folsom, CA*)

Success Despite Barriers

Elizabeth Rodriguez (*Special Assistant, Director of Defense, Research, and Engineering, U.S. Dept. of Defense, Washington, DC*)

Women in the Health and Environmental Sciences: Building Effective Organizations in the Federal Government and in the Public Sector

Elizabeth L. Anderson (*President, Clement International Corp., Fairfax, VA*)

The road to equality in the sciences has been long and arduous for women. In this workshop, prominent women in science will share their secrets to success in a "no-holds-barred" forum of questions, answers, and discussion. The panel will consist of members of academia, industry, and applied professions in which scientific backgrounds are a foundation for success. The session will be aimed at the practicing scientist as well as those entering scientific fields. It will deal with such issues as the definition of success, the concept of balance between career and outside priorities such as family, and techniques for developing and implementing success strategies. For career women, it will explore creative approaches to successful career paths. For those considering scientific careers, it will stress the diversity in careers available to women with scientific educational backgrounds.

[Sponsors: AAAS Section X; Sigma Delta Epsilon/Graduate Women in Science. Cosponsors: AAAS Sections H and Y; AAAS Southwestern and Rocky Mountain Division.]

Other Symposia

14-5. Science with the Hubble Space Telescope (Tue/am, OS/Palladian). Cameras, spectrographs, early results. Org.: Eric Chaisson, Colin Norman (Space Telescope Science Inst.)

21-T2. National and International Efforts in Plant Genome Mapping (Tue/am, SW/Idaho). Gene sequencing, networks. Org.: David R. MacKenzie (USDA); Bruno Quebedeaux (Univ. of Maryland)

23-T2. Firearm Injury Prevention: Scientific and Public Policy Directions (Tue/pm, SW/Baltimore). Regulation, homicide rates. Org.: James A. Mercy (Centers for Disease Control)

25-4. Nonrandom Evolution: Matter, Life, Mind (Tue/am, SW/Arlington). Big Bang, protobiotic transition, genetic code, biological form. Org.: Sidney W. Fox, John H. Yopp (Southern Illinois Univ.)

37-W1. Science in National Life: A Videohistory Workshop (Tue/am, SW/Colorado). Lab techniques, artifact preservation. Org.: David H. DeVorkin (Nat. Air and Space Museum)

AJAS Student Research Papers

The following American Junior Academy of Science (AJAS) research papers will be presented on Saturday, 16 February, 9:45–11:45 am, in the Sheraton Washington Exhibit Hall C.

101. Utilizing 5-FU for Maximizing TNT-1 MAb Uptake in HT-29 Multicellular Tumor Spheroids — Lawrence Wang (*Los Angeles, CA*)
102. The Role of Calcium and Other Agents in Melanophore Cells — Michael Shen (*Cherry Creek High School, CO*)
103. The Effects of Selenium on the Growth of Bacteria and Its Incorporation into the Amino Acids of *Rhizobium leguminosarum* — Jonathan Alden Dyer (*Central High School, MO*)
104. Effect of Ultrasound and Electrical Current on Competence of *E. coli* Cells — Sarah Cho (*Notre Dame Academy*)
105. Comparison of Two Transformation Procedures Using Purified, Unpurified, and Recombinant Plasmids — Jennifer Stevens (*Yorktown High School, VA*)
106. An Observation of the Differences Between the Inhibition Efficacy of Liposome-Encapsulated and Non-Encapsulated Tetracycline on the Growth of *Escherichia coli* — Stan Lu (*Bridgewater-Raritan High School West, NJ*)
107. Cloning, Expression, and the Transport Studies of Proteins From the Wild Type and Mutant F-Sendai Virus — Anna Kim (*Alhambra High School, CA*)
108. Genetic Engineering of Lactic Acid Bacteria — Purbita Ray (*Laramie, WY*)
109. Structural Organization and Expression of Tyrosine Kinase Proto-Oncogenes in Hydra — Timothy Chan (*University High, CA*)
110. The Effects of Varying the Amount of Indole-3-Acetic Acid, in a Basic Plant Tissue Culture, on Boston Fern (*Nephrolepis exaltate bostoniensis*) — Erez Liebermann (*Ocean Township High School, NJ*)
111. Polyhydroxybutyrate: A Polymer Produced and Degraded by Bacteria — Yuch Z. Lee (*Shawnee Mission South High School, KS*)
112. Does Presoaking and/or Hyperthermia Cause Stimulation in Bean Seed Germination and Growth? — David Stoffel (*Bettendorf High School, IA*)
113. The Effects of Decreased Watering on Plant Growth, Production, and Nutrition — Dan Woodard (*Kenton High School, OH*)
114. The Effects of Different Culture Media on the Growth of a Lichen Synthesized from Separate Alga and Fungus Symbionts — Amy M. Elfner (*Hayes High School, OH*)
115. Rhododendron Propagation Part III — John L. Harrington (*Menchville High School, VA*)
116. Parenchymal Cell Proliferation Activity in Adult Male Mouse Submandibular Gland — Yaofay Lin (*Rowland Heights High School, CA*)
117. Cholesterol in Children — Nisha Kuttothara (*Loudonville Jr. High School, OH*)
118. Does Psychological Stress Affect the Antibody Level for the Epstein-Barr Virus? — Jennie Evenson (*Linden-McKinley High School, OH*)
119. Role of Endothelium in Nitroglycerin-Induced Desensitization to Nitrovasodilators — JoAnn Beck (*Hamilton High School, OH*)
120. Do Some Common Foods Have Mutagenic Effects on Three Different Strains of *Salmonella typhimurium*? — Marilyn Koch (*Tom C. Clark High School, TX*)
121. A One-Year Study of the Coliform Bacteria Population of Green River in Casey County — Donna Holder (*Casey County High School, KY*)
122. More Damage, More Satisfaction? Nicotine Concentration in Relation to Oral Mucosal Damage — Alan Adams (*Regis High School, LA*)
123. Analysis of Gap Junction-Mediated Communication Using Freeze-Fracturing Technique — Kurt Hong (*CA*)
124. Cryoprotectants: A Protective Means of Acclimation — Estelle H. Cline (*The North Carolina School of Science and Mathematics, NC*)
125. Effects of Olfactory Imprinting in *Rattus norvegicus* — Amy Jo Roy (*Ashland High School, OH*)
126. Asthma and Weather — Griffin Weber (*Dozier Middle School, VA*)
127. Incidence and Types of Bulk Tank Mastitis Bacteria in Herds with High and Low Bulk Tank Somatic Cell Count — Rebecca A. Spore (*Ashland High School, OH*)
128. MCF-7 or Not MCF-7?: The Use of Isozyme Analysis and DNA Fingerprinting to Determine the Origins and Genetic Fingerprints of Various MCF-7 Breast Carcinoma Cell Cultures — Ilea A. Mathis (*Westerville North High School, OH*)
129. How Safe Is Your Food When the Power Goes Off? — Claire M. Compton (*Lexington High School, SC*)
130. Factors Affecting the Reading of Geometrically Inverted Text — Dawn Lam (*Notre Dame Academy, KY*)
131. How Do You Communicate with a Deaf-Blind Person from a Distance? — Scott Yano (*Evergreen Middle School, OH*)
132. Greenhouse Earth: A Rising Threat — Jerome Henson (*Leesville High School, LA*)
133. Goose Creek Limestone Discovered in Horry County, SC — Matthew Campbell (*Spartanburg High School, SC*)
134. Experimental Turbulence and the k-Epsilon Transport Equations — Cameron R. Haight (*Santa Fe High School, NM*)
135. Turbulent Drag Reduction in Fluid Flow Through Linear and Non-Linear Pipe Configurations — Daniel A. Lane (*Robert E. Lee High School, TN*)
136. Sound Velocity Measurements and Estimation of Upper Limit of Hydrogen Penetration in Titanium by Ultrasonics Techniques — Luong Tran (*San Diego, CA*)
137. The Propagation of Sound in Gasses — Kurt A. Franke (*John Marshall High School, TX*)
138. The Chaos Game: Infinite Possibilities — A Fractal Study — Clint S. Wilkins (*Spartanburg High School, SC*)
139. Arithmetic Sequences and Fibonacci Quadratics — Mahesh Mahanthappa (*Fairview Senior High School, CO*)

*We invite you to attend the
AAAS Annual Meeting, 14–19 February
Sheraton Washington
and Omni Shoreham hotels*

*For free admission, wear your
Science Encounters '91 badge.
Pick up additional badges
and a copy of the
"Program at a Glance"
at the Information Desk
(located in the Atrium
AAAS Registration Area)
in the Sheraton Washington Hotel.*



American Association for the Advancement of Science
1333 H Street, NW, Washington, DC 20005

AAAS★91

The AAAS Annual Meeting

EXHIBITS

WASHINGTON, DC

15 –18 February 1991



**AAAS Directorate for
Education and Human
Resources Programs** #520, 522

1333 H Street, NW
Washington, DC 20005
202-326-6620

This Directorate is involved in projects and programs to strengthen and improve formal and informal education in science, mathematics, and technology for all Americans. Newsletters, descriptive brochures, and publications are on display. Stop by for a free gift.

**AAAS Directorate for Science
and Policy Programs** #517

1333 H Street, NW
Washington, DC 20005
202-326-6600

Programs include Scientific Freedom, Responsibility & Law; Science, Technology & Government; and Science & Human Rights. Visit this booth and learn about fellowship programs; federal R&D budget analyses; science, ethics & law activities; and human rights issues.

AAAS Membership #521

1333 H Street, NW
Washington, DC 20005
202-326-6430

Attending staff is available to answer questions about your membership and member benefits. Also available – information about the AAAS Directorate for International Programs and about the AAAS Employment Exchange.

AAAS Publications #516, 518

1333 H Street, NW
Washington, DC 20005
202-326-6446

AAAS publishes professional and general interest books that make a substantial contribution to the scientific and policymaking community, advance education in the sciences, and increase public understanding of science.

Academia Book Exhibits #202

3925 Rust Hill Place
Fairfax, VA 22030
703-691-1109

Organizes and arranges book and journal displays at scientific congresses and symposia in the United States as well as in Europe. A catalog, listing full addresses of participating publishing houses and bibliographic information on the titles they've sent for display, is prepared for each meeting, and is available to all participants.

American Geological Institute #607

4220 King Street
Alexandria, VA 22302
703-379-2480

AGI provides informational services to geoscientists through publications and GeoRef; is a leader in K-12 earth science education program development; and works to improve public and governmental understanding of earth resources and environmental issues.

American Institute of Physics #506

335 East 45th Street
New York, NY 10017
212-661-9404

Scientific and educational materials of the American Institute of Physics, the American Association of Physics Teachers, the American Physical Society, and certain other societies.

**American Society of
Mechanical Engineers** #213

22 Law Drive
Fairfield, NJ 07006
201-882-1170

The ASME booth will represent a wide variety of programs in the areas of publishing, technical conferences and exhibits, engineering education, government relations, public education and the development of codes and standards, all aimed at serving the engineering profession, the public, industry, and government.

Animal Welfare Information Center #613

Room 205, National Agricultural Library
Beltsville, MD 20705
301-344-3212

The Animal Welfare Information Center (AWIC) is a federally mandated information center that provides information on alternatives, training materials, animal care and use, and federal legislation. AWIC distributes bibliographies, listings, newsletters, and brochures related to animal care and use.

Armed Forces Institute of Pathology #120

Walter Reed Army Medical Center
Washington, DC 20306-6000
202-576-2861

This AFIP exhibit depicts the accomplishments in the area of wound healing, made with the hyperbaric chamber at the AFIP.

See Floorplan in Centerfold

Association of American Geographers

#206

*Department 199, 1718 M Street, NW
Washington, DC 20036-4503
202-234-1450*

The Association of American Geographers' exhibit will present information regarding the AAG's programs and publications, display books written by geographers, and demonstrate the use of geographic information systems (GIS) for environmental and social research.

The Association of American University Presses, Inc.

#402

*584 Broadway, Suite 410
New York, NY 10012
212-941-6610*

Cooperative book display from university presses.

Bernan Associates – UNIPUB

#118

*4611-F Assembly Drive
Lanham, MD 20706-4391
301-459-7666*

Bernan Associates is the largest private distributor of government and government-related publications. UNIPUB is the exclusive distributor for international agencies including IAEA, FAO, UNESCO, PUDOC, and GATT, the sole North American agent for HMSO and the sole official agent for the European Communities in the United States. UNIPUB distributes publications across many disciplines in the scientific field.

Betty Jane Learning Center of the Betty Jane Memorial Rehabilitation Center

#704

*65 St. Francis Avenue
Tiffin, OH 44883
419-448-8852*

The General Elementary Processing Inventory, a multi-level test for adults and children, is used to diagnose specific learning disabilities and develop remedial and compensatory methods for the diagnosed problems. Exhibited by the author and staff.

BIOCON, Inc.

#113

*416 Hungerford Drive, Suite 420
Rockville, MD 20850
301-762-3202*

BIOCON, Inc. is a research laboratory servicing the biomedical and biotechnology communities. We specialize in animal-related services and are equipped to provide all

phases of Animal Holding, Animal Breeding, Custom Antibody Production, Animal Diagnostics, Contract Management, and Contract Technician Services.

**BRS Colleague,
A Division of Maxwell Online**

#512

*8000 Westpark Drive
McLean, VA 22102
703-442-0900*

BRS Colleague is an electronic medical library designed specifically to facilitate the searching of medical literature through online search retrieval. BRS Colleague provides information through simple menu-driven commands, making it a powerful research tool for both novice and experienced computer users. With over 70 major journals including the *New England Journal of Medicine*, *Lancet*, and the *Annals of Internal Medicine*, and over 40 databases including MEDLINE, EMBASE (Excerpta Medica), and International Pharmaceutical Abstracts, BRS Colleague is the most timely and cost-effective method of online research available today.

Casio, Inc.

#412

*570 Mt. Pleasant Avenue
Dover, NJ 07801
201-361-5400*

Electronic calculators, which include: graphic scientific calculators, scientific calculators, overhead projector calculators, printing calculators, and basic calculators.

**Conference Book Service, Inc.,
A Division of Infocus
Communications**

#419

*80 South Early Street
Alexandria, VA 22304
703-823-6966*

A cooperative exhibit of professional books and journals from publishers worldwide.

**Defense Technical
Information Center**

#415

*Cameron Station
Alexandria, VA 22304-6145
202-274-3848*

The Defense Technical Information Center (DTIC) collects, stores, and disseminates Department of Defense technical reports, studies and analyses, and research management information. Products and services include bibliographies, documents, online services, and Information Analysis Center.

- Dover Publications, Inc.** #511
 180 Varick Street
 New York, NY 10014
 212-255-3755
 Book publisher specializing in reprints of important books in all areas of science, with emphasis on mathematics and the physical sciences.
- Ecological Society of America** #115
 Center for Environmental Studies
 Arizona State University
 Tempe, AZ 85287-1201
 602-965-3000
 (Tabletop display within AAAS Combined Affiliates Exhibit)
- EDVOTEK, Inc.** #212
 P.O. Box 1232
 West Bethesda, MD 20827
 301-251-5990
 EDVOTEK is the educational company with the mission of developing biotechnology reagents, equipment, and biologicals for the college and precollege levels. Information about EDVOTEK workshops and the NABT-EDVOTEK NSF-Bioreep partnership will also be available.
- Elsevier Science Publishing Co.** #302
 655 6th Avenue
 New York, NY 10010
 212-989-5800
 Elsevier Science Publishing, a leading international science publisher, will display a broad selection of its books and journals. Complimentary copies of many of its highly acclaimed journals will be available at the booth.
- Encyclopaedia Britannica USA** #316
 310 South Michigan Avenue
 Chicago, IL 60604
 312-347-7349
 Encyclopaedia Britannica, Great Books of the Western World, and a complete line of educational accessories.
- F-D-C Reports, Inc.** #801
 5550 Friendship Boulevard, Suite One
 Chevy Chase, MD 20815
 301-657-9830
 Healthcare publisher will display and discuss its publications, which range in coverage from pharmaceuticals to medical devices to biomedical research to health policy to cosmetics. Publications report regulatory, legislative, and scientific developments in a timely manner. Full text online delivery available through various vendors.
- Feminist Majority Foundation** #114
 186 South Street
 Boston, MA 02111
 617-695-9688
 The Feminist Majority Foundation is conducting a national campaign for RU 486 and contraceptive research. The campaign involves scientists, academicians, and health care professionals in efforts to make RU 486 available to American women.
- Fogarty International Center, National Institutes of Health** #802
 9000 Rockville Pike
 Bethesda, MD 20892
 301-496-1653
 The Fogarty International Center of the National Institutes of Health supports U.S. and foreign scientists who wish to conduct collaborative research abroad in the biomedical, behavioral, and other health-related sciences through fellowships and health scientist exchange programs.
- Gordon and Breach Science Publishers/ Harwood Academic Publishers** #317
 P.O. Box 786 Cooper Station
 New York, NY 10276
 212-206-8900
 Publishers of scientific and technical books and journals. Over 100 journal titles. Publications in life science, physical sciences, and social sciences. Sample journals copies available at the booth. Call 212-206-8900.
- Harvard University Press** #418
 79 Garden Street
 Cambridge, MA 02138
 617-495-2600
 Harvard University Press will display a selection of books representing the latest word in contemporary science. Featured titles include *It's a Matter of Survival* by Anita Gordon & David Suzuki and *Ozone Diplomacy* by Richard Benedick.
- Health & Environment International, Ltd.** #611
 111 Chestnut Avenue
 Wilmington, DE 19809
 302-764-8810
 Health & Environment International provides information services to scientists involved in human health and environ-

mental issues. Its principal publications are entitled "Comprehensive Health and Environmental Monographs" (CHEMs) on individual chemicals. Sample CHEMs will be available for inspection.

Heldref Publications #112

4000 Albemarle Street, NW
Washington, DC 20016
202-362-6445

Journals and magazines for teachers, administrators, and researchers.

History of Science Society #116

35 Dean Street
Worcester, MA 01609
508-831-5712

Three organizations — the Society for History of Technology, the Society for Social Studies of Science, and the History of Science Society — support scholarly research and teaching on these subjects through publications, meetings, and other activities.

Hitachi America, Ltd. #608, 610, 612

50 Prospect Avenue
Tarrytown, NY 10591-4698
914-332-5800

Hitachi, a world leader in innovative electronics and electrical products, will present videotaped highlights of its self-learning neuro-computer, graphics applications on its supercomputer, and medical applications on its ultra-high speed magnetic resonance imaging system.

The Humana Press, Inc. #122

P.O. Box 2148
Clifton, NJ 07015
201-773-4389

Humana Press features many new and recent titles (as well as journals) of special interest to a wide variety of disciplines.

IBM Corporation #305

1501 LBJ Freeway
Dallas, TX 75234
214-406-7332

IBM has supercomputing solutions for engineers and scientists. State-of-the-art scientific and technical computing applications are available across a network of high-performance workstations and supercomputers.

IMSL, Inc. #505

2500 CityWest Boulevard
Houston, TX 77042-3020
713-782-6060

IMSL provides high-quality, high-value software for problem solving in science, engineering, and business. For 20 years, the IMSL Libraries of FORTRAN subroutines have been satisfying the advanced computing needs of professionals who solve mathematical and statistical problems using FORTRAN.

Island Press #703

1718 Connecticut Avenue, NW
Washington, DC 20009
202-232-7933

State-of-the-art books on conservation and environmental science, featuring the new book, *Climate Change: The IPCC Response Strategies*.

**The Johns Hopkins University,
Welch Medical Library** #215

1830 E. Monument Street, 3rd Floor
Baltimore, MD 21205
301-955-9656

The Welch Medical Library provides access to the GDB and OMIM databases. OMIM is the online computer database of Victor A. McKusick's *Mendelian Inheritance in Man*. GDB encompasses data pertaining to the Human Genome project.

Language Systems Corporation #504

441 Carlisle Drive
Herndon, VA 22070
703-478-0181

Language Systems FORTRAN lets you run your high-performance FORTRAN programs on a Macintosh. Full ANSI-77, VAX source code compatibility (namelist, structures, etc.), and Mac-like scrollable output windows make this compiler the most powerful FORTRAN for the Macintosh.

Learning Services, Inc. #501

P.O. Box 10636
Eugene, OR 97440
503-683-3827

Learning Services offers a full range of quality products at prices from 10% to 50% off suggested retail, including software, hardware, supplies, peripherals, accessories, and robotics kits for the Apple Macintosh, IBM, and Commodore computers.

Mathematical Connections #306

Dolciani Mathematical Center
 1529 18th Street, NW
 Washington, DC 20036
 202-387-5200

Mathematical Connections is a joint presentation by the National Council of Teachers of Mathematics, the Society for Industrial and Applied Mathematics, the Mathematical Association of America, the American Statistical Association, the Institute of Mathematical Statistics, and the American Mathematical Society.

NASA/Goddard Space Flight Center #701

Code 900
 Greenbelt, MD 20771
 301-286-3411

The Earth Observing System (EOS) is a planned NASA program for observing the Earth from space, using unmanned platforms in conjunction with other observing systems. The goal is to understand the Earth as an integrated system.

NASA Scientific and Technical Information Program #315

National Aeronautics and Space Administration
 Washington, DC 20546
 703-271-5600

The NASA Scientific and Technical Information Program supports R&D efforts by fostering the creation and exchange of information, by operating a database of international scope, and by providing services and products to the aerospace research community.

National Academy Press #208

2101 Constitution Avenue, NW
 Washington, DC 20418
 202-334-3180

The National Academy Press publishes academic and trade books in the fields of science, medicine, and technology. They are the publisher for the National Academy of Sciences, National Academy of Engineering, National Research Council, and Institute of Medicine.

National Agricultural Library, USDA #414

10301 Baltimore Boulevard
 Beltsville, MD 20705
 301-344-3755

Provides reference and document delivery services to the agricultural community worldwide. NAL houses over two million volumes on agriculture and related sciences;

produces the bibliographic database, AGRICOLA; and evaluates new technologies for preservation and dissemination of agricultural information.

National Association of Academies of Science #115

The Ohio Academy of Science
 445 King Avenue
 Columbus, OH 43201
 614-424-6045

(Tabletop display within AAAS Combined Affiliates Exhibit)

National Biological Control Institute, USDA-APHIS #615

Room 539, Federal Building
 6505 Belcrest Road
 Hyattsville, MD 20782
 301-436-5478

The National Biological Control Institute was established by USDA-APHIS in 1990 to promote, facilitate, and provide leadership for biological control. It is dedicated to furthering all aspects of the development and implementation of biological control.

National Center for Research Resources, National Institutes of Health #318

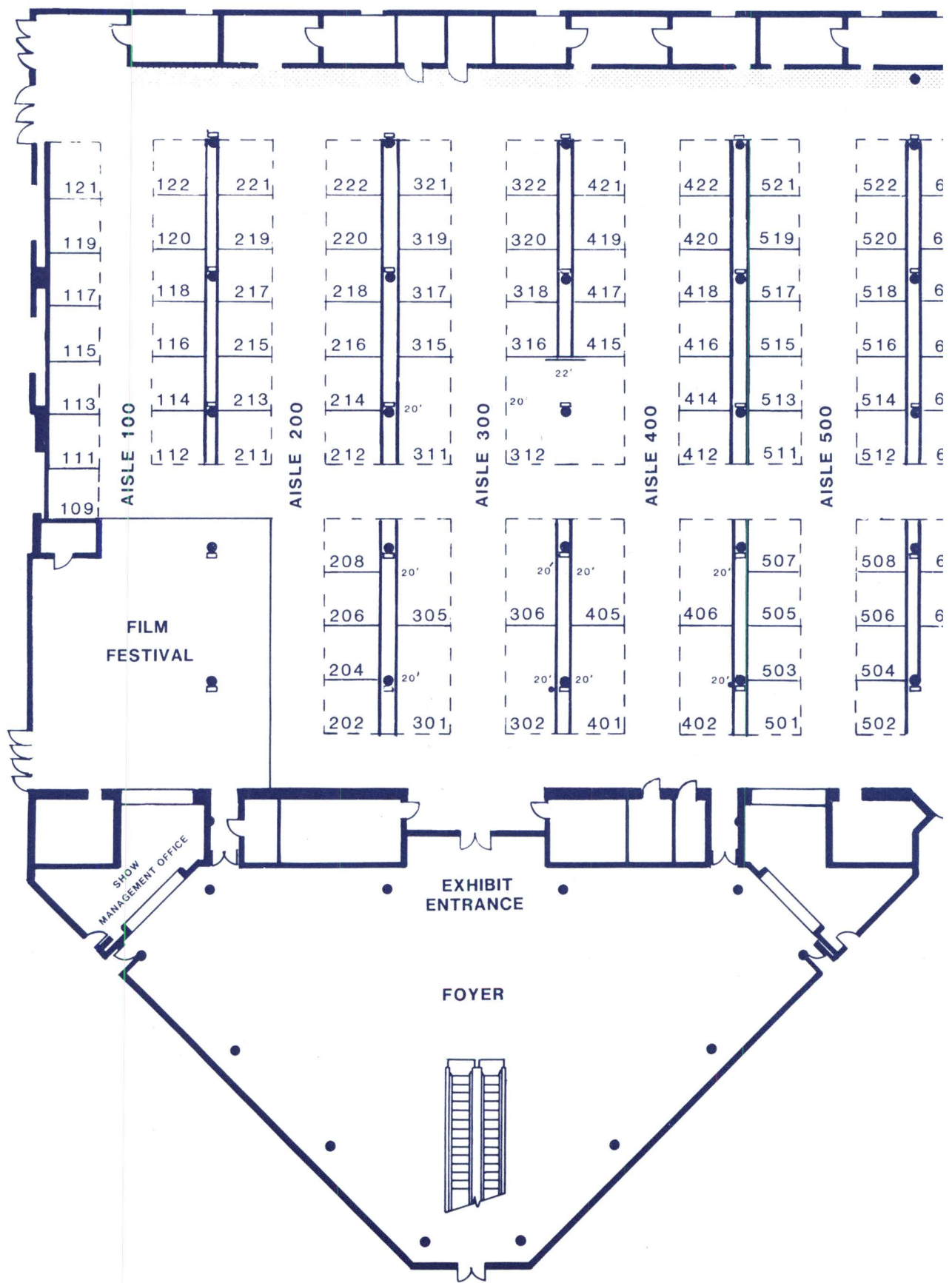
Westwood Building, Room 10A15
 5333 Westbard Avenue
 Bethesda, MD 20892
 301-496-5545

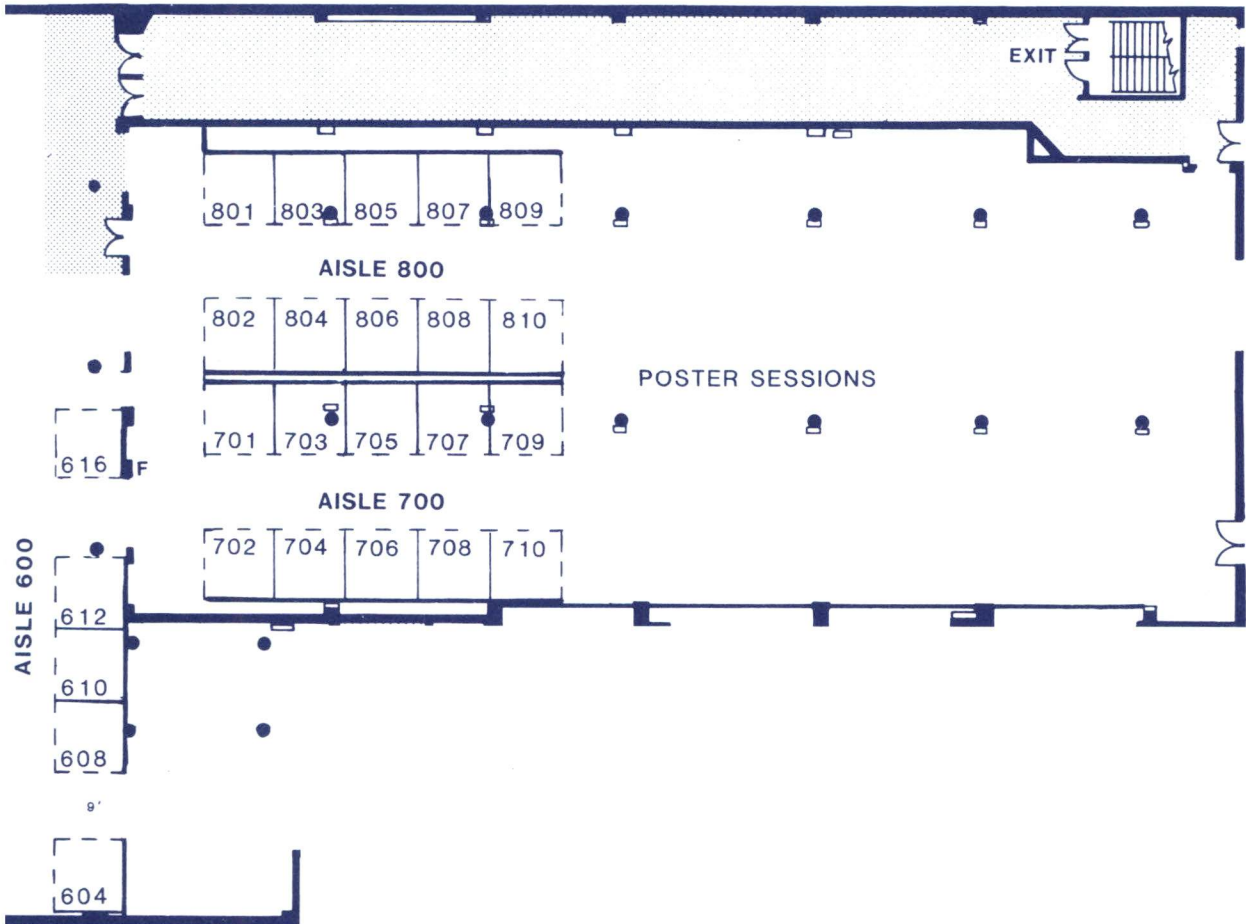
The National Center for Research Resources, NIH, will distribute free copies of resource directories, animal use and care guidelines, an annual report, and an award-winning science newsletter for biomedical investigators.

National Institute on Deafness and Other Communication Disorders #804

Building 31, Room 1B-62
 9000 Rockville Pike
 Bethesda, MD 20892
 301-496-7243

NIDCD, one of the 13 institutes within the National Institutes of Health, conducts and supports research and research training on normal and disordered mechanisms of hearing, balance, smell, taste, voice, speech, and language.





AAAS★91

Exhibition

HOURS

Friday, 15 February 6:00 pm – 8:00 pm
 Saturday, 16 February 9:00am – 3:00 pm
 Sunday, 17 February 9:00 am – 3:00 pm
 Monday, 18 February 9:00 am – 3:00 pm

National Institutes for the Environment Committee #616
*730 11th Street, NW
Washington, DC 20001
202-628-4303*

The Committee proposes a National Institutes for the Environment, analogous to the NIH, to increase environmental protection through greatly enhanced environmental research and education. The NIE would provide extramural grants for mission-oriented research through problem-oriented institutes.

National Institutes of Health, Office of AIDS Research #319
*Building 31, Room 3B19
Bethesda, MD 20892
301-402-0192*

Students, physicians, and Ph.D.'s are invited to learn of pre- and postdoctoral training opportunities at the NIH. Potential trainees interested in AIDS research are encouraged to inquire about our loan repayment program (\$20,000/year).

National Institutes of Health, Office of Education #319
*Building 10, Room 1C129
Bethesda, MD 20892
301-496-2427*

Students, physicians, and Ph.D.'s are invited to learn of pre- and postdoctoral training opportunities at the NIH.

National Institutes of Health, Research Documentation Section, Division of Research Grants #320
*Westwood Building, Room 148
Bethesda, MD 20892
301-496-7543*

The CRISP system — CRISP is a major scientific information system containing data on the research projects supported by the U.S. Public Health Service and the National Institutes of Health, NIH.

National Library of Medicine #406
*8600 Rockville Pike
Bethesda, MD 20894
301-496-1131*

The National Library of Medicine's Medical Literature Analysis and Retrieval System (MEDLARS) is an easy to access computerized collection of databases and

databanks. The exhibit will highlight MEDLARS toxicologically oriented files, which are especially useful for professionals concerned with environmental issues, human exposure, laboratory safety, and regulatory requirements related to hazardous substances.

National Marine Fisheries Services, DOC, NOAA #619
*1335 East-West Highway
Room 9350 SSMC1
Silver Spring, MD 20910
301-427-2239*

Research on, and management of, all living marine resources within the exclusive economic zone of the United States.

National Oceanic and Atmospheric Administration, Office of Legislative Affairs, Educational Affairs Division #617
*1825 Connecticut Avenue, NW, Room 627
Washington, DC 20235
202-673-5380*

NOAA's educational outreach programs, products, and services, including how remote sensing satellite data sets are being used in classrooms across the United States, will be featured. The Educational Affairs Division is a new unit in NOAA.

National Optical Astronomy Observatories #117
*950 N. Cherry/P.O. Box 26732
Tucson, AZ 85726-6732
602-327-5511*

National Optical Astronomy Observatories, funded by the NSF through the Associated Universities for Research in Astronomy, provides research facilities in optical and infrared astronomy for astronomers from the United States and around the world.

National Park Service, Wildlife and Vegetation Division #420
*P.O. Box 37127, MS 490
Washington, DC 20013-7127
202-343-8100*

The Division provides direction for national-level programs involving research and management of the biological resources of the national parks, including programs in global climate change, endangered and exotic species, and biological diversity.

National Science Foundation #321

1800 G Street, NW
Washington, DC 20550
202-357-7425

The National Science Foundation is an independent agency of the Federal Government that promotes scientific progress in the U.S. by sponsoring scientific and engineering research and by supporting selected education activities. The NSF exhibit booth will display information on NSF grant programs and other funding activities.

National Science Foundation, Directorate for Biological, Behavioral, and Social Sciences #216

1800 G Street, NW, Room 506
Washington, DC 20550
202-357-9854

The Directorate for Biological, Behavioral, and Social Sciences (BBS) at the National Science Foundation supports research to promote the progress of science through programs designed to strengthen scientific understanding of biological and social phenomena.

National Science Teachers Association #507

1742 Connecticut Avenue, NW
Washington, DC 20009
202-328-5800

The world's largest organization dedicated to science education, NSTA will have its award-winning professional journals as well as some of its special publications on display. Come by for a complimentary copy of an NSTA journal.

Neil Patterson Publishers #514

1308 Rainey Street
Burlington, NC 27217
800-227-1150

On display are the following titles: de Duve, *Blueprint for a Cell*; Rawn, *Biochemistry*.

NTIS #111

Springfield, VA 22161
703-487-4811

NTIS (National Technical Information Service), an agency of the U.S. Department of Commerce, is the central source for the public sale of U.S. Government-sponsored research, development, and engineering reports and for sales of foreign technical reports and other analyses prepared by national and local government agencies and their contractors or grantees.

Oak Ridge Associated Universities #416

P.O. Box 117
Oak Ridge, TN 37831-0117
615-576-3146

Oak Ridge Associated Universities is a consortium of colleges and universities and a contractor to the U.S. Department of Energy. It seeks to make increasingly positive contributions to society through science and technology.

Office of the Chief of Naval Research #222

800 N. Quincy Street
Arlington, VA 22217-5000
703-696-5031

The Office of Naval Research supports basic scientific research through contracts, grants, special programs, and educational opportunities. Information/handouts will be available on all of these programs.

Oxford University Press #502

200 Madison Avenue
New York, NY 10016
212-679-7300

Oxford will feature a complete display of related books and journals.

PaperChase® #109

Longwood Galleria, 350 Longwood Avenue
Boston, MA 02115
800-722-2075

PaperChase® is a computer program that provides easy and economical access to MEDLINE, the world's largest biomedical database. Using simple menus, PaperChase® enables the first-time user to search MEDLINE without training, 24 hours a day, 365 days a year, from any computer with modem.

Pattern Recognition Society #115

National Biomedical Research Foundation
3900 Reservoir Road, NW
Washington, DC 20007
202-687-2121

(Tabletop display within AAAS Combined Affiliates Exhibit)

The Planetary Society #211

65 North Catalina Avenue
Pasadena, CA 91106
818-793-5100

In 1980, Carl Sagan, Bruce Murray, and Louis Friedman founded The Planetary Society, the world's largest space interest group, as a non-profit organization that supports

AAAS☆91 Exhibition

solar system exploration and continues the search for extraterrestrial life.

Prescience Corporation #604

939 Howard Street
San Francisco, CA 94103
415-543-2252

Prescience (pronounced PRE shence) Corporation is dedicated to scientific education software development by concentrating on easy-to-use intuitive tools for mathematics users. As publishers of Expressionist 2.07 and Theorist 1.1, Prescience Corporation has developed a new standard user interface for mathematical typesetting and symbolic computation software.

Project 2061: Education for a Changing Future #519

1333 H Street, NW
Washington, DC 20005
202-326-6622

Project 2061 is a three-stage, comprehensive, long-term initiative of the American Association for the Advancement of Science to transform science, mathematics, and technology education for the 21st century.

Publishers Book Exhibit #301

86 Millwood Road
Millwood, NY 10546
914-762-2422

The Publishers Book Exhibit will present a collection of books, periodicals, audiocassettes, and videocassettes from a variety of publishers. A subject-arranged catalog will be provided.

Research Biochemicals Incorporated #621

One Strathmore Road
Natick, MA 01760
508-651-8151

Research Biochemicals Incorporated manufactures and sells over 600 pharmacologically active compounds for research purposes. These compounds are active at all of the known receptor systems and include ion channel modulators, neurotoxins, and protein kinase inhibitors.

Science #515

1333 H Street, NW
Washington, DC 20005
202-326-6526

Science magazine — the world's foremost scientific weekly journal. *Science* features news, research articles, articles

and reports on advanced research. Free copies of the magazine will be distributed at the booth.

Science By Mail, Museum of Science #219

Science Park
Boston, MA 02114-1099
800-729-3300

Science-By-Mail is an international pen pal program developed by the Museum of Science in Boston. The program teams up children with volunteer scientists to solve three creative, open-ended science challenges a year.

Scientific, Medical Publications of France, Inc. #417

100 E. 42nd Street, Suite 1002
New York, NY 10017
212-983-6278

French Association of Publishers in the field of Sciences & Medicine (Books & Journals in French & English).

The Scientist #121

3501 Market Street
Philadelphia, PA 19104
215-386-0100

The Scientist focuses on the careers, funding, and earning opportunities of researchers in industry, government, and academia. The biweekly newspaper addresses the interest of administrators, funding agencies, and others who need to be informed on issues ranging from hiring trends to major scientific breakthroughs.

Scientists Center for Animal Welfare #503

4805 St. Elmo Avenue
Bethesda, MD 20814
301-654-6390

A nonprofit organization concerned with the well-being of animals in research, testing, and education. SCAW promotes responsible and humane treatment of laboratory, farm, and wildlife research animals; compliance with Federal mandates; and consideration of alternatives.

Senior Scientists & Engineers #119

1333 H Street, NW
Washington, DC 20005
202-326-6664

The SSE program is a national cooperative effort of leading scientific, engineering, and medical societies for the purpose of applying the knowledge and experience of senior scientists and engineers to the needs of the nation.

Sigma Delta Epsilon/Graduate Women in Science (SDE/GWIS) #421

*P.O. Box 4748
Ithaca, NY 14852
607-273-9416*

SDE/GWIS is a national society of scientists whose aim is to encourage women in science through grants, awards, fellowships, conferences, speakers, publications, and other scientific and professional programs.

Space Telescope Science Institute #220

*3700 San Martin Drive
Baltimore, MD 21218
301-338-4707*

Recent science images from the Hubble Space Telescope demonstrate its ability to produce unprecedented, detailed studies of the environments of neighboring galaxies, the Milky Way's stellar population and structure, stellar evolution and star clusters, and the solar system.

Texas Instruments, Inc. #221

*P.O. Box 655303, MS-8214
Dallas, TX 75265
214-917-6278*

Calculators for the classrooms, grade K-12 overhead calculators, and instructional material.

U.S. Department of Energy #605

*ER-80
Washington, DC 20585
202-586-8949*

The FEDIX exhibit describes an online computer database of DOE research programs for use by universities.

U.S. Department of Energy #218

*ER-80
Washington, DC 20585
202-586-8949*

This exhibit outlines a number of pre-university programs available through DOE laboratories.

U.S. Department of Energy/OCRWM #312

*1000 Independence Avenue, SW
Washington, DC 20585
202-586-5723*

This exhibit, entitled "Managing the Nation's Nuclear Waste," has two video monitors and numerous free publications describing the U.S. Waste Management Program, Types of Nuclear Waste, Site Investigations, Disposal, Storage Technology, and Transportation. Also includes information on INFOLINK, OCRWM's computerized data base and communications network, created to assist

users in accessing OCRWM program information as well as in identifying and ordering OCRWM information products.

U.S. Department of Energy/Science & Engineering Research Semester #513

*Office of Energy Research
ER-44, Room 3F-061
1000 Independence Avenue, SW
Washington, DC 20585
202-488-2426*

The U.S. Department of Energy Science and Engineering Research Semester (SERS) program offers undergraduate juniors and seniors the opportunity to spend an academic term in off-campus, energy-related research at one of six national laboratories.

U.S. Department of Veterans Affairs #214

*810 Vermont Avenue, NW
Washington, DC 20420
202-233-2200*

The exhibit presents examples of progress in the Department of Veterans Affairs Rehabilitation Research & Development program for improving the quality of life for the disabled.

U.S. Geological Survey #401, 405

*790 National Center
Reston, VA 22092
703-648-4377*

Panels depicting research and products of the U.S. Geological Survey dealing with earth sciences.

Union of Concerned Scientists #217

*26 Church Street
Cambridge, MA 02238
617-547-5552*

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AAAS☆91 Exhibition

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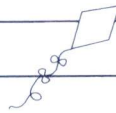
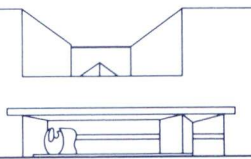
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Sheraton Washington Hotel
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Organized by Katrina L. Kelner
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American Association for the Advancement of Science
1333 H Street, NW, Washington, DC 20005

Seminar Program

Saturday, 16 February

8:30 am *Session 1: Stimulus-Transcription Coupling in Neuronal Cells*

Presiding: James I. Morgan (*Dept. of Neuroscience, Roche Institute of Molecular Biology, Nutley, NJ*)

Inducible Proto-oncogenes in the Nervous System
James I. Morgan

Regulation of Neuronal Gene Expression by Depolarization
Michael Greenberg (*Dept. of Microbiology, Harvard Medical School, Boston, MA*)

Pleasure, Pain, and Proto-oncogenes
Michael J. Iadarola (*Neurobiology and Anesthesia Branch, National Institute of Dental Research, National Institutes of Health, Bethesda, MD*)

NGF Induces Transcription of Genes Encoding Zinc-finger Proteins
Jeffrey Milbrandt (*Dept. of Pathology, Washington Univ. School of Medicine, St. Louis, MO*)



1:00 pm *Plenary Lecture* *Washington Ballroom*

Molecular Insights into the Function of Neurotransmitter Receptors and Ionic Channels
Shosaku Numa (*Professor, Depts. of Medical Chemistry and Molecular Genetics, Kyoto Univ. Faculty of Medicine, Kyoto, Japan*)



2:30 pm *Session 2: Structure and Function of Potassium Channels*

Presiding: Arthur M. Brown (*Professor and Chairman, Dept. of Physiology, Baylor College of Medicine, Houston, TX*)

A Minimalist Potassium Channel
Arthur M. Brown

Molecular Studies of Voltage-gated Potassium Channels
Lily Y. Jan (*Professor, Dept. of Physiology, Univ. of California, San Francisco, CA*)

Structure-Function Correlations in a Family of Rat Brain Potassium Channels
Walter Stühmer (*Max Planck Institute, Göttingen, FRG*)

Biophysical and Molecular Mechanisms of Potassium Channel Gating

Richard W. Aldrich (*Associate Professor, Dept. of Neurobiology, Stanford Univ. School of Medicine Stanford, CA*)

Sunday, 17 February

8:30 am *Session 3: Olfaction and Taste*

Presiding: Gordon M. Shepherd (*Professor, Section of Neuroanatomy, Yale Univ. School of Medicine, New Haven, CT*)

From Ions and Molecules to Perception and Cognition
Gordon M. Shepherd

Molecular Mechanisms of Transduction in Olfaction: A Model for Receptor-Ligand Signaling Systems
Stuart Firestein (*Dept. of Neuroanatomy, Yale Univ. School of Medicine, New Haven, CT*)

Long-term Potentiation and Serial Memory Processing in the Olfactory Hippocampal Circuit
Gary S. Lynch (*Professor, Center for Neurobiology of Learning, Univ. of California, Irvine, CA*)

The Initial Events in Taste Transduction
Stephen D. Roper (*Dept. of Anatomy/Neurobiology, Colorado State Univ., Fort Collins, CO*)

Sensory Coding of Gustatory Information
David V. Smith (*Dept. of Otolaryngology, Univ. of Cincinnati, Cincinnati, OH*)



11:45 am- *Poster Session*

2:15 pm *Sheraton Exhibit Hall C*



2:30 pm *Session 4: Activity-dependent Plasticity in Development and Learning*

Presiding: Carla J. Shatz (*Professor, Dept. of Neurobiology, Stanford Univ. School of Medicine, Stanford, CA*)

Long-term Potentiation: A Cellular Model for Learning
Roger A. Nicoll (*Dept. of Pharmacology, Univ. of California School of Medicine, San Francisco, CA*)

Mechanisms for Use-dependent Synaptic Plasticity in the Developing and Mature Visual Cortex

Wolf Singer (*Dept. of Neurophysiology, Max Planck Institute, Frankfurt, FRG*)

Regulation of Synapse Stabilization by Regulation of a Receptor System

Martha Constantine-Paton (*Professor, Dept. of Biology, Yale Univ., New Haven, CT*)

Spontaneous Activity and the Patterning of Connections in Fetal Development

Carla J. Shatz

Monday, 18 February

8:30 am Session 5: Cognitive Processes

Presiding: Larry Squire (*Veterans Administration Medical Center, San Diego, CA*)

Memory: Brain Systems and Cognition

Larry Squire

Attentional Control of Visual Perception: Cortical and Subcortical Mechanisms

Robert Desimone (*Laboratory of Neuropsychology, National Institute for Mental Health, National Institutes of Health, Bethesda, MD*)

Components of High-level Vision: A Cognitive Neuroscience Analysis

Stephen Kosslyn (*Associate Professor, Dept. of Psychology, Harvard Univ., Cambridge, MA*)

Neural Circuits That Mediate Perceptual Judgements of Motion Direction

William T. Newsome III (*Dept. of Neurobiology, Stanford Univ. School of Medicine, Stanford, CA*)



2:30 pm Session 6: Molecular Basis of Neurological Disease

Presiding: Joseph B. Martin (*Office of the Dean, Univ. of California School of Medicine, San Francisco, CA*)

Molecular Genetic Approaches to Identification of Mutant Genes in Neurological Disorders

Joseph B. Martin

Molecular Genetics Retinoblastoma

Thaddeus P. Dryja (*Dept. of Ophthalmology, Massachusetts Eye and Ear Infirmary, Boston, MA*)

Neuronal Polarity and Microtubule System: A Target of Alzheimer's Pathology

Kenneth S. Kosik (*Center for Neurologic Diseases, Brigham and Women's Hospital, Boston, MA*)

Molecular Biology and Genetics of Prions Causing Neurodegeneration

Stanley B. Prusiner (*Dept. of Neurology, Univ. of California School of Medicine, San Francisco, CA*)

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Speaker Papers

Stimulus-Transcription Coupling in Neuronal Cells

Saturday, 16 February (8:30 am)

From Proto-Oncogenes To Transgenes: Inducible Transcription Factors In The Mammalian CNS. JAMES I. MORGAN (Dept. of Neurosciences) and TOM CURRAN (Dept. of Molecular Oncology and Virology, Roche Institute of Molecular Biology, Nutley, N.J. 07110).

A central question in neurobiology is to define the mechanisms that convert short term event in the nervous system into long-lasting alteration in behaviour. In recent years, studies aimed at understanding the molecular biology of oncogenes (genes that cause cancer) and their normal cellular counterparts, proto-oncogenes, have pointed to a class of inducible genes that may represent a link between cell stimulation and long-term alterations in phenotype. Glutamatergic stimulation of the rodent nervous system results in rapid and transient induction of a class of genes referred to generically as cellular immediate-early (cIE) genes. Several cIE genes encode transcription factors, the best known being the *c-fos* and *c-jun* proto-oncogenes. The products of *fos* (Fos) and *jun* (Jun) form homo- and hetero-dimeric complexes that are components of transcription factor AP-1. Fos, Jun and several Fos-and Jun-related proteins are induced in a staggered manner in brain such that the precise composition of AP-1 varies over time. This provides a temporally staged series of transcriptional regulatory events that may be important in orchestrating long-term changes. Recently, transgenic mice strains have been derived that express a *c-fos-lac Z* fusion gene. These mice have been used to map the sites of *c-fos* expression in several seizure paradigms.

Neurotransmitter Regulation of c-fos Proto-oncogene Transcription
MORGAN SHENG, TAM THOMPSON and MICHAEL E. GREENBERG
(Department of Microbiology and Molecular Genetics, Harvard Medical School)

Depolarization of neurons and PC12 cells results in a rapid transcriptional induction of a number of immediate early genes including *c-fos*. These genes are thought to play important regulatory roles in long term neuronal responses to trans-synaptic activity. This work is directed toward understanding the molecular mechanisms underlying depolarization induction of *c-fos* expression. Activation of *c-fos* transcription by membrane depolarization is dependent on the influx of Ca^{++} through voltage-gated Ca^{++} channels, and is mediated by a DNA element, the Ca^{++} response element (CaRE), located at position -60 in the *c-fos* promoter. The CaRE is identical in sequence requirement to the cAMP response element (CRE) and forms the specific binding site for the CRE binding protein (CREB). Experiments which suggest that CaRE dependent gene activation is mediated by CREB or a related protein will be presented. We find that depolarization of PC12 cells results in a rapid phosphorylation of CREB on serine 133, the major site of phosphorylation by the cAMP-dependent kinase. The swiftness of the *in vivo* phosphorylation is consistent with the idea that phosphorylation mediates the depolarization induction of *c-fos* transcription. The calcium-calmodulin dependent kinases I and II (CaM kinases I and II) phosphorylate CREB *in-vitro* on serine 133. These kinases are activated in depolarized cells and may mediate the depolarization induced phosphorylation of CREB. As a target for convergent cAMP and Ca^{++} regulated kinases, CREB appears to integrate second messenger signals from both cAMP and Ca^{++} pathways in the control of gene expression. In support of this, we have shown that a GAL4-CREB fusion protein expressed in PC12 cells confers Ca^{++} and cAMP inducible transcription to reporter plasmids containing GAL4 binding sites. When serine 133 is mutated to an alanine in the context of GAL4-CREB, both the depolarization and cAMP induction of *c-fos*

transcription are greatly reduced. This suggests that phosphorylation of CREB on serine 133 is critical to depolarization activation of *c-fos* transcription.

Nerve Growth Factor Induces Transcription of Genes Encoding Zinc Finger Proteins. JEFFREY MILBRANDT (Washington University School of Medicine, St. Louis, MO)

Nerve growth factor (NGF) is a neurotrophic factor that is essential for the differentiation and survival of sympathetic and neural crest-derived sensory neurons. Our laboratory is investigating the changes in gene expression that occur during the NGF-mediated differentiation of the rat pheochromocytoma cell line PC12. Using differential hybridization several cDNAs have been identified which correspond to genes whose transcription was rapidly activated after NGF administration. The nucleotide sequence of two of these cDNAs, NGFI-A and NGFI-B, has been determined and analysis of this sequence revealed that both of these early response genes encode zinc finger proteins. The NGFI-B gene encodes a protein with a predicted molecular mass of ≈ 61 kDa that is homologous to members of the steroid/thyroid receptor gene family. The NGFI-B protein is rapidly synthesized in response to NGF. Pulse-chase analysis revealed that it is a very short-lived protein that is rapidly modified post-translationally via phosphorylation. A novel yeast selection scheme has been devised and used to identify DNA fragments containing NGFI-B binding sites (BRES). The BRE sequence has been delimited by DNase I footprinting and by gel retardation assays. Luciferase reporter constructs containing this binding site have been co-transfected along with NGFI-B expression plasmids to explore the transcriptional properties of NGFI-B.

Plenary Lecture

Saturday, 16 February (1:00 pm)

Molecular Insights into the Function of Neurotransmitter Receptors and Ionic Channels SHOSAKU NUMA (Kyoto Univ. Faculty of Medicine, Kyoto, Japan)

Neurotransmitter receptors and ionic channels are membrane proteins essential for neural signaling. Cloning and sequencing of cDNAs have revealed the primary structures of different families of receptors and channels, i.e., a neurotransmitter-gated channel (nicotinic acetylcholine receptor); voltage-gated channels (sodium channel and calcium channel); a cyclic, nucleotide-gated channel (cyclic GMP-gated channel); an intracellular membrane channel (calcium release channel); and a G-protein-coupled receptor (muscarinic acetylcholine receptor). Expression of the cloned cDNAs yields functional receptors and channels. The structural basis for the function of neurotransmitter receptors and ionic channels has been investigated by the combination of recombinant DNA techniques and electrophysiological measurements; wild-type and specifically mutated proteins produced by cDNA expression have been analyzed for functional properties. The main findings obtained concern the identification of a channel-forming region of the nicotinic acetylcholine receptor, the identification of a voltage-sensing segment responsible for activation of the sodium channel, the functional role of the skeletal muscle slow calcium channel in excitation-contraction coupling, and the molecular basis of the functional heterogeneity of the muscarinic acetylcholine receptor.

Structure and Function of Potassium Channels

Saturday, 16 February (2:30 pm)

Defining A Minimal K⁺ Channel. ARTHUR M. BROWN (Baylor College of Medicine).

K⁺ channels may be voltage- or ligand-gated and each type is highly regulated. A structural family of voltage-gated K⁺ channels has been cloned from *Drosophila*, rat, mouse and human. The members share properties of rapid activation by depolarizing potentials and selective conduction of K⁺. Using expression cloning a member of the Shab subset, *drk1*, was isolated. The putative transmembrane segments consumed about 1/4 of the amino acid sequence and we began a structure-function analysis by deleting large parts of the non-membrane N- and C-termini. Removal of 139 amino acids from the N-terminus slowed activation greatly and shifted voltage-dependent gating to depolarized potentials. Removal of 318 amino acids from the C-terminus had opposite effects. In neither case was voltage sensitivity of gating or K⁺ selectivity changed. Double deletions restored wild type function in a channel that was now less than half its original length. We suggest that: both termini are cytoplasmic, shifting is due to changes in charged residues producing effects analogous to changes in surface charge and voltage sensitivity and K⁺ selectivity reside in the transmembrane core of the molecule. Ligand-gated channels usually conduct K⁺ better in the inward direction. Their structures are unknown but their regulation has been extensively studied. For one type we have shown that the α subunit of the heterotrimeric G protein G_{i-3} directly activates and mimics the effects of muscarinic activation. Subsequently we found that the monomeric G protein ras p21 blocks muscarinic activation in combination with its effector the GTP-ase activating protein GAP. Thus small and large G proteins may regulate ligand-gated K⁺ channels.

Molecular Studies of Voltage-gated Potassium Channels. EHUD ISACOFF, WILLIAM KIMMERLY, GEORGE LOPEZ, DIANE PAPAZIAN*, YUH NUNG JAN AND LILY YEH JAN. Howard Hughes Medical Institute and the Department of Physiology and Biochemistry, UCSF. *Department of Physiology, UCLA.

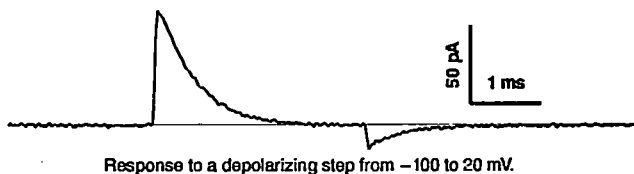
Potassium channels represent a diverse group of ion channels found in most eukaryotic cells studied. They are often regulated by second messengers and are involved in a wide range of cellular functions including secretion, heart beat, neuronal excitability and synaptic plasticity. Because of the scarcity and heterogeneity of these potassium channels, we approached the cloning of a potassium channel gene by taking advantage of *Drosophila* genetics. Cloning of this gene, *Shaker*, and its homologs in different vertebrates and invertebrates by a number of researchers allowed molecular studies of the mechanism underlying potassium channel diversity as well as identification of structural elements involved in channel functions such as voltage-dependent activation, inactivation, and ion permeation. A progress report of our studies will be presented.

Gating Currents of Potassium Channels Expressed in *Xenopus* Oocytes

W. STÜHMER, S. H. HEINEMANN (Max-Planck-Institut für biophysikalische Chemie, D-3400 Göttingen, FRG), M. STOCKER, O. FONGS (Lehrstuhl für Biochemie, Ruhr-Universität Bochum, D-4630 Bochum) and F. CONTI (CNR, Istituto di Cibernetica e Biofisica, I-16146 Genova, Italy).

While the study of potassium gating currents has so far been hampered by the simultaneous presence of sodium channels in excitable cells, the approach of exogenous ion channel expression in oocytes meets the requirements for such investigations. We report on recordings of gating currents from oocytes which have been injected with cRNA corresponding to potassium channels from *Drosophila* and rat brain in the inside-out patch configuration providing high time resolution and a low-noise performance. The rising phase of the recorded potassium gating currents is close to the recording bandwidth of 10 kHz ruling out slow initial steps in the activation process. The on gating currents show a double exponential time course between -60 and 0 mV. The fast recovery of Q_{on} upon repolarization is incomplete. In contrast to sodium

channels, gating charge becomes totally immobilized for positive membrane potentials and long pulses regardless of whether the channels show inactivation or not. The ratio of Q_{on} and Q_{off} versus membrane potential is consistent with four independent gating units per channel.



Molecular Mechanisms of *Shaker* Potassium Channel Inactivation. RICHARD ALDRICH (Stanford University and Howard Hughes Medical Institute).

Most classes of voltage-gated ion channels undergo inactivation. The time course of inactivation varies widely among different channels types, with time constants of a few milliseconds to seconds. Voltage-gated sodium channels, T-type calcium channels, and *Shaker* potassium channels have been shown to inactivate by a mechanism where the inactivating conformational change involves little or no redistribution of charged particles across the cell membrane and therefore is not influenced by the voltage across the membrane. We have used genetic engineering and single-channel recording techniques to investigate the conformational changes that underlie fast inactivation in *Shaker* potassium channels. Our results demonstrate that the first 10 or so hydrophobic amino acids and the positively charged amino acids in positions 16 through 19 are important in the inactivation mechanism. By altering these amino acids we can change the inactivation rate in a graded manner up to about 20 times slower than normal. Deletion and insertion mutations in an adjacent region alter the inactivation rate proportional to the length of the remaining amino acid chain, suggesting this region acts as a spacer. Our results are strikingly consistent with the "ball and chain" model of inactivation originally proposed for the voltage-dependent Na channel by Armstrong and Bezanilla in 1977, where the amino terminus of the *Shaker* channel acts as an "agonist" for inactivation. The inactivation "receptor" is located elsewhere on the cytoplasmic side of the molecule. When the inactivation agonist is bound to the receptor, the channel closes. This model is further supported by experiments in which a synthetic peptide with the sequence of the first 20 amino acids of the amino terminus can restore inactivation in mutant channels that do not inactivate.

Olfaction and Taste

Sunday, 17 February (8:30 am)

From Ions and Molecules to Perception and Cognition. GORDON M. SHEPHERD, Section of Neuroanatomy, Yale University Medical School, New Haven, CT.

Olfaction and taste differ from other sensory modalities in that the sensory information is not restricted to secondary effects of the temporal or spatial patterns of stimulation, but is carried in the stimulating ions and molecules themselves. Taste involves an unusual range of stimuli, from single ion species (salt, sour) through simple molecules (sweet) to complex molecules (bitter). In olfaction, most odor molecules can be considered as ligands which bind to molecular receptors. Studies of the pharmacology of ligand-receptor binding are needed to give insight into the nature of the information that is transduced. The activated sensory neurons constitute a spatial array in which neural space is used to encode information carried in the stimulating molecules. This information is successively re-mapped in the neural space of the olfactory bulb and olfactory cortex. Recent studies of activity maps at these levels need to be assessed for the kinds of neural computations carried out on molecular information in the neural domain, and the ways these computations can serve as the basis for perception and cognition.

Molecular Mechanisms of Transduction in Olfaction: A Model for Receptor-Ligand Signalling. STUART FIRESTEIN, Section of Neuroanatomy, Yale University Medical School, New Haven CT.

The detection and discrimination of chemicals, such as neurotransmitters or hormones, is an essential function for

all neurons. Recently it has become clear that, although there are many different molecules of importance, there are only a few common mechanisms for recognizing these molecules and transducing this recognition into a neurally relevant signal, for example a change in membrane voltage. Since olfactory receptor neurons are highly specialized for the recognition of as many as 2000 different chemicals, most small organic molecules, they represent a useful model system for studying the general principles underlying molecular transduction. This presentation will trace the series of events, as we now understand them, from the interaction of an odor molecule with the olfactory cell membrane, to the generation of an electrical signal transmitted to higher order brain structures for processing. The mechanisms functioning in olfactory transduction will be compared to those known in other systems such as photo-, beta-adrenergic, and muscarinic receptors. Finally, strategies for approaching important questions generally relevant to signal transducing systems through analysis of olfactory transduction will be presented.

Long-term Potentiation and Serial Memory Processing in the Olfactory Hippocampal Circuit. GARY LYNCH (University of California, Irvine).

Olfactory cortex projects directly to higher order memory-related structures including hippocampus, amygdala, and frontal cortex. The sampling patterns and physiological rhythms associated with olfactory learning are also peculiarly well-suited for inducing long-term potentiation (LTP), a stable form of synaptic change probably involved in memory encoding. Recent studies have led to the hypothesis that the patterned stimulation produces LTP by i) transiently suppressing inhibitory potentials, ii) causing stimulation of a trophic factor receptor associated with the regulation of post-synaptic calcium, iii) modifying the properties of transmitter receptors, and iv) stabilizing these changes via a type of a cell adhesion response. Other lines of work have shown that the properties of LTP vary across the sequential links leading from the olfactory bulb through the hippocampus. Induction at one stage is dependent upon the past experience of the animal; at another site, LTP is decremental and decays over a period of one to two weeks. A third site uses a form of potentiation that is unrelated to LTP. These and other observations suggest that LTP in the olfactory hippocampal circuit provides for serial memory processing involving the following sequence of questions: i) recognize cue? ii) how long since last encounter? iii) responded to known cue today? iv) is response to cue followed by appropriate event? In summary, olfactory physiology is closely related to the machinery that causes LTP and the characteristics of LTP provide clues concerning the nature of olfactory memory.

Voltage-gated Ion Channels and their Role in Taste Transduction. A. BIG- IANI and S. ROPER (Dept. of Anatomy and Neurobiology, Colorado State University, Ft. Collins, CO 80523 and The Rocky Mt. Taste and Smell Center, Denver, CO 80262)

Vertebrate taste receptor cells possess a number of voltage-gated ion channels that play critical roles in chemosensory transduction mechanisms. Ion channels are not distributed evenly on the taste cell surface and their non-uniform distribution is key to understanding how chemical stimuli generate receptor potentials. Where its distribution has been studied in detail, namely in taste cells from *Necturus maculosus*, voltage-gated potassium conductance has been found to be limited to the apical membrane of receptor cells. Voltage-gated potassium channels are particularly important in transducing bitter, sweet, and sour taste. A number of chemosensory stimuli, including quinine, calcium salts, sugars, and acids block the apical voltage-gated potassium conductance and thus generate depolarizing receptor potentials in taste cells. Potassium salts, themselves potent taste stimuli, merely distribute across the apical membrane by passing through voltage-gated apical potassium channels that are open at rest and thereby also generate depolarizing receptor potentials. The finding that chemosensory stimuli operate through voltage-gated potassium channels raises the possibility that fluctuations in the resting potential can modulate sensory responses in taste receptor cells. That is, membrane hyperpolarization will block voltage-gated potassium conductance and thus should reduce or eliminate responses that are mediated through apical potassium channels. These predicted effects on receptor potentials evoked by chemical stimuli have been observed in *Necturus* taste cells when the membrane potential has been controlled by injecting current through an intracellular microelectrode. Whether endogenous current sources, such as electrogenic Na pumps, can generate fluctuations in membrane potential sufficient to modulate receptor potentials remains to be determined.

Sensory Coding of Gustatory Information. DAVID V. SMITH (University of Cincinnati College of Medicine).

Gustatory input to the brain provides information important for food selection and avoidance of potential poisons. Complex behavioral sequences, including oral and somatic motor responses, salivation, cephalic phase insulin release, and conscious taste perception are triggered by gustatory stimuli. Studies of taste transduction are beginning to suggest that stimuli representing different taste qualities may initiate receptor activity through different mechanisms. Nevertheless, the activity of any given first-order nerve fiber can be modulated by several classes of stimuli. Thus, there has been considerable argument over the mechanisms of taste coding within the peripheral and central pathways. These arguments focus on whether activity in a given taste neuron (e.g., sucrose-best) codes for a single taste quality (e.g., sweet) or whether quality is represented by a population response. Taste buds in several different locations (anterior and posterior tongue, palate, nasopharynx, and larynx) are innervated by different cranial nerves (VII, IX, and X) and possess dramatically different profiles of sensitivity. Thus, the receptor mechanisms for the various taste qualities are differentially distributed across the several populations of taste buds. Nonetheless, these peripheral fibers respond to more than one class of stimuli. Neurons in the medullary and pontine taste nuclei are more broadly tuned than peripheral fibers, although they are easily classified according to their response profiles. Fibers that are sharply tuned to a given taste quality (e.g., sucrose-best) are a critical determinant of the population response for that particular quality. Discrimination among stimuli of different quality requires comparisons of the activity in different neuron types.

Activity-dependent Plasticity in Development and Learning

Sunday, 17 February (2:30 pm)

LTP: A cellular model for learning.

R.A. NICOLL (Depts. of Pharmacology and Physiology, University of California, San Francisco)

Brief repetitive activation of excitatory synapses in the hippocampus, a structure known to play a key role in learning and memory, results in a long lasting enhancement of synaptic transmission. This long term potentiation (LTP) provides a useful cellular model for learning and memory. Release of glutamate from these excitatory synapses acts on both N-methyl-D-aspartate (NMDA) and non-NMDA receptors. The induction of LTP requires simultaneous NMDA receptor activation and postsynaptic depolarization. This dependence on coincidence between pre- and postsynaptic activity is remarkably similar to the proposal made by Hebb in 1949 for a synaptic mechanism for learning and memory. Considerable evidence indicates that depolarization relieves a voltage dependent Mg^{2+} block of the NMDA receptor channel, and that entry of Ca^{2+} through the NMDA receptor channel serves as the trigger for LTP. In addition to the NMDA-dependent "Hebbian" LTP which is most clearly demonstrated in the CA1 region of the hippocampus, there is also an NMDA independent form of LTP in the CA3 region of the hippocampus. This form of LTP does not appear to depend on a rise in postsynaptic Ca^{2+} or on depolarization of the postsynaptic cell. The properties of these two forms of LTP will be compared and possible roles discussed.

Mechanisms of use-dependent synaptic plasticity in developing and mature visual cortex

WOLF SINGER (Max Planck Institute for Brain Research, Deutschordenstr. 46, D-6000 Frankfurt/M. 71, F.R.G.)

In the developing visual cortex neuronal connections are subject to experience-dependent modifications consisting of selective consolidation and disruption of excitatory pathways. These changes are gated by modulatory projections which employ noradrenaline, acetylcholine and serotonin as transmitters. Circuit modifications cannot be induced in the absence of these modulatory inputs. Moreover, retinal signals need to activate N-methyl-D-aspartate receptor-dependent conductances in order to induce circuit modifications. Use-dependent changes of synaptic gain can also be induced in slice-preparations of the mature visual cortex.

This *in vitro* assay allows for a more detailed analysis of the underlying molecular mechanisms. The synaptic modification rules identified in the mature system are surprisingly similar to those governing developmental plasticity. Crucial variables are the level of postsynaptic depolarization and the temporal contiguity of pre- and postsynaptic activity. Changes of synaptic gain occur only when postsynaptic depolarization exceeds a critical level. Synapses weaken when NMDA-receptors are not activated, and they strengthen when this is the case. These results suggest that developmental self-organization and learning in the mature system depend on similar mechanisms.

Regulation of Synapse Stabilization by Regulation of a Receptor System. MARTHA CONSTANTINE-PATON (Yale University).

A mechanism which stabilizes converging synapses on the basis of temporal correlations in the patterns of action potential activity has been implicated in afferent competition and the point to point ordering of mapped projections during vertebrate pathway development. The unique current and voltage gating requirements of the N-methyl-D-aspartate subtype of glutamate receptor make it a good candidate for the detector of correlated inputs and the initiator of the stabilization mechanism. We have demonstrated that chronic blockade of this receptor with its specific antagonists eliminates both point to point order in the retinotopic map and the segregation of ocular dominance stripes within the developing optic tectum. We have also used chronic treatment with low levels of agonist to downregulate the effectiveness of the NMDA receptor and we have demonstrated that this is associated with decreases in synapse stabilization in regions of the retinotectal neuropil where correlations in converging activity are expected to be low. We are currently investigating the mechanism of receptor down-regulation and the cytoplasmic cascades initiated by NMDA receptor activation which may lead to the structural reinforcement of synapses.

Supported by grants EY06039 and EY08760.

Spontaneous activity and the patterning of connections during fetal development. C.J. SHATZ (Stanford University).

In the mammalian visual system, retinal ganglion cell (RGC) axons terminate within their target, the lateral geniculate nucleus (LGN), in a pattern of alternating eye-specific layers which are not present initially during development. In the cat they emerge by birth, following a prenatal period in which originally intermixed inputs from the two eyes gradually segregate. Much evidence suggests that activity-dependent competitive interactions play an important role in this process of segregation. Individual RGC axons from one eye extend, then retract, branches from territory later occupied exclusively by axons from the other eye; many of these branches are sites of synaptic contacts. *In vitro* microelectrode recordings show that LGN neurons can receive convergent synaptic excitation from both optic nerves before, but not after, the eye-specific layers form, suggesting that at least some synaptic contacts are functional. These results indicate that the machinery necessary for synaptic transmission and activity-dependent competition is present during fetal life. Moreover, recent microelectrode recordings *in vivo* (Galli and Maffei, 1988) and *in vitro* (Meister, Wong, Baylor and Shatz, 1990) have revealed that fetal retinal ganglion cells spontaneously generate bursts of action potentials, with neighboring ganglion cells firing synchronously, thereby providing a necessary spatio-temporal pattern of activation of the retinogeniculate pathway. (Photoreceptors are not present at these early ages.) Finally, intracranial infusion of tetrodotoxin, which blocks RGC action potentials, prevents the segregation of RGC axons into layers. The results of these experiments indicate that even before vision is possible, activity-dependent competition in the retinogeniculate system may contribute to the final patterning of connections present in the adult. Spontaneous neural activity may shape connections in an analogous fashion elsewhere in the nervous system during fetal development.

Cognitive Processes

Monday, 18 February (8:30 am)

Brain Systems and the Structure of Memory

L.R. Squire, (Veterans Administration Medical Center,

San Diego, and Department of Psychiatry, University of California, School of Medicine, San Diego, California)

Studies of animals with complex nervous systems, including humans, have provided new insights about how memory is organized in the brain. One new development is the possibility of studying the anatomy of memory in humans using magnetic resonance imaging. In addition, work with monkeys, using an animal model of human amnesia, has led to identification of the major components of the medial temporal lobe memory system. The system includes the hippocampal formation and adjacent, anatomically-related cortex, especially perirhinal and parahippocampal cortex. Neuropsychological analysis of patients with circumscribed memory impairment (amnesia) has led to a distinction between declarative (conscious) memory, which is dependent on the structures damaged in amnesia, and nondeclarative (unconscious) memory, which is independent of these structures. The brain system damaged in amnesia is essential for the formation and storage of declarative memory, and for its retrieval during a lengthy period of consolidation and reorganization. As time passes, the role of the hippocampal formation in memory diminishes, and a more permanent memory gradually develops elsewhere, probably in neocortex.

Neural Mechanisms of Attention and Memory.

ROBERT DESIMONE (Laboratory of Neuropsychology, NIMH, Bethesda, MD).

Much of the information impinging on our sensory surfaces is filtered out centrally and thus never reaches awareness. Correspondingly, our neuronal recordings in extrastriate cortex of behaving monkeys have shown that sensory processing is under the control of selective attention. Selective attention serves both to remove irrelevant information from the receptive fields of extrastriate neurons and to sharpen neuronal selectivity for visual features. In this way, attention also regulates the flow of information from extrastriate neurons to neuronal mechanisms for memory in the temporal lobe. Our recent recordings in the anterior temporal cortex have identified neuronal response changes to repeated stimulation that may underlie that storage of visual memories over at least short periods of time.

Functional Organization of High-Level Vision. STEPHEN M. KOSSLYN (Harvard University).

Vision can be divided into two general levels, based on whether stored information about objects and their properties alters processing. Low-level vision is not altered by such stored information, whereas high-level vision is. Although there has been enormous progress in the study of low-level vision, high-level vision is just beginning to be understood. Progress in understanding high-level vision is being made by combining studies of the neurophysiology and neuroanatomy of the visual system in nonhuman primates with computational analyses and behavioral experimentation in humans. Some of this experimentation makes use of new brain imaging techniques, which allow us to observe which brain areas are recruited when humans perform specific tasks. This talk illustrates how the combined use of the different methodologies and types of information is revealing the broad outlines of the functional organization of high-level vision, and how this emerging picture allows us to understand the effects of brain damage on visual abilities and on visual mental imagery.

Neural Circuits that Mediate Perceptual Judgements of Motion Direction.

William T. Newsome, C. Daniel Salzman, Chieko M. Murasugi and Kenneth H. Britten. Department of Neurobiology, Stanford University School of Medicine, Stanford, CA 94305.

In primates, visual perception results primarily from neural activity in visual areas of the cerebral cortex. Single neurons in these visual areas can be remarkably selective in their responses to visual stimuli. For

example, some neurons discharge selectively to line contours of a particular orientation, some respond to stimulus motion in a particular direction, while others are selective for the color or distance of a visual stimulus. An intuitively appealing hypothesis is that such neurons contribute to distinct cortical circuits that mediate our perception of local contour, motion, color and depth, respectively. While a great deal of contemporary vision research is based on this premise, the evidence in its favor is generally indirect. We have tested this idea directly by analyzing the relationship between the activity of direction selective neurons and perceptual judgements of motion direction. We trained rhesus monkeys to report the direction of motion in a video display, and we employed electrical microstimulation to manipulate the responses of direction selective neurons. We found that activation of direction selective neurons biased the monkeys' perceptual decisions toward the direction encoded by the stimulated neurons. This result establishes a causal relationship between the activity of a class of cortical neurons and a particular aspect of perceptual performance. The approach should prove useful for analyzing the circuits that mediate other dimensions of visual perception as well.

This work was made possible by grants from the National Eye Institute, the Office of Naval Research, and the McKnight Endowment Fund for Neuroscience.

Molecular Basis of Neurological Disease

Monday, 18 February (2:30 pm)

Molecular Genetics: Applications to Neurology.

JOSEPH B. MARTIN (University of California, San Francisco School of Medicine)

Until recently, the likelihood of discovering the molecular genetic basis of most neurological diseases seemed remote. Now, the application of molecular biology techniques, with DNA probes that reveal restriction fragment length polymorphisms (RFLPs) combined with linkage analysis, has resulted in the chromosomal localization of the genes responsible for several of these disorders. In addition, more refined methods of cytogenetics have permitted recognition of chromosomal aberrations (deletions, translocations, or duplications) associated with some of these conditions. Furthermore, abnormal genes have now been cloned in some of the autosomal recessive lysosomal storage diseases. This review summarizes advances made in selected neurological disorders on which these recent discoveries have had a major impact. DNA polymorphisms, first demonstrated in the B-globin gene family have been used to identify the chromosomal location of the abnormal gene in Huntington's disease (chromosome 4), Duchenne dystrophy (X chromosome), familial amyloidotic polyneuropathy (chromosome 18), myotonic dystrophy (chromosome 19), familial Alzheimer's disease (chromosome 21), von Recklinghausen's neurofibromatosis (chromosome 17), bilateral acoustic neurofibromatosis (chromosome 22), and autosomal dominant (chromosome 11) and X-linked recessive manic-depressive illness. These discoveries demonstrate the possibility of locating the gene for any inherited disease, provided that sufficiently large families with the disorder are available.

Molecular genetics of retinoblastoma. T. P. DRVJA, M.D. (Harvard Medical School and Massachusetts Eye and Ear Infirmary).

Retinoblastoma is a cancer that arises in the retinas of young children. It serves as a model for the study of oncogenesis primarily because, unlike most human neoplasms, the molecular genetics of its origin appears to be simple: absence or inactivation of the protein product of one gene (the retinoblastoma gene) is apparently the crucial phenomenon. There are various mechanisms by which this can happen. The first event typically is a loss-of-function mutation of one copy of the gene and can occur in the germline (causing hereditary retinoblastoma) or in a

somatic cell (causing nonhereditary retinoblastoma). This initial "hit" is usually a genetic change, such as a base substitution, deletion, translocation, or more complex rearrangement, although epigenetic changes are theoretically possible, such as erroneous inactivation of the gene by hypermethylation of the promoter region. Loss of the second gene homologue can be due to a second mutation, or, more often, to a chromosomal rearrangement leading to homozygosity of the initial defect in a susceptible retinal cell. Finally, there is evidence from in vitro studies that inactivation of the retinoblastoma protein might bypass the genome and occur instead via the formation of a protein complex including the retinoblastoma protein and a viral oncoprotein such as the Ela or large T antigens. Knowledge of the molecular genetics of this cancer has important implications for the clinical care and genetic counseling of affected families.

The Molecular Unfolding of Alzheimer Plaques and Tangles and the Elusive Link Between Them. K.S. KOSIK (Harvard Medical School, Brigham & Women's Hospital, Boston, MA 02115).

Since the principal molecular constituent of the amyloid at the core of the senile plaque has been identified and the microtubule-associated protein, tau, appears increasingly central in the neurofibrillary tangle, the pace of research on these molecules has accelerated. The fragment of the β -amyloid precursor protein that is deposited as amyloid in Alzheimer's disease is not generated during normal catabolism of the precursor (Sisodia et al., 1990; Esch et al., 1990). However, in PC12 cells, under conditions of enhanced phosphorylation by protein kinase C, a putative amyloidogenic fragment is produced (Buxbaum et al., 1990). Despite the necessary association with Alzheimer's disease, amyloid deposition alone is not a sufficient cause of the disease. A concomitant process in which neurites become dystrophic and reactive with tau and ubiquitin antibodies bears the closest relationship to the clinical dementia (McKee et al., 1990). An abnormal phosphorylation state of tau has also emerged as part of the pathogenesis of these lesions.

Molecular Biology and Transgenetics of Prions Causing CNS Degeneration. STANLEY B. PRUSINER (University of California, San Francisco).

Prions are slow infectious pathogens composed largely, if not entirely, of an abnormal isoform (PrP^{Sc}) of the cellular prion protein (PrP^C) which is encoded by a chromosomal gene. Prions cause scrapie of sheep, bovine spongiform encephalopathy of cattle and three transmissible, neurodegenerative diseases of humans. PrP^{Sc} is generated from PrP^C or a precursor by a post-translational process. PrP^C is bound to the external surface of cultured cells by a glycoinositol phospholipid anchor while PrP^{Sc} accumulates within the cytoplasm, primarily in secondary lysosomes. The scrapie incubation time for transgenic (Tg) mice expressing Syrian hamster (Ha) PrP genes was inversely proportional to the level of HaPrP^C expression after inoculation with Ha prions. Bioassays of brain extracts from Tg(HaPrP) mice inoculated with either Ha or mouse (Mo) prions indicate that the formation of infectious prions is initiated by a species-specific interaction between Ha or MoPrP^{Sc} in the inoculum and homologous PrP^C. A point mutation in the PrP gene of humans with ataxic Gerstmann-Sträussler-Scheinker syndrome (GSS) results in a Pro₁₀₂→Leu substitution. Tg mice expressing a MoPrP transgene carrying the Pro→Leu change and ranging in age from 49 to 272 days developed CNS dysfunction, spongiform degeneration and astrocytic gliosis similar to that found in experimental scrapie. The foregoing observations argue that prion diseases can be both infectious and genetic, and that prions are novel infectious pathogens distinct from both viruses and viroids.

Contributed Papers

Sunday, 17 February (11:45 am–2:15 pm)
Sheraton Exhibit Hall C

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Molecular Analysis of a Gene Encoding a Structural Component of a Ca²⁺-Activated K⁺ Channel. NIGEL ATKINSON (Department of Zoology, University of Texas, Austin, TX), GAIL ROBERTSON (Laboratory of Genetics, University of Wisconsin-Madison, Madison, WI) AND BARRY GANETZKY (Laboratory of Genetics, University of Wisconsin-Madison, Madison, WI).

The transient Ca²⁺-activated K⁺ current, I_{CF}, is required for the normal repolarization of action potentials in muscles and neurons of *Drosophila melanogaster*. Mutations in slowpoke (*slo*) eliminate I_{CF} but not other K⁺ currents and produce characteristic behavioral phenotypes. These phenotypes were exploited in genetic screens to isolate *slo* alleles that resulted from gross chromosomal rearrangements. These chromosome rearrangements provided a means of isolating genomic and cDNA clones from the *slo* locus. A *slo* cDNA has been sequenced, conceptually translated and compared to the sequences of voltage-gated K⁺, Na⁺ and Ca²⁺ channels. Strong similarities between *slo* and the S4 domains of Na⁺ and Ca²⁺ channels and H5 domains of K⁺ channels were observed. On the basis of this evidence we conclude that *slo* encodes a structural component of a Ca²⁺-activated K⁺ channel, the first such gene to be characterized molecularly.

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Structure-Function Studies of the Rat IIA Voltage-Gated Sodium Channel: The Effects of Negative Charge Neutralization in Transmembrane Segments of Domain II. KRIS J. KONTIS (Dept. Microbiology and Molecular Genetics, University of California, Irvine) and ALAN L. GOLDIN (Department of Microbiology and Molecular Genetics, University of California, Irvine)

Voltage-gated ion channels have a common motif consisting of positive charges spaced three residues apart within a proposed transmembrane segment (S4). Stuhmer et al. have shown that these positively charged residues form all or part of the voltage sensing apparatus in sodium channels (1989, Nature 339, 597-603). It has been proposed that these positive charges form salt bridges with negatively charged side chains within other transmembrane segments. To test this idea we have used site-directed mutagenesis to neutralize negative charges within proposed transmembrane segments in domain II of the rat brain voltage-gated sodium channel, Rat IIA (Auld et al., 1988, Neuron 1, 449-461). In vitro transcribed mRNA was microinjected into stage V *Xenopus* oocytes, and, after 2 days incubation, the oocytes were analyzed by two electrode voltage clamping. Our results show that two mutations, D827N and E837Q in IIS3, have distinct effects on the voltage dependence of activation and steady state inactivation (D827N only). Both mutations result in a positive shift in the I-V relationship (peak current vs. test potential). Sodium channels with the D827N mutation show a negative shift in the voltage dependence of steady state inactivation. The mutation D758N, in S1, has no apparent effect on the I-V relationship. Although other interpretations are possible, the results suggest that at least some transmembrane negative residues interact with the voltage sensor positive charges and that these interactions have functional significance. Other mutations are being tested to further investigate this hypothesis.

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INCORPORATION OF CALCIUM-INDEPENDENT POTASSIUM CHANNELS FROM CHROMAFFIN GRANULE MEMBRANES INTO ACIDIC PHOSPHOLIPID BILAYERS. N. Arispe, H.B. Pollard, and E. Rojas, Lab. of Cell Biology and Genetics, NIDDK, NIH, Bethesda, MD. 20892

Chromaffin granules support a transmembrane potential which is dependent upon external chloride and pH, although the existence of a K⁺ conductance mechanism seems to be implicit in results from elemental imaging and osmotic fragility experiments. We therefore searched for such a hypothetical K-channel by incorporating purified chromaffin granule membranes into acidic phospholipid bilayer membranes

made from equal concentrations of PS and POPE. We found that such K-channels could be readily detected when incorporation was carried out in a medium of 400 mM K-HEPES, pH 7.4, and 1 mM CaCl₂. Under these conditions the conductance was ca. 108 pS in the potential range from 20 to 60 mV (cis side negative). A complete I/V curve indicated that K⁺ current was somewhat rectified, in that greater current was carried from cis-to-trans for positive potentials. Ca²⁺ was included in the medium, not only to facilitate fusion of membranes to the target BLM, but also to provide a possible activator for the K-channel. However, we found that charybdotoxin, a specific inhibitor K_{Ca}-channels in plasma membranes, or addition of EGTA to chelate free calcium, failed to affect either the kinetics or conductance of the channel. We conclude that this K-channel in the chromaffin granule membrane is not dependent upon Ca, and suggest that this new channel may be involved in the granular processes of holding and releasing transmitters.

304 Cloning and Expression of a Rat Cardiac Delayed Rectifier Potassium Channel. P. NASMITH, M. PAULMICHLE*, R. HELLMISS, K. REED*, D. CLAPHAM*, and E. PERALTA. (Dept. of Biochemistry and Molecular Biology, Harvard University, Cambridge, MA; and *Dept. of Pharmacology, Mayo Foundation, Rochester, MN).

Using a probe encoding a rat forebrain K⁺ channel, we have cloned a cDNA coding for a rat atrial delayed rectifier K⁺ channel (RAK1). When cRNA from RAK1 was expressed in *Xenopus* oocytes, depolarization of the membrane from -70 mV to potentials of -40 mV and above elicited a large outward K⁺-selective current that showed rapid activation and little to no inactivation within 800 msec. The current was blocked by 4-aminopyridine > barium >> tetraethylammonium. The deduced RAK1 protein sequence contains six putative transmembrane segments, including an S4 voltage sensor domain. RAK1 is highly homologous to the amino terminal end of a rat brain K⁺ channel, BK2 (Mckinnon, D. (1989) J. Biol. Chem. 264, 8230-8236), but diverges at the carboxy terminus, suggesting that these two K⁺ channel proteins are encoded by alternatively spliced mRNAs derived from the same gene. Northern blot analysis showed a transcript of 8.6 kb in adult rat atrial RNA. A similar band was detected adult rat ventricular RNA, but at significantly lower levels.

305 Potassium Channels are Localised on the Presumptive Dorsal Surface of an Insect Follicle. E. BOWDAN¹, M. ANDERSON², J.G. KUNKEL¹. ¹ Univ. of Massachusetts and ²Smith College.

The presumptive dorsal and ventral surfaces of the embryo of the german cockroach *Blattella germanica* can be recognised in the unfertilised, mid-vitellogenic, follicle (oocyte and surrounding follicle cells) by its shape. Follicles of many animals produce stable ionic currents (resulting from net flux of ions) measurable by means of a vibrating probe. In the mid-vitellogenic *B. germanica* oocyte these currents are outward at the dorsal surface, inward at the ventral. In K⁺- and Cl⁻-free medium both outward and inward currents showed a substantial transient increase suggesting that K⁺ left via dorsally localised channels and/or pumps and that Cl⁻ left by way of ventrally localised channels and/or pumps. In 6 of 9 experiments outward currents were reduced in the presence of TEA. In recordings up to 30min, outward currents were decreased in response to high [K⁺]_{out} and increased in response to low [K⁺]_{out}. Inward currents were unchanged, or less consistently affected by TEA and changes in [K⁺]_{out}. However, they showed a substantial transient increase in Cl⁻-free medium and, in 30min recordings, an increase in response to low [Cl⁻]_{out}. Outward currents were unaffected or showed a less consistent reduction in response to changes in [Cl⁻]_{out}. Supported by NSF grant # DCB8905552

I_h and Post-Inhibitory Firing in Identified Superior Colliculus-Projecting Neurons in Culture. J.S. SOLOMON, Washington University School of Medicine, J.M. NERBONNE, Dept. of Pharmacology, Washington University School of Medicine, St. Louis, MO 63110.

We have previously reported that β -adrenergic agonists attenuate a hyperpolarization-activated inward current, I_h, in layer V superior colliculus-projecting (SCP) neurons of rat primary visual cortex. Because norepinephrine disrupts rhythmic firing of lower layer cortical neurons *in vivo*, we are investigating the possibility that this disruption represents a decrease in post-inhibitory firing due to a β -adrenergic receptor-mediated decrease in I_h.

Whole-cell recordings were obtained from dissociated SCP neurons isolated from postnatal day 7-13 Long-Evans rats and identified *in vitro* following *in vivo* retrograde labeling with rhodamine beads. In all SCP cells, hyperpolarizations from a holding potential of -40 mV evoke an instantaneous, noninactivating inward current; steps negative to -70 mV also reveal the slowly activating I_h. The current-voltage relation for I_h is linear at potentials more negative than -90 mV (n=44), and the fully activated conductance reverses near -35 mV (n=5). The rates of rise of I_h are best fit by single exponentials with mean (\pm SD) activation time constants of 1.71 \pm 0.97 and 0.40 \pm 0.18 sec at -80 mV (n=24) and -110 mV (n=29), respectively. Under current clamp, the activation of I_h attenuates responses to hyperpolarizing current pulses. Moreover, deactivation of I_h on removal of the hyperpolarizing current causes a transient overshoot of the rest potential and augments the firing of action potentials. I_h, therefore, appears to be important in modulating the efficacy of sustained inhibitory inputs to SCP neurons and patterning cell firing following release from inhibition. (Supported by NSF #BNS 8809823 and NIH #5T32 GM07805).

307 High Frequency Electrical Stimulation and the Phosphoinositide Cell Signalling System in the Dentate Gyrus of Rat Hippocampal Slice. M.J. BONNER, E.C. BURGARD and J.M. SARVEY (Dep. of Pharmacology, Uniformed Services University of the Health Sciences, Bethesda, MD 20814).

Phosphoinositide (PI) hydrolysis stimulated by a high frequency train (HFT) of electrical stimulation of the perforant path and norepinephrine (NE) in the dentate gyrus was studied in hippocampal slices. HFT increased total PI hydrolysis 1 min post-stimulation (100%, n=12 slices/gp). Exposure to NE after the HFT further enhanced the potentiated PI hydrolysis (220%, n=12 slices/gp). Increases in PI metabolism induced by HFT and by HFT and NE were antagonized by CPP. (n=12 slices/gp). Increased PI turnover was also reflected in increases in IP₁, IP₂, and IP₃ at 1 min and 30 min post-HFT (n=9 slices/gp). In addition, HFT and NE significantly increased IP₁, IP₂, and IP₃ above that induced by HFT alone (n=8 slices/gp). These results suggest that PI hydrolysis is involved in the expression of long-term potentiation, a form of synaptic plasticity, in the dentate gyrus.

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CALCIUM DEPENDENT DESENSITIZATION OF THE KAINATE RESPONSES IN OOCYTES INJECTED WITH BRAIN RNA. Rassendren F-A, Lory P. and Nargeot J. CNRS-CRBM BP 5051. 34033 Montpellier Cedex. France

It is generally accepted that there are two types of desensitization of excitatory amino acid receptors: (i) a rapid desensitization of the quisqualate (QA) current and (ii) a slow, Ca²⁺ dependent, desensitization of the NMDA current. We have observed that, in *Xenopus* oocytes injected with rat brain mRNA, the kainate (KA) response can also be desensitized. We therefore study this phenomenon further using double microelectrode voltage clamp technique on injected oocytes. When oocytes were perfused for five minutes with 100 μ M KA, the induced current slowly decayed to a steady-state level (T_{1/2} = 74 s.). This event was stable and a total recovery of the initial response was not observed within one hour. Furthermore, QA or AMPA responses co-desensitized with KA responses. This phenomenon is inhibited by the lectine concanavalin A and does not show any current dependency. We have further tested the Ca²⁺ dependency of the KA desensitization. Our results clearly show that in the absence of extracellular Ca²⁺, the KA response does not fade.

Oppositely, when external Ca²⁺ is adjusted to 9 mM, desensitization are significantly enhanced. Additionally, we demonstrated that KA induces Ca²⁺-activated chloride channels, due to the entry of Ca²⁺ through KA channel. Our results clearly show that KA response desensitizes via a calcium dependent phenomenon, and that one KA activated channel is permeant to Ca²⁺. This may be an evidence for a KA/AMPA receptor heterogeneity expressed in brain mRNA injected oocytes.

309 Improved Fiber Optic Recording of Action Potentials. E.A. GAN*, C.C. DAVIS*, *University of Maryland, Dept. of Electrical Engineering, College Park, MD 20742, and V. KRAUTHAMER, FDA, Center for Devices and Radiological Health (HFZ-133), Rockville, MD 20857

Optical recording of cellular electrical activity with the use of voltage-sensitive fluorescent dyes provides a means for non-invasively recording the action potential without electrical interference. In previous work, we used a single implantable monomode fiber to both excite and transmit fluorescence from cells stained with a voltage-sensitive dye to a photomultiplier tube. In this paper, we use a multimode fiber coupler with splitting ratio 1:15 to carry the injected green He-Ne laser light (wavelength 543nm) and reflected fluorescence signals. The benefits of using a fiber coupler are: 1) the laser beam can be split between a number of fibers, and 2) more efficient collection of reflected fluorescence can improve the signal-to-noise ratio. In frog heart, maintained in 0 Ca⁺⁺ to prevent movement, bath-applied styryl (RH 237) dyes produced signals with a peak wavelength of 664nm. We blocked the weak reflected laser light with a longpass filter. Work is ongoing to develop a multichannel detection system using a combination of fiber couplers to record action potentials from different regions of frog heart simultaneously.

310 Weak Electrotonic Coupling Enhances Information Processing Power in a Mathematical Model for Excitable Cells ARTHUR SHERMAN, JOHN RINZEL (Mathematical Research Branch, National Institutes of Health, Bethesda, MD)

We explore the effects of weak electrotonic (gap junctional) coupling on a simple two-variable membrane model which can be either excitable or oscillatory. While strong coupling synchronizes two cells, weak coupling can lead to periodic anti-phase (180° out of phase) oscillations. Such oscillations can exist for parameters which do not allow oscillations in isolated cells. Thus, coupling two silent, but excitable, cells can lead to sustained oscillation. Such an arrangement could function as a gateway, with a transient output when uncoupled and a steady output when coupled. Augmenting the spike dynamics with a slow negative feedback allows an isolated cell to burst. Coupling two such bursters substantially increases burst period. Parameters in the augmented model can also be adjusted to yield tonic-firing instead of bursting. In that case coupling two cells can lead to bursting. We present examples with a model for pancreatic β -cells, but we also find some of the above phenomena in neuronal models. In conclusion, small changes in gap junctional conductance can be the basis of elaborate switching mechanisms which could be useful in biological neuronal networks.

311 Different Effects of Corticosterone and Dexamethasone on the Glucocorticoid Receptor mRNA Level in the RAT Hippocampus. YAN-MIN WANG (Neurobiology Curriculum, University of North Carolina), and JOHN A. CIDLOWSKI (Physiology Department, University of North Carolina).

We have examined regulation of the glucocorticoid receptor (GR) mRNA level in the rat hippocampus by both the natural hormone corticosterone and its synthetic analogue dexamethasone. In a Northern blot analysis, administration of dexamethasone resulted in the classical phenomenon of down-regulation of GR mRNA in the rat hippocampus. In contrast, injection of corticosterone yielded drastic increase of hippocampal GR mRNA in the same experiment. Although repeated experiments showed variable magnitudes of response (2.5-61 fold increase), the direction of change was clearly opposite for the two steroids employed. Dexamethasone causes down-regulation while corticosterone induces up-regulation.

Considering the fact that dexamethasone has

routinely been used in place of corticosterone for various kinds of experiments, the above observation raises the question whether these two stereochemically distinct agents are indeed interchangeable.

312 The Role of a Negative Regulatory Element in the Modulation of Peripherin Gene Expression. MARY ANN THOMPSON and EDWARD B. ZIFF, New York University Medical Center, New York.

We are studying the transcriptional regulation of the peripherin gene, which is induced when nerve growth factor (NGF) stimulates PC12 cells to differentiate into neurons. The peripherin gene, encoding a neuronal-specific type III intermediate filament protein, is induced at the time during which the cells begin to develop neuronal characteristics (12 hr to 2 days). 5' deletion mapping of the peripherin promoter coupled to a CAT reporter gene indicates that there are two positive regulatory elements necessary for full induction by NGF: a distal element greater than 2209 bp upstream from the transcriptional start site, and a proximal element within 110 bp of the start site. In addition, there is a negative regulatory element (situated between nt -179 and -111), deletion of which results in elevated basal expression of the reporter gene.

Methylation interference experiments, performed with a ³²P-labelled DNA probe spanning the boundaries of the negative regulatory element (NRE), implicate a sequence with partial dyad symmetry around nt -173 as the binding site of protein present in nuclear extracts from both undifferentiated and differentiated (1 week of NGF exposure) PC12 cells. This sequence has not previously been described as a transcription factor binding site. DNA mobility shift experiments using an oligonucleotide containing the footprint sequence demonstrate retarded bands in extracts of undifferentiated PC12 cells and liver cells which migrate more slowly than the bands produced in differentiated PC12 cell extracts. Competition with mutant oligonucleotides indicates that complexes in undifferentiated or differentiated PC12 cell extracts are dependent on the intact footprint site. This data is consistent with the hypothesis that NGF-induced differentiation of PC12 cells results in the release of a repressor protein from the protein complex at the NRE. Mutagenesis of the NRE in the context of the full length promoter is being performed to assess the degree to which derepression is the mechanism of NGF-mediated induction of peripherin.

313 Fos and Fos-Related Antigens are altered following NMDA Administration T.E. HELTON, R.P. DILTS and J.F. MCGINTY East Carolina University School of Medicine, Greenville, NC 27858.

Fos and Fos-Related Antigens (FRA's) comprise a family of nuclear transcription factor proteins which are thought to bind and influence the regulation of tertiary sets of genes, such as the opioid peptides dynorphin and enkephalin. In this study we used the excitatory amino acid agonist (EAA), N-methyl-D-Aspartate (NMDA), to induce limbic seizures and alter the metabolism of the opioid peptides and the fos proteins. Rats were implanted with a 24g stainless steel guide cannula (AP-5.2, ML -5.4, DV -2, <2°) and handled daily for 1 week. All rats received a single injection of sterile saline 3 days prior to the day of the experiment to habituate them to restraint during injection. This was necessary to reduce the non-specific induction of FRA's. On the day of the experiment, rats received 0.9% saline or 100nmols NMDA in 0.5µl into the ventral hippocampus. NMDA treated rats displayed several levels of limbic activity ranging from staring and wet dog shakes to hyperactivity and forelimb clonus. Seizure activity lasted for 1 to 2 hours after the injection. Rats were anesthetized with equithesin and perfused with buffered 4% paraformaldehyde 1, 3, 6, 24, or 48 hours after injection. Frozen sections were cut at 50µm and collected for immunocytochemistry. At 1 hour Fos immunoreactivity (ir) and FRA-ir were detected predominantly in the dentate gyrus (DG). By 3 hours, both Fos-ir and FRA-ir could be found throughout all cell fields in the hippocampus. At 6 hours following NMDA, all Fos-ir had disappeared from the hippocampus while FRA-ir remained in the DG and CA1. By 24 hours following NMDA FRA-ir could still be seen within the DG. These studies indicate that the prolonged expression of proteins in the FOS family may play a role in cellular adaptation. Analysis of Fos mRNA by *in situ* hybridization is presently in progress. Supported by DA03982.

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Selective Induction of FOS and FOS-Related Antigens within the Mesostriatal and Mesolimbic Dopamine Systems. R.P. Dilts, T.E. Helton and J.F. McGinty East Carolina University School of Medicine, Greenville, NC 27858-4354.

The immediate early gene products FOS and FOS-related antigens (FRA) have been proposed as indices of cellular activity within the CNS (Sagar et al., *Science* 240:1388, 1988). To test this hypothesis within selected terminal fields of the mesolimbic and mesostriatal dopamine systems, rats were injected with the dopamine agonist, apomorphine (5 mg/kg), the dopamine antagonist, haloperidol (2 mg/kg), vehicle (0.2% ascorbate), or handled without receiving an injection. The rats were anesthetized with equithesin and perfused with 4% buffered paraformaldehyde at 0.5, 1.0, 2.0, 4.0 and 18.0 hours after the injections. Frozen sections were processed to detect FOS-immunoreactive (FOS-IR) or FOS/FRA immunoreactive (FRA-IR) nuclei using a DAB/imidazole reaction produced with Vectastain Elite peroxidase kit. FOS antibody (1:2000) was a monoclonal recognizing the N-terminal sequence 1-17 of authentic FOS and was a gift from F. Sharp (UCSF). FOS/FRA antiserum (1:30,000), a gift from M. Iadarola (NIDR), was directed towards the conserved M2 sequence in

FOS and multiple related proteins. Immunoreactive nuclei were manually counted in multiple sections from each animal over a defined area. FOS-IR and FRA-IR nuclei were detectable at 0.5 hours after treatments and reached maximal numbers at 1.0 and 2.0 hours following apomorphine or haloperidol. Apomorphine induced a non-uniform, patchy distribution of FRA-IR within the striatum whereas haloperidol induced FRA-IR was uniformly distributed but restricted to the lateral aspect of the striatum and medial nucleus accumbens. Additionally, apomorphine stimulated FRA-IR was accompanied by FOS-IR whereas haloperidol produced many more FRA-IR nuclei than FOS-IR nuclei. In conclusion, FOS and FRA are differentially expressed within selected dopaminergic terminal fields and appear to provide a useful index to identify neuronal populations activated by pharmacological manipulations. Supported by BRSG 2S07 RR05812-11 (R.P.D.) and DA-03982 (J.F.M.).

315 Fos and Jun Immunoreactivity in Gerbil Brain: Effect of Transient Ischemia. SADAO SUGA, THADDEUS S. NOWAK, JR. (Laboratory of Neuropathology and Neuroanatomical Sciences, National Institute of Neurological Disorders and Stroke, NIH, Bethesda, Maryland).

Induction of c-fos mRNA occurs in neurons following ischemia. The Fos protein, together with Jun and related transcription factors, may play a role in the response to brain injury. Previous studies showed that failure to recover protein synthesis can limit postischemic expression of the 70 kDa heat shock / stress protein, hsp70, in vulnerable neurons. Hippocampal CA1 neurons minimally accumulate hsp70 protein, but strongly express its mRNA until their death at 3-4 days recirculation. These studies were designed to evaluate Fos and Jun expression in vibratome sections of gerbil hippocampus after ischemia, using antibodies obtained from Oncogene Science, Inc. Only scattered Fos staining was detected in control animals. After 5 min ischemia Fos was expressed in dentate granule cells during 1-3 h recirculation, and in CA3 neurons during 2-6 h, while no Fos staining was seen in CA1 at any interval through 24 h. With a threshold insult of 2 min the time course was more rapid, with Fos detected only at 1-2 h and 2-3 h in dentate and CA3, respectively. There appeared to be more Fos-positive neurons in the vulnerable dentate hilus during 2-6 h after 2 min ischemia, than after a 5 min insult. Jun staining was strong in control dentate granule cells and CA3 neurons, but was only weakly detected in CA1 neurons of dorsal hippocampus. Jun staining increased in dentate at 3-6 h and in CA3 at 6 h after 5 min ischemia, while no increase was observed in CA1. With a 2 min insult Jun staining was elevated at 2-3 h in dentate and at 3 h in CA3, and was increased in CA1 at 6-24 h. These results suggest that the time course of Fos and Jun expression after ischemic insults of graded intensity may be determined in part by the sequential recovery of translational activity in specific neuron populations.

316 Expression of Fos protein is induced in neurons of the rat medulla after selective stimulation of the carotid sinus nerve. JEFFERY T. ERICKSON and DAVID E. MILLHORN (University of North Carolina, Chapel Hill, NC).

Expression of the protooncogene c-fos has been used as a metabolic marker for tracing polysynaptic neuronal pathways after discrete central or peripheral stimulation (*Science* 237:192, 1987). We have identified cells in the rat medulla oblongata which express Fos protein after carotid sinus nerve (CSN) stimulation and believe they represent higher order neurons within the baro- and chemoreceptor reflex pathways. CSN fibers of anesthetized rats were stimulated electrically or via hypoxia. After a 2 hr recovery period, the medulla was perfused, sectioned, and processed for the immunohistochemical detection of Fos protein. A discrete distribution of Fos-labeled cells was observed within nucleus tractus solitarius, area postrema, the ventrolateral medulla in the vicinity of nucleus ambiguus/retroambiguus, nucleus raphe pallidus, and superficially on the ventral medullary surface. Anesthetized and nonsurgerized control animals were devoid of Fos labeling, while in surgerized but unstimulated animals labeling was significantly reduced. Thus, the majority of Fos expression was induced by CSN afferent stimulation. Studies using immunohistochemistry and *in situ* hybridization double labeling techniques suggest that some of these functionally activated cells colocalize serotonin or tyrosine hydroxylase, the rate-limiting enzyme for catecholamine biosynthesis. (HL 33831 and AHA 88108).

317 c-fos and Fos-Related Antigen Expression is Developmentally-Regulated in the Rat Nervous System. ADRIANA A. ALCANTARA, CHAD A. STRITTMATTER, WILLIAM T. GREENOUGH (Beckman Institute, Univ. of Illinois, Urbana, IL 61801).

Cellular immediate-early gene (cIEG) influences in the nervous system have been described by

Greenberg et al., (1985), and Morgan and Curran (1986). The nuclear phosphoprotein product (Fos) of the IEG, *c-fos* binds as a heterodimer with the product of the *jun* proto-oncogene to specific DNA regulatory sequences, thereby modulating transcription of target genes. *c-fos* expression in the adult is induced by a variety of stimuli. We examined *c-fos* expression in the intact animal during early postnatal development when the brain undergoes many plastic changes. 10 μ coronal cryostat sections from rats during postnatal weeks 1 and 2 were immunolabelled for *c-fos*. Developmental changes of *c-fos* and Fos-related antigen expression existed across ages and within a given age corresponding to ontogenetic development. Nuclear labelling was evident in cerebellar Purkinje cells, hippocampal pyramidal cells and cerebral cortex layer VI cells during postnatal week 1. By P7, cytoplasmic labelling increased and dendrites were labelled. Most labelling was absent by P10.

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318 Developmental Sequence of Acetylcholinesterase Positive (AChE+) Fibers in Rat Neocortex. CHARLES L. KYTSCHER, Syracuse University and MICHAEL KWASNIEWSKI, Syracuse University.

The Tago AChE stain technique makes possible analysis of exquisite detail of both nerve cells and fibers in the brain. In the neonate rat the subcortex abounds in stainable cells and some fiber tracts, but the neocortex contains sparse AChE+ fibers only in the anterior half. The Tago technique indicated that these fibers, with the possible exception of a compact medial bundle, originate in neurons posterior to the striatum and travel through the striatum in relatively straight pathways to emerge through the external capsule in two fiber groups: (1) from the anterior striatum through the external capsule into the anterior neocortex at several different depths and (2) laterally through the external capsule mostly at the horizontal plane containing the anterior commissure. The latter fibers course in two directions: mostly anterior to innervate the anterior half of the cortex and dorsally to bring innervation in to the dorsal cortex. By 7 days some fibers emerge from the extreme posterior striatum, penetrate the external capsule and course posteriorly to innervate the rear half of the cortex. In adults, knife cuts used to interrupt fiber flow patterns produced unstained regions distal to the site of fiber origin. These findings suggest that AChE+ fibers are axons from cholinergic neurons in the basal forebrain.

319 Expression Of Prothrombin mRNA In Developing Rat Brain. MATTHEW R KASER (Department of Microbiology and Molecular Genetics, University of California, Irvine, Ca, 92717, and DENNIS D CUNNINGHAM (Department of Microbiology and Molecular Genetics, University of California, Irvine, Ca, 92717).

Previous studies in our laboratory have demonstrated that thrombin is irreversibly inhibited by protease nexin 1 (PN-1) both *in vitro* and *in vivo*; furthermore, PN-1 attenuates the action of thrombin when incubated with neuronal and glial-derived cells in culture. We now demonstrate that mRNA encoding prothrombin is expressed in developing rat brain, as detected both by hybridization to a human prothrombin RNA probe, and by amplification of cDNA by PCR. Levels of prothrombin message (analyzed by PCR) appear to decrease (1.13 to 0.08 relative to beta-actin cRNA) immediately before birth, return to higher levels during the next twenty four hours (0.32 relative to beta-actin), and then remain elevated until at least post-natal day 21 (0.24 relative to beta-actin). Analysis of densitometric scans of "Northern" autoradiograms show similar results.

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Embryonic Foci of Neuropeptide mRNA Expressing Cells Predate the Adult Pattern in Vertebrate Brain. W. P. HAYES AND Y. P. LOH. Laboratory of Developmental Neurobiology, NIH-NICHD, Bethesda, MD 20892.

It has been difficult to identify embryonic mechanisms underlying the spatially appropriate onset of neural gene transcription in developing brain due to lack of appropriate markers in an animal model accessible to experimental manipulation. Recently, we found that the neuropeptide polyprotein, proopiomelanocortin (POMC), is an ideal marker of neural differentiation in the embryonic frog, *Xenopus laevis*. Our analysis of POMC gene expression using *in situ* hybridization histochemistry showed that embryonic POMC cells are at first highly restricted before brain morphogenesis is complete, providing evidence for the testable idea in this system that POMC gene transcription is locally induced (Hayes and Loh, *Development* 110, in press).

The present focus is on the neuropeptide gene encoding thyrotropin-releasing hormone (TRH) to address how its more widespread, but equally stereotyped distribution is set up in brain. Unexpectedly, we found that the TRH pattern in adult posterior forebrain, comprising many different diencephalic nuclei, arises in embryos from single elongated bilateral groups which in turn develop from highly localized groups of TRH cells. TRH mRNA was first detected at day 1.5 (stage 29/30) in discrete anterior and posterior foci in the lateral walls of presumptive diencephalon and metencephalon. These diencephalic foci then underwent anterior-to-posterior expansion to form rows which bifurcated in the dorsal and ventral walls of the infundibulum. As early as day 3.3 (stage 42), these rows became discontinuous and distinct TRH-expressing nuclei could be discerned, whereas in hindbrain, two pairs of elongated nuclei formed. These findings show that certain subsets of neuronal cells develop as a group before discrete brain nuclei form, arguing in this instance, that cell fate is dictated by local induction or cell lineage, and not by final position.

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Long-Term Exposure to Lysine Metabolites Induces Allosteric Uncoupling of the γ -Aminobutyric Acid/Benzodiazepine Receptor Complex In Fetal Rat Brain Culture. MAY J. TSAI and Y.F. CHANG, Dept. of Biochem., Univ. of Maryland, Dental School, Baltimore, MD 21201.

Pipecolic acid (PA) is a major metabolite of lysine in rat brain. Further degradation of PA produces α -amino adipate, a five carbon analog of glutamate. PA seems to have connections with some neurological diseases in infants such as hyperpipecolatemia, hyperlysinemia and cerebro-hepato-renal syndrome of Zellweger. Values as high as 200 μ mole/g have been found in human brain tissue from patients suffering from hyperpipecolatemia, a metabolic disorder involving severe degeneration of the CNS. PA concentrations in the rat brain were reported to be highest in the cerebellum, medulla oblongata and hypothalamus. In the present study, dissociated cell cultures prepared from the fetal rat cerebellum, medulla oblongata and spinal cord were used to study the effect of L-lysine metabolites on the cellular regulation of the γ -amino butyric acid/benzodiazepine (GABA_A) receptor. Second day after cell plating; incubation with PA at concentrations of 0.05 and 0.2 mM for five days, GABA enhanced [³H]flunitrazepam (FTZ) binding was decreased to 76% and 60%, respectively. Whereas PA had no effect on the release of lactate dehydrogenase (LDH), an index of cytotoxicity. L-lysine and α -amino adipate both at 0.2 mM had no effect on GABA_A receptor or cytotoxicity. Five days incubation of α -amino adipate at the concentration of 0.34 mM reduced both the cell number and GABA enhanced FTZ binding (52%) and increased LDH release (37%). Whether the decrease in specific FTZ binding by chronic exposure to lysine metabolites is due to change in B_{max} or K_D value, or whether this change can be antagonized by bicuculline or picrotoxin is under study. A study of GABA enhanced ³⁶Cl⁻ influx is planned. The link between the effect of lysine metabolites on GABA_A receptor in neuronal development and the defect in neuromigration in Zellweger syndrome needs to be seen.

322 A Review of the Development of the Feline Central Nervous System, its Unique Features, and its Implications for the Behavior and Personality of the Domesticated Feline, and the Ability of Domesticated Felines to Cope, Adapt, and Ultimately Survive in an Increasingly Changing Environment.

JAMES S. JAMISON (School Psychologist, Franklin County, Virginia Public Schools), RUTH C. JAMISON (Teacher, Roanoke City, Virginia Public Schools), AMY F. SPIES (Veterinarian in Private Practice in Roanoke, Virginia).

A new and fresh look is taken at the development of the feline central nervous system. A particular emphasis is placed upon the unique features of the feline central nervous system, its behavioral and personality correlates, and its implications for the ultimate adaptability and survivability of domesticated felines in the years to come. With changing environmental conditions now posing potential threats to the survival of the domesticated

feline, this is a topic which is worthy of the attention of the neurosciences during the challenge years of the 1990s, and one which will underscore the inevitable interaction which will increasingly occur between the neurosciences and the social sciences. New avenues for further study and research are presented.

323 Characterization of Allatrinhibin, a Neuropeptide from *Manduca sexta*. B.G. UNNI, P. BARRERA, G. BHASKARAN and K.H. DAHM. Biology Department, Texas A&M University, College Station TX 77843.

Breeds of wandering Vth instar larvae of *Manduca sexta* release *in vitro* as well as *in vivo* allatrinhibin (AI), a factor which inhibits juvenile hormone biosynthesis in corpora allata (CA). The inhibition is stable and apparently only reversed during metamorphosis to the adult. CA *in vitro* must be exposed to AI for 12-16 h before consistently inhibition is demonstrated by a bioassay. The effects of various chemical and enzymatic treatments on the biological activity have established the peptidic nature of AI. It is heat labile and inactivated by acid, but stable in alkali and can be stored at low temperature for an indefinite period. After treatment with pronase the activity was completely lost. Trypsin and protease type XVII-S caused only partial inactivation which suggests presence of no or few lysyl, arginyl, aspartyl and glutamyl residues. Inactivation by chymotrypsin indicates the presence of aromatic amino acids. Carboxypeptidases A and M and also leucine aminopeptidase deleted AI activity, hence, carboxyl and amino terminals are free. Pyroglutamate aminopeptidase also inactivated AI, however, this result may be due to presence of proline in the peptide. Purification on sephadex indicates a molecular weight in the range 1000-3000 dalton.

324 High expression level of biologically active recombinant human Nerve Growth Factor by Chinese Hamster Ovarian cells. I. MARTINI, *G. FERRARI, E. BIGON, G. CORONA, C. SORANZO, F. CAZZOLA, °C. GRANDI, °D. DAL ZOPPO, A. NEGRO and L. CALLEGARO. (Advanced Technology Division and * Fidia Research Labs, FIDIA S.p.A., Abano Terme (PD), Italy; ° Dept. of Organic Chemistry, University of Padua, Italy.)

Nerve Growth Factor (NGF) is a well-characterized protein essential for development and function of peripheral sympathetic and neural crest-derived sensory neurons. In order to provide large amounts of human NGF, the h β NGF gene was expressed in Chinese Hamster Ovarian (CHO) cells. A high level of expression was obtained by a plasmid carrying the hNGF gene, under the control of the SV40 and the hMTIIa promoters, and the entire hMTIIa gene. Stable expression was selected for by the neomycin analogue G418. Gene copy number was amplified in CHO cells by the addition of increasing concentrations of CdCl₂ in the medium. The highest producing clone secreted approximately 400 ng/ml of recombinant human NGF (rhNGF) into the medium. The protein was completely purified by two cation-exchange chromatography and one RP-HPLC steps. The final product was homogeneous on SDS-PAGE migrating as a single band of approximately 26 kDa at the molecular weight of the dimer. The N-terminal amino acid sequence of the purified polypeptide was SSSHPHFHRGEFSA.... corresponding to the correct human protein. The rhNGF was able to stimulate neurite outgrowth in PC12 cells and the biological activity was completely blocked by the adding of polyclonal anti-mouse NGF antibodies, which were shown to crossreact with the human protein purified from placental tissue, and of the protein kinase inhibitor K252a, which selectively blocks NGF effects on PC12 cells. This system, carrying a high number of copies of the h β NGF gene, could potentially provide sufficient protein for research and therapeutic purposes.

325 Axotomy-induced Depression of Neurofilament Gene Expression in DRG Neurons is Up-Regulated When Axons Are Stopped by a Physiological Barrier, But Not By A Mechanical Barrier. BRUCE TEDESCHI (Eastern Virginia Medical School), FRANCIS J. LIUZZI (Eastern Virginia Medical School).

Within 1 day following crush injury to dorsal root axons, Neurofilament (NF) gene expression in DRG neurons is decreased approximately 50% relative to uninjured control DRG. When the regenerating daughter axons reach, and are stopped by, the Dorsal Root Transition Zone (DRTZ) of the spinal cord, NF gene expression returns to normal levels. However, if the regenerating daughter

axons are stopped by a mechanical ligation placed between the crush site and the spinal cord, NF gene expression remains depressed relative to control. Thus, stoppage of axons by a mechanical barrier is not sufficient to upregulate DRG NF gene expression. Cellular or soluble factors produced by the physiological target (DRTZ) may be responsible for the upregulation of DRG NF gene expression.

326 Selective Autostimulation of Endothelins in Primary Astrocyte Cultures. H. EHRENREICH (NIAID), P. RIECKMANN (NIAID), T. COSTA (NCHHD), M. HOEHE (NIMH), JE. COLIGAN (NIAID), JH. KEHRL (NIAID), AS. FAUCI (NIAID)

Endothelins are peptides, originally isolated from endothelial cells, with potent smooth muscle contracting and mitogenic properties. Applied into the cisterna magna, they are able to elicit at very low doses chronic vasospasm in brain. Little is known to date about their expression in brain under pathophysiological conditions and their significance for the development of cerebral vasospasm. Observations that primary rat astrocytes express high affinity binding sites for endothelins and are capable of producing not only endothelin-3 but also endothelin-1 prompted the investigation of a possible relationship of endothelin peptides and receptors in these cells. Sarafotoxin S6b, an endothelin receptor agonist which was found to have similar characteristics as endothelin-1 in stimulating inositolphospholipid turnover as well as in inducing AP-1 in our primary astrocyte cultures was employed as a tool to study endothelin receptor mediated changes in endothelin-1 and -3 secretion. A low crossreactivity of sarafotoxin S6b with endothelin-1 and -3 in the endothelin radioimmunoassays used here along with a distinctly different elution position in high performance liquid chromatography allowed a clear discrimination between sarafotoxin and endothelins in the culture media. Stimulation of primary rat astrocytes with 10⁻⁶M sarafotoxin S6b for 1 h resulted in a substantial increase in endothelin-1 immunoreactivity in the medium reaching a peak at 3 h. No further elevation in endothelin-1 concentration was noted after 8 and 24 h. Treatment of our cultures with phorbol myristate acetate, lipopolysaccharide, tumor necrosis factor-alpha and norepinephrine for 24 h led to only a moderate elevation of endothelin-1 immunoreactivity. Immunoreactive endothelin-3 was not affected by any of the treatments tested. Thus, our data suggest the existence of a selective autoregulation of endothelins in primary astrocytes, i.e. a potentiation of endothelin-1 secretion following activation of glial endothelin receptors. If this is true *in vivo*, the autocrine induction of endothelin secretion may play a role in cerebral vasospasm.

327 Astrocyte Response To Environmental Factors. SUJATA TEWARI, Depts. Psychiatry/Molecular Biology, Univ. CA., Irvine; THOMAS VAN, Dept. Psychiatry, Univ. CA., Irvine; and LALITA KOMANAPALLI, Dept. Psychiatry, Univ. CA., Irvine.

Astrocytes are well recognized for their crucial role in brain development, neurological disorders and as the immunocompetent cells of the nervous system. The properties of 2 - 4 days old primary rat brain astrocyte cultures were examined following 72 h exposure to either gamma-Interferon (G-IFN) or norepinephrine (NE), or ethanol. Data show that astrocyte proliferation as measured by [³H]-thymidine incorporation into DNA was stimulated markedly by G-IFN or NE exposure and reflected in an increased protein synthesis. However, both DNA and protein synthesis were significantly reduced in cultures exposed to ethanol. In addition, the G-IFN response of astrocytes was not additive in the presence of NE and was abolished following ethanol exposure. The glutamine synthetase, an astrocyte specific enzyme, showed increased activity following exposure to NE or G-IFN but not ethanol. Data suggest that astrocytes are specific targets for the action of hormones, neurotransmitters, toxins and CNS acting drugs possibly through interactions with either specific receptors and/or the biochemical/neuroimmunological reactions. An injury to the astrocytes would interfere with the protection mechanism of the brain.

328 Maternal Neglect and Coat Color in Interbreeding Laboratory Merionis Unquiculatus. M. MULHARE, D. MIZRAHI, J. MCINTYRE, F. ATHALIE, M. BAREHE, P. HARRIS (SUNY/College at Old Westbury)

Black coated pups began appearing in two separate breeding configurations traced to the same ancestral pair after four generations of brown coated gerbils. The black coated males behaved in stereotypical fashion and fathered both brown and black coated pups with brown females. The black coated females were not receptive to mating. Only

three out of 13 adult females produced litters, all brown, with brown coated fathers. All the pups died from maternal neglect. The black coated females did not nest. They walked over their litters with no acknowledgement of their existence. Attempts to breed black coated females to black coated males resulted in their mortally wounding each other. Various combinations have been tried without improving outcome. Changes in hypothalamic function in black coated females could be interfering with hormonal releases and prolactin levels, and could account for lack of receptivity to mating and failure to lactate. This possibility is illustrated, data from estrous checks is presented, and photos of behavior are shown. An evolutionary interpretation could also be made. The research is supported by ADMHA/MARC.

329 Persistent HIV-1 Infection in Human Fetal Glial Cells - Reactivated in The Presence of CD4+ T Cells. CARLO TORNATORE, AVI NATH, KEI AMEMIYA, EUGENE MAJOR. Laboratory of Viral and Molecular Pathogenesis, National Institute of Neurological Disorders and Stroke, Bethesda, Md. 20892

HIV-1 infection of the brain has been associated with a severe dementing illness in children and adults. However, HIV-1 antigens are most frequently found in macrophages and microglial cells. To determine whether neuroglial cells are susceptible to infection, HIV-1 genome was introduced into cells cultured from human fetal brain tissue. Astroglial cells rapidly transcribed the viral genome producing high levels of p24 protein and infectious virions which peaked two days post transfection. Thereafter, HIV-1 genome expression progressively diminished and a persistent phase of infection developed during which virus could not be demonstrated by immunodetection methods. Co-cultivation with CD4+ T cells at any time during the persistent infection resulted in resumption of p24 synthesis and viral multiplication. The release of persistence did not require direct cell-cell contact between the glial and T cells since separation of the two cell types across a permeable membrane resulted in a delayed but similar resumption of p24 synthesis and virus multiplication. These results suggest that astrocytes may serve as an undetected reservoir for HIV-1 and disseminate the virus to other susceptible cells in the brain upon triggering by some cellular or biochemical signal.

330 Platelet Secretory Products Have a Damaging Effect on Neurons. RAJIV JOSEPH, Henry Ford Hospital, D.M. SAROFF, Harvard Medical School, J.R. DELFS, Harvard Medical School.

Some platelet secretory products such as serotonin and thromboxane may cause neuronal dysfunction. Therefore, we studied the direct effect of human platelet secretory products on CNS neurons. The rollertube method was used to maintain explants of neonatal rat spinal cord in culture and their neurons identified by acetylcholinesterase staining. Changes in neuron number and size in the ventral horns were morphometrically quantified. A total of 59 cultures matched for age, anatomical grade and spinal level were divided into three groups: control (n= 20), platelet-treated (n= 19) and platelet secretory product-treated (n= 20). The specimens were incubated at 36°C for 72 hours. Eighty percent of the control but only 37 and 40% of the treated cultures remained intact for analysis. Compared to control cultures (n= 16), there was a decrease in the number of neurons per ventral horn in the platelet-treated explants (n= 7) ($p < 0.01$), particularly in the 100-500 μm size range, and a shift towards a smaller size of the surviving neurons. This effect was quantitatively and qualitatively similar for the platelet secretory product-treated explants (n= 8) ($p < 0.05$). The results indicate that the neuronal damage from platelets is through their secretory products. Aspirin treatment of platelets appeared to lessen this damage. Considering the large number of platelets involved in thrombus formation, we suspect an abundant local release of their products that could contribute to ischemic neuronal injury.

331 Alternative splicing of APP is induced by Interleukin 1 in Alzheimer's disease fibroblasts. A. NEGRO, D. CAMPOCCIA, R. RICERCATO, L. CALLEGARO and *A. MORANDI. (Advanced Technology Division and *Fidia Research Laboratories - FIDIA S.p.A., Abano Terme (PD), Italy.)

Alzheimer's disease (AD) is characterized by the accumulation of β -amyloid (BAP) in neuritic plaques and in the walls of cerebral vessels. BAP is a small peptide (4.2 kD) derived from a larger precursor, the amyloid precursor protein (APP). Alternative splicing of APP mRNA can give rise to several forms of the protein. The major species in the aged human brain is the native 695 amino acid form (APP695) while in peripheral tissues the major forms contain (751APP) and (770APP) amino acids. In the same areas of AD brain APP751 expression prevails over that of its 695APP. Interleukin-1 (IL-1) acts as a modulator of APP expression in endothelial cells and is present in excess in AD brain. We have used human fibroblast cell lines from sporadic and familial AD, as well as from age matched controls to evaluate with RT-PCR the alternative splicing of APP mRNA in normal conditions and in presence of human IL-1 β . IL-1 β was found to induce an increased expression of all the forms of APP mRNA. In cells lines from control donors, the ratio between the expression of the different forms of APP mRNA was unchanged; however in AD fibroblasts there was a specific increase of the APP751 mRNA transcript. Thus, AD skin fibroblasts seem to express, subclinically, one feature characteristic of in AD brain and which can be made detectable with IL-1. These observations give importance to the role of the Kunitz insert in BAP deposition, as well as to a possible role for IL-1 in AD pathogenesis. This, in turn, may have important implications in the diagnosis of AD.

332 cDNA-Directed Survey of Expressed Sequences Within a Mapped Chromosome Region. Patrick W. Dunne, Shang-wu Wang, Tetsuo Ashizawa, M. Benjamin Perryman and Henry F. Epstein. (Departments of Neurology and Medicine, Baylor College of Medicine).

Through our efforts to identify candidate genes for myotonic dystrophy (DM), we have developed a method to detect expressed sequences from genomic DNA that has been localized by genetic and physical mapping to a short segment of chromosome 19. Dot blots of genomic clones are probed with cDNA derived from tissues (Purkinje fibers, lens, skeletal muscle) affected by DM. cDNA is depleted of repeat sequences by hybridization with a DNA-Sepharose matrix to a Cot of 50. DNA from clones that strongly hybridize to all three tissues is Southern blotted and reprobbed with cDNAs to identify exon-containing restriction fragments. Exon-containing bands are subcloned and used as hybridization probes against DM regional mapping panels. Localized subclones are then used to screen cDNA libraries (muscle, lens), isolated cDNA clones are sequenced and analyzed for homologies to known proteins. Several candidate genes have been identified through this procedure.

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333 Chemosensory sensilla are not necessary for woolly bear caterpillars (*Diacrisia virginica*) to feed normally on a normal food. E.BOWDAN, Univ. Massachusetts,

It is generally assumed that stimulation of chemosensory receptors is necessary to excite a well nourished animal to eat and that continued stimulation is necessary to maintain feeding. Caterpillars have well developed chemosensory systems but can grow normally in the absence of these receptors. In order to examine how animals compensate for the lack of chemosensory information the microstructure of feeding (each bite, pause, chewing bout etc.) of chemosensory ablates was compared with that of normals and operated controls. Both antennae and all maxillary sensilla were removed. Ablates, like normals, could begin to eat without preliminary activity. In addition: bite frequency, percent time eating, normalised number of bites, normalised number of meals, and meal size were all the same as for controls. There were some subtle differences from normal in relationships among activities. Thus for these animals eating a normal food, normal feeding is not dependent upon chemosensory input. Nor does there seem to be much shift in behavior to compensate for the lack.

334 Pineal melatonin suppression in rats with electroluminescent light
J.S. SCHIFFMAN (Neurology, Jefferson Medical College), E. GLOVER, S. MILLER (CDRH, FDA), M.D. ROLLAG (Anatomy, USUHS), and G.C. BRAINARD (Neurology, Jefferson Medical College)

To optimize environmental lighting for animals onboard space vehicles, we evaluated a novel illumination source for its versatility and influence on melatonin suppression. A flat, electroluminescent panel (3 x 8 inches) was installed on one wall of a 4.5 x 4.5 x 8.5 inch black plexiglass chamber. The electroluminescent light was broad-band white (400 to 740 nm, peak wavelength 510 nm). Intensity was varied with neutral density filters. Adult male Sprague Dawley rats (64) were entrained to a 12:12 light:dark cycle at least 3 weeks before the experiment under typical fluorescent laboratory lighting. Between 5 and 8 hours into the dark cycle, animals were exposed to electroluminescent light at 55, 4.4, 0.5 or 0.03 $\mu\text{W}/\text{cm}^2$ in the chamber for 5 minutes. After light exposure, the animals were held in darkness for 15 minutes before sacrifice. Pineal glands were removed immediately, frozen on dry ice, and assayed for melatonin content by RIA. Control animals were handled similarly but not exposed to electroluminescent light. Data were analyzed for significance by Student's t-test. Animals exposed to 55, 4.4 and 0.5 $\mu\text{W}/\text{cm}^2$ showed a significant melatonin suppression ($p < 0.001$, 0.001, and 0.005, respectively). Percent melatonin suppression versus intensity indicated a dose-response relationship. This experiment demonstrates that illumination from electroluminescent panels can regulate at least one component of the neuroendocrine system. The light source may be useful for animal research aboard the unmanned space lab, space shuttle, and space station. Technically, electroluminescent panels are flat, lightweight and likely to withstand the vibration and stresses of space travel making them a potentially superior lighting source for animal habitats in space.

This work supported by NASA Grant NAGW 1196 (to GCB) and NSF Grant DCB-8916019 (to MDR).

335. Effect of Capsaicin Pretreatment on Content of Substance P (SP), Neurokinin A (NKA) and Calcitonin Gene Related Peptide (CGRP) in Dorsal Root Ganglia (DRG), Prevertebral Ganglia and Gastrointestinal System of Guinea Pig. R.C. MA, D.M. BEARSON, J.E. BAILEY, D.R. RODDY, D.K. NELSON AND J.H. SZURSZEWSKI, Dept. of Physiology and Biophysics and GI Research Unit, Mayo Clinic, Rochester, MN.

Neurons of the guinea pig celiac (CG) and inferior mesenteric (IMG) ganglia are surrounded by a dense network of SP-, NKA- and CGRP-containing nerve fibers. The present studies were designed to identify the origin of these fibers. Sixteen guinea pigs were pretreated with capsaicin *in vivo* and 24 were treated with vehicle only and used as controls. Thoracic (T) and lumbar (L) DRG, CG, IMG, gastric antrum, duodenum and distal colon were assayed for SP-, NKA- and CGRP-immunoreactive material by RIA. SP and NKA in T-DRG, L-DRG, CG and IMG were nearly absent in capsaicin treated animals. CGRP in T-DRG, L-DRG, CG and IMG was significantly ($P < 0.01$) reduced by 59.1%, 54.3%, 22.3% and 21.5%, respectively. In the gastrointestinal tract, only CGRP in the gastric antrum of capsaicin treated animals was significantly ($P < 0.01$) reduced (78.1%). It is suggested that: 1) a substantial portion (54-59%) of CGRP-containing DRG neurons contained SP and NKA as cotransmitters and were capsaicin sensitive; 2) approximately 41-46% of CGRP-containing DRG neurons were insensitive to capsaicin; 3) CGRP-containing neurons in DRG and enteric ganglia send projections to prevertebral ganglia; 4) SP- and NKA-DRG neurons send projections to prevertebral ganglia. (DK17632 and DK34988).

336 Opioid Peptide Biosynthesis: Purification and Characterization of a Novel Thiol Protease Involved in Enkephalin Precursor Processing. TIMOTHY J. KRIEGER and VIVIAN Y.H. HOOK, Dept. of Biochemistry, Uniformed Services University of the Health Sciences, Bethesda, MD.

We have isolated a novel thiol protease from bovine chromaffin granules that meets several requirements expected of a proenkephalin processing enzyme. Firstly, the thiol protease is present within highly purified secretory vesicles (chromaffin granules), the site of neuropeptide precursor processing. Secondly, the enzyme cleaves the model enkephalin precursor ^{35}S -(Met)-preproenkephalin (^{35}S -(Met)-PPE) optimally at pH 5.5 which is consistent with the acidic pH 5.5-5.8 intravesicular environment. Thirdly, thiol proteolytic processing of ^{35}S -(Met)-PPE resulted in high molecular weight intermediates (8-25 kDa) possessing the NH_2 -terminal fragment of the precursor that lacks (Met)enkephalin sequences; proenkephalin *in vivo* is also processed in this manner. Furthermore, authentic (Met)enkephalin was generated from peptide F by cleavage at Lys-Arg and Lys-Lys dibasic amino acid sites. Of particular interest, was the finding that this chromaffin granule thiol protease demonstrated precursor selectivity, since it preferred the

enkephalin over a tachykinin precursor as substrate. Biochemical characterization showed that the enzyme's binding to concanavalin A-Sepharose, molecular weight of 33 kDa, pI of 6.0, and pH optimum differ from cathepsin B, H, and other thiol proteases. These results suggest that a novel thiol protease may be involved in proenkephalin processing.

337 The Antinociceptive Effect of Imipramine in Rabbits and Its Effect on Fentanyl. K. ASHER, L. ALVAREZ, R. WYNN, N. MYSLINSKI, S. BERGMAN (Depis. of Physiology and Pharmacology, Univ. of Maryland Dental School).

Fentanyl (F) produces rapid and effective antinociception but has the dangerous side effect of respiratory depression. Recent reports indicate that the tricyclic antidepressant imipramine (I) may produce antinociception in mice. The purpose of this study was to determine (1) the antinociceptive properties of I, (2) its effect on F antinociception, and (3) its effect on respiration in the rabbit tooth pulp pain model. Eight New Zealand white rabbits (1.5-3.0 kg) were prepared according to the method of Wynn et al. An electrical stimulus was applied to the tooth pulp of each rabbit, and the voltage that evoked a lick-chew response was recorded. Control volts (CV) were recorded before IV administration of I, and test volts (TV) were recorded after. It was considered effective if TV were more than twice CV. Three doses of I, 2.5, 5, and 7.5 mg/kg were used, and 8 rabbits prepared for each dose. A graded dose response of antinociception was observed. The ED50 value of I (4.3 mg/kg) and F (11.2 $\mu\text{g}/\text{kg}$) was calculated using the method of Litchfield and Wilcoxon. Three more ED50 values for F were then determined 15 mins after pretreating rabbits with 1/4, 1/2, and 3/4 the ED50 dose of I. The ED50 values were plotted on an isobologram for drug combination, and the points fell well within the area for super additivity. The effect of I on respiration was determined by measuring the blood PCO_2 and counting the number of breaths per minute (BPM) 5 minutes after IV administration of I. No significant change in PCO_2 or BPM was found. This study showed that I produces antinociception, is super additive with F, and does not depress respiration in the rabbit model.

338 Observational Learning in Octopus vulgaris (Mollusca, Cephalopoda) G. FIORITO (Lab. Neurobiologia, Stazione Zoologica "A. Dohrn" di Napoli), P. SCOTTO (Dip. Fisiologia "F. Bottazzi", Università di Napoli, Italy).

Previous studies have shown that *Octopus vulgaris* are able to solve problems and discrimination tasks. Our experiments indicate that *O. vulgaris* are also capable of observational learning. Isolated octopuses learned to discriminate between two objects, similar in shape but different in color, by a classical conditioning method, in 35.4 ± 3.2 trials (mean \pm SE, $N = 14$). Conspecifics that observed four times demonstrators choosing the same colored ball, later in isolation chose the same ball with only 0.2% error rate ($N = 14$). In a different experiment, other individuals learned to open a glass jar, closed up with a plastic cork and containing a live crab, by trial and error in 5 ± 0.9 trials (mean \pm SE; $N = 20$). Naive *O. vulgaris* ($N = 20$) that observed two times the solution of the jar problem, later in isolation, solved the same problem in the first trial without significant error, as compared to the five trials necessary for octopuses that had not previously observed the task. These results suggest that *O. vulgaris* are able to learn both motor and visual tasks more rapidly and accurately by observing a conspecific performing these tasks.

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Protein Kinase C Activation Enhances Learning for a Weakly Learned Passive Avoidance Task in the 2-day-old Chick. SERRANO, P.A., OXONIAN, M.G., BENNETT, E.L. AND ROSENZWEIG, M.R. University of California, Berkeley, Dept. of Psychology.

Protein kinase C (PKC) has been related to learning in paradigms such as LTP, long-term sensitization, and classical conditioning. We have found that the inhibition of specific protein kinases will produce amnesia in chicks for a one-trial passive avoidance task (Serrano, et al. 1990). Two-day-old chicks were trained to avoid a mildly aversive bead

dipped in 10% methylantranilate. Chicks show improved memory for the learning experience when injected with bradykinin or forskolin. We have found that bradykinin, which activates diacylglycerol, a precursor of PKC, significantly improves memory for the training experience ($p < .01$). In contrast, forskolin stimulates adenylate cyclase, a precursor of PKA, enhanced memory only weakly (n.s.) A time course for the appearance of enhancement with bradykinin is currently being investigated.

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Does Neurodarwinism explain plasticity of functional maps in the mouse whisker-to-barrel pathway? PETER MELZER (NIMH).

In his book "Neural Darwinism" Gerald Edelman hypothesizes that during brain maturation neurons are distributed into groups of common intrinsic and extrinsic connectivity by selection from two distinct repertoires: (i) the repertoire of neuronal projections and (ii) the repertoire of synaptic contacts. Does this distinction and the concept of group selection help to explain plasticity of the functional whisker map in the mouse barrel cortex after removal of whisker follicles? In 9 mice the follicles of left whiskers C1-3 were removed by 2 days of age (i). In 7 mice the same follicles were removed at 8 weeks of age (ii). Ten (i) and 23 (ii) weeks after injury the fully quantitative [14 C]deoxyglucose autoradiographic method was applied during stimulation of left whiskers B1-3 & D1-3. Nine adult control mice were subjected to the same mapping study. Autoradiograms were taken from tangential sections through the barrel cortex. Sections were stained for cytochrome oxidase activity or Nissl substance. After removal of whisker follicles in infants and in adults the deprived territory became part of the functional map of neighboring whiskers. Lesions in infants induced an enlargement of the terminal fields of thalamocortical projections, while lesions in adults left the size of these fields normal. Thus, it is justified to distinguish two repertoires. Yet that the peripheral map instructs the central map cannot be ruled out.

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A new look at the lower field representation in the striate-recipient area of the lateral suprasylvian cortex of the cat. K. MULLIGAN and H. SHERK. Dept. of Biological Structure, University of Washington, Seattle, WA 98195.

The retinotopic organization of the lateral suprasylvian visual cortex has been studied by several groups previously. We have reexamined the lower visual field representation in the suprasylvian region that receives input from area 17 (the Clare-Bishop area) because of peculiarities in its map that we encountered in other experiments. Physiological recording was carried out as well as anatomical mapping by the injection of tracers at defined sites in area 17. Suprasylvian cortex was flattened graphically by computer and maps were generated by interpolation between recording sites, and (if present) patches of label. The map appeared to be moderately orderly, and its overall layout was consistent from cat to cat. As noted by others, the lowest part of the visual field was represented anteriorly, and the central field, posteriorly. In many penetrations, a progression from the periphery to the vertical meridian (VM) occurred as the electrode moved down the medial suprasylvian bank to the sulcal fundus, again as observed by others.

We found, however, that the retinotopic organization was not as straightforward as in area 17. One consistent anomaly was a duplication of the area centralis at the map's posterior end. Also, the lower VM was split into two islands in most (possibly all) cats, with more peripheral field occupying the gap between islands. Curiously, the posterior VM island did not lie on the map's boundary, but was embedded within the map. Consequently, the region of visual field adjacent to the VM must be represented twice. Anatomical experiments confirmed this duplication of the central lower field.

As in the macaque's area MT, the representation of the far lower VM appeared quite compressed or absent. Receptive field sizes also suggested a compression of the lower VM: they increased with eccentricity, but the increase was more rapid along the vertical than the horizontal meridian.

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Memory for Temporal Order in Monkeys (*M. Fascicularis*). ELLEN C. GOWER (Boston University School of Medicine, & the Boston DVA Medical Center).

The question of how order information is represented in memory and to what extent it is independent of the representation of items has been addressed in studies of both normal and amnesic people. To begin a complementary investigation of these relationships in non-verbal, non-human primates, we trained a normal adult monkey

in a trial-unique serial-order task using a manually-operated primate testing apparatus. The format was a 2-alternative, forced-choice recency discrimination.

In acquisition (Experiment I), two samples (A and B) drawn randomly from a pool of 200 objects were presented individually in that order. Ten seconds later, the objects were represented as a pair and the subject required to choose between them. In acquisition and all following transfer tests, the rewarded choice was of the object that had appeared first in the sample list (i.e., A+B). Since the items are both present at the time of the test, the controlling cues in this task can only be the recall of serial order information associated with the items in a mnemonic representation of the list. Performance in the A+B task stabilized at 82% correct in 2500 trials. Experiment II then demonstrated that the learned rule immediately generalized to discriminations of the order of objects presented in longer lists of 3 and 4. Experiment III tested temporal order judgments in a fully randomized design. Lists contained 3, 4 or 5 items, and the test probes were all the pairs of adjacent objects plus the pair constructed of the 2 end-objects in each list (e.g., A+B, B+C and A+C in a 3-item list). List length, probe type and the laterality of the correct object were randomized within sessions, and 40 trials collected in each of the 12 list-length/probe-type conditions.

The temporal interrelationships of the items comprising the test pair and their relationship to the time of the probe event had significant effects on the accuracy of recency judgments. 1. For adjacent-item pairs, the frequency of correct choices was related by a decreasing function to lag; i.e., the distance between the presentation of the objects and the test event. 2. However, accuracy in judging the order of end-item pairs increased directly with their temporal separation. These findings suggest that the representations of serial order in monkey and human memory are directly comparable.

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Behavioral Disturbances in the Developing Rhesus Monkey Following Neonatal Lesions of Inferior Temporal Cortex (Area TE) Resemble Those in Attention-Deficit Hyperactivity Disorder. P. M. MERJANIAN, J. CACHEVALIER, K. D. PETTIGREW, and M. MISHKIN. (NIMH).

Early damage to the limbic system in monkeys yields severe socio-emotional disturbances resembling those seen in autistic children (Merjanian et al., *Soc. Neurosci. Abstr.*, 12:23, 1986 and 14:2, 1988). Although the 6 operated controls that had received early damage to area TE did not show these disturbances, they did display other behavioral abnormalities. Six monkeys had received area TE lesions (TE) neonatally, 6 were normals (N/TE) reared with monkeys from Group TE and 6 were normals reared with other normals (N/N). At 2 and 6 months of age, each animal from Group TE was paired in a play cage with its age-matched control (N/TE), and their behavior was observed for 12, 5-minute intervals on 6 days. Similarly, each N/N was paired with another N/N. At 2 months, the monkeys in Group TE were hyperactive, shifted more from one behavior to another, and showed more stereotyped behaviors than monkeys in either Group N/TE or Group N/N. In addition, animals in Group N/TE showed more aggressive behavior towards animals with TE lesions and had more temper tantrums than both other groups. Although these behavioral disturbances in both the operated animals and their unoperated controls were less severe at 6 months of age, they strongly resemble those of people with attention-deficit hyperactivity disorder and the responses of their peers.

344 Hippocampal Cells in Squirrel Monkeys Reflect Intersession Solution Strategies in a DMTS Task. DR. JOHN A. BRENDEL (Lock Haven University)

This paper proposes a theory of hippocampal functioning based on single cell data collected from the hippocampus of squirrel monkeys while they are performing a delayed match-to-sample task. The single cell data is analysed using multiple regression analysis and multiple discrimination techniques which test the significance of cell firing rates as predictors of future trial events. Cells have been found whose firing rates predict the symbol to be presented, the position of the response to be made, and the correct or incorrect response outcome. These findings suggest a mnemonic property for functional neural networks within the hippocampus.

However, the purpose to which this mnemonic information is put is to generate outcome expectations that can be used to monitor or modify ongoing behaviors not to simply store or retrieve information. These hippocampal cells demonstrate the properties of a heterosynaptic autocorrelation matrix within an intact neural system functioning in a behaving animal.

345 The Data Independence Function of Cortical Columns.
GARY W. STRONG (Drexel University).

Explanation of how synchrony unites distributed neurons into a unitary cortical representation remains a challenge. Simultaneous action pulses in distant neurons is problematic when considering that the delay of intracortical cables is often longer than the width of a typical action pulse. Synchrony should be independent of the specific delay between any two components of a neural representation since there isn't enough information in the genome to direct development of specific delays. Furthermore, synchrony must occur in spite of the observed bursty activity of cortical neurons. A computer simulation was developed to show the feasibility of synchrony under these difficult constraints. It models neural interconnections at the group level which may be indeterminate at the one-to-one level. This architecture is based on the recognition that all mammalian neocortex consists of vertical columns with an amazingly consistent density of neurons across species. The simulation shows that representations can coexist as mutually-facilitating subsets of columns. The activity of any subset can be characterized as a semi-random stream of action potentials from all of its member columns. Such emergent activity constitutes a representation that has data independence. The model also predicts that representational activity requires generalized "cortical fatigue" in order to avoid getting "stuck" in attractor basins.

346 Possible Underlying Mechanism of Lead Toxicosis Induced Encephalopathy in Bovines.
AVTAR SINGH, Deptt. of Veterinary Physiology Punjab Agricultural University Ludhiana-141004 India

The lead poisoning in bovines is associated with neurologic symptoms because of encephalopathy leading to death of motor neurons. The possible role of cobalt in metabolic disturbances of motor neurons with premature cell deaths was evaluated. The cobalt content was estimated in cerebrospinal fluid (CSF) collected from the calves exhibiting neurologic symptoms following lead toxicosis. Though it is possible that CSF may not actually reflect the tissue levels, still the severely reduced cobalt contents ($0.086 \pm 0.024 \mu\text{g/dl}$) may reflect the origin of neurologic symptoms and encephalopathy. Cobalt is a constituent of cobalamin which is a coenzyme for methyltetrahydrofolate oxidoreductase, homocystein methyltransferase and methylmalonyl CoA mutase. The biological role of elemental cobalt has been suggested as an activator of glycylglycine dipeptidase. Because of vital role of cobalt in maintaining the structural integrity of nucleic acids, it is suggested that reduced cobalt content of CSF would have led to non-specific loss of nucleic acids in motor neurons causing premature cell deaths. Other associated histochemical and electronmicroscopic level changes are discussed.

347 A Possible Mechanism For Lead Mediated Neurotoxicity.
JOSEPH BRESSLER, SHEILA FORMAN and GARY GOLDSTEIN (Kennedy Institute, Baltimore, MD 21205)

The ability of lead (Pb) to substitute for calcium (Ca) or to increase intracellular Ca levels may serve as a biochemical mechanism for Pb mediated neurotoxicity. Though a large number of processes are Ca dependent, it is not clear which of these are activated by Pb and which play a role in Pb mediated neurotoxicity. We have found that Pb can substitute for Ca in ionomycin mediated arachidonic acid release in rat astroglial cultures. In these studies, secondary rat astroglial cultures from whole brains are labeled for 16 h with $[^3\text{H}]$ arachidonic acid and challenged with ionomycin in a phosphate free media containing Pb or Ca. The Ed 50 for Pb and Ca was $15 \mu\text{M}$ and 5 mM , respectively. Arachidonic acid was not observed if lanthanum or cadmium was substituted for Ca. Both the Ca and Pb responses were inhibited by the inorganic Ca channel blockers, cadmium and cobalt, but were not effected by voltage sensitive Ca channel blockers such as verapamil or nifedipine. Two calmodulin antagonists at micromolar concentrations, calmidazolium and trifluoperazine, inhibited Pb and Ca mediated

arachidonic acid. Pb was incapable of substituting for Ca in ionomycin mediated phosphatidylcholine or phosphatidylinositol turnover. Based on these observations, we suggest that Pb increases arachidonic acid release through a Ca-dependent mechanism. Furthermore, the specificity observed by Pb for activating arachidonic acid release, but not other pathways, may indicate a selective pathway that is important for Pb mediated neurotoxicity.

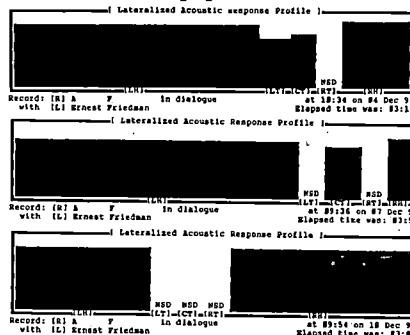
348 Acetyl-L-Carnitine: A Drug Able to Slow the Progression of Alzheimer's Disease

M. CALVANI, G. CARUSO, A. CARTA (Dept. of Neurological Research, Sigma Tau, Pomezia, Italy)

A pure defect of the cholinergic neurotransmission does not sufficiently explain the occurrence of Alzheimer's Disease (AD). Recent findings point out that abnormalities in membrane phospholipid turnover and brain energy metabolism may play an important role in the pathophysiology of AD. Acetyl-L-Carnitine (ALC) is an endogenous substance who acts as an energy carrier at mitochondrial level, controlling the availability of Acetyl-CoA. ALC shows a variety of pharmacological properties, mainly linked by a restorative or even protective action against aging processes and neurodegeneration. A review of a series of clinical controlled studies suggest that ALC may slow the natural course of AD. Data of 629 patients (310 on ALC, 319 on Placebo treatment) will be presented and discussed.

349 Speech Timing of Psychotic Remission.
ERNEST H. FRIEDMAN (Case Western Reserve University) and GARY G. SANDERS (Voxaflex).

Frequency and duration of speech pauses correlated to coronary risk and mood, respectively. Long pauses $1+ \text{ s}$ (LP) were sorted into fluency levels. Peak fluency of LP irrespective of pause-time (PT), at maximal PT, and at intermediate fluencies were left/right hemisphere (LH/RH) and interhemispheric transit (LT/CT/RT), respectively. Short pauses $< 1 \text{ s}$ at LP nodes monitored psychotic remission.



350 The Association Between Carbohydrate Craving and History of Depression and Anxiety: Support for Serotonergic Involvement. DAVID B. ALLISON and RONALD D. FRANKLIN (Kennedy Institute, Johns Hopkins University School of Medicine).

Consumption of carbohydrate-dense foods raises insulin levels that, in turn, depress levels of large neutral amino acids which compete with tryptophan for transport across the blood-brain barrier. This produces increased CNS levels of tryptophan and, subsequently serotonin (5-HT). A putative final link in this chain is elevated mood. It has been proposed that a subgroup of obese persons alleviate dysphoria by consuming excess calories in the form of carbohydrates. This hypothesis meshes well with data that people with seasonal affective disorder tend to crave carbohydrates and with some psychosomatic theories which view eating in response to emotional discomfort as pathogenic to obesity. In order to test this hypothesis, data were analyzed from a sample of 719 obese persons (641 females, 78 males) who

anonymously responded to a questionnaire eliciting a broad range of psychological, medical, behavioral, and demographic information. Means and standard deviations of weight in pounds, body mass index (BMI), and age were, respectively, 285.3 (66.7), 40.5 (9.5), 46.0 (10.7). Subjects' self-reported cravings for carbohydrates were correlated with a linear composite of self-reported history of depression and tendency to eat in response to dysphoric moods. The uncorrected correlation coefficient was .28 ($p < .001$). After correction for attenuation, the correlation rose to .43 ($p < .001$). Results are consistent with serotonergic involvement in carbohydrate craving.

351 Symptoms of Learning Disabilities Tested Directly RUTH M. GETMAN, PH.D., (Betty Jane Memorial Rehabilitation Center) Tiffin, Ohio; WALTER OLSON, M.D., (Toledo Neurological Institute) Maumee, Ohio

The symptoms of learning disabilities can be tested directly using a norm referenced test called the General Elementary Processing Inventory (GEPI). The test yields a diagnosis of specific symptoms. These symptoms are dysgraphia, auditory processing deficits, dyslexia, dysphasia, long term memory retrieval, and short term memory retrieval. The identification leads to a set of recommendations for adaptation. Protocols for teaching and training children and adults as well as adaptive devices are used to effectively aid clients in the regular classrooms and vocational settings.

352 The Coordinated Noninvasive Studies (CNS) Project JUDITH L. LAUTER (University of Arizona).

The CNS Project exploits the complementarity of several noninvasive devices for studying human brain structure and function by combining them for the first time in a test battery to study aspects of brain/behavior relations in the same subjects. Each individual is tested with psychophysical behavioral methods, MRI, EPs, qEEG, PET, and MEG. Current focus is on asymmetries for complex sounds. First, each subject is trained on dichotic listening for two sound sets which evoke "opposite" asymmetries. Then brain anatomical asymmetries are measured using MRI, and a repeated-measures auditory EP series is done to define brainstem asymmetries. Then each subject is run on the two types of sounds while being monitored with qEEG, then PET, then MEG. Results to date show: 1) striking "internal consistency" comparing behavioral, anatomical, and physiological asymmetries within subjects; 2) dramatic individual differences in the details of the various asymmetries; and 3) excellent agreement across subjects in the patterns of the asymmetry "profiles." Findings suggest that this approach is not only viable, but that exploiting the complementary nature of the noninvasive techniques may reveal unsuspected and otherwise indescribable relations among aspects of human neuroanatomy, neurophysiology, and behavior. [Work supported by AFOSR]

353 Ripley's "Believe It or Not!": An Historical Representation of Neuroscience Facts and Artefacts in the Popular Press RUSSELL A. JOHNSON (Behavioral Neuroscience Program, Department of Psychology, UCLA, Los Angeles, CA 90024).

In 1918, New York sports cartoonist Robert Ripley published the first of what would prove to be untold thousands of facts and factoids, under the rubric "Believe It or Not!" (BION). In his worldwide pursuit of truth that was stranger, or at least more interesting, than fiction, Ripley could not help but encounter and advertise some of Neuroscience's more intriguing anecdotes and artefacts. He and his successors presented these in over 300 newspapers in 17 languages, to a circulation reaching at one point 80 million, in the same stylized black and white illustrations and exclamation-pointed statements as his other claims.

Ripley's biographers have noted that "his was a mind uncluttered by culture", and that he had "the curiosity of the unlearned". He was interested in the fascinating, the curious, and the bizarre, with often-reprinted neuroscience oddities such as Phineas Gage and trephined skulls falling among the steady stream of topics teasing the public's

seemingly insatiable appetite for anecdotes and minutiae. The popular impact of BION is undeniable; BION was a national institution, a forerunner of modern tabloids in the appreciation of the facts of science without consideration of the scientific process, but with a reputation for scrupulous documentation of its claims.

This poster is the beginning of a project examining the popular representation and perception of Neuroscience. Neuroscience-themed BION panels will be presented, compared with their original sources, and examined with respect to salience of interpretation and accuracy of content. Attendees of the Meeting will be invited to recollect and discuss encounters with BION and other popular sources, especially as the popular accounts sparked personal interest in the neurosciences.

354 Differences in Serotonin_{1A} Receptors between Fawn-Hooded and Sprague-Dawley Rats BRIDGET A. HULIHAN-GIBLIN, ROBERTA J. HABER, DAVID GOLDMAN (NIAAA/LCS Bethesda, MD.)

Rats of the Fawn-Hooded (FH) strain exhibit a hemorrhagic disorder known as platelet storage pool deficiency¹. Some reports indicate that there is a reduction in [³H]mipramine binding in both brain and platelets of FH rats compared to Sprague-Dawley (SD)^{2,3}. It is possible that in addition to the platelet dysfunction, there is abnormal serotonergic function in the CNS of FH rats providing a potential genetic model for altered serotonin function. 5-HT_{1A} receptors in several brain regions were compared in FH and SD rats using [³H]8-OH-DPAT to label the receptor site. The kD values of 8-OH-DPAT binding to frontal cortex, hippocampus, striatum, hypothalamus, and brainstem were similar in FH rats compared to SD rats. However, the Bmax values for 8-OH-DPAT binding in striatum of FH rats were significantly lower than those of the SD rats. In addition female FH rats displayed a greater density of 5-HT_{1A} receptors in several brain regions compared to male FH rats. There were no significant differences in Bmax values in the other regions examined between FH and SD rats. Ongoing studies to compare mRNA levels between these two strains will provide further information on the 5-HT_{1A} receptor differences.

355 Inhibition of ³H-proline binding by NMDA antagonists M. L. CORDERO, J. G. ORTIZ, A. E. NEGRON, G. SANTIAGO AND C. BLANCO Dept. of Pharmacology, Univ. of Puerto Rico School of Medicine, San Juan, Puerto Rico 00936

L-proline is a normal constituent of the mammalian brain for which possible neuromodulatory functions have been described. AP-7 (2-amino-7-phosphonoheptanoic acid) a competitive NMDA antagonist, inhibits 60 % of ³H-proline binding to rat midbrain synaptosomal membranes. However, AP-7 inhibits only 30 % of ³H-proline binding to cerebellar membranes. Such difference points to possible region-specific proline/NMDA interaction(s). Kynurenic acid, a glycine site antagonist inhibits 60 %, while MK-801 inhibits ≈ 50 % of ³H-proline binding to rat midbrain membranes. These results are in agreement with possible proline/NMDA interaction(s) within specific brain regions and are in agreement with previous reports. (Ault et al., 1987, Nadler et al., 1989, and Helm et al., 1990). (Supported by NIH/MBRS program)

356 An Endogenous Astrocytic Receptor for the Neuronal Glycoprotein Thy-1: A Proposed Role in Neurite Outgrowth PAUL LUCEK, EVAN DREYER, DANA LEIFER, & STUART LIPTON. Harvard University, Children's Hospital, & Massachusetts Eye and Ear Infirmary, Boston, MA.

Work in our laboratory has shown that specific monoclonal antibodies against the neuronal glycoprotein Thy-1 promote neurite outgrowth by postnatal rodent retinal ganglion cells in culture. Using two monoclonal anti-idiotypic antibodies as probes, we have previously identified a putative endogenous binding site for Thy-1. We have shown that this receptor has a similar effect in promoting neurite outgrowth to that seen with the Thy-1 antibodies. The putative Thy-1 receptor has been identified in cultured astrocytes and whole brain preparations. Anti-idiotypic binding to the proposed receptor is competitively blocked by purified Thy-1. This receptor has also been identified on Western blots of whole brain and astrocyte preparations. Anti-idiotypic binding to blots of two dimensional gels provides further biochemical characterization of this Thy-1 receptor. A human brain cDNA library has been probed with these anti-idiotypes, and a clone that may code for part of this receptor has been identified and

sequenced. These data strongly suggest that a receptor for the neuronal glycoprotein Thy-1 exists on the surface of astrocytes and that this receptor plays a role in modulating retinal ganglion cell neurite outgrowth.

357 Toward a Quantometric Version of Color Vision Theory and Statistical Colorimetry. DMITRY A. NOVIK (Bioscan Inc. Washington, DC)

This paper presents the basic principles and properties of the author's proposed quantometric color vision theory (CVT), which is an alternative to the Young-Helmholtz-Maxwell wave version of CVT. The foundations of the proposed new CVT are the quantum theory of light radiation and the quantometric methods of photon-by-photon registration (counting) of light radiation quanta in the energy-disper-

sive spectrometry regime. According to the quantometric version of CVT, the light-sensitive elements of the retina work as photon-by-photon counters; moreover, the rods work in the regime of Geiger-Muller counters and the color-sensitive cones work as proportional counters. It is shown that this quantometric version of CVT is in full agreement with experimental results of physiological investigations into color vision. A comparison is given between phenomenological wave CVT and the quantometric physical version of CVT. Foundations of statistical colorimetry are presented. The main attention of the paper is concentrated on the physical and statistical aspects of the quantometric version of CVT. Also discussed are some possibilities for constructing an artificial retina on the basis of the quantometric version of CVT.

Molecules to Models

Advances in Neuroscience

Edited by Katrina L. Kelner and Daniel E. Koshland, Jr.

This collection of 37 *Science* articles in the neurosciences provides a comprehensive survey on the entire field. It is especially valuable for graduate students who want to gain a broad understanding of the neurosciences, and for neuroscientists who want to learn more about other areas of the disciplines. Contributors include William A. Catterall, Joseph B. Martin, Corey S. Goodman, Michael I. Posner, Terrence J. Sejnowski, Stephen G. Lisberger, Larry R. Squire, and many other well-known specialists in the field.

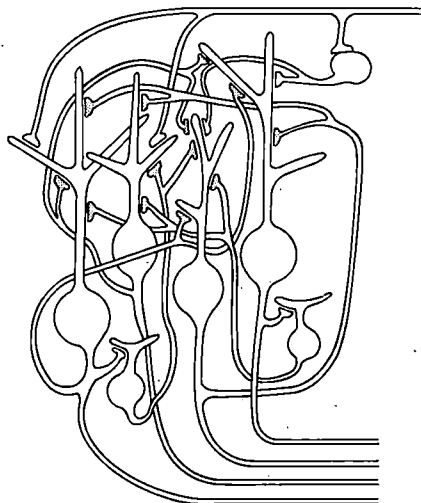
Contents:

I. Ion Channels: Multiple calcium channels and neuronal function; structure and function of voltage-sensitive ion channels; heterologous expression of excitability proteins—route to more specific drugs?; genetic reconstitution of functional acetylcholine receptor channels in mouse fibroblasts; coupling of neurotransmitter receptors to ion channels in the brain; direct activation of mammalian atrial muscarinic potassium channels by GTP regulatory protein G_k ; intrinsic electrophysiological properties of mammalian neurons—insights into central nervous system function.

II. Neural Development: Neuronal cytomechanics—the actin-based motility of growth cones; neural cell adhesion molecule (NCAM) as a regulator of cell-cell interactions; growth cone guidance in insects—fasciclin II is a member of the immunoglobulin superfamily; axon guidance and patterning of neuronal projections in vertebrates; specification of cerebral cortical areas; physiological basis for a theory of synapse modification.

III. Learning and Memory: Biochemistry of information storage in the nervous system; long-term synaptic potentiation; the neural basis for learning simple motor skills; neurobiology of learning and memory; mechanisms of memory.

IV. Cortical Function and Behavior: Three-dimensional representation and anal-



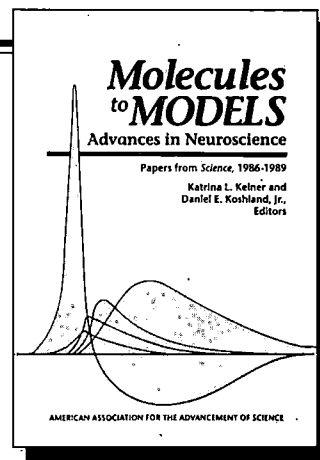
"Anatomy" of a simple model neural circuit, from the chapter "Computing with Neural Circuits: A Model," by John J. Hopfield and David W. Tank.

ysis of brain energy metabolism; behavioral neurophysiology—insights into seeing and grasping; neuronal population coding of movement direction; mental rotation of the neuronal population vector; localization of cognitive operations in the human brain.

V. Neural Modeling: Computing with neural circuits—a model; dynamic pattern generation in behavioral and neural systems; neural model of adaptive hand-eye coordination for single postures; parallel integration of vision modules; synthesizing a color algorithm from examples; inversion of sensory processing by feedback pathways—a model of visual cognitive functions; computational neuroscience; perspectives on cognitive neuroscience.

VI. Addiction: Neurogenetic, adaptive mechanisms in alcoholism; cellular and molecular mechanisms of drug dependence; the biological tangle of drug addiction; breaking the addiction cycle.

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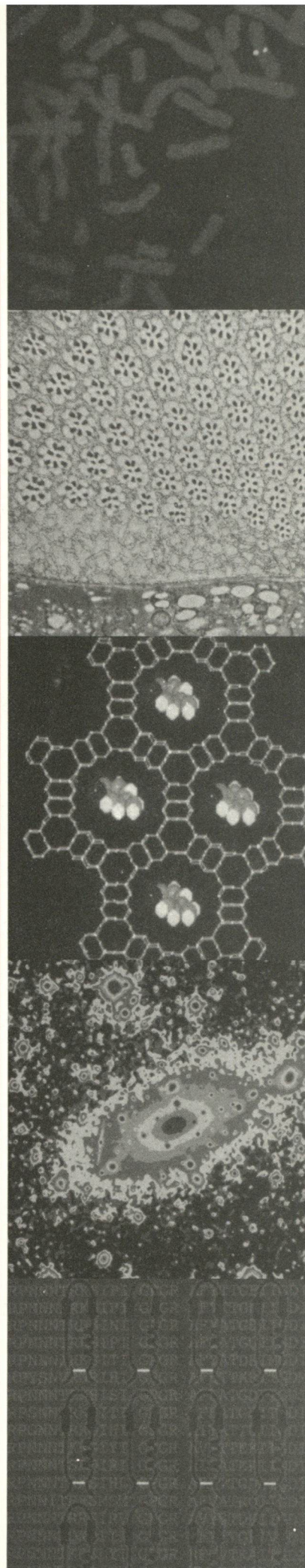
American Association for the Advancement of Science

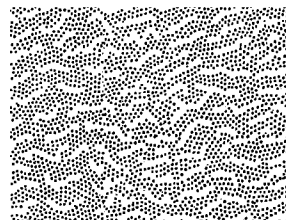
Supplement to SCIENCE

SCIENCE:
THE END
OF THE
FRONTIER?

A Report from
Leon M. Lederman, President-Elect
to the Board of Directors
of the
American Association
for the Advancement of Science
1333 H Street, NW
Washington, DC

January 1991





Preface

The importance of scientific research to the well-being of the nation has long been recognized by U.S. policymakers. Since the mid-1980s, in the face of enormous pressures on the budget, federal investment in basic research has grown significantly—faster, in fact, than nearly any other area of non-defense government spending. In spite of this, evidence of low morale in the scientific community has been building steadily during this period in press reports, in Congressional testimony, in op-ed pieces, and in other public forums.

In recent months, these reports have taken on a tone of greater urgency. Colleagues have told me of senior researchers about to “throw in the towel” because of the loss of long-term grant support, and of bright and promising assistant professors at top universities unable to get funds to initiate their research. When I took office as President-Elect of the American Association for the Advancement of Science in February 1990, I decided to look more deeply into these reports to see if I could resolve the apparent paradox of continuing increases in federal research funding and growing dissatisfaction in academic laboratories.

With the help of the staff of the AAAS Directorate for Science and Policy Programs, I conducted an informal survey of key faculty in selected U.S. universities. This report, which I submit to the Board of the AAAS, describes the story as told by the nearly 250 scientists who wrote letters in response to my inquiry. Limited and informal as it was, the survey confirmed my expectations of trouble, but with a depth of despair and discouragement that I have not experienced in my forty years in science. I have included in the report my attempts to understand and interpret the situation, to evaluate the consequences, and to estimate what it might take to correct it.

Although the report may perhaps reveal indications of passion and advocacy, my concern is not for the unhappiness of my colleagues in science, much as I love and value them. My concern is for the future of science in the United States and for the profound cultural and economic benefits that science brings. My aim is to stimulate urgent discussion in the widest possible context. My hope is that this will lead to vigorous and appropriate follow-up activities.

In writing this report I am well aware of the hesitations of some colleagues, hesitations based on the desire not to appear self-serving, not to bring science down to the level of “just another interest group.” However, if in fact U.S. science is at risk, then what course should we take? Is it not the obligation of societies like AAAS to bring the state of science to the attention of policymakers and the public that pays for and ultimately benefits from research? It is my opinion that the risks of appearing to be self-serving are far outweighed by the risks inherent in not making the case.

Please note that when I refer to academic research in this report I generally include both basic and applied research or, in the newer vernacular, fundamental and strategic research. Also, I recognize that I have focused narrowly on one sector of the research community and good science policy will require that any solution must also consider non-academic research as well as those issues outside of science which influence the health of the research universities.

Many people contributed to this report. Thanks are due to Richard S. Nicholson, AAAS Executive Officer; to Albert H. Teich, director of the AAAS Science and Policy Programs Directorate; and to Stephen D. Nelson, program director for science, technology and government, for their many contributions. The assistance of my physicist colleague James Trefil of George Mason University was invaluable in framing the issues described here. John Schoneboom and June Wiaz provided able research assistance at AAAS, Denise Graveline, head of the AAAS Office of Communications, provided important guidance and advice, and Patricia Morgan and her staff in the Office of Publications transformed the manuscript into the report that you see. Most of all, I owe a debt of gratitude to the nearly 250 academic researchers whose articulate and heartfelt responses are the basis for this report.

Leon M. Lederman
University of Chicago

December 1990



[There were] three incidents where we had to stand by while competitors from abroad moved forward on research based on our ideas. . . . The history of the past decade is one of continued harassment over money, lost opportunities due to inadequate support, and a stifling of imagination due to money worries. If U.S. scientists must continue to stand by and watch as our best ideas are carried forward by groups from abroad, our nation cannot hope to escape a rapid decline.

—Professor of Physics, MIT

The effect . . . is devastating. Our senior faculty are demoralized and our junior faculty are jumping ship. Undergraduate and graduate students sense the despair and are turning away from science at a time when we need them most.

—Professor of Biology, U. of Illinois, Urbana

The funding situation is the worst I've seen in 25 years as a successful researcher.

—Professor of Chemistry, Yale

Once upon a time American science sheltered an Einstein, went to the moon, and gave to the world the laser, the electronic computer, nylon, television, the cure for polio, and observations of our planet's location in an expanding universe. Today we are in the process, albeit unwittingly, of abandoning this leadership role. It is up to the President, the Congress, and the American people to decide whether this is really the road we want this country to travel.

America has lived and grown great through science and technology. From the founding of land grant universities and the flowering of agricultural research in the 19th century to the boom in microelectronics and information technology in the last two decades, we have hitched our economy to the best scientific research system we could develop and have prospered as a result. In this long-running success story, American universities have played a special role. University researchers have produced new knowledge to drive the economy and at the same time have trained successive generations of scientists and engineers to staff American industry.

But now, at a time when problems of international economic competition, environmental degradation, and quality of life demand the very best from our research community, new information assembled by the American Association for the Advancement of Science (AAAS) documents a deeply troubled mood among university researchers, even those who have been successful in pursuing research careers in our most prestigious institutions. This troubled mood is so pervasive that it raises serious questions about the very future of science in the United States.

The quotations that punctuate this report are drawn from an informal survey by the AAAS on the state of academic scientific research in the United States. Asked about their personal experiences with research funding, the respondents, who include some of the nation's most promising young academic scientists, portray an environment of slow, but steady erosion. One group can no longer train graduate students. Another sees its advances in technologies with millions of dollars of industrial potential dissipate for lack of a \$100,000 laser. A third describes how it is abandoning innovative but risky research for more pedestrian projects for which funding is more certain.

The responses paint a picture of an academic research community beset by flagging morale, diminishing expectations, and constricting horizons. From one institution to the next, across demographic categories, across disciplines of research, the nation's scientists are sending a warning. Academic research in the United States is in serious trouble.

While it is difficult to make accurate predictions as to possible outcomes of the current situation, a major decline in research capability is certainly within the range of plausible projections. Indeed, given the current economic situation and budget climate, such a worst case scenario might be considered probable. In view of the close coupling we believe to hold between a vigorous and dynamic science and the economic and cultural well-being of the nation, this becomes a national problem.

Ironically, there is, among policymakers and the informed public, a general sense that American science is strong and healthy. Every year, we do well in the Nobel prize sweepstakes. Over the past decade federal funding for basic research has fared rather well in the budget battles, at least as compared to other areas of government spending.



Nevertheless, the AAAS survey provides a strong signal of trouble. It forces us to recognize that, however rosy the research funding picture may look from Washington, D.C., there are serious problems at the laboratory benches.

To understand the morale problems in the research community, it is necessary to look at the long-term picture, not just at how federal investment in R&D for this fiscal year compares to last or how R&D funding compares to transportation, agriculture, or other “domestic discretionary” programs. In this perspective, it is not hard to see the source of the problem. Despite recent growth, the level of federal support for basic and applied research in the universities in 1990, after correcting for inflation, is only slightly larger than it was in 1968, over twenty years ago.

In 1968 this level of funding was adequate. Indeed, 1968 was the peak year of a period that is considered the “golden age” of American science. Today, however, there are twice as many doctoral scientists in universities competing for those funds. Furthermore, in all areas of research the last decade’s “easy” problems have been solved, and the cost of creating new understanding of nature has increased considerably. Finally, new regulatory requirements have added to overhead costs and reduced the funds available for the direct costs of research. Is it any wonder that morale among academic scientists is low?

Academic science has not arrived at its present state through a conscious decision by the Administration or Congress. No political leader has advocated starving science—indeed, most feel that they support it strongly. Presidents Reagan and Bush have both promised to double the size of the National Science Foundation’s budget within five years, and Congress, almost every year, appropriates more for the National Institutes of Health than the Administration requests.

Scientists in the universities began to feel the pinch in the early 1970s, when the sustained growth of the previous decade came to an end and rapid inflation combined with constraints on the federal budget to produce a constant-dollar decline of more than 20 percent in federal funding for academic research. Warning signals arose at that time and eventually, to an extent, they were heeded. The trend in federal funding turned upward beginning in 1983. However, recent growth has been insufficient to compensate for the effects of the long drought that preceded it. Thus, in the view of those in the laboratories, there has been a gradual year-by-year erosion in the availability of funding and in the health of academic science over nearly two decades.

As the referee reports indicate, I do excellent, important work and I write excellent proposals. When this is not enough to obtain funding, I wonder what else could be asked of me. . . . It is all very discouraging.

—Assistant Professor of Physics,
U. of
North Carolina, Chapel Hill

My students . . . find their current situation difficult and the prospects of trying to do research as faculty members positively frightening. They will avoid academic jobs. . . . There may be some rationale for allowing small-scale basic research to decline and for discouraging students from becoming academic researchers. If so, I haven’t heard it.

—Professor of Physics, U. of
Illinois

I suspect that if I were twenty years younger I would not choose an academic research career. Even now I find myself considering other options. I’m tired of writing “excellent” proposals that aren’t funded.

—Professor of Chemistry, Duke

As funds for research disappear, I lose the ability to support students and to operate a laboratory. My current plans are to quit.

—Professor of Physics, U. of
Texas



The Survey

In May 1990, at my request, the staff of the American Association for the Advancement of Science initiated an inquiry to determine the professional “quality of life” as perceived by members of the academic research community. We sent letters to the chairs of the physics, chemistry, and biology departments at 50 universities—the 30 largest research-oriented universities, as determined by the amount of federal research funding they receive, and 20 additional universities, representing a range of less research-intensive institutions.

Each chair was asked to answer the letter personally and to forward it to a few faculty members, including at least one third- or fourth-year assistant professor in the department, and the youngest full professor. We wanted to hear from a range of researchers but especially from the “winners” in the game of academic science—the people with successful careers in the best-funded disciplines at prestigious institutions. If this group perceived itself to be in trouble, it would be a fair assumption that the great body of American scientists in other fields and initiatives could only be worse off.

Each respondent was asked to write a letter commenting on personal experiences in obtaining funding, the general availability of funding in the field, and how these factors would influence productivity and future plans. We made no pretense of drawing a scientific, random sample, nor did we attempt to cover all fields, types of institutions or geographic areas. Our purpose was not to generate statistics, but rather to collect anecdotes so that we might assess the prevailing mood among academic scientists. (*See Survey Questions, page 7.*)

We were not naive about what to expect. We recognize that no researcher is ever totally happy with his or her situation, and we expected a good deal of common, garden variety griping. Good scientists can always see more things to do, and those who are dissatisfied are more likely than others to take the time to respond to an inquiry such as ours. However, the emotional intensity of the letters and the depth of their pessimism was so far above these ordinary levels that we can only conclude that they register a mood of deep depression in the research community. And this depression is widespread, independent of institution, field and rank.

Nearly 250 letters, many of them long and detailed, were received. The overall tone of the letters, as exemplified by the excerpts that appear throughout this report, is one of deep concern, discouragement, frustration, and even despair and resignation. The traditional optimism of research scientists is being quenched. In its place are lowered expectations and a gloomy vision of the future.

The scientists write that obtaining funding occupies an increasing portion of their time. They describe growing regulatory burdens and increasing overhead costs. Many say they are embarrassed because they feel they are unable to serve as adequate role models for their graduate students. And, because the respondents are among the “best and the brightest,” they are most keenly aware of the opportunities, the excitement and the ultimate benefits of their research—and the sharp contrast to the increasing difficulty in obtaining resources for it.

One scientist reports chagrin at the “superbright” post-doctoral student he cannot afford to hire. Another writes of discouragement at the two graduate students she has been forced to tell to go elsewhere. There is despair at seeing one's own ideas implemented by competitors abroad with the equipment one cannot afford. And overall, the *leitmotif* in the letters is of long hours spent writing (and reading) proposals and arguing and pleading with funding agency personnel.

The future is quite bleak. Realistic analysis of the odds indicate the likelihood that, in the not too distant future, I will not obtain sustained funding. As my travel funds disappear and I can no longer have personal contact with my colleagues in the field, my reputation and the recognition factor, which are now essential to become the 1 in 10 who is funded, will dwindle. And when my start-up funds disappear, then I will not be able to keep a competitive lab going at all.

—Professor of Physics, Carnegie-Mellon U.

... I am dismayed by the great difficulties that so many of [the young faculty] encounter in obtaining grants. These are highly qualified young scientists, yet they are in much more dire straits, in the early stages of their careers, with regard to research funding than were their predecessors.

—Professor of Physics, U. of Michigan



The scientists write that obtaining funding occupies an increasing portion of their time. They describe growing regulatory burdens and increasing overhead costs. Many say they are embarrassed because they feel they are unable to serve as adequate role models for their graduate students. And, because the respondents are among the “best and the brightest,” they are most keenly aware of the opportunities, the excitement and the ultimate benefits of their research—and the sharp contrast to the increasing difficulty in obtaining resources for it.

More than half the respondents in the top 30 institutions indicated that they are experiencing serious difficulties in research support or, at best, are treading water. An additional third reported that they were getting by for the moment, but saw problems ahead for their research. Even the minority of respondents who reported that they were managing pretty well themselves indicated they were affected by the depressed mood of their colleagues.

The distribution of responses from the less research-intensive universities was not much different: about 60 percent wrote that they are in trouble or are barely managing; an additional third reported they are coping but see problems on the horizon; while most of the remainder see colleagues in serious difficulties.

Survey Questions

Please write us a letter addressing each of the following issues:

- 1.** The availability of research funding in your own area of research. Please comment on your own personal experience with the research funding system. Be as specific as possible.
- 2.** The relative ease or difficulty of obtaining research grant funding currently as compared to past years (including the number of appropriate sources of funding for your research). Again, we are interested primarily in your own personal experience.
- 3.** Your thoughts on how your recent experiences with research funding might influence your plans and expectations for the future.
- 4.** Other factors significantly influencing your own productivity and ability to conduct research in your current setting.

I spend about 30 percent of my time writing proposals and progress reports . . . I love what I am doing but . . . morale, momentum, critical mass are all in grave danger.

—Professor of Chemistry, MIT

Nearly all our research groups have had to get by with at most level funding. The effect is devastating when continued over a number of years. Equipment is not replaced, students are not trained, and faculty grow discouraged. It is disheartening to see us lose our competitive edge at a time in which it could be especially important.

—Professor of Physics, U. of Washington

I expect that you will find . . . irreparable damage is being done to new young investigators starting up their first labs.

—Professor of Biology, U. of California, Berkeley

Why is the Morale of American Scientists So Low?

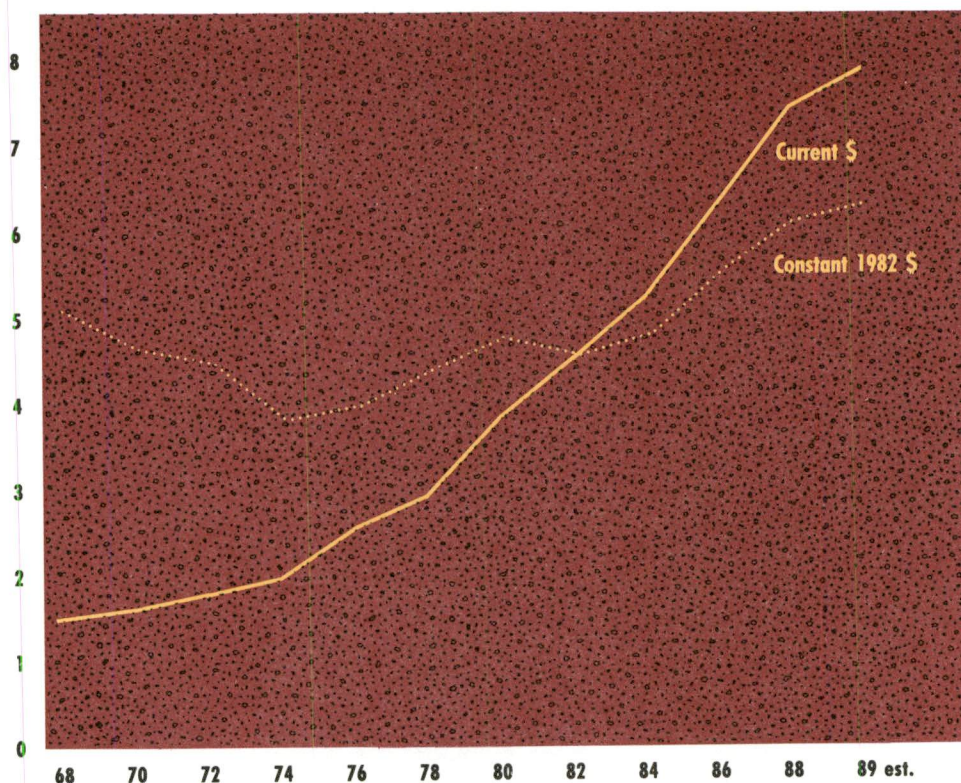
The principal source of the morale problems the survey uncovered is no mystery. It appeared in letter after letter. It is essentially a lack of funding. For many scientists the difficulties of obtaining research support are beginning to overshadow the rewards of actually doing research. To understand why funding is so problematical, it is useful to review a few figures.

Level Funding and a Growing Community

Since 1983, federal support for academic research in constant—that is, inflation-adjusted—dollars has grown by about 30 percent. However, as shown in Figure 1, this recent increase followed a long period of relatively flat funding which was itself preceded by a sharp drop between 1968 and 1974. Consequently, **the amount of federal funding for basic plus applied research in universities in 1989 (expressed in constant dollars) is only 20 percent higher today than it was in 1968!**

At the same time, as shown in Figure 2, the number of doctoral scientists and engineers in colleges and universities has more than doubled. In other words, in 1990 there are over twice as many researchers competing for a pot of money not much bigger than it was in 1968.

Figure 1 Federal Expenditures for Basic and Applied Research at Colleges and Universities, 1968–89 (billions of dollars)

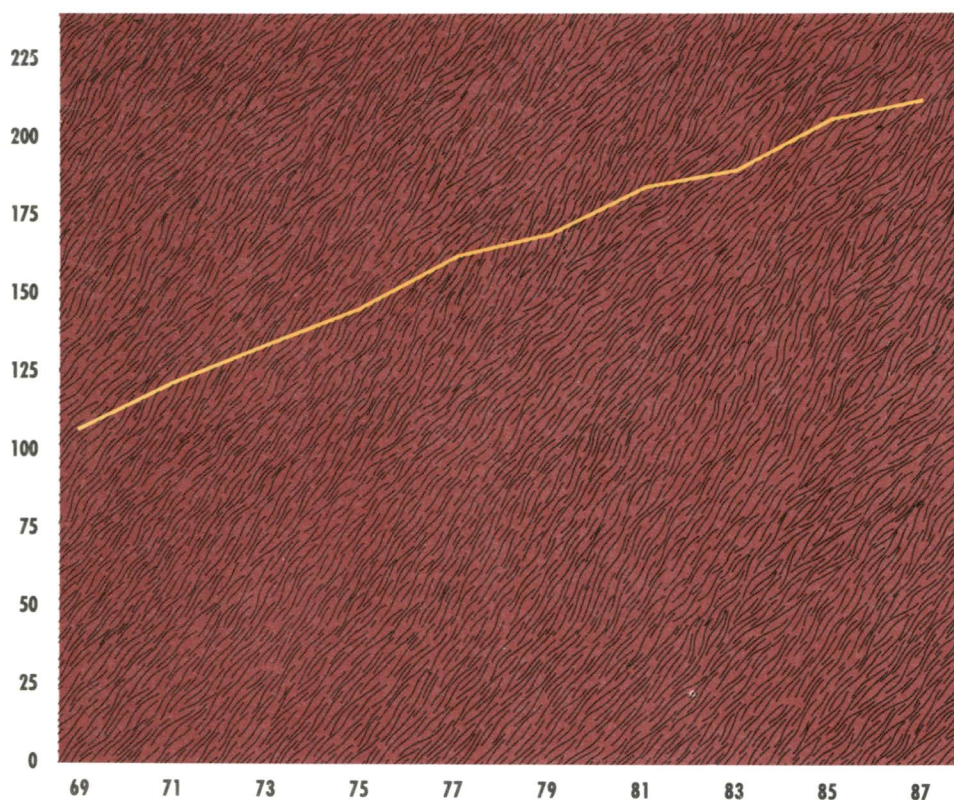


Source: National Science Foundation (Constant dollar conversions by AAAS, using OMB R&D deflator).



Figure 2

**Number of Doctoral Scientists and Engineers Employed
By 4-Year Colleges and Universities, 1969–87**




Source: National Science Foundation and AAAS estimates.

The growth in the academic research community, averaging about four percent per year, has gone largely to populate new and vital fields of research which, in 1968, were either non-existent or embryonic. This is simply an indication that it is in the nature of science to expand. Some examples of areas which have arisen to compete for funds with older, more established fields are molecular genetics, organometallic chemistry, materials science, chaos and complexity. Typically, older fields evolve into new areas of discovery. We cannot think of any field, thriving in the 1960s, that has disappeared in the past two decades.

The Increased Cost of Doing Research

The phenomenon of level funding and a growing community of researchers in itself would clearly cause considerable hardship in the scientific community. The problem is compounded, however, by a number of other factors that, taken together, further restrict the results that can be obtained from each research dollar.



My failure to obtain a renewal . . . was a tremendous blow to my confidence. . . . I have since become more conservative in my research, rather than taking risks on potentially exciting areas.
—Assistant Professor of Biology, U. of California, Berkeley

. . . I feel pressure not to share information about exciting data . . . for fear that others, with larger labs, will be able to use this information to write a similar proposal.
—Assistant Professor of Biology, U. of Minnesota

1. Complexity

One factor is complexity—or what some observers have called “sophistication inflation.” As our understanding of nature increases, the questions we need to answer become more complex. There is a corresponding increase in the sophistication (and cost) of the equipment needed to do research, both for small, “table top” experiments and large facilities such as telescopes and accelerators.

For example, a state-of-the-art dye laser cost about \$19,000 in 1974. The corresponding state-of-the-art laser today costs \$160,000. Even if we correct for inflation, a scientist who wishes to remain in the forefront of research in 1990 has to pay three times as much for this piece of equipment as he or she did fifteen years ago. Similarly, the cost of equipping a laboratory for a starting assistant professor in a university science department has increased by a factor of ten since 1968.

One might argue that there are countervailing trends. As the cost of certain technologies decreases, the cost of doing science should go down as well. Ordinary hand calculators, for example, once cost several hundred dollars, but now cost only a fraction of that sum. While this cost reduction is real, in practice it is completely swamped by the increased demands for computation. Although the cost *per arithmetic operation* has gone down dramatically since 1968, the increased need for computing power has made computer costs a major portion of today’s science budget. Similarly, the unit cost of building an accelerator has dropped from \$1,000 per MeV at Fermilab (in 1970) to \$100 per MeV at the SSC, but the energy required to do meaningful research in high energy physics has gone up so much that the total cost of the required accelerator is much higher today than it was in 1968.

These are not just examples of researchers trying to keep up with the Joneses—one can no more do 1990s research with 1974 equipment than one can build a modern superhighway with pick-and-shovel labor. The complexity factor is a direct cost imposed on research by increasing sophistication in science.

2. Increasing Costs of Regulation

The cost of regulation is a second factor. In many fields, particularly in the life sciences, increased regulation absorbs significant funds and research time. Requiring researchers to comply with guidelines such as those concerning animal care, human subjects, low level radioactive waste, and hazardous substances is important and certainly justifiable, but it must be recognized that the costs of complying with these regulations reduce the amount of research that can be done for a given amount of money.

3. Increased Overhead

A third factor is institutional overhead. According to the National Science Foundation, indirect costs at universities (including administration, maintenance of buildings, utilities, etc.) have risen from 16 percent of the national academic R&D budget in 1966 to about 28 percent in 1986. Charges equivalent to 70 percent of salaries are not unusual today. In the minds of many faculty members, overhead amounts to a tax on research. Obviously, it is a legitimate component of the cost of doing research and its recovery in research grants is essential to the survival of the universities. But, as is the case with increased regulation, the absorption of a growing share of research money by overhead means that less money is available to the laboratory scientist for the direct costs of the research.

Impacts of the Funding Situation

Let us turn now from the sources of the problem to its impacts. The letters suggest that—apart from just being a source of frustration to academic scientists—the squeeze on research funding is likely to have a number of more subtle adverse consequences for research and for the nation.

With more scientists competing for what is essentially a fixed pot of money, the percentage of grant applications funded by NSF and NIH has dropped precipitously. As *Science* magazine has reported, success rates in some fields are down to the neighborhood of 10–15 percent. Scientists, particularly young scientists, report spending more and more of their time chasing fewer and fewer dollars. While the average grant size has increased somewhat at NIH, the typical NSF grant is, in constant dollars, considerably smaller in 1990 than it was in the early 1980s.

The problem is more serious than average grant size or proposal success rates, however. The letters reveal potentially important changes in the way scientists as individuals pursue their craft. As a consequence of the increasingly difficult search for funding, academic scientists are less willing to take chances on high risk areas with potentially big payoffs. Instead, they prefer to play it safe, sticking to research in which an end product is assured, or worse, working in fields that they believe are favored by funding agency officials. These scientists are also increasingly viewing their fellows as competitors, rather than colleagues, leading to an increasingly corrosive atmosphere. The manifestations of this attitude range from a reluctance to share new results with other scientists to public bickering about relative priorities in funding different fields.

While the current loss of productive groups is serious, even more disturbing is the negative influence the present difficulties are having on the next generation. On a recent visit to MIT I had an informal lunch with about twenty graduate students in organic chemistry and asked how many of them were going into academic science. One person raised his hand and he was returning to a small liberal arts college where he had been a student. This group agreed that their lack of interest in university level positions is their perception that the challenge of gaining funding is now dominant over the challenge of the science.

—Professor of Chemistry, U. of Illinois

I am so heavily invested on a personal level in basic research that I cannot imagine changing my own career direction even if the present funding situation persists. However, I am finding it harder and harder to recommend this career to the many bright undergraduate students who regularly seek my advice in career opportunities in basic research.

—Assistant Professor of Biology, U. of California, Berkeley

But there are other effects of the funding situation that are evident in the letters—effects that will not be felt for some time, but that are potentially much more damaging. Over and over again the respondents reported that they are cutting back on the number of students they are training, and that students now in the laboratories are opting out of research careers. It is not too hard to imagine the thoughts in the mind of a graduate student who watches as a professor spends a third of his or her time searching for funds to keep a laboratory going.

Every time you write a proposal for a renewal of your grant, you are playing Russian roulette with people's lives. You soon find that your chief responsibility is no longer to do science at all; it is to feed your graduate students' children.


—Professor of Physics, Caltech

We are tending to do "safer" projects, avoiding the high risk, but high payoff projects. In the present climate we cannot afford to have experiments not work. . . . Undergraduates, graduate students and postdocs continually ask about the benefits of pursuing an academic career when funding is so tight.

—Assistant Professor of Biology, Carnegie Mellon U.

The shortage of research funds has led to higher competition. There is now much more pressure to produce in order to secure funding. Consequently, in selecting research problems, we have to put emphasis on the less uncertain ones. The more fascinating but risky problems are being shelved for the time being.

—Professor of Physics, U. of California, Berkeley



I will wait a while to take on more students because I will not have support for them.

—Professor of Ecology, U. of Minnesota

In the longer term, the shortage of funds . . . will probably cause me to take on fewer graduate students.

—Professor of Physics, Harvard

The professor-graduate student relationship is one of the most important ingredients of a scientist's education and is widely regarded as a key to the success of U.S. science. One of the prime tasks of the faculty member is to serve as a role model for the student—to say, in effect, “This is what a scientist is like.” The relationship entails obligations on both sides of course, but the professor usually assumes a responsibility for seeing that his or her students are supported during their studies and placed in appropriate jobs when they finish.

In one letter after another, those responding to the survey expressed concern that they could not fulfill the obligations they had assumed when they took on students—that they could not serve as successful role models for the next generation of scientists. This breakdown of an important part of the traditional education is another serious and unexpected consequence of the funding situation. And the mood will inevitably be communicated to undergraduates in an ever-widening ripple effect.

While the difficulty in obtaining research funding has taken its toll of time and energy, I plan to continue in this position and with basic research. However, it is clear that my first three postdoctoral research fellows (now on the job market) and other postdoctoral fellows at Caltech who I know, have a quite different perspective from that which I had a few years ago when I conducted my job search: they are extremely pessimistic about obtaining any funds to run their labs and are considering quite different sorts of jobs.

—Assistant Professor of Biology, Caltech

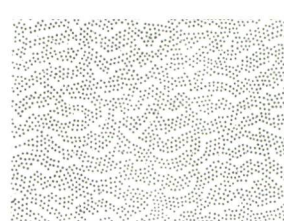
The difficulty of acquiring research funding leaves me with a grim impression of my professional future. I love research too much to contemplate leaving this career, at least at this point, but I often wonder about the level at which I will be able to pursue my professional interests in the coming years. I am certain that my anxieties on this subject, and those of my colleagues, have a negative effect on the impressions of scientific careers formed by the undergraduates and graduates with whom we are in constant contact.

—Assistant Professor of Chemistry, U. of Wisconsin

Perhaps the most serious consequence of diminishing prospects for funding is the effect it has in discouraging graduate students and post-docs from pursuing scientific careers. As a junior faculty member, I remain in close contact with colleagues from my days as a student and post-doc, but several of the best of these individuals will not show up in your survey—they have already chosen to leave science.

—Assistant Professor of Biology, U. of Pennsylvania

The responses to the AAAS survey suggest that in the coming years we can expect even fewer students to enter careers in science than do so now. It is ironic that as the enormous efforts to improve science and mathematics education that were initiated in the 1980s begin to bear fruit, the scientific infrastructure they were designed to support is being progressively eroded.



Why Keep Science Healthy?

How much does all of this matter to the nation-at-large? Given that low morale is a problem for the science community, why should the rest of the nation care? Scientists are, after all, a privileged class far better off than many in our society, and besides, there are already more crises around today than our overloaded national consciousness can handle.

The answer is, of course, that science pays. It is impossible to imagine modern society without the fruits of 400 years of scientific research. An extensive literature documents the returns to the economy generated by expenditures on science and technology. One has only to examine the ingredients of our GNP to see that a large fraction is derived from the results of the scientific research of the past 60 years or so.

Economists have estimated that for every dollar spent on the Apollo program in the 1960s, seven dollars of economic activity was generated in the American economy. More recently, economist Edwin Mansfield of the University of Pennsylvania studied the rate of return on investments in academic research. His work covered 76 major firms in seven industries: information processing, drugs, metals, electricity, chemicals, instruments, and oil. His assumptions are conservative but his result is startling: the annual social rate of return on investments in academic research is no less than 28 percent.

The tasks which are faced by American science and technology today are crucial as never before to the well being of our nation. They include:

- providing the basis for new industry to enhance the quality of life of our citizens, while extending those benefits to regions and groups that have not yet shared in them;
- improving the general health of the population while containing the costs of medical care;
- understanding the complex circumstances surrounding ecological and environmental issues and providing guidance to policymakers in these areas;
- developing alternate sources of energy and substitutes for scarce natural resources; and
- enhancing our culture by expanding our understanding of the universe and humanity's place in it.

To carry out these daunting tasks in an ever more competitive world, we will need more scientists and engineers. Yet demographic projections—such as those cited by Richard Atkinson in his 1990 Presidential Address to the AAAS—tell us that we are falling short of producing the required number of Ph.D. scientists and engineers by about 10,000 each year. Huge deficits in the number of technically trained personnel (estimated by some at up to 700,000) are expected in the first decade of the 21st century.

I am aware that such projections have large uncertainties, but I should also point out that they may be underestimated because they fail to take account of the new demands that will be placed on science and technology by environmental problems, energy and natural resources, and the needs of developing nations. Given that graduate education depends so strongly on research funding, the finding that faculty members are cutting back on the number of students they train means that the current funding situation can only exacerbate future problems in human resources for science and technology.

I'm rather bewildered. I believe that I'm one of the best young theorists in the country. Without a doubt, I've had by far the most successful group of graduate students in my field. [Yet my] NSF single-investigator funding is being cut from four students to none. In the past two years, my efforts to avert this disaster have been fruitless. For obvious reasons, I'm forced to change my style of research. In the next two years I'm shifting a large part of my efforts to workstation software development, for which there is support from private industry.

—Associate Professor of Physics,
Cornell

How Much Research Do We Need?

I contend that the United States is underinvesting in research. The result is a drastic decline in the morale of even the best academic researchers. I believe that if U.S. science is going to have a chance to help the nation meet the challenges it faces, we must create a new environment for research. The ideal environment is one in which any talented scientist can obtain research funding if he or she has a good idea and can meet the burden of reasonable review and resistance.

Since a portion of the current funding crisis arises from the increase in the number of scientists, some might argue that it would make sense to practice a kind of “scientific birth control”—to limit the number of scientists plying their trade, in order to fund the remainder adequately. Is such an approach reasonable? The answer to this question depends on how much scientific work one feels needs to be done.

There are two ways to approach the question. One is to look at nations that are doing a good job economically—nations that seem to be doing well in international economic competition. The other is to look at what society requires of science in a broader sense and assess the adequacy of any proposed system to meet those needs.

The period from shortly after World War II to 1968 has often been referred to as the “golden age” of American science. It was heralded by a report to the President in 1945 by Vannevar Bush, entitled *Science, the Endless Frontier*. The “golden age” was characterized in effect by just the conditions I now advocate, a funding level that permitted full play to the creativity and imagination of scientists. As Figure 3 indicates, we are still benefiting from the fruits of that era. I believe that the creation of a new golden age is not only affordable, but holds vast potential for benefits to the nation.

Figure 3 Partial list of Technologies Developed since World War II that are at the Forefront of Economic Growth.



Semiconductors	High-Temperature Ceramics
Solid State Electronics	Fiber Reinforced Plastics
Integrated Circuits	Medical Diagnostics—CAT, PET, MRI
Computers	Numerically Controlled Tools
Nuclear Power	Powder Metallurgy
Satellite Communications	Genetic Engineering
Air Traffic Control	Laser Surveying, Surgery, Etc.
Microwave Telecommunications	X-Ray Lithography
Long-Range Navigation	Particle-Beam Therapy
Antibiotics	Optical Fibers
Pesticides	Microprocessor Controls
High Strength Alloys	Robotics
Titanium	Superconductivity

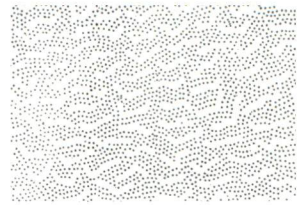
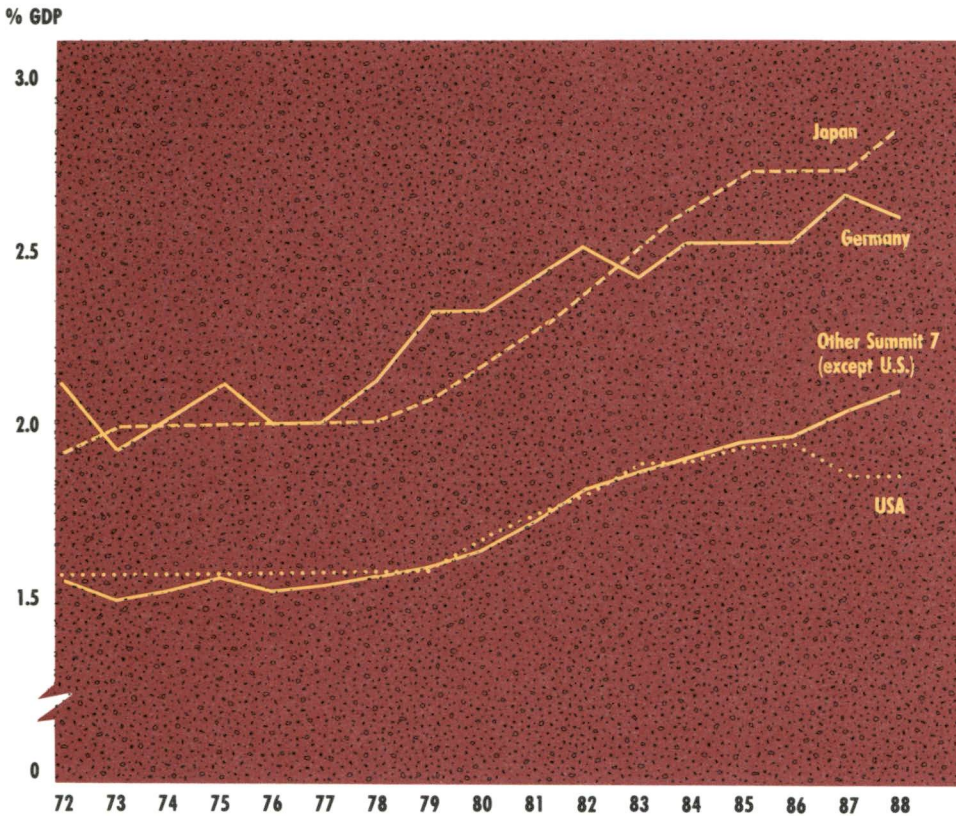


Figure 4

Non-Defense R&D Expenditure as a Percentage of Gross Domestic Product



Source: Council on Competitiveness and National Science Foundation.

The world of the 1990s is a far cry from 1968. In the late 1960s, the United States was the undisputed leader in world science. Our basic research establishment was turning out results that would fuel the boom in Silicon Valley and establish new centers of information technology on the outskirts of our major cities. Medical techniques we now consider routine—CAT scans, for example, or magnetic resonance imaging—were still gleams in the eye of basic researchers or in the early stages of development. The future was bright and there seemed to be no limits to our dreams.

Today, after 20 years of gradual attrition, the effects of which are vividly documented in the AAAS survey, the future no longer looks so bright. The United States can no longer claim undisputed leadership in world science. Western Europe and Japan both have thriving scientific establishments, offering both collaboration and competition to their American colleagues. Figure 4 shows funding for nondefense R&D as a fraction of GNP in several countries including the United States. The story is all too clear. Our own expenditures have remained almost constant during the past two decades, while those of Western Europe and Japan have grown. Measured



The country loses by not taking advantage of creative genius while the opportunity exists.
—Professor of Physics, U. of Washington

We invented the technology [of ferroelectric crystals], but who do you think has developed it almost to the point of commercialization? Yes, of course, Japan.
—Associate Professor of Physics, U. of Colorado

We now watch as the former RCA Lab in New Jersey is sold into a contract house as Nippon Electric opens a first rate research lab one mile away.
—Professor of Physics, Carnegie-Mellon U.

against our most successful international competitors, then, the current level of research funding in the United States is evidently inadequate.

Looking toward the future, Figure 5 lists some “emerging technologies” identified by the Department of Commerce, which are projected to have a total economic activity of about \$1 trillion by the year 2000. The connection of these technologies with mastery in the relevant fields of science and engineering should be obvious. The question the nation must ask of its policymakers is: What fraction of this huge sum will belong to the United States?

The second part of the answer involves the huge tasks and enormous opportunities facing science and science-based technology today. These have been outlined above, and include improving the nation’s health, economy, and quality of life and tackling the complex of environmental, energy and resource problems that loom ahead. Whether we will be able to meet these demands and exploit these opportunities depends to a large extent on how well we will be able to recruit young people into science and engineering studies. This has been recognized by the President, the nation’s governors, and by the Congress.

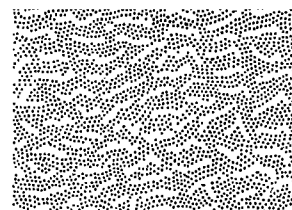
Support for science education, with recent emphasis on the elementary and secondary levels, has been increased impressively. States and communities across the nation are instituting reforms in an escalating effort to catch up to our foreign competitors whose children do so much better in international assessments. A major part (by no means the entire part) of this effort is to increase the flow of American children into science, mathematics and technology. Without this effort in science education, our research capability both in and out of academia would increasingly depend on immigrants for whom there is increasingly vigorous world-wide competition. However, if we ignore the health of the academic research system, this entire effort will surely be compromised.

I would argue that it is unwise to attempt to solve the present crisis by reducing the number of scientists at our universities. Not only would this reduce our ability to solve our nation’s problems in the short term, but, even worse, it could start a downward spiral in the size and quality of the U.S. academic research system that would be difficult, if not impossible, to reverse.

Figure 5 Critical Technologies



Source: U.S. Department of Commerce.



An End to the Frontier?

The warning in the AAAS survey is clear. American science shows signs of extreme stress. Morale is declining, students are turning away from science, and American leadership in scientific research, as measured by published papers and Nobel prizes, is threatening to go the way of the automotive, tire, machine tool, and consumer electronics industries.*

The implications of the loss of such leadership are immense. Just as the "brain drain" drew talented scientists from Europe and the Third World to the United States in the 1950s and 1960s, so too will some American scientists (and potential immigrants) follow the frontiers of their fields to Europe, the Pacific Rim, or wherever they might be in the future. The pipeline of new research that has nourished our high-tech industry will dry up, crippling our ability to compete in a world where science and technology play an ever more important role.

We can already see ominous signs in economic trends. In 1986, for the first time in history, the United States imported more high-tech manufactured products than it exported. Residents of foreign countries now receive almost half of the patents granted by the U.S. Patent Office. And the three corporations registering the most U.S. patents last year were Canon, Toshiba and Hitachi.

Finally, we should not neglect to mention the more subtle, less quantifiable but nonetheless profound influence that science has upon society. We are a great nation which must value the culture that the success of science engenders. This success permeates society, generates self-confidence, inspires our youth, creates a sense of endless frontiers of the human mind and of human aspirations which would otherwise become increasingly confined in an ever-shrinking world. The loss of this scientific and technological exuberance would be another heavy price to pay, perhaps even the greatest penalty in the long run, for the decline of the research system.

The full effects of the impoverishment of basic research will not be felt next year or the year after. We have been living on our accumulated scientific capital for a while, and we will probably be able to do so for a while longer. But if we persist on this course, we can expect to see America's position in the world gradually weaken. We will watch as our technology-based products become less and less competitive in world markets. By then, of course, it will be too late.

It is the long-term nature of the enterprise that makes the issue so dangerous. Once we begin to weaken, there are many feedback forces that tend to accelerate the decline. The best people move on to other activities. Students are no longer attracted. The stream of immigrants diminishes. The essential influx of young investigators dries up. Within the range of possible outcomes are both acceptable and unacceptable consequences. Yet to wait rather than take action now is to invite a situation that will be difficult and very time-consuming to reverse.

*It is worth noting that the bulk of U.S. Nobel prizes in recent years have been based on work done before 1970.



Conclusions and Recommendations

A large-scale anecdotal survey of some of the most capable and productive U.S. academic scientists has been carried out. The results are a clear warning that all is far from well in the laboratories of our research universities. The depressed state of the academic scientific community is attributed to a failure of our system of science funding to recognize and maintain the essential needs of a healthy infrastructure.

Science funding has increased steadily in the past several years, yet it is apparent that current levels are far below what is required for healthy, even lean, science. Perhaps this may give some policymakers a sense of frustration at the "ungrateful and insatiable scientists." Yet we are not alone in seeing this problem. Warnings have been creeping up everywhere. Almost five years ago, the Packard-Bromley report documented an obsolescence of university research equipment and evaluated the cost of renovation at \$10 billion. Since becoming the President's Science Advisor in 1989, Allan Bromley has continued to speak out about underinvestment in research, as has Frank Press, the President of the National Academy of Sciences. There is an emerging consensus among science policy leaders that we are not making the long-term investment in research required to restore our economic and scientific leadership.

The United States today finds itself slipping in its ability to compete with dynamic societies abroad. The new Europe, Japan and the Pacific Rim nations are increasing their investment in research, having already surpassed us in the various activities needed to convert research results to economic benefit. It is up to us as a nation to decide whether the U.S. will remain a major player in world science and science-based technology or whether we will continue to slide.

One could argue that since the results of basic research are globally available, we need maintain only the ability to read the scientific literature in order to compete in technology. However, the current large increases in European and Japanese investments in basic research and the dignity of a great nation argue against this. Looming over and above the economic factors are the complex issues of ecology, energy, and natural resources in a world which must, in the next century, see vast development in the South. Such development cannot be sustained without research to create the technologies which are required to reduce the uncertainties in environmental predictions and to solve the energy-ecology problem.

What would it take to relieve the acute problems in academic research and restore U.S. science to its pre-1968 excellence? Let us consider this question independently of "practical" constraints dictated by current events. My analysis of the complexity factor, the growth of new areas, and the increasing costs of research indicate that we should be spending at least twice as much as we were in 1968 (in constant dollars) if we are to approach the conditions of the golden age. Indications from NSF, NIH and DOE tend to confirm the pressure for a doubling of the current level of funding for academic science, which amounts to about \$10 billion a year. This huge sum could, I believe, be effectively deployed in two or three fiscal years.

Beyond this, in future years, I would argue that the growth of four percent per year in the number of academic scientists and the complexity factor growth estimate of five percent per year imply that a sustained flourishing of academic research requires annual real growth of eight to ten percent. It has been estimated that this kind of growth would move the proposal success rate in NSF and NIH closer to 50 percent from the present much lower levels. Such an increment may sound substantial in our current climate, but as the economy responds, academic research would remain only a tiny fraction of total federal spending for many decades. Furthermore, even with such increases, it would be a decade or two before our level of nondefense research expenditure proportional to GNP would equal the 1989 levels of Japan or West Germany.

Can we afford this kind of money? In 1980, the President of the United States convinced the Congress and the American people that we must double the defense budget to \$300 billion a



year. This was done and somehow the nation was able to absorb the cost. In 1990, the threat to the security of the nation lies in an endangered scientific infrastructure. The required sums are substantially smaller. The danger is long term but the longer we wait, the more difficult will be the remediation.

Let us for the moment accept that this investment in science funding is in fact required. How shall we proceed? In the present climate of deficits and escalating demands on the federal budget, there arises a fundamental policy dilemma. The federal deficit, the savings and loan bailout, the Persian Gulf crisis are real and immediate. The crisis of American science, no matter how serious, is a long-term affair—it is for our children and our children's children. Given the characteristic short-term philosophy that has dominated American policy for the past several decades, we have no illusions as to the probable fate of our recommendation.

Nevertheless, strong efforts must be made immediately to strengthen federal funding for research. Appropriations of NSF, NIH, DOE, and other federal agencies that support academic research should be increased sharply as soon as possible. Beyond this, however, in order to alleviate the dilemma of short-term priorities and long-term problems, I recommend that serious efforts be made to find innovative ways to fund academic research on a national scale *outside* of the regular federal budget. One approach might be to establish a trust fund supported by special taxes on high technology consumer products that benefit from basic research. Another possibility is to form a partnership between the government and the investment community. One can contemplate government bonds, designated for research, with interest keyed to the returns on that research.

To investigate such possibilities and others, I am recommending that a Commission be established consisting of representatives from the Executive and Legislative Branches of the federal government, industry, the financial community, and the academic community. AAAS should take the initiative in promoting and organizing such a Commission.

In addition to examining funding mechanisms, the Commission could also look at ways of improving the efficiency and the strategic planning of research funding and ways of assuring that academic research serves the nation most effectively. An assortment of problems we have not been able to address in this report cry for attention. I am, of course, aware that academic science is not the only component of higher education, and that the health of academia as a whole must be addressed. University issues such as graduate student support, the effect of new tax policies on philanthropy, student stipends and the ability of institutions to raise capital should be examined where relevant to the research environment. The contentious issues of balance between big science projects and individual investigator research, and the role of centers versus project grants also demand attention. It seems entirely appropriate for AAAS, in collaboration with other organizations, to foster creation of a Commission to make a broad study of what it will take to make U.S. science whole again and to design an appropriate strategy. I stress that the time is short and the issues are urgent.

In concentrating on funding, I am aware that there is much we must do in those crucial activities which connect research results to economic utility. These involve subtleties of technology transfer, tax laws, marketing and other functions which the academic community has traditionally ignored, but with which it must learn to interface more gracefully. The Commission should include this important area in its charge.

Apart from establishing the Commission, the AAAS Board should make the communication of the precarious state of U.S. science a high priority. The best efforts of the Association must be applied to create an environment where the health of American science is widely perceived to be

essential to the future of our nation. To that end, AAAS must provide leadership in rallying all segments of our society to the cause of rescuing U.S. science.

I conclude this report with an excerpt from Vannevar Bush's landmark report, *Science, the Endless Frontier*, which in 1945, set the nation on a course that has had profound consequences for its well being:

It has been basic United States policy that Government should foster the opening of new frontiers. It opened the seas to clipper ships and furnished land for pioneers. Although these frontiers have more or less disappeared, the frontier of science remains. It is in keeping with the American tradition—one which has made the United States great—that new frontiers shall be made accessible for development by all American citizens.

Moreover, since health, well-being, and security are proper concerns of Government, scientific progress is, and must be, of vital interest to Government. Without scientific progress the national health would deteriorate; without scientific progress we could not hope for improvement in our standard of living or for an increased number of jobs for our citizens; and without scientific progress we could not have maintained our liberties against tyranny.

References and Suggested Readings

- Atkinson, Richard, "Supply and Demand for Scientists and Engineers: A National Crisis in the Making," *Science*, April 27, 1990, pp. 425-432.
- Bloom, Floyd E. and Mark A. Randolph (eds.), *Funding Health Sciences Research: A Strategy to Restore Balance*, Washington, D.C., National Academy Press, 1990.
- Blum, Debra E., "Younger Scientists Feel Big Pressure in Battle for Grants," *The Chronicle of Higher Education*, Sept. 26, 1990, pp. A1, A16-17.
- Bush, Vannevar, *Science, the Endless Frontier*, New York, Arno Press, 1980. (Reprint of 1945 ed.)
- Koshland, Daniel E., Jr., "The Funding Crisis," *Science*, July 27, 1990, p. 1593.
- Mansfield, Edwin, "Academic Research and Industrial Innovation," *Research Policy*, (in press).
- Milbank, Dana, "Scientists Have to Beat the Bushes for Money to Stay in Business," *The Wall Street Journal*, Nov. 7, 1990, pp. A1, A8.
- National Science Board, *Science & Engineering Indicators—1989*, Washington, D.C., U.S. Government Printing Office, 1989.
- Palca, Joseph, "Young Investigators at Risk," *Science*, July 27, 1990, pp. 351-353.
- , "NSF: Hard Times Amid Plenty," *Science*, May 4, 1990, pp. 541-543.
- , "Hard Times at NIH," *Science*, Nov. 24, 1989, pp. 988-990.
- Sauer, Susan L. (ed.), *Science and Technology and the Changing World Order: Colloquium Proceedings*, Washington, D.C., AAAS 1990.
- Summary: Forum on Supporting Biomedical Research: Near-Term Problems and Options for Action*, Washington, D.C., National Academy Press, 1990.
- Zurer, Pamela S., "Researchers Seek Solution to Sharp Drop in NIH Research Grants," *Chemical & Engineering News*, July 16, 1990, pp. 20-21.