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**Series:** Bromley, D. Allan, Files  
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**OA/ID Number:** 62079  
**Folder ID Number:** 62079-004

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**Folder Title:**  
President's Council of Advisors for Science and Technology: Meetings - 5/2/91-5/3/91 [2 of 2]

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**CRADAS**  
**Cooperative Research and Development Agreements**

*Background Materials*

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## QUOTABLE

“[The Department of Energy’s defense laboratories] have got 12,000 Ph.D. engineers and 6,000 Ph.D. scientists and I’d like to turn everyone of those into a technology transfer advocate. That doesn’t require extra dollars, that’s people.

“Right now, we might have 50 out there at most of these types of guys trying to make [tech transfer] work and every time we go out [to the labs] we find more and more converts coming to us and giving us lectures about their great ideas. If we could just get half of these guys trying to set up relationships with industry in which their expertise could be shared with industry, the potential is unbelievable. But these guys have been locked behind a chain linked fence for 40 years now and they’ve developed that culture.

“It’s not that they have purposely not participated in this process, it’s just never been open to them as an opportunity and as the doors start to open, the light makes them blink like everyone else and then they say, “My God, there’s something out there.

“At the Los Alamos CRADA [Cooperative Research and Development Agreement] signing ceremony on Capitol Hill [on March 21, 1991], the Japanese press guy assigned to the White House came over to talk to me and I did everything I could to make him think the end was near. The national labs, a resource they didn’t have in Japan, were joining with industry and we were going to take over.

“We cannot have a negative attitude.”

—BRIAN SIEBERT, Director, Office of Classification, Office of Security Affairs, U.S. Department of Energy.

## ✓ WHAT IS A CRDA ?

Any agreement between one or more Federal laboratories and one or more non-Federal parties under which the Government, through its laboratories, provides personnel, services, facilities, equipment, or other resources with or without reimbursement (but not funds to non-Federal parties) and the non-Federal parties provide funds, personnel, services, facilities, equipment, or other resources toward the conduct of specified research or development efforts which are consistent with the missions of the laboratory; except that such term does not include a procurement contract or cooperative agreement as those terms are used in sections 6303, 6304, and 6505 of title 31, USC.99

Section 12 (d)(1) P.L. 99-502 Technology Transfer Act  
(October 20, 1986)

✓ WHY WAS CRDA CREATED ?

- PROMOTE ADDITIONAL ACCESS TO FEDERAL LABORATORIES
- PROVIDE AUTHORITY FOR LAB DIRECTORS TO ACCEPT FUNDS, PERSONNEL, SERVICES, AND/OR PROPERTY
- PERMIT INDUSTRY TO OBTAIN RIGHTS TO INTELLECTUAL PROPERTY CREATED BY GOVERNMENT
- PERMIT GOVERNMENT LABS AND PERSONNEL TO PARTICIPATE IN COMMERCIALIZATION ACTIVITIES

## COMMERCIALIZING FEDERAL TECHNOLOGY

The Reagan and Bush Administrations have dramatically improved the private sector's ability to develop the commercial implications of federally-funded R&D in the last ten years and the Department of Commerce has played a central role in bringing about these improvements:

- o 1980- The Bayh-Dole Act made it possible for small businesses and non-profit institutions to hold title to patents derived from R&D performed with federal funding. The Department of Commerce led executive branch efforts to secure passage of this first, and most fundamental portion of the technology transfer laws.
- o 1983- President Reagan's patent policy memorandum ordered all agencies to make available to all Government contractors, to the extent permitted by then-existing law, the same benefits concerning the ownership of patents derived from federally-funded R&D made available to small businesses and not-for-profits under the Bayh-Dole Act. The Department of Commerce worked closely with the White House and other executive branch agencies in the formulation of this important document.
- o 1984- The Bayh-Dole Act was amended to provide the same patent ownership rights to university-operated laboratories as were given to small businesses and non-profit institutions. Once again, the Department of Commerce played a leading role among executive branch agencies in working for this extension and improvement of the technology transfer laws.
- o 1984- The National Cooperative Research Act lessened the antitrust risks of companies engaged in cooperative research. It authorized the recovery of actual (rather than treble) damages, the application of the "rule of reason" standard (rather than the standard of per se illegality) and the recovery of attorney's fees from plaintiffs who initiated spurious litigation. More than 160 consortia have been registered under the Act and the Bush Administration has proposed legislation extending these provisions to cover cooperative production activities, as well as research. The Department of Commerce was a forceful advocate for these changes within the executive branch and before Congress.
- o 1986- The Federal Technology Transfer Act (FTTA) amended the Stevenson-Wydler Technology Innovation Act of 1980 to improve the process for private sector commercialization of federally-funded R&D.

- o Government-owned, Government-operated ("Go-Go") laboratories were permitted to enter into cooperative research agreements with private companies, universities and others.
- o Title to or licenses for federal inventions could be granted to participants; ownership rights in inventions resulting from the collaborative effort could be waived in advance; and royalties could be received as part of these agreements (at least 15% of which must go to the employee responsible for the invention).
- o The Department of Commerce once again led executive branch efforts to secure these important improvements to the technology transfer process.
- o 1987- President Reagan issued Executive Order 12591, Facilitating Access to Science and Technology, which carried out the provisions of the FTTA and preceding legislation; directed agencies to assist in technology commercialization and to award title to inventions resulting from federally-funded R&D to all contractors; and required that international Science and Technology agreements conform to the requirements of domestic law. The Department of Commerce made significant contributions to this document, working directly with the White House and other concerned agencies.
- o 1989- The National Competitiveness Technology Transfer Act of 1989 amended the FTTA to authorize Government-owned and contractor-operated Department of Energy laboratories to engage in cooperative research agreements on the same basis as GO-GO labs. It also amended the Freedom of Information Act to permit federal labs to withhold from disclosure certain types of information developed in connection with cooperative research efforts with private sector partners. Commerce played a critical role in persuading Congress of the importance of broadening the FTTA in this manner.
- o 1990- The Department of Commerce has led executive branch efforts in drafting a bill, recently submitted to Congress on behalf of the Administration, providing copyright protection to federal computer software made in cooperation with the private sector. Passage of this bill would mark another important step forward in creating effective mechanisms for the commercialization of federally-funded research. The bill would have significant impacts on the commercialization of federally developed computer software - removing concerns private firms might have that their collaborative work with the federal labs may fall into the public domain and encouraging federal employees to develop commercially viable software as part of such collaborative research.

SAMPLE OF COMPANIES/ORGANIZATIONS INVOLVED

AIR TECHNIQUES  
ALUMINUM ASSN.  
ARMSTRONG  
ASTRON  
ASTM  
AT&T BELL CORP.  
BDM CORP.  
CARBORUNDUM CORP.  
CEM CORP.  
DEC  
DENTSPLY  
DIONEX CORP.  
DUPONT

EASTMAN KODAK  
EXXON  
FUSION SYSTEMS  
GENERAL ELECTRIC  
IBM CORP.  
INTEL CORP.  
ONTOLOGIC, INC.  
ROCKWELL  
TANDEM COMPUTER  
UNION-CARBIDE  
WARNER-SWASEY  
3-M CORP.

# INTELLECTUAL PROPERTY RIGHTS

UNDER CRDAs .....

- TITLE TO, OR LICENSES FOR, INVENTIONS MADE BY FEDERAL EMPLOYEES MAY BE ASSIGNED IN ADVANCE TO THE COLLABORATOR
- GOVERNMENT CAN WAIVE IN ADVANCE RIGHT OF OWNERSHIP IT MIGHT HAVE TO INVENTIONS RESULTING FROM CRDA COLLABORATION
- GOVERNMENT MAINTAINS NONEXCLUSIVE, PAID-UP, LICENSE TO PRACTICE INVENTIONS WORLDWIDE

# NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

- Traditionally Has Provided Measurement Technology and Standards Services to Industry, Other Agencies, and State and Local Governments
- Trade Act of 1988 Expanded NIST Mission To Emphasize Technology Assistance to Industry and State and Local Governments for Manufacturing Modernization and Economic Development

# TECHNOLOGY COMMERCIALIZATION

OBJECTIVE: Assist U.S. Industry in Rapid Commercialization of Federal Technology

- Collaborative R&D Activities Drawing from NIST Technology and Expertise
- Independent Research Using NIST Facilities
- Patents and Licenses of NIST Developed Technology

# OPPORTUNITIES FOR COOPERATIVE RESEARCH AT NIST

NIST Conducts Basic and Applied Research in:

- Physics
- Chemical Science and Technology
- Computing and Applied Mathematics
- Electronics and Electrical Engineering
- Building and Fire Technology
- Manufacturing Engineering
- Materials Science and Engineering
- Computer Systems

## KEYS TO NIST SUCCESS IN DEVELOPING PARTNERSHIPS WITH INDUSTRY

- Strong Technical Credentials of Programs and Staff
- Open Door Policy to Industrial Partnering - Supported at All Levels of NIST
- Long Standing Attitude by Bench Level Staff that Cooperative Research Programs Are Worthwhile Pursuing
- Flexible Administrative Requirements/Agreements
- Good Technical Outreach Effort to Industry To Identify and Capitalize on Cooperative Opportunities

## SUMMARY

CRDAs ARE EFFECTIVE TOOLS FOR R&D PARTNERING

NIST IS A LEADER IN USE OF CRDAs

COMING IMPROVEMENTS TO CRDAs WILL EXPAND USAGE

**NEW TECHNOLOGY WEEK CONFERENCE**  
**Wednesday May 15, 1991**

**Capitalizing on CRADAs:  
The New Currency for Technology Transfer**

**CRADAs and other Technology Transfer Opportunities  
at the National Institutes of Health**

Reid G. Adler, J.D.  
Director  
Office of Technology Transfer  
National Institutes of Health  
Bethesda, Maryland  
(301) 496-0750

1. A broad Congressional mandate to encourage commercial development of Government inventions and collaborative research with the private sector was enacted with the Federal Technology Transfer Act of 1986 (FTTA). The NIH is recognized as one of the leading Federal agencies in the implementation of a formal technology transfer program under the FTFA. This outline describes the organization and key elements of the NIH program and the NIH Office of Technology Transfer (OTT). It also identifies technology transfer from the Government and identifies opportunities for counsel to facilitate the process.

2. Implementation of the FTFA at NIH reflects five general principles: (1) awareness of our central mission as a basic biomedical research institution, (2) adoption of procedures that complement but do not unduly complicate our research efforts, (3) recognition that public health and U.S. industrial competitiveness both are served by efficient technology transfer activities, (4) decentralized technology transfer authority, and (5) the involvement of industry in the review of emerging policies and draft model agreements.

3. NIH is the world's largest basic biomedical research facility. It is located on a 300-acre campus in Bethesda, Maryland, about 12 miles north of the Capitol, that is shared with the Alcohol, Drug Abuse and Mental Health Administration (ADAMHA), a sister agency of the Public Health Service (PHS). The NIH and ADAMHA consist of 21 research institutes, divisions, centers and bureaus, with an integrated 540-bed research hospital and laboratory complex. Over 14,000 NIH employees include more than 2,300 permanent staff with doctoral level degrees. The NIH provides about \$7 billion per year in "extramural" academic grants, and spends about \$900 million on its in-house, "intramural" research program. Currently, about 1,300 active patent cases make up the PHS patent portfolio, and over 300 cases are filed annually. The OTT also handles patents and licensing for the Centers for Disease Control (CDC) and patents for the Food and Drug Administration.

4. The FTFA authorizes Government laboratories to enter into cooperative research and development agreements (CRADAs) with outside collaborators, analogous in many ways (other than outside funding) to the sponsored research conducted at universities. Under a CRADA, Federal laboratories and the private sector jointly conduct a specified research and development project and, at the NIH, the collaborating company acquires an option at the outset to negotiate for exclusive patent rights. The CRADA program at the NIH reflects an acknowledgement of our basic research mission and an emphasis on contributing to scientific knowledge, as well as maintaining the research agenda of our component institutes. Accordingly, for example, NIH will not agree to reserve its research findings as trade secrets made available only to corporate collaborators. Over 150 CRADAs have been entered into by NIH since enactment of the FTFA.

5. As an incentive for innovation and a reward for inventive efforts, the FTFA also mandates the sharing with inventors of license royalties from inventions developed under CRADAs as well as from inventions made through the NIH intramural research program.

6. The licensing of intramural inventions is authorized by the patent law in Title 35 of the United States Code, discussed below, which also, for example, provides for university ownership and commercial licensing of inventions made with Federal grants.
7. A key element of the Patent Policy Board's technology transfer program is the "Policy Statement on Cooperative Research and Development Agreements and Intellectual Property Licensing." This policy statement defines NIH's primary statutory missions in terms of conducting basic biomedical and behavioral research, rather than in terms of transferring technology. It affirms a commitment to transfer technology within a framework that promotes the free exchange of information. For example, NIH investigators retain the freedom to publish their research results. Generally, attempts are made to safeguard the collegiality and integrity of NIH/ADAMHA research programs, as well as public confidence in these institutions. Specific sections of the "CRADA/Licensing Policy Statement" treat questions of "fair access" by outside companies to the NIH/ADAMHA laboratories, and the handling of confidential or proprietary information.
8. As directed by the Patent Policy Board and consistent with the programmatic principles discussed above, the OTT has implemented a technology management program for NIH, ADAMHA and CDC with wide-ranging activities. In conjunction with the various subcommittees of the Patent Policy Board, the OTT convenes an annual technology transfer forum, and formal in-house training initiatives including a "Technology Transfer Briefing" for scientists and a monthly speakers series called the "Technology Transfer Grand Rounds." The OTT, along with the Drug Discovery Management Subsection of the Pharmaceutical Manufacturers Association, co-hosts a major national technology transfer conference in the spring (this year on April 25-26) to explore several issues in government-academia-industry research collaborations.
9. The OTT has three operational branches: the Technology Licensing Branch, the Patent Branch and the Technology Management Branch. Current permanent staff is about 30 employees.
10. An Electronic Bulletin Board (EBB), an effort of major significance for the PHS technology transfer programs, is a computer-based information system which provides access via modem to a variety of essential data. The EBB provides downloadable copies of PHS technology transfer guidelines and model agreements, and downloadable full-text files of patent applications available for licensing. The Board includes the names and phone numbers of PHS researchers interested in potential CRADA collaborations with private industry. Existing CRADAs are listed along with a brief description, and a PHS "resource" directory of the various Technology Development Coordinators will assist users in gaining access to the system. This system can be used by counsel to identify collaborative research opportunities for client companies as well as technologies available for licensing.

11. The licensing of inventions made with Federal funding is governed by the patent law, 35 U.S.C. § 200-212, and its implementing regulations at 37 C.F.R. Part 404. For inventions made at Federal laboratories, 35 U.S.C. § 209(a) sets forth the requirement that no license may be granted without the submission of a plan for the development and/or marketing of the licensed invention. This is amplified by 37 C.F.R. § 404.5(a)(1), which requires that the "plan" be satisfactory and that the applicant for license also supply the licensing agency with information about the applicant's ability to fulfill the plan. The patent statute (§ 209(f)(1)) further requires "periodic" reporting on a licensee's efforts with particular reference to the plan submitted, and the regulations (§ 405(b)(5)) require that the licensee carry out the submitted plan for development. Finally, the license may be terminated if the licensee is not executing the plan submitted with its request for a license, or cannot otherwise demonstrate to the licensor's satisfaction that the licensee can take effective steps within a reasonable period of time to achieve practical application of the invention (§ 209(f)(2) and § 404.5(b)(9)(i)). Similar provisions have been adopted by NIH/ADAMHA for the licensing of CRADA inventions.

12. A license application form is available from OTT. In general, a license applicant will be asked to respond to the following topics: Product and Market Analysis, Product Development Plan and License Terms. (Note that where various fields of use can be identified, these topics should be treated separately for each field in which license rights are sought.)

13. Also required for the exclusive licensing of intramural (non-CRADA) inventions are formal findings by the licensing agency that: (1) the Federal and public interests are best served by exclusive licensing; (2) expeditious practical application of the invention is unlikely to occur under a nonexclusive license; (3) exclusive licensing is a reasonable and necessary incentive to attract investment of risk capital; (4) exclusive licensing will not tend substantially to lessen competition or result in undue concentration; and (5) the proposed terms and scope of exclusivity are not greater than reasonably necessary. Applicants for exclusive license to intramural inventions should supplement the foregoing license application with persuasive comments on these additional criteria. The foregoing findings are not required by the FTTA, and it is the expectation of NIH that collaborators may obtain an exclusive license upon request, subject to the submission of a satisfactory commercial development plan.

14. NIH believes that the FTTA and the technology management program implemented at NIH have begun to play a critical role in the transfer of Government inventions in the biomedical field to the health care companies in the private sector for commercial evaluation and product development. This process is an essential component of caring for the public health. The model license agreements and license application forms at the NIH are intended to facilitate the technology transfer process. Comments and constructive suggestions from the private sector, however, are imperative, if these technology transfer efforts are to achieve their potential utility and effectiveness. Because counsel for industry have a major presence in negotiating joint research projects, in licensing transactions and in patent-related matters, they can play a major role in developing NIH's technology transfer potential.

Cooperative R&D Opportunities  
with Army Laboratories and Centers

**More  
than  
National  
Defense!**



Army Domestic Technology  
Transfer Program

# Opportunities for Cooperative R&D

## Army Domestic Technology Transfer Program

### CRDA's and Industry

The Army Domestic Technology Transfer Program seeks to promote the transfer of Army technology and expertise to the private sector, so that this technology can be exploited for improving U.S. competitiveness. One mechanism for such transfers is the use of Cooperative R&D Agreements (CRDA's) between Army R&D activities, and U.S. industry.

The CRDA is a contract to cooperate and share intellectual property resulting from joint efforts. Private organizations can contribute resources to the cooperative effort, including personnel, services, property, and funding, while the government can contribute all of these except funding. Since the CRDA is not a procurement (the government does not provide funding for services or products), complex military procurement

procedures can be avoided.

CRDA's provide an easy way for U.S. industry to collaborate with Army R&D activities. The intellectual property created by work under the CRDA can be exclusively exploited by the company for commercial uses, while the government retains a license to use the technology for its own purposes

### ORTA's—Points of Contact for Industry

By law, each federal laboratory is required to establish an Office of Research and Technology Applications (ORTA) to actively seek technology transfer opportunities. The ORTA is also a point of contact for potential users of the laboratory's technology.

The Army Domestic Technology Transfer Program is intended to work through the decentralized but coordinated activity of the ORTA's at the laboratories and centers. As part of a network of federal laboratories called the Federal Laboratory Consortium (FLC), each ORTA can provide assistance and make referrals to appropriate sources of technology among the federal laboratories.

For help in identifying the appropriate Army technology for your needs and in developing a cooperative relationship, contact the appropriate ORTA (see reverse of flyer) or call the one nearest you for information.

### Legal Background

The Stevenson-Wydler Act (15 USC 3701 et seq.) made technology transfer part of the mission of every federal laboratory. The Federal Technology Transfer Act of 1986 (PL 99-502), which amended the original law, provided significant new authorities for Army laboratories to establish CRDA's with private companies, as well as public and nonprofit organizations. Further, PL 99-502 authorized and Executive Order 12591 required that the commander or director of each appropriate Army R&D activity be delegated the authority to enter into CRDA's and to license, assign, or waive rights to intellectual property on behalf of the government

### Partnership with Industry

Army laboratories and centers have a wealth of technology, advanced facilities, and expertise that can be used for more than national defense. Army technology can also help to produce a stronger civilian economy, but only in partnership with U.S. industry, which can bring new products and processes to the marketplace.

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For additional information on technology transfer contact:  
Clifford E. Lanham  
Manager—Army Domestic Technology Transfer Program  
U.S. Army Laboratory Command, AMCLD-TT  
2800 Powder Mill Road, Adelphi, MD 20783-1145

DRAFT

As of July 8, 1991

PRESIDENT'S COUNCIL OF ADVISORS  
ON  
SCIENCE AND TECHNOLOGY

SEPTEMBER 12-13, 1991  
AGENDA

THURSDAY, SEPTEMBER 12, 1991

OPEN SESSION 9:00 AM - 11:15 AM  
CONFERENCE ROOM  
COUNCIL ON ENVIRONMENTAL QUALITY  
722 JACKSON PLACE, NW

8:30 - 9:00	ARRIVAL AND COFFEE	
9:00 - 9:15	OPENING REMARKS	DR. BROMLEY
9:15 - 10:00	THE COUNCIL ON COMPETITIVENESS	GEORGE FISHER
10:00 - 10:15	DISCUSSION	
10:15 - 10:45	S&T STATISTICS AND DATA COLLECTION	JANET NORWOOD
10:45 - 11:00	DISCUSSION	
11:00 - 11:15	CLOSING REMARKS AND MOVE TO INDIAN TREATY ROOM, ROOM 474, OLD EXECUTIVE OFFICE BUILDING	DR. BROMLEY



DRAFT

FRIDAY, SEPTEMBER 13, 1991

**CLOSED SESSION 9:00 AM - 12:00 NOON  
ROOSEVELT ROOM  
WEST WING  
WHITE HOUSE**

8:30 - 8:50	ARRIVAL AND COFFEE <u>(DR. BROMLEY'S OFFICE, ROOM 358, OEOB)</u>	
8:50 - 9:00	MOVE TO ROOSEVELT ROOM	
9:00 - 9:15	PREPARATION FOR THIS MORNING	DR. BROMLEY
9:15 - 9:45	THE PRESIDENT'S FOREIGN INTELLIGENCE ADVISORY BOARD - An Overview	ADMIRAL INMAN
9:45 - 10:00	DISCUSSION	
10:00 - 11:00	OTHER BUSINESS	
11:00 - 11:30	DISCUSSION OF OCTOBER AGENDA AND FUTURE MEETING FORMAT	DR. BROMLEY
11:30 - 12:00	OTHER BUSINESS AND CLOSING REMARKS	DR. BROMLEY

THE PRESIDENT'S COUNCIL OF ADVISORS  
ON SCIENCE AND TECHNOLOGY

*PANEL CALENDAR*  
*July 10, 1991*

Technology and National Security Panel

- June - Sol Buchsbaum held several conversations with Deputy Secretary Atwood.
- June 26 Fact-finding meeting with Sol Buchsbaum, Johnny Foster, Tom Welch and Charles Herzfeld.
- Aug 5,6 Tentative Panel meeting in Washington.

High Performance Computing and Communications Panel

- 1990  
August 1 Fact-finding meeting was held.
- 1991  
March 15 Fact-finding meeting was held.

Global Environment and Natural Resources Panel

- April 3 Fact-finding meeting was held.
- May 1 Fact-finding meeting was held.

Megaprojects in the Sciences

- June - John McTague holding conversations with presenters and Tom Ratchford.
- June - Background Binder sent to all Panel members.
- September - Meeting of experts.
- November - U.S. - E.C. Joint Consultative Group meeting.

Education and Human Resources

- June - Peter Likins has received a positive responses from all Panel presenters. Dr. Likins and Dr. Drake will receive presenters separately.

Bioscience and Biotechnology

June - Dan Nathans is waiting for response from presenters before scheduling a meeting.

International Economic Competitiveness

June - Panel presenters not selected as of July 7, 1991.

PCAST PANEL ACTIONS  
(July 10, 1991)

	Sol, Ralph	Ralph, Harold	Dan, Norman	Peter, Chuck	Sol, Johnny Foster, David	Tom, David, Norman	John
High Perfor. Computing & Commun.	MAR '90	INTERNATIONAL Economic Competitive.	Bioscience and Biotech.	Education & Human Resources	Technology & National Security	Global Environ. & Natural Res.	Megaprojects in the Sciences
Information Briefing on Topic	MAR '90	MAY '90 JUL '90	APR '90	APR '90	FEB '91	MAY '90 JUL '90 FEB '91	FEB '91
Issues & Panel Members Discussed	MAR '90	APR '91	MAY '90 MAR '91	JUL '90 SEP '90 MAR '91	FEB '91 MAR '91	FEB '91	FEB '91 MAR '91 APR '91
Terms of Reference, Members Approved	APR '90	MAY '91	MAY '91	MAY '91	APR '91	MAY '91	MAY '91
Progress Report #1	JUL '90	JUL '91	JUL '91	JUL '91	JUL '91	JUL '91	JUL '91
Progress Report #N	APR '91 MAY '91 JUL '91						
PCAST Briefed							
PCAST Position Taken							
Meet With President							
Status Review							

PCAST MEETING CALENDAR  
AND EXPECTED PCAST ATTENDANCE

1991

Member	May 2-3	July 11-12	Sep. 12-13	Oct. 10-11	Nov. 14-15	Dec. 12-13
Borlaug	Yes	Yes	Yes	Yes	Yes	Yes
Buchsbaum	Yes	Yes	Yes	Yes	No	Yes
Drake	Yes	Yes	Yes	Yes	Yes	Yes
Gomory	Yes	Yes	N 12, Y 13	Yes	N 14, Y 15	Yes
Likins	N 2, Y 3	N 11, Y 12	Yes	No	No	No
Lovejoy	Yes	Yes	Yes	Yes	Yes	Yes
McTague	Yes	Yes	Yes	Yes	Yes	No
Nathans	Yes	Yes	Yes	No	Yes	No
Packard	Yes	Yes	Yes	Yes	Yes	No
Shapiro	Yes	N 11, Y 12	Yes	N 10, Y 11	No	Y 12, N 13

1992

Member	Jan. 9-10	Feb. 6-7	Mar. 5-6	Apr. 2-3	May 7-8	June 4-5	July 9-10	Aug. 6-7	Sep. 10-11	Oct. 15-16	Nov. 5-6	Dec. 3-4
Borlaug	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Buchsbaum	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Drake	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Gomory	N 9, Y 10	Yes	Yes	Yes	Yes	Yes	N 9, Y 10	Yes	N 10, Y 11	Yes	No	Yes
Likins	Yes	Yes	Yes	Y 2, N 3	Yes	Y 4, N 5	Yes	Yes	Yes	Y 15, N 16	Yes	Yes
Lovejoy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
McTague	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nathans	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Packard	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shapiro	N 9, Y 10	Yes	Yes	Yes	Yes	No	N 9, Y 10	Yes	N 10, Y 11	Yes	Yes	Yes

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**PCAST**  
**Biographical Sketches**

*Joe Allen*  
*Maryanne Bach*  
*Robert Grady*  
*Charles Herzfeld*  
*Michelle Van Cleave*  
*James Watson*

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UNITED STATES DEPARTMENT OF COMMERCE  
The Assistant Secretary for Technology Policy  
Washington, D.C. 20230

### Biographical Data

Joseph P. Allen

Director, Office of Technology Commercialization  
U.S. Department of Commerce

The Office of Technology Commercialization is the principal industrial liaison for the Department's Technology Administration created to spur Government-industry cooperation. The mission of the Office of Technology Commercialization is to improve the process of commercialization of new technology in the U.S. The Office oversees four separate programs: Advanced Manufacturing, Federal Technology Management, the Clearinghouse on State and Local Initiatives and the National Medal of Technology.

Joe Allen has been involved in the passage of major laws making possible joint R&D projects between Federal laboratories, universities and the private sector -- the 1980 Bayh-Dole Act, its amendment in 1984, and the Federal Technology Transfer Act. He is now responsible for oversight of these laws for the Department. Joe was very involved in the passage of a bill signed into law by the President giving significant authorities to the Department of Energy's laboratories to work with industry.

Before coming to the Department of Commerce he was Executive Director of Intellectual Property Owners, Inc., a trade association representing many research intensive companies. There he helped coordinate the successful legislative campaign establishing the new Court of Appeals for the Federal Circuit -- a major court reform re-establishing uniform patent standards throughout the U.S. after years of confusion.

From 1974-1981 he served as a Professional Staff Member on the Senate Judiciary Committee. On the Committee he was directly involved in passing the Bayh-Dole University and Small Business Patent Policy Act. This law is the basis for the present high degree of U.S. university-industry cooperative R&D.

**MARYANNE C. BACH**  
Assistant Director, Responsible for the  
Federal Coordinating Council for Science,  
Engineering, and Technology (FCCSET)

Maryanne Bach is the Assistant Director, Responsible for FCCSET working directly for Dr. D. Allan Bromley, Assistant to the President for Science and Technology and Director of the White House Office of Science and Technology Policy (OSTP). Ms. Bach came to FCCSET from the Department of the Interior where she most currently was appointed by Secretary Manuel Lujan, Jr. to serve as the Department's Director of the Office of Program Analysis. Reporting to the Assistant Secretary for Policy, Management and Budget, the Office oversees and coordinates major program and policy development for Interior, including wetlands, global change, energy strategy, and initiatives to enhance stewardship of our natural resources.

Prior to October 1988, Bach served as Special Assistant to the Secretary and the Deputy Assistant Secretary for Fish and Wildlife and Parks where she was key to the Department's endorsement of major steps to enhance and protect prime wildlife and wetland habitat, including legislation to expand the Everglades National Park and an international wetlands agreement, the North American Waterfowl Management Plan. She has also chaired the Department's Wetlands Working Group. In addition, Ms. Bach serves as the Secretary's representative to the National Park Systems Advisory Board, a sixteen member group that gives independent advise on Park matters.

Prior to her arrival at the Interior Department, Bach served eight years on the Republican staff of the Committee on Science, Space and Technology of the U.S. House of Representatives. As the Republican Science Coordinator, Ms. Bach oversaw major policy development in the field on non-military federal research and development. This included the coordination of the legislative and oversight activities for: the National Oceanic and Atmospheric Administration (NOAA), the research and development programs of the Environmental Protection Agency (EPA), the environmental program in the DOE, the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the National Technical Information Service (NTIS) within the Department of Commerce (DOC), all international R&D activities, as well as technology transfer and biotechnology issues under the jurisdiction of the Committee. Formerly, she coordinated the work of the Investigations and Oversight Subcommittee, as well as served as the principal Minority representative on the Committee's Supercomputer and Biotechnology Task Forces during their existence in 1985-87.

A native of New York, Bach received her B.S. degree (cum laude) in biology from Providence College, Rhode Island and a M.S. in Botany and Plant Ecology (magna cum laude) from Iowa State University. While at Iowa State, she worked for the Science and Humanities Research Institute and The Nature Conservancy.

Bach is a member of the American Association for the Advancement of Science (AAAS), Phi Sigma Tau, Phi Kappa Phi, the Iowa Academy of Science and The Nature Conservancy.



EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF MANAGEMENT AND BUDGET  
WASHINGTON, D.C. 20503

ROBERT E. GRADY

Robert Grady is Associate Director for Natural Resources, Energy and Science of the Office of Management and Budget. He was appointed by the President and joined OMB on Inauguration Day, 1989. In that position, he oversees budget and policy development for the Environmental Protection Agency, the Departments of Interior, Energy and Agriculture, the National Science Foundation, and the National Aeronautics and Space Administration. He has played a central role in drafting the Administration's budget and Clean Air Act proposals and the President's maiden State of the Union address in 1989.

Prior to joining OMB, Mr. Grady was a senior advisor on President-Elect Bush's transition team. He also served as a top advisor on the Bush-Quayle '88 campaign, drafting a number of the candidate's principal policy speeches and advising him on the development of economic and environmental policies. He held the position of speechwriter in the Office of then Vice-President Bush in 1986.

From 1983 to 1986, Mr. Grady was Director of Communications for Governor Thomas H. Kean of New Jersey, and was a principal strategist in the Governor's 1985 campaign, which led to the Governor's re-election by the largest margin in New Jersey history.

From 1979 to 1982, Mr. Grady served in the office of Congresswoman Millicent Fenwick (R-N.J.), first as Legislative Assistant, then as Legislative Director, and, in 1982, as Chief of Staff.

A native of Livingston, New Jersey, Mr. Grady holds an AB degree, with honors, from Harvard College, and an MBA degree from Stanford University Graduate School of Business.

# # #

**CHARLES M. HERZFELD**

**At Present Dr. Charles M. Herzfeld is a Department of Defense Consultant reporting jointly to the Assistant to the President for Science and Technology and the Assistant to the President for National Security Affairs. He will support the work of the President's Council of Advisors on Science and Technology Panel on Technology and National Security as Senior Director.**

**From March 1990 to May 1991 Dr. Herzfeld served as Director of Defense Research and Engineering, Department of Defense.**

**From 1985 to 1990 he was vice chairman of Aetne, Jacobs and Ramo Technology Ventures.**

**He was with ITT Corporation from 1967 to 1985 serving last as Vice President and Director of Research and Technology.**

**He was Director of the Defense Advance Research Projects Agency (DARPA) from 1965 to 1967.**

**Dr. Herzfeld has also served as a member of the Defense Science Board and the Defense Policy Board.**

**Dr. Herzfeld graduated from Catholic University in 1945 with a Bachelor of Science in Chemical Engineering and from the University of Chicago in 1951 with a Ph.D. in Physical Chemistry. He was born in Vienna, Austria on June 29, 1925 and is a naturalized citizen of the United States.**

EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20506

MICHELLE K. VAN CLEAVE

ASSISTANT DIRECTOR FOR NATIONAL SECURITY AFFAIRS  
AND  
COUNSEL

Michelle Kim Van Cleave was reappointed Assistant Director for National Security Affairs and Counsel, White House Office of Science and Technology Policy, on October 1, 1989--positions she had held from August 1987 through February 1989. Prior to rejoining OSTP, Ms. Van Cleave served as Republican Counsel to the Committee on Science, Space, and Technology, U.S. House of Representatives.

From 1981 through July 1987, Ms. Van Cleave was Assistant for Defense and Foreign Policy to Congressman Jack Kemp (R-NY), serving concurrently as National Security Assistant to the House Republican Conference and Associate Staff Member, House Appropriations Subcommittee on Foreign Operations, U.S. House of Representatives.

From 1979 through 1981, Ms. Van Cleave was an associate with the Los Angeles law firm of Horvitz and Greines, specializing in appellate advocacy.

Ms. Van Cleave was Coordinator and Staff Attorney in the Office of the General Counsel, 1981 Presidential Inaugural Committee, and assisted in the work of the Department of Defense Transition Team Office of President-elect Reagan 1980. At the Republican Convention in 1984, Ms. Van Cleave was a member of the Platform Committee staff, with responsibility for foreign policy.

Ms. Van Cleave has served as a member of the Board of Advisors, Center for Security Policy, and as consultant to the Heritage Foundation, the Fund for an American Renaissance, and the American Security Council. She has spoken before a variety of conferences and organizations including the Aspen Institute Berlin, the New York Institute of Technology, the National Defense University, Tufts University, Johns Hopkins School for Advanced International Studies, Republican National Committee regional meetings, the Military Operations Research Society and the American Chamber of Commerce (Manila). She also served as a Congressional Staff Advisor to the U.S. delegation to the United Nations Second Special Session on Disarmament.

Ms. Van Cleave holds M.A. and B.A. degrees in international relations from the University of Southern California and a J.D. from the U.S.C. School of Law. She is a member of the State Bar of California.

December 1989

## Biographical Sketch of James Dewey Watson

James D. Watson is best known for his discovery of the structure of DNA (deoxyribonucleic acid) for which he shared with Francis Crick and Maurice Wilkins the 1962 Nobel Prize in Physiology and Medicine. They proposed that the DNA molecule takes the shape of a double helix, an elegantly simple structure that resembles a gently-twisted ladder. The rails of the ladder are made of alternating units of phosphate and the sugar deoxyribose; the rungs are each composed of a pair of nitrogen-containing nucleotides.

This research emphasized a concept central to the emerging field of molecular biology: understanding the structure of a molecule can give clues about how it functions. Because each nucleotide within a rung of the DNA ladder is always paired with the same complementary nucleotide, one half of the molecule can serve as a template for the construction of the other half. This complementary pairing explains how identical copies of parental DNA can be passed on to two daughter cells. During cell division, the DNA helix "unzips," and two new molecules are formed from the half-ladder templates. Later research showed that the "genetic code," which determines the identity of a living organism and directs the manufacture of proteins, is contained in the precise sequence of nucleotide rungs of the DNA ladder. Research on DNA-protein interactions launched a revolution in biology which culminated in the development of modern recombinant-DNA techniques.

In 1968, Dr. Watson became Director of Cold Spring Harbor Laboratory on Long Island, New York. Under his direction, this renowned but financially-endangered institution was revitalized. Dr. Watson steered the Laboratory into the field of tumor virology, from which emerged our present understanding of oncogenes (cancer genes) and the molecular basis of cancer. In addition to the high-level research on cancer, plant molecular biology, and cell biochemistry, the Laboratory functions as a postgraduate university on DNA science. Each year some 4,000 visiting scientists from around the world are drawn to more than 52 professional meetings and advanced courses held at Cold Spring Harbor. Thus, the Laboratory exerts an influence on biological research that is far out of proportion to its relatively small size (375 employees).

Born in Chicago, Illinois, in 1928, Dr. Watson received a B.S. degree (1947) from the University of Chicago, and a Ph.D. (1950) from Indiana University, both in Zoology. Following a National Research Fellowship in Copenhagen and a National Foundation of Infantile Paralysis Fellowship at the University of Cambridge, England, he spent two years at the California Institute of Technology. He joined the Harvard faculty in 1955 and became professor in 1961, resigning in 1976 to become full-time Director of Cold Spring Harbor Laboratory. In 1988, he was appointed Associate Director for Human Genome Research at the National Institutes of Health. In 1989, he became Director of the National Center for Human Genome Research, the newly established NIH component charged with administering its role in the Human Genome Project.

Dr. Watson was awarded the John Collins Warren Prize of Massachusetts General Hospital (1959), the Eli Lilly Award in Biochemistry (1960), the Albert Lasker Prize, awarded by the American Public Health Association (1960), the Research Corporation Prize (1962), the John J. Carty Gold Medal of the National Academy of Sciences (1971), and the Presidential Medal of Freedom (1977).

J.D. Watson  
Biographical Sketch  
Page 2

His memberships include the American Academy of Arts and Sciences (1958), the American Society of Biological Chemists (1958), the National Academy of Sciences (1962), the American Association for Cancer Research (1972), and the American Philosophical Society (1977). He holds honorary affiliations with the Danish Academy of Arts and Sciences (1963), Clare College, Cambridge University (1968), Athenaeum, London (1980), the Royal Society, London (1981), and the Academy of Sciences, USSR (1989).

Dr. Watson has received honorary degrees from 14 universities and has published five books: Molecular Biology of the Gene, The Double Helix, The DNA Story, Molecular Biology of the Cell, and Recombinant DNA: A Short Course.

He is married to the former Elizabeth Lewis, with whom he has two sons: Rufus and Duncan.

**The PCAST dinner will be hosted by Tom Lovejoy at his home in McLean, Virginia on Wednesday evening. Transportation will be provided from the Old Executive Office Building leaving at about 6:30 PM and returning at about 9:00 PM. Tom is recommending lightweight, casual attire.**

**Dinner guests should meet in Dr. Bromley's office, OEOB Room 358, at about 6:15 PM.**

## DINNER ATTENDEES

### PCAST

**D. ALLAN BROMLEY**, Assistant to the President for Science and Technology  
**NORMAN BORLAUG**, Distinguished Professor, Department of Soils and Crop Sciences, Texas A&M University.  
**SOLOMON BUCHSBAUM**, Senior Vice President, Technology Systems, AT&T Bell Laboratories.  
**CHARLES DRAKE**, Albert Bradley Professor of Earth Sciences and Professor of Geology, Dartmouth College.  
**THOMAS LOVEJOY**, Assistant Secretary for External Affairs, Smithsonian Institution.  
**PETER LIKINS**, President, Lehigh University.  
**JOHN McTAGUE**, Vice President, Technical Affairs, Ford Motor Company.  
**DANIEL NATHANS**, Professor of Molecular Biology and Genetics, Johns Hopkins University School of Medicine.

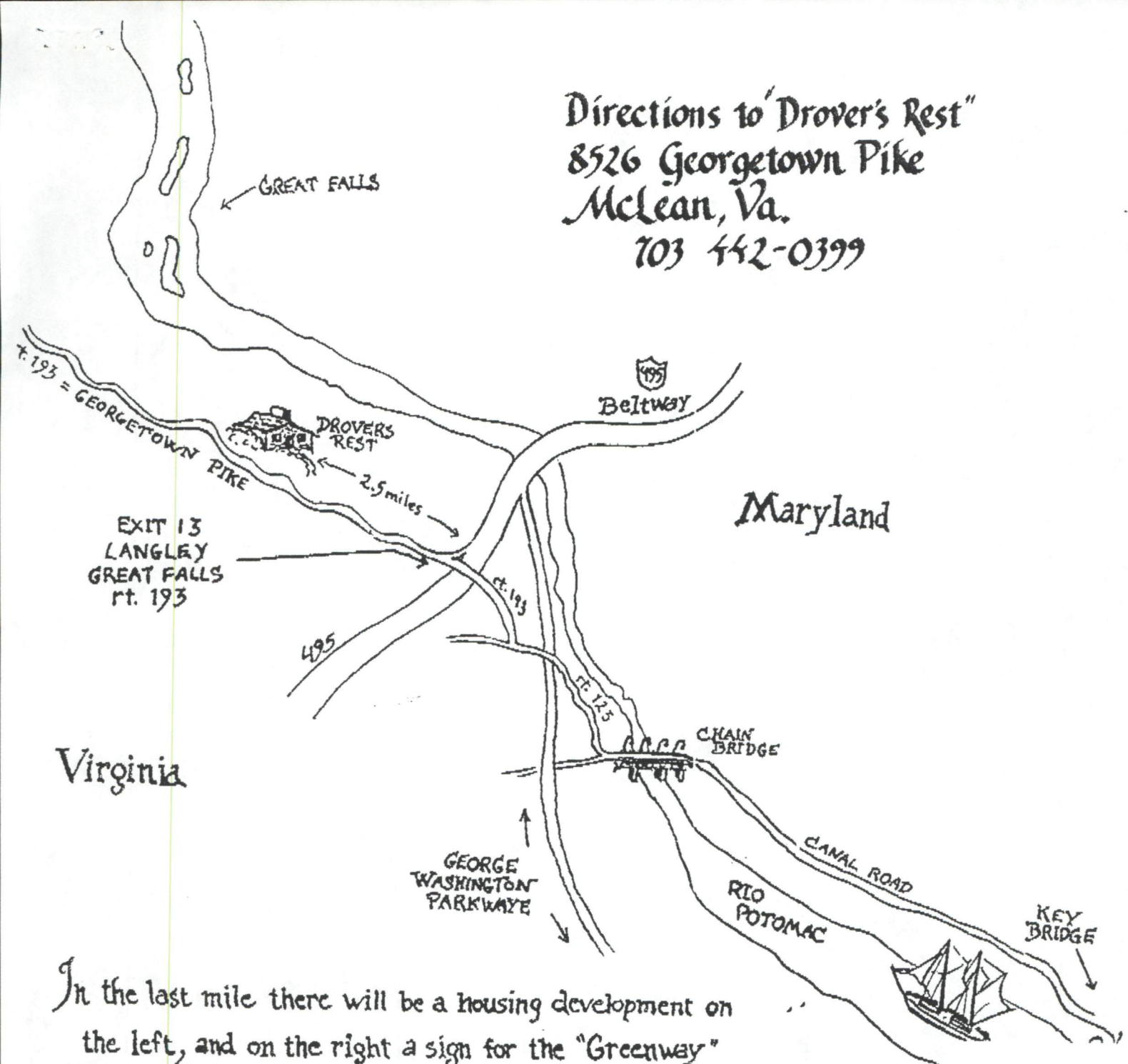
**WALTER MASSEY**, Director, National Science Foundation.  
**BERNADINE HEALY**, Director, National Institutes of Health.

### OSTP Staff

**D.A. HENDERSON**, Associate Director for Life Sciences.  
**J. THOMAS RATCHFORD**, Associated Director for Policy and International Affairs.  
**CHARLES HERZFELD**, Consultant to the Director  
**KEN YALE**, Chief of Staff  
**MARYANNE BACH**, Assistant Director Responsible for FCCSET  
**RACHEL LEVINSON**, Assistant Director for Life Sciences  
**NANCY MAYNARD**, Assistant Director for the Environment  
**KARL ERB**, Assistant Director for Physical Sciences and Engineering.  
**THOMAS WELCH**, Executive Director, PCAST

# Directions to 'Drover's Rest' 8526 Georgetown Pike McLean, Va.

703 442-0399



In the last mile there will be a housing development on the left, and on the right a sign for the "Greenway" (Madeira School) entrance in the middle of an extensive white fence. After the Greenway sign the road goes downhill, curving to the right.

The Madeira white fence ends and there will be a place to pull off the road on the right.

If you go too far you will come to a new bridge much wider than the road.

Traffic tends to tailgate vehicles moving slowly while seeking landmarks. Don't feel forced to go faster than you wish

PRESIDENT'S COUNCIL ON COMPETITIVENESS

FACT SHEET

**Achieving Competitiveness in National Critical Technologies  
Policies in Support of Technology Development in America**

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"If America is to maintain and strengthen our competitive position, we must continue not only to create new technologies but to learn to more effectively translate those technologies into commercial products.

President George Bush  
November 13, 1990

"For America to be number one in the development of critical technologies and commercialization of related products, we must have a healthy entrepreneurial climate for private sector development of these technologies."

Vice President Quayle  
April 24, 1991

INTRODUCTION

1. The release of the Report of the National Critical Technologies Panel provides an important opportunity to restate those steps necessary to improve the U.S. entrepreneurial climate and maintain our competitiveness. While the American private sector is asked to invest in our future, the government must continue to remove those unnecessary government restraints that chill the climate for investment in new technology. The benefits of technology will bring us closer to the national goals of improved quality of life for all Americans, continued economic growth, and national security.
2. This Fact Sheet incorporates points made in previous Administration initiatives such as the critical technologies reports of the Department of Defense and the Department of Commerce, U.S. Technology Policy prepared by the Office of Science and Technology Policy, and the National Energy Strategy. These policies encourage the development of technologies.
3. Critical technologies are fundamental "building blocks" for American industry and international competitiveness. Market

forces must be allowed to support their development, not selection and promotion by government.

### The Free Market

4. The free market has served to make the United States the world's largest economy. The United States has a \$5.5 trillion economy that achieves one-quarter of the world's production with 5% of the world's population. We are the world's leading exporter of goods and services, and the world's leading importer.

5. Creating and maintaining the proper entrepreneurial climate for national critical technologies depends on:

- o A quality workforce that is educated, trained, and flexible in adapting to technological and competitive change;
- o A financial environment that is conducive to longer-term investment in technology;
- o The translation of innovation into timely, cost competitive, high quality manufactured products;
- o An efficient technological infrastructure, especially in transfer of information;
- o A legal and regulatory environment that provides stability for innovation and does not contain unnecessary barriers to private investments in R&D and domestic production

### The Private Sector Role

6. In the free market system it is the role of the private sector to identify and utilize technologies for commercial products and processes. Responsibilities of the private sector include:

- o Conduct R&D to advance industry-related knowledge and technology;
- o Identify and aggressively pursue potential commercial applications for technologies developed by private laboratories as well as by universities, Federal laboratories and foreign sources;
- o Increase quality, output, and productivity by undertaking necessary investments in physical capital;

- o Improve the skills and abilities of the private sector workforce to meet its own needs;

In addition, the private sector can participate cooperatively in improving the quality of U.S. education.

#### The Government Role

7. The government role is to foster a stable economic environment that is conducive to investment. Steady non-inflationary growth and adequate national savings are critical requirements for investment because investors need confidence in the future. Investment decisions should not be dominated by fears of erratic government policy, uncertainty in tax laws, or excessive or uncertain regulation.

8. The government role regarding critical technologies should be limited to (1) providing needed support to activities that are clearly undersupported by the market because they generate economic benefits that greatly exceed their profitability, and (2) removing unnecessary and artificial barriers to proper market functioning, including legal and regulatory barriers.

9. In order to assure that economic considerations determine allocations of resources in the market, the government should forego policies, tax laws, and practices that benefit specific industries, products or sectors in relation to others except where market externalities exist which prevent private sector investment from realizing full economic benefit of the investment. Actions that yield encouraging results for a particular industry create a larger cost to the economy in terms of reduced efficiency, productivity and standards of living.

#### ADVANCEMENT AND TRANSFER OF SCIENTIFIC KNOWLEDGE

10. Education, enhancement of technical knowledge in science, and the conduct of research and development in science and technology are responsibilities shared by government at all levels and a broad range of private organizations. Scientific literacy benefits all Americans.

11. The government helps to support research especially in situations where the private sector cannot reasonably be expected to recover sufficient benefits. Generic enabling technologies that cut across industries and at the precompetitive stage, often cannot be developed by individual firms acting solely on their own. Support also may be needed for areas where the private sector could not be expected to earn an adequate rate of return on its R&D investments because it would be unable to assert property rights if the research results were commercialized. This precompetitive research is often crucial to maintaining public health, safety, and national security.

## Federal Funding

12. President Bush's budget proposal to Congress for FY '92 allocates \$76 billion to R&D, an increase of 13 percent over FY' 91 enacted levels. Activities targeted for increases are examples of the types of areas where Federal support is appropriate:

- o Basic research at the National Institutes of Health
- o Basic research at the National Science Foundation
- o Defense R&D
- o Space activities
- o Mathematics and science education
- o Global change research
- o Biomedical (including AIDS) research
- o National Agricultural Research Initiative
- o Superconducting Super Collider
- o High-performance computing and communications
- o Energy R&D
- o Advanced manufacturing and materials R&D
- o Aeronautics R&D
- o R&D at the National Institute of Standards and Technology

## Federal Technology Transfer

13. Technology transfer between Federally-supported researchers and the commercial market place is an important government function that offers fruitful opportunities for development of national critical technologies. Technology transfer conducted under cost sharing arrangements increases the benefits from Federal R&D expenditures and boosts government-private sector partnerships. The climate for technology transfer is enhanced by laws and arrangements that protect intellectual property rights and avoid conflicts of interest. Defense-related research can make major contributions when adequate safeguards for protecting information important to national security are available.

14. The 1980 Bayh-Dole Patent and Trademark Amendments Act permitted universities, nonprofit corporations and small businesses to retain patent rights resulting from Federally supported R&D. The Federal Technology Transfer Act of 1986 allowed Federally owned and operated laboratories to manage patentable rights. The 1986 Act also encourages directors of Federal laboratories to form joint R&D projects with businesses, universities and the states, and allowed Federal inventors to receive a portion of royalties resulting from commercialization of patents obtained from the research developed. Executive Order No. 12591 further mandated implementation of technology transfer by Federal agencies. In 1989 the provisions of the 1986 Act were

extended to the National Laboratories operated for the Department of Energy.

### Federal Procurement

15. Because the U.S. government is the country's largest purchaser, spending nearly \$200 billion for products and services annually, it can influence the development of commercial technologies. Government procurement practices generally should not dictate which technologies to use, rather firms should be able to compete to find the best way of meeting government's needs. In this way, government procurement practices should emulate the best commercial practices, allow government to participate to the greatest possible extent in the commercial marketplace, and take full advantage of the free market's ability to generate innovation.

16. Two special issues in Federal procurement are technical data rights and recoupment. Firms producing for the Federal government should be able to provide their best technical expertise without fear of its free release to their competitors. And firms should have the right to appropriately profit from the investment they make in commercial applications of technologies developed under Federal contracts. The government benefits from these practices through ready access to innovations occurring in the commercial market place, expansion of the industrial base supporting government activities, and price discounts recognizing the value of commercialization rights. The Administration will soon issue proposed regulations to ensure that government purchases only those rights and data required to meet the government's needs and to protect those it does not buy. The Administration is now reviewing the requirements to recoup R&D costs from contractors that develop commercial derivatives of products.

17. The Administration is pursuing a number of other changes in the Federal government's procurement practices that would contribute to technological innovation and development. Federal procurement statutes and regulations need to permit greater integration of government and commercial production at the factory level, as well as encourage greater innovation and efficiency in development and production. Also, the government should use commercial products, to the extent feasible, for defense, space, and other government applications. For those products and processes for which it is the sole or major consumer and no commercially available products can be substituted, the Federal government should (1) rely principally on the private sector to undertake the development process; and (2) strengthen the abilities of companies involved in developing and demonstrating these products to use the same research and technologies for commercial purposes.

## THE LEGAL AND REGULATORY CLIMATE

### Antitrust Concerns

18. Effective antitrust laws and their enforcement are crucial to the maintenance of a competitive economy, and thus to international competitiveness. Undue concern with antitrust enforcement should not, however, provide an unwarranted deterrent to activities that may in many circumstances enhance efficiency and competition. In particular, American firms should be assured that antitrust laws will not be applied in an overly restrictive way to joint ventures, including joint ventures among competitors, to engage in research and development of new technology, and to commercialize that technology. Reducing unwarranted antitrust uncertainties related to such interfirm cooperation would facilitate, where parties so desire, the pooling of limited resource and a rapid diffusion of results while still protecting against anticompetitive practices.

19. The National Cooperative Research Act of 1984 took an important step to mitigate antitrust uncertainty with respect to joint R&D. The Act clarified that R&D joint ventures should be analyzed under the antitrust "rule of reason," which takes full account not only of domestic and international competition to such ventures, but also of their potential procompetitive efficiencies. The Administration has proposed expansion of the NCRA to cover joint production ventures as well. Such ventures could promote the commercialization of new technology and help assure that United States leadership in basic scientific research is translated into leadership in commerce as well. At the same time, NCRA coverage of joint production ventures will permit the antitrust laws to play their proper role in preserving competition and thus the competitiveness of the American economy.

### Intellectual Property Rights

20. Essential to the free market development of technology is the right of the private sector to maintain ownership of intellectual property rights of inventions at home and overseas. The Administration is aggressively pursuing improved international protection of intellectual property through the achievement of international agreements that would increase protections abroad in the Uruguay Round of the GATT, at the World Intellectual Property Organization and in trilateral talks with the European Community and Japan. Bilateral negotiations are also conducted under the provision of the 1988 Omnibus Trade and Competitiveness Act. The Administration also supports strengthened domestic patent protection.

### Product liability

21. The current product liability system generates excessive litigation and concomitant transactional costs, thereby increasing the cost of doing business in the United States and discouraging innovation for products and related services such as health care. The Administration supports the adoption of a single, Federal, uniform product liability law based on three principles of fairness: the right to fair compensation for actual damages where there is liability, the remedy of liability based on responsibility for harm and not ability to pay, and the encouragement of alternatives to costly litigation. These proposals would maintain the appropriate incentives to produce safe products while restoring balance to the tort system and reducing uncertainty surrounding the introduction of new products.

#### Prohibitions on Competition

22. Clearly among the potentially most damaging aspects of government laws are prohibitions or restrictions on competition in particular markets. Competition drives the free market to optimal price and output for the benefit of consumers and society generally, and creates incentives for innovations and the means for new product introductions. When government erects barriers to market competition, it reduces the economy's flexibility, competitiveness and innovative capacity. In the energy area, for example, the Administration's National Energy Strategy calls for an end to unnecessary regulatory impediments to the expanded utilization of natural gas and innovative technologies for electricity generation. In telecommunications the Administration is seeking to change the antitrust consent decree that prohibits telephone companies from conducting R&D and manufacturing telecommunications equipment.

#### Export Controls

23. Export controls restrict the export of specific "dual use" products to certain destinations, for national security and foreign policy reasons. In an increasingly international economy, with rapid technological innovation in other countries, these controls require continuing revisions to ensure that the burden and delays associated with licensing do not adversely affect American firms relative to foreign firms in their ability to compete in international markets, and thereby, discourage R&D investments in the United States.

#### Non-Tariff Trade Barriers

24. Non-tariff trade barriers prevent open markets for international commerce and thus, injure competition by reducing opportunities for new products, particularly high volume products such as certain electronic components. The U.S. is working through GATT, other multi-national and bilateral negotiations to

ensure that U.S. firms will be allowed to compete fairly in foreign markets. Private restraints on imports also can constitute significant non-tariff barriers to trade by American firms. Among the Administration's goals in the Structural Impediment Initiative talks with Japan is more effective enforcement of that nation's competition laws against private restraints on imports in Japan, such as group boycotts.

### Regulatory Concerns

25. In high technology industries, Federal regulation is a critical determinant of the time and the cost required to bring a product to market. Regulation is also a major factor influencing investment decisions for new technologies. Regulatory uncertainty or the expectation of burdensome regulation increases risk for potential investors, and reduces incentives for investment. Because technological innovation holds the promise of providing new and better ways to meet the very objectives of particular health, safety, or environmental regulations, those regulations that discourage or penalize innovation are self-perpetuating burdens on American industry.

26. In general terms, Federal regulations impose direct costs on the economy of estimated to be \$185 billion annually. While appropriate regulation in response to market failures can serve valuable social and economic functions, it may also impose significant costs that particularly affect the ability and incentive of firms to develop new high technology products. Some regulatory regimes are no longer appropriate to new technologies, others were developed without adequate consideration of the burdens placed on international competition, and many regulations explicitly impose greater burdens on new facilities and products, such as the New Source Review provisions of the old Clean Air Act and the rules for "new chemicals" under the Toxic Substances Control Act.

27. Regulation most inhibits innovation when the regulatory agency takes on the task of specifying which technologies or designs industry must employ. Further, once a technology is enshrined in regulation, firms have little incentive to invest in better techniques. This has been the experience with numerous environmental regulations in which the Federal government selects control technologies. An excellent example is the old Clean Air Act's mandate that firms employ "best available control technology" (BACT) to reduce SO<sub>2</sub> emissions. BACT was translated into smokestack scrubber technology. Mandating scrubbers, however, discouraged innovation of other means to remove sulfur, such as removal from the fuel before combustion; and it discouraged use of low-sulfur coal to begin with. The Administration's new Clean Air Act cuts SO<sub>2</sub> by 50% -- but lets industry choose how best to do so.

28. In general, regulatory reform can substantially improve the incentives for innovation by using market-based incentive approaches that set performance goals but let industry devise the best means to attain those goals. An example is the Administration's emissions trading program to reduce acid rain in the 1990 Clean Air Act.

29. The Administration has developed principles that Executive Branch agencies are to use when developing regulations or reviewing current standards. These principles offer a useful set of guidance for minimizing the burden of regulation on innovation.

- o Regulations should be issued only on evidence that their potential benefits exceed their potential costs. Regulatory objectives, and the methods for achieving these objectives, should be chosen to maximize the net benefits to society.
- o Regulations that seek to reduce health or safety risks should be based upon scientific risk-assessment procedures, and should address risks that are real and significant rather than hypothetical or remote.
- o Regulation of prices and products in competitive markets should be avoided. Entry into competitive or potentially competitive markets should be regulated only where it is clearly necessary to protect health or safety.
- o Voluntary private standards and disclosure should be relied on where possible instead of inflexible regulation.
- o Health, safety and environmental regulations should address ends rather than means. They should employ performance-based incentives that harness the creativity of market actors to design and continually innovate better ways of reducing excess risks. They should not specify technologies or designs that firms must employ.
- o Where regulations create private rights or obligations, unrestricted exchange of these rights or obligations should be encouraged.
- o Federal regulations should not preempt state laws or regulations, except to guarantee rights of national citizenship or to avoid significant burdens on interstate commerce.

- o Regulations establishing terms or conditions of Federal grants, contracts, or financial assistance should be limited to the minimum necessary to achieving the purposes for which the funds were authorized and appropriated.
- o Licensing and permitting decisions and review of new products should be made swiftly and should be based on standards that are clearly defined in advance.
- o Standards for receiving government licenses and permits should not exceed the necessary minimum. If the number of comparably qualified applicants exceeds the number of available licenses, the licenses should be allocated by auction or other market-based means rather than by administrative procedure.

**THE FINANCIAL CLIMATE: INCREASING THE POOL OF CAPITAL FOR INVESTMENT**

30. Recent Federal policy has been successful in improving the environment for private investment in R&D. Important actions have been taken to increase incentives to invest, including investment in R&D. The Tax Reform Act of 1986 substantially reduced marginal income tax rates for businesses and individuals. The maximum tax rate on corporate income dropped from 46% to 34%. The top personal income tax rate that had been 70% as recently as 1981 was dropped to 28% in 1986 and increased to 31% in 1990. "Subchapter S" corporations generally can pass through their income to shareholders and have it taxed at lower individual tax rates and avoid the double taxation of corporate income.

31. Discipline must be maintained to curb the Federal budget deficit. The single greatest contribution that the Federal government can make to increase the pool of capital available for investment is to reduce the Federal budget deficit. The budget deficit has a major impact on the level of gross domestic savings available for investment. Efforts to reduce the Federal budget deficit (the Omnibus Budget Reconciliation Act of 1990) and to impose Federal credit programs (Federal Credit Reform Act of 1990) will increase the availability of national savings for private sector uses, including investment in new technology. The Omnibus Budget Reconciliation Act of 1990 will reduce Federal budget deficits, and therefore national dissaving, by almost \$500 billion over the next five years, and will virtually eliminate the Federal budget deficit by fiscal year 1995. In addition, better control of the deficit enhances the opportunity for the Federal Reserve to pursue a noninflationary growth monetary policy.

32. Through the use of guarantees and interest rate subsidies, the Federal Government redirects credit in the economy to certain favored activities. In doing so, non-favored activities in the economy are penalized and the efficiency of the resources available to the economy is reduced. The Federal Credit Reform Act of 1990 places the cost of credit programs on the same budgetary basis as direct Federal spending. For 1991 it is estimated that direct Federal loan guarantees will total \$119 billion and direct Federal loans will total \$16.8 billion; these exclude secondary loan guarantees. Discipline will be needed to constrain the growth of Federal credit programs.

#### Increased Savings

33. A larger pool of capital also would be assured if proposals advanced by the Administration are enacted. These include the capital gains tax cut, family savings accounts and enhanced IRAs. Failure to act on these proposals will have a negative effect on national savings and the availability of capital for investment.

34. Pressures to increase Federal expenditures continue for a wide variety of purposes and programs. This has led to proposals to raise marginal tax rates for upper income individuals and corporations. Higher marginal tax rates reduce the return from investment. If Federal actions discourage investment, inevitably economic growth will suffer. The Administration will continue to resist pressures to raise marginal income tax rates.

#### Research and Experimentation Tax Credit

35. The Administration has proposed to make permanent the Research and Experimentation (R&E) tax credit. Current law allows a 20% tax credit for a certain portion of a taxpayer's qualified research expenses. The credit is computed on the increase in qualified expenses compared to a base period. The credit will expire at the end of 1991 unless it is extended or made permanent. A permanent credit would provide more certainty for firms regarding the availability of the credit as they make investment plans for future years. The credit cannot induce additional R&E expenditures unless its future availability is known at the time firms are planning future outlays. Thus, to have its intended incentive effect, the credit should be permanent.

#### R&E Expense Allocation

36. The Administration has proposed a change in the rules for allocating R&E expenses on foreign source income for the purpose of computing net income from foreign sources. Under the proposal, there would be a lower allocation of U.S. R&D against foreign source income than required by the original 1977 regulations. For companies with unused foreign tax credits, the

lower allocation would permit them to take a larger foreign tax credit, and thus, lower their U.S. tax liability. The provisions will expire at the end of this year unless extended by law.

### Banking Reforms

37. The financial system has been undergoing change in recent years as a result of deregulation, increased competition from non-traditional sources and international competition. Yet, America's depression era banking laws inhibit the ability of financial institutions to respond to this changing environment and they encourage excessive risk taking by banks. This has led to unhealthy lending practices in some instances and, in general, the banking system is now restricting loans to many borrowers. While tight lending practices of the banks affect all potential borrowers, we should not overlook the fact that start-up companies and firms that are developing new products or attempting to bring them to market may be particularly hard hit in a tight credit environment. The Administration's proposals would improve the health and flexibility of the banking system. Of course, banking system reform should not hinge on improving credit availability just for R&D; still those who are concerned about the availability of capital for R&D should recognize that there is a connection between restoring the health of the banking system and the availability of capital for research, development and competition.

**Thursday evening dinner will be at the West Wing of the White House in the Executive Room of the White House Mess. We ask that you place a check (or cash) for \$65 in the basket during lunch to cover the cost of coffee for today and tomorrow, and today's lunch, cocktails and dinner. Please make checks payable to D. Allan Bromley.**

**Cocktails will begin this evening at 6:30 PM and dinner will be served at 7:00 PM. You may enter the West Wing unescorted through the Southwest gate of the White House.**

DINNER MENU FOR DR BROMLEYS OSTP DINNER  
MAY 2, 1991 7:00pm  
STAFF DINING ROOM AT THE WHITE HOUSE MESS

MENU III

**MUSHROOM MEDLEY SOUP**

Seasoned beef broth reduced with wine and simmered with three types of mushrooms.

**MEDALLIONS OF VEAL CHAMPIGNON**

Slices of select baby veal braised in a champagne and mushroom sauce, served with a timple of wild rice and fanned pencil asparagus and baby carrots.

**BIBB AND BELGIUM ENDIVE SALAD**

Fresh bibb lettuce and on a bed of crisp Belgium endive tossed in a tarragon vinegarette and garnished with fresh herbs.

**STRAWBERRY CHEESECAKE**

Rich cheesecake served with a strawberry puree and topped with fresh whipped cream.

WINE SELECTION:

I. Monterey Classic White Wine

PRESIDENT'S COUNCIL OF ADVISORS  
ON  
SCIENCE AND TECHNOLOGY

JULY 11, 1991  
AGENDA

THURSDAY, JULY 11, 1991

OPEN SESSION 9:00 AM - 11:15 AM  
CONFERENCE ROOM  
COUNCIL ON ENVIRONMENTAL QUALITY  
722 JACKSON PLACE, NW

8:30 - 9:00	ARRIVAL AND COFFEE	
9:00 - 9:15	OPENING REMARKS	DR. BROMLEY
9:15 - 10:00	THE HUMAN GENOME PROJECT	DR. WATSON
10:00 - 10:15	DISCUSSION	
10:15 - 10:45	CRADAs - COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS - An Overview	MR. ALLEN
10:45 - 11:00	DISCUSSION	
11:00 -	CLOSING REMARKS AND MOVE TO INDIAN TREATY ROOM, ROOM 474, OLD EXECUTIVE OFFICE BUILDING	DR. BROMLEY

Note: Please use the Pennsylvania Avenue Entrance  
to the OEOB.

## Biographical Sketch of James Dewey Watson

James D. Watson is best known for his discovery of the structure of DNA (deoxyribonucleic acid) for which he shared with Francis Crick and Maurice Wilkins the 1962 Nobel Prize in Physiology and Medicine. They proposed that the DNA molecule takes the shape of a double helix, an elegantly simple structure that resembles a gently-twisted ladder. The rails of the ladder are made of alternating units of phosphate and the sugar deoxyribose; the rungs are each composed of a pair of nitrogen-containing nucleotides.

This research emphasized a concept central to the emerging field of molecular biology: understanding the structure of a molecule can give clues about how it functions. Because each nucleotide within a rung of the DNA ladder is always paired with the same complementary nucleotide, one half of the molecule can serve as a template for the construction of the other half. This complementary pairing explains how identical copies of parental DNA can be passed on to two daughter cells. During cell division, the DNA helix "unzips," and two new molecules are formed from the half-ladder templates. Later research showed that the "genetic code," which determines the identity of a living organism and directs the manufacture of proteins, is contained in the precise sequence of nucleotide rungs of the DNA ladder. Research on DNA-protein interactions launched a revolution in biology which culminated in the development of modern recombinant-DNA techniques.

In 1968, Dr. Watson became Director of Cold Spring Harbor Laboratory on Long Island, New York. Under his direction, this renowned but financially-endangered institution was revitalized. Dr. Watson steered the Laboratory into the field of tumor virology, from which emerged our present understanding of oncogenes (cancer genes) and the molecular basis of cancer. In addition to the high-level research on cancer, plant molecular biology, and cell biochemistry, the Laboratory functions as a postgraduate university on DNA science. Each year some 4,000 visiting scientists from around the world are drawn to more than 52 professional meetings and advanced courses held at Cold Spring Harbor. Thus, the Laboratory exerts an influence on biological research that is far out of proportion to its relatively small size (375 employees).

Born in Chicago, Illinois, in 1928, Dr. Watson received a B.S. degree (1947) from the University of Chicago, and a Ph.D. (1950) from Indiana University, both in Zoology. Following a National Research Fellowship in Copenhagen and a National Foundation of Infantile Paralysis Fellowship at the University of Cambridge, England, he spent two years at the California Institute of Technology. He joined the Harvard faculty in 1955 and became professor in 1961, resigning in 1976 to become full-time Director of Cold Spring Harbor Laboratory. In 1988, he was appointed Associate Director for Human Genome Research at the National Institutes of Health. In 1989, he became Director of the National Center for Human Genome Research, the newly established NIH component charged with administering its role in the Human Genome Project.

Dr. Watson was awarded the John Collins Warren Prize of Massachusetts General Hospital (1959), the Eli Lilly Award in Biochemistry (1960), the Albert Lasker Prize, awarded by the American Public Health Association (1960), the Research Corporation Prize (1962), the John J. Carty Gold Medal of the National Academy of Sciences (1971), and the Presidential Medal of Freedom (1977).

J.D. Watson  
Biographical Sketch  
Page 2

His memberships include the American Academy of Arts and Sciences (1958), the American Society of Biological Chemists (1958), the National Academy of Sciences (1962), the American Association for Cancer Research (1972), and the American Philosophical Society (1977). He holds honorary affiliations with the Danish Academy of Arts and Sciences (1963), Clare College, Cambridge University (1968), Athenaeum, London (1980), the Royal Society, London (1981), and the Academy of Sciences, USSR (1989).

Dr. Watson has received honorary degrees from 14 universities and has published five books: Molecular Biology of the Gene, The Double Helix, The DNA Story, Molecular Biology of the Cell, and Recombinant DNA: A Short Course.

He is married to the former Elizabeth Lewis, with whom he has two sons: Rufus and Duncan.



UNITED STATES DEPARTMENT OF COMMERCE  
The Assistant Secretary for Technology Policy  
Washington, D.C. 20230

## Biographical Data

Joseph P. Allen

### Director, Office of Technology Commercialization U.S. Department of Commerce

The Office of Technology Commercialization is the principal industrial liaison for the Department's Technology Administration created to spur Government-industry cooperation. The mission of the Office of Technology Commercialization is to improve the process of commercialization of new technology in the U.S. The Office oversees four separate programs: Advanced Manufacturing, Federal Technology Management, the Clearinghouse on State and Local Initiatives and the National Medal of Technology.

Joe Allen has been involved in the passage of major laws making possible joint R&D projects between Federal laboratories, universities and the private sector -- the 1980 Bayh-Dole Act, its amendment in 1984, and the Federal Technology Transfer Act. He is now responsible for oversight of these laws for the Department. Joe was very involved in the passage of a bill signed into law by the President giving significant authorities to the Department of Energy's laboratories to work with industry.

Before coming to the Department of Commerce he was Executive Director of Intellectual Property Owners, Inc., a trade association representing many research intensive companies. There he helped coordinate the successful legislative campaign establishing the new Court of Appeals for the Federal Circuit -- a major court reform re-establishing uniform patent standards throughout the U.S. after years of confusion.

From 1974-1981 he served as a Professional Staff Member on the Senate Judiciary Committee. On the Committee he was directly involved in passing the Bayh-Dole University and Small Business Patent Policy Act. This law is the basis for the present high degree of U.S. university-industry cooperative R&D.

commercial influences.

Let AT&T's Ross sum things up: "I think that having a basic research activity within your company to work on your own special missions, in addition to knowing what is going on in the universities, is absolutely essential. Then you match your research capability with whatever insights you can get into human needs, and select the technologies to back." He continued, "You look at your needs, at your competitors, at what you can afford, and you cut your cloth accordingly." ♦

*This article is also based on interviews by Alfred Rosenblatt, Tekla S. Perry, Katherine T. Chen, Fred Guterl, and Peggy Trautman.*

## Federal laboratories meet the marketplace

By D. Allan Bromley's estimation, "a significant number" of the 726 U.S. Federal laboratories—many in the Department of Defense—may disappear within the next few years, having outlived their missions. President Bush's science advisor and a Yale University physicist, Bromley told *IEEE Spectrum* that "we'll see a major change in the next few years" so that industry and university can make better use of the remaining laboratories, some of which he calls "national treasures."

Bromley faces a tough challenge, but the rewards would be great. More so than in Japan and Germany, Government-funded laboratories in the United States are a large part of the scientific and technologic enterprise. So-called Federal laboratories conduct more R&D than the nation's universities and employ one-sixth of U.S. engineers and scientists.

Indeed, in some hot areas like superconductivity, the Federal labs are the main recipients of U.S. government funds. A single big laboratory like Sandia National Laboratories, Albuquerque, N.M., or a NASA field center like the Marshall Space Flight Center, Huntsville, Ala., spends about as much on R&D—more than US \$1 billion a year—as a big research-oriented company like General Electric Co. [see table, p. 41].

Past efforts, begun in the 1980s, to revamp the laboratories have moved slowly or mired completely. In addition, "the Federal labs still have a long way to go before realizing their potential as a source of new ideas for industry," concluded a February 1990 report, "Making Things Better," by the U.S. Congressional Office of Technology Assessment (OTA).

But a dwindling budget and a looming trade deficit are forcing more dramatic changes. New bills passed by the U.S. Congress since 1986 (extending to a proprietary software bill to be acted on next year) mean that most constraints on ventures between labs and industry are finally lifted, said Joseph P. Allen, the Commerce Department director of Federal technology commercialization.

Various indicators show that Federal-lab cooperation with industry is happening faster than that of universities and industry in the early 1980s. Allen told *Spectrum*. "It's not widely known yet—the scale of what's happening—but it's really going up exponentially," he said.

To better use each Federal R&D dollar, both the Pentagon and the Department of Energy (DOE) are evaluating their extensive laboratory networks, which, according to the OTA, account for the lion's share of Federal lab funding of some US \$15 billion to \$21 billion a year. (Estimates vary with whether such facilities as engineering test centers, regional extension facilities, or hospital laboratories are included.)

No one argues that the Federal labs should compete in the market. The task is to shed inefficient or redundant labs and encourage industry, now that the laws are changed, to make use of their world-class research.

*John A. Adam* Senior Associate Editor



*One of the more successful examples of technology transferred from the Federal laboratories is DYNA3D, a code originally developed at Lawrence Livermore National Laboratory for three-dimensional structural analysis of weapon systems. Now, more than 300 organizations use it, including automotive and computer manufacturers, aerospace companies, research laboratories, and universities. Shown here in a series of computer-generated images is the effect of a steel ball breaking a steel plate.*

"There's a mind-set that's changing gradually" in the Department of Defense (DOD) laboratories that economic security is critical to national security and that the labs should aid U.S. competitiveness by sharing technology, said David Applier, the domestic technology transfer specialist in the Pentagon.

Gerold Yonas, director of laboratory development at Sandia National Laboratories told *Spectrum* that lab researchers "generally have an ethic of service to the nation" and now realize the imperative to bolster U.S.-based business.

But he added, "The world doesn't owe us a living. We're going to have to provide a good return on the taxpayer's investment."

### 'Inadequate scrutiny'

Each Government laboratory was created in support of a specific mission. The history of laboratory innovation includes radar, graphite-epoxy composites, malaria vaccines, the clean room, and contributions to magnetic resonance imaging.

But David Packard, co-founder of Hewlett-Packard Co., and other White House Science Council members complained in 1983 that the laboratory apparatus had grown to such proportions that many laboratories had only ill-defined or obsolete missions and that "in most cases, the agencies' oversight means an excessive amount of reporting and paperwork, but inadequate scrutiny of the quality and relevance of the laboratories' activities." The members were concerned that laboratories would confuse their missions with activities guaranteeing their self-preservation.

In the last decade, the Government has relinquished only a few of its labs, according to a House Science and Technology Committee staffer. Cuts in fossil energy research funds forced the DOE to divest some small facilities in Grand Forks, N.D., and Laramie, Wyo. Packard's recommendation was all but ignored. A Government official, who is urging a private sector review of laboratory missions, noted that "if you're doing the wrong research and have the wrong mission, tech transfer is a Band-Aid."

The U.S. Army, Navy, and Air Force each run their own laboratories with budgetary oversight by the Pentagon. A Pentagon official familiar with the labs told *Spectrum* that the current review being done by the Defense Management Office aims to avoid duplication among the labs of the three services.

The most recent figures from the Pentagon on its laboratories date from fiscal 1986. They show that 41 243 researchers, mostly civilians, worked with equipment valued at more than US \$6 billion and property worth that much again. The laboratory management office of the Pentagon said it monitors about 65 DOD labs.

Some duplication (among the three services, not to mention the private sector) may be apparent from the services' medical research. According to the 1986 documents, the Army maintains an aeromedical research laboratory staffed by 136 professionals, an institute of dental research and another of surgical research; two medical research institutes, one each for chemical defense and infectious disease; a research institute of environmental medicine; and the Walter Reed Army Institute of Research.

The Navy has its unique submarine medical research laboratory but also a 95-person aerospace medical research lab, its own dental institute, a health research center, and three other medical research institutes.

The Air Force, like the Army and Navy, maintains its own aerospace medical research lab, with a 384-person staff and a school of aerospace medicine.

Total medical staffing and in-house funding for fiscal 1986 at these research labs was 2600 professionals and US \$164 million for the Army; 1054 professionals and US \$57.3 million for the Navy; and 893 professionals and US \$61.5 million for the Air Force. The combined equipment and real estate value was estimated to exceed US \$350 million.

Granted, some military medical labs have made important discoveries, but how can their relevance be judged today? A July 1989 report on Federal technology transfer by the Department of Commerce suggests that, regarding Federal labs in general,

for "those whose missions are less clear, the degree or absence of private sector interest may be a useful indicator as to whether that facility's charter warrants reexamination."

If there are no private sector buyers of obsolete labs, then closing them presents an even stickier issue than shutting down military bases, observed James Gover, a Sandia researcher who spent a year as an IEEE Congressional Fellow. Because local economies are boosted in communities with labs, the communities wish to retain highly paid lab professionals. A staff member of the House Space, Science, and Technology Committee noted that the initiative to close any labs will have to come from the Administration because "Congress is a reactive body when it comes to consolidating anything" because of constituencies.

### Those big DOE labs

Special attention is also focusing on the nine big, multiprogram DOE labs, which account for about one-sixth of total Government spending on Federal labs. Besides Sandia, the Lawrence Livermore and Los Alamos national labs, in Livermore, Calif., and Los Alamos, N.M., have billion-dollar budgets and concentrate on military work. Idaho National Engineering, Idaho Falls, Idaho, handling primarily defense research, and Oak Ridge National Laboratory, Oak Ridge, Tenn., involved primarily in energy work, received US \$503 million and US \$425 million respectively in 1989. Argonne, Brookhaven, Lawrence Berkeley, and Pacific Northwest national labs have annual budgets for primarily energy research that ranges from US \$200 million to US \$300 million.

As reported in a 213-page, 1990 DOE review of its technology transfer program, each big lab has at least one and often many "designated user facilities" to be shared with the private sector. Facilities extend from Brookhaven's National Synchrotron Light Source, Upton, N.Y., and Oak Ridge's Shared Research Equipment Microanalysis Facility to Los Alamos' National Genetic Sequence Data Bank and Idaho National Engineering's Environmental Research Park.

What distinguishes many DOE laboratories from most of those of the DOD, the National Aeronautics and Space Administration (NASA), the Commerce Department, and most other agencies is their operation by university or industrial contractors, a practice that the DOE says helps tap talent. Sandia, for instance, is operated by and modeled after AT&T Bell Laboratories and often uses Bell Labs managers.

Now that some intellectual property is protected by exclusions from the Freedom of Information Act and Sandia's mission was changed to include competitiveness, the lab is actively seeking industry partners. Sandia's Yonas notes that "more than two dozen cooperative agreements are in the works" from energy and health to the environment and manufacturing. Over 85 percent of Sandia's work has military ties, he told us. While he expects the lab to be "first and foremost" a national security facility, the proportion of military work will decrease.

The same could be said of the other big weapons labs at Livermore and Los Alamos. With arms control reducing arsenals, work with nuclear weapons will focus on reliability and safety as opposed to development of new warheads, according to DOE Secretary James D. Watkins. Among new or strengthened missions for the DOE labs are work in arms control, the human genome project, the environment, and education.

### Transferring technology

Despite abundant resources, no Silicon Valleys or Route 128s have sprung up around the national laboratories. (One possible exception is the biotechnology firms in the Washington, D.C., area around the National Institutes of Health.)

The 1990 OTA report points out the Massachusetts Institute of Technology in Cambridge, with a research budget of some US \$310 million and seven professional staff working on patents and licensing, produces about the same number of licensing agreements and new startups as do all of DOE's labs combined, with

their budget exceeding US \$5 billion.

Congress's OTA states that three-fifths of the US \$21 billion appropriated for the labs each year is for defense applications; much of the rest is for basic research. Yet Leo Young, the Pentagon's ex-director of research and laboratory management, estimates that most of the DOD laboratories' work has civilian applications. The private sector is already employing spread-spectrum communications, and magnetic resonance imaging and ocean tomography research by the Navy for submarine warfare has been useful for commercial medical diagnostics.

Although most of Sandia's work is for the military, Yonas told us almost everything the laboratory does is of dual use. Appler of the Pentagon seemed to agree: "We do research in just about every scientific discipline that you can imagine. And it's all transferrable, in varying degrees."

For instance, nuclear weapons—not traditionally associated with much technology transfer potential—encouraged the development and improvement of supercomputers at Los Alamos. At Livermore, the DYNA3D computer code to model the structural response of weapons systems has found applications in scores of automotive, aerospace, and computer companies. Sandia's expertise in process engineering—the lab is responsible for more than 4500 parts of the 5000-odd components of a nuclear weapon—spawned the "clean room," and made the lab a partner of Sematech Inc., Austin, Texas, and the cornerstone of a new manufacturing consortium. Another of Sandia's nuclear weapon devices is finding use as a trigger for air bags in passenger cars.

On the whole, the OTA states, technology transfer at the DOE

and the DOD has been underfunded. A report by the DOD Inspector General last October sharply criticized the military labs' failure to encourage technology transfer, decrying the lack of patent lawyers and policy guidance at low enough levels in the DOD hierarchy. Within individual labs, however, such as Marshall Space Flight Center, Sandia, and the Naval Research Lab, technology transfer is receiving more attention, often at the director's level.

NASA's Lewis Research Center in Cleveland, Ohio, hoped to smooth the path of technology transfer by sponsoring a conference where the innovators of some 50-plus "technologies with commercial potential" go one-on-one with industrial executives looking for commercial products. But, the Great Lakes Federal Technology Congress, to have been held October 16-17 in Cleveland, Ohio, was cancelled because of NASA's budget uncertainties.

Security concerns, too, may dampen defense program technology transfer. The Naval Research Laboratory, Washington, D.C., requires outside researchers to have at least a secret clearance to work within the lab; Sandia requires a DOE "Q" clearance, which takes about nine months to process, according to a 1988 GAO report. But the lab has recently built a major facility outside its secure area to facilitate technology transfer.

### Recent collaboration

The National Institutes of Health, which spends about US \$1 billion in Federal laboratories, and the National Institute of Standards and Technology, which spends about US \$180 million (the

**A view of some U.S. government-supported laboratories**

Laboratory (operator)	Budget, in U.S. dollar billions	Research staffers	Technology transfer indicators	Technology spinoffs
Sandia National Laboratories Albuquerque, N.M. (AT&T for Energy Dept.)	1.2	3601	28 licenses granted in 1990, 1 in 1989; recent pacts on manufacturing and specialty metals	Laminar-flow clean rooms; n-tuple pattern recognition; radiation-hardened microchips; various battery components; optical spark-plug probe; hot-air solder leveler for circuit boards
Lawrence Livermore National Laboratory Livermore, Calif. (Univ. of Calif. for Energy Dept.)	1.09	3304*	Some 50-100 spinoff companies; 25 licenses projected for 1990, up from 1 in 1986; 21 cooperative R&D agreements; money from industry and Government collaborative projects up from US \$0.4 million in 1986 to US \$8.6 million in 1990	Aerogels for insulation; DYNA3D computer simulation code; blood cell sorter instrument; supercomputer information storage system; laser-drive X-ray lithography
Oak Ridge National Laboratory Oak Ridge, Tenn. (Martin Marietta for Energy Dept.)	0.5	2073	45 licenses; 16 cooperative R&D agreements; US \$0.6 million royalties annually; 1500 visiting researchers	Parallel computing architecture; optical data storage; motor current signature analyzer; ultrasonic range and detector system
Lincoln Laboratory Lexington, Mass. (MIT for Defense Dept.)	0.426	1350	15 patents and 7 licenses granted in 1989; 61 spinoff companies; consortium with MIT, IBM, and AT&T on superconducting electronics	Magnetic-core memory, binary optics, diamond transistors, designs for neural networks, micro-acoustic waveguide
Naval Research Laboratory Washington, D.C. (U.S. Navy)	0.361	1588	11 licenses in 1990; 2 cooperative R&D agreements; 26 patents awarded in 1989	Pioneering radar work; erbium laser for surgery; many medical diagnostic instruments
Wright R&D Center Wright-Patterson Air Force Base, Ohio	0.983	2081	2 licenses; 2 cooperative R&D agreements; US \$63 000 royalties annually; working agreement with the Ohio technology transfer organization since 1984	Pioneering microelectronics work; efficient aircraft fueling; laser imaging
George C. Marshall Space Flight Center Huntsville, Ala. (NASA)	2.6	2386	22 patents in fiscal 1990; 8 patent licenses in last 12 months; 16 cooperative R&D projects in addition to 6 state agreements; 40 visiting researchers	Techniques for vacuum plasma spraying for coating and forming metals; welding; metal cleaning and manufacturing with environmental controls; albumin crystal growth; and collection of lightning data for weather forecasting
National Institute of Standards and Technology Gaithersburg, Md. (Commerce Dept.)	0.321	1591	12 licenses; 90 cooperative R&D agreements (95 in 1989); 1000 visiting researchers daily	Absolute voltage standard; real-time robotic controls; software error correction

Source: Laboratories listed.

\* Includes 98 postdoctoral fellows.

rest of its budget is from other sources), have done collaborative work with industry for years and have good reputations, observes the OTA report. Such collaboration has been rare in the DOE labs. But legislation passed in late 1989 should spur cooperation with laboratories operated by DOE contractors.

From 1985 to 1990, 140 startups were formed to commercialize technology from DOE labs, according to recent testimony by DOE chief Watkins. A few labs, such as Oak Ridge, provide services to entrepreneurs via a center created in 1985 by Oak Ridge's operator, Martin Marietta Corp., Bethesda, Md.

At the end of 1988, agencies had negotiated more than 100 cooperative R&D agreements (most by the Department of Agriculture and the Health and Human Services Department), and the pace has accelerated. Commerce's Allen said the number of cooperative pacts has jumped to 500 now. Some examples:

- The DOE set up high-temperature superconductivity centers at Argonne, Oak Ridge, and Los Alamos laboratories in October 1988 as an experiment in rapid technology transfer. Over 40 com-

panies and universities are involved. Labs and industry collaborate from basic research to product development, and industry requests which projects to pursue. For work that industry funds by 50 percent or more, the DOE allows the withholding of technical data from publication for up to two years to give the firm a head start in the market.

- A state-aided industrial consortium in Ohio is tapping the billion-dollar military research program at the five laboratories at Wright-Patterson Air Force Base and also at NASA's Lewis Research Center in Cleveland. Spinoffs from Wright-Patterson that eventually found commercial uses include artificial hip joints made from carbon composite developed for missile nose cones, computer-based information systems, and graphite-epoxy material used in tennis rackets and golf clubs. Industry, through the recently formed Ohio Advanced Technology Center in Dayton, hopes to tap into automated manufacturing, quality management, materials, and electronics research.

- Oak Ridge is working with 12 sponsoring companies to develop

## Defense R&D: bucking the trend

As aerospace and defense industry executives in the United States, Japan, and Europe prepare for cuts in planned military budgets, many are betting that their research and development operations will emerge relatively unscathed. Nonetheless, most are hedging that bet by seeking commercial business and nondefense applications for some of their military-spawned technologies, such as radar, gallium arsenide semiconductors, and satellite communications.

U.S. Secretary of Defense Dick Cheney's 1991 budget request calls for a 6 percent reduction in funds for procurement, R&D, testing, and evaluation—to US \$116 billion. But defense executives contacted by *IEEE Spectrum* noted that the Defense Department's ambitious plans to replace existing weapons and platforms with more advanced ones, such as stealth aircraft and robotic vehicles, are incompatible with deep cuts in R&D.

"My gut feeling is that R&D funding is going to increase within the Department of Defense, even though there is going to be less production," said Robert G. Morra, vice president for technical operations at Martin Marietta Corp. in Bethesda, Md.

Japan's Defense Agency recently scaled back plans for a five-year military buildup, to begin in 1991. But analysts there, too, are not expecting R&D to suffer—quite the contrary: many predict that Government funds will be redirected from weapons systems and platforms to communications systems and R&D, according to a recent report in *The Nihon Keizai Shimbun*, the largest Japanese financial newspaper.

The situation is somewhat different in Europe, where a few major military-development projects are already being reformulated on a smaller scale. Executives at some of the largest defense firms there said their own R&D operations may decline moderately as European nations collaborate more and more on defense research. This collaboration is taking place under international organizations, such as the North Atlantic Treaty Organization (NATO), and research initiatives, such as Euclid (European Corporation for the Long-Term in Defense), which is outlining a 10-year defense-research framework for NATO's Independent European Program Group. Such joint efforts have been mounted in Europe partly to better leverage military spending and partly as a result of a general emphasis on collaboration associated with the European Community's plans for market unification.

### Commercial markets sought

For now, few of these executives are planning significant changes in the content or structure of their R&D programs, so today's R&D thrusts are likely to be tomorrow's as well. A recently released Department of Defense list of "critical technologies" in the United States included photonics, signal processing, and software. For example, artificial intelligence (AI) techniques have been an important area of investigation for

years and most observers expect this work to continue for the foreseeable future. The work focuses on applying AI to command and control, battlefield vehicles, ships, and aircraft, to aid in recognizing targets and otherwise reducing the information and workload presented to crews and soldiers.

In the systems area, widespread activity is devoted to developing better infrared electro-optics for forward-looking passive sensors and other uses. And in semiconductor electronics, gallium arsenide remains of intense military interest. Martin Marietta, for example, is trying to build a single-chip GaAs seeker for guided missiles by integrating a transmitter-receiver pair operating at 30/95 gigahertz.

Although commercial spinoffs of such R&D work may seem improbable, defense executives have begun considering them, somewhat reluctantly. Most remember all too well the period after the Vietnam War, when many U.S. defense contractors tried unsuccessfully to compensate for the decline in their defense businesses by pursuing commercial markets.

But the need to supplement defense income in the near future is fast becoming a foregone conclusion, and contractors are confident they can avoid the mistakes of their last efforts to commercialize. This time many are staying with what they know best: selling to the Government. Their primary targets are several large, nonmilitary, R&D-intensive projects planned for the 1990s. They include: the National Aeronautics and Space Administration's Mission to Planet Earth, Space Exploration Initiative, and space station; the National Aerospace Plane; and the Department of Energy's ongoing efforts to clean up nuclear waste at its weapons plants, an effort that could take 30 years and cost an estimated US \$200 billion.

And despite the skepticism concerning commercial ventures, many defense firms that derive some of their business from commercial markets are seeking to expand their share of those markets. Hughes Aircraft Co., for example, depends on the commercial market for less than 25 percent of its income, but hopes to increase that share to 40 percent within five years, according to Milton E. Radant, vice president of technology at the Los Angeles-based company.

Hughes, a leader in military satellite and communications technology, is expanding its sales of receiving terminals and central-hub control systems for business-satellite communications systems and other nondefense customers. A subsidiary of General Motors Corp. since 1985, Hughes also hopes to greatly increase its share of the automotive electronics market.

Last summer, Hughes and Delco Electronics Corp., Kokomo, Ind., formed an affiliated subsidiary called HE Microwave in Tucson, Ariz. Among other things, the venture will develop and produce microelectronic modules for automotive radar applications, including collision-avoidance and near-obstacle detection.

Several firms, both large and small, are adapting or selling

intelligent software systems for finite element analysis.

- NASA's Marshall Space Flight Center reached agreement with governors from six states—Alabama, Georgia, Louisiana, Mississippi, Tennessee, and West Virginia—to help local companies manufacture more competitively. Researchers from the Marshall lab hold workshops, do consulting work, and occasionally visit local companies.
- Massachusetts, after learning of the DOD's new emphasis on technology transfer, signed an agreement in February with military labs in the state, notably one at the Electronic Systems Division Hanscom Air Force Base and an Army laboratory at Natick.
- New York State last October agreed with the Air Force's Rome Air Development Center at Griffiss Air Force Base to conduct cooperative research in photonics.
- A Sandia consortium of 11 companies is to improve the quality of specialty metals such as nickel-based or titanium alloys, using the lab's furnaces. From 1989 to 1994, industry is to con-

GaAs electronics originally developed for military use for application in commercial systems. Until 1988, tiny Anadigics Inc. in Warren, N.J., produced prototype quantities of radio-frequency microwave GaAs devices for military applications. It now produces 70 000 ICs a month for shipment to a European firm that uses them in the down-converter receivers in its direct-broadcast satellite (DBS) system. "We're the only company in the world cranking out gallium arsenide ICs in high volume," said chief executive officer Ronald Rosenzweig [see p. 65].

William Bardo, technical director of Britain's GEC-Marconi Defense Systems Ltd. in Stanmore, Middlesex, one of the largest European defense firms, is encouraged by increasing civilian use of the company's microwave technology in DBS receivers for the home. The technology, developed after World War II, is the basis for missile-seeker heads, electronic-warfare systems, and airborne radar. But over the last three years, GEC-Marconi has applied the technology to the growing European DBS market. The company, which produced over a million DBS receiver antennas for home use last year, is now by its own reckoning the world's largest supplier of such units.

#### UK situation different

Bardo told *Spectrum* that such commercial applications may help defense-oriented firms sustain their research budgets, because "in the early stages of research, we don't distinguish between military and civil applications."

He cautioned, however, that "the situation in the UK is a bit more complicated than elsewhere" in Europe, because the British Ministry of Defense is now distancing itself from the major Government research establishments that have traditionally played central roles in military R&D.

These establishments, including the Royal Signals and Radar Establishment, the Royal Aerospace Establishment, the Admiralty Research Establishment, and the Royal Armaments and R&D Establishment, are Government owned and staffed; they are charged with advising the Defense Ministry and procuring certain systems and technology for it. These functions are not expected to change, but in the future, the establishments will have to compete for R&D funds rather than get them automatically from the ministry, as they have in the past, Bardo said.

Within Europe as a whole, Bardo doubted that the receding threat of war on the continent would lead to significant cuts in defense R&D. Like many other defense specialists on both sides of the Atlantic contacted by *Spectrum* in mid-August, he pointed to the worsening situation in the Middle East as evidence that continued rigorous R&D was necessary. "Probably the view will prevail that state-of-the-art capabilities must be maintained. So enough development programs will be funded to maintain them," he said.

—Glenn Zorpette

tribute US \$2.5 million and the Government, US \$2 million.

- The DOE recently signed a pact with the National Center for Manufacturing Sciences, a nonprofit consortium of more than 100 companies in Ann Arbor, Mich. The DOE has identified 39 technological innovations applicable to precision manufacturing that have been kept out of the private sector. Work will also explore such areas as advanced controller software and artificial intelligence.

Other ventures include the Department of Agriculture's Peoria Biotechnology Consortium and the Army's Construction Productivity Advancement Research program. To spur more deals, the Department of Commerce's Allen recommends holding conferences to bring industry in contact with laboratory researchers. Many labs—and even some Government agencies—are setting these up. The first, held by Health and Human Services in October 1988, attracted more than 250 representatives from pharmaceutical and biotechnology companies. A similar conference on materials is to be held in October and one on the environment is planned for early 1991, according to Allen.

Such collaboration can also be lucrative to lab researchers. Because of the 1986 Federal Technology Transfer Act, Federal researchers earn at least 15 percent of any royalties their invention may bring in. Since the act was passed, the number of Federal inventions has jumped markedly; for instance, the Army's 309 in fiscal 1987 increased to 424 in fiscal 1988. A Commerce Department report published last year observed that university patents jumped from 230 a year in 1976 to 900 in 1987.

Royalties for DOE contractor-operated labs have jumped from US \$14 000 in 1981 to US \$584 000 in 1988. Royalties from Federally owned and operated labs collected from the National Technical Information Service, Springfield, Va., rose from US \$1.5 million in 1985 to US \$5.6 million three years later.

#### Non-U.S. vs. U.S. industry

The U.S. laboratories are a worldwide resource. A recent survey sponsored by Japan's Science and Technology Agency of 385 prestigious Japanese scientists rated the U.S. government's National Institutes of Health as the world's top research center, followed by the Massachusetts Institute of Technology and Germany's Max Planck Institutes.

Non-U.S. use of the labs has been a matter of some controversy. A 1989 Commerce Department technology transfer report notes that non-U.S. companies, unlike those in the United States, "are adept at identifying valuable research projects at Federal facilities."

According to a 1988 report by the U.S. General Accounting Office, the 3597 non-U.S. researchers who worked during 1986 at 50 large Federal labs comprised 30 percent of the total outside researchers. The most popular destination for both U.S. and non-U.S. researchers was the DOE energy labs, followed by the National Institutes of Health and NASA. More than 80 percent of the outside researchers were affiliated with universities and other nonprofit groups. Japan sent the most researchers (758), followed by the United Kingdom (448), and China (438).

According to several research managers and administrators interviewed by the GAO, the best way to control non-U.S. participation in R&D is to stimulate U.S. participation because staffing and space constraints limit the total number of researchers. "By giving preference to U.S. researchers, the Federal laboratories would be able to limit foreign involvement to collaborations that are particularly useful," the GAO reported. Many managers stated that U.S. laboratories benefited more from the collaborations than the outside researchers and their countries.

The 1986 Federal Technology Transfer Act tried to ensure that taxpayer-financed technology would not be given away without an adequate *quid pro quo*, according to the 1989 Commerce Department report. In 1988, Congress passed legislation requiring that agreements with non-U.S. participants consider whether symmetrical opportunities existed in other nations and whether intellectual properties were protected. But the Commerce Depart-

ment noted that "U.S. firms, until recently, have shown only limited interest in working with Federal facilities, much less with those operated by foreign Governments."

The GAO report also noted that few U.S. researchers go abroad. In Japan, for instance, the best research is often in corporate labs that are not as accessible as Government labs. Federal labs sent 1679 researchers to work in another country in 1986, the GAO reported; more than half of them worked for the Geological Survey, often on short visits in conjunction with conferences.

Yonas noted that non-U.S. participation in U.S. research often benefits the nation's economy. Two of the companies in Sandia's specialty metals consortium have overseas owners. Examining criteria such as the number of jobs provided, where the technology resides, and how profits are reinvested, the lab's management decided that the non-U.S. companies' participation benefited the United States, according to Yonas.

Allen told *Spectrum* that scientists from abroad gain know-how rather than patentable inventions from their laboratory stays. He added that there is a shortage of U.S. scientists, and many non-U.S. scientists at the laboratories choose to stay in the United States. ♦

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## Software R&D: from an art to a science

"Software is an art, not a science" has long been an axiom of that field of engineering. Its exponents have had the image, even among other engineers, of lone cowboys, programming largely by intuition in a field that lacks formal rules and physical laws to govern it. Another saying, "You can do anything—it's software," has meant not only that software can accomplish nearly any task but also that it can be created in an unlimited number of ways, few of them measurably more effective than others.

Although the perception of the individualistic software engineer may linger, the reality is changing. While the lack of physical laws remains, formal rules and structures are being adopted to create a methodical engineering discipline along the lines of electrical or mechanical engineering. "Software engineering is not a freestyle event," said Lou Mazzucchelli, vice president and chief technical officer at Cadre Technologies Inc., Providence, R.I., a manufacturer of computer-aided software engineering (CASE) tools.

Development techniques are becoming increasingly structured and disciplined, and more attention is being paid to building a mathematical basis of software engineering. Also, software engineers are modifying the classic "waterfall" model of software development more radically than before, stopping at certain stages to build prototypes or changing the way the cycle progresses to better accommodate the necessary maintenance.

Perhaps the hottest technology today in software engineering is object-oriented programming, which was first developed in the late 1960s and early 1970s. Regarded more as a research topic than as a viable programming method, languages and support tools such as C++ have proliferated only over the past few years. Object-oriented programming focuses on the structure and intrinsic functions of the objects that are manipulated, rather than on the steps taken to manipulate the objects, as conventional programming techniques do. Objects are built in hierarchical ways and are largely self-contained; changing, say, the length of a data field could be done in one step by changing the object, instead of altering the many parts of the system that use that data. The procedures that call the objects need not know such details about the object, unlike those used in other programming methods.

The properties of objects qualify them almost ideally for reusability—potentially a boon to software developers, who too often have to develop systems from scratch. Reusable components

such as off-the-shelf op amps and adders are now widely used in chip design. However, some engineers have their doubts about the future of reusable software: software engineers "don't want to use other people's reusable components," Mazzucchelli said. Also, software developers must realize that object-oriented programming is not the answer to all their problems, cautioned Mary Shaw, a professor in Carnegie Mellon University's computer science department in Pittsburgh and also with the university's Software Engineering Institute. Software engineering badly needs sound, theoretical rules that guide developers in deciding when to use each technology.

### *New ways to navigate the waterfall*

Whatever the programming technique used, software development tends to follow the basic waterfall model: requirements, specification, design, implementation, testing, and maintenance. The requirements are usually stated in narrative fashion, rather than in a formal computer language, and express what the software must be able to do. They are translated into functional specifications, preferably written in a computer-executable language. The design encapsulates the structure of the software system, detailing how the different parts of the program are connected. Then the design is turned into code, written in a computer language, and tested to ferret out bugs. But it is not until the maintenance phase—which consists primarily of fixing errors and implementing changes in the design—that the real work begins: it generally accounts for 60–80 percent of the time and money spent on a program, a far larger share than for hardware.

There are numerous variations on the waterfall model, and often parts of it are repeated as problems are discovered or the program's requirements change. Software engineers have recognized for years that the model is far from perfect, and different models are being explored. Some feel that it overemphasizes the production of documents, such as a requirements statement, without helping engineers produce them.

Others feel that the process itself is sound but leaves room for error in execution. For example, if the specifications do not accurately reflect the intent of the requirements, the end result may be useless. Also, integrating a program's components can be extremely difficult when different teams of engineers are designing and implementing the various pieces of a large system.

One alteration of the waterfall model favors creating prototypes, long a staple of the hardware engineering process: a rough version of the product is built and studied to discover problems and solutions. For example, Microsoft developed a prototype of the Windows 3.0 user interface to test for ease of use. Similarly, Synopsys Inc., Mountain View, Calif., created a prototype of its recently released ECL synthesis tool for designers of emitter-coupled logic (ECL) to test. However, a prototype robust enough for customers to use fairly easily requires a significant investment of time and money to fine-tune it. Prototyping is possible at just about any step in the waterfall cycle and can actually help produce most of the necessary documents. In the past, some software developers doubted the value of examining a prototype of a software project before code was written.

Although the prototyping concept is borrowed from hardware engineering, other changes in software engineering are moving it closer to disciplines like electrical engineering. Thus, spending more time on the front end of the process, thinking about the problem to minimize difficulties in the later stages, is a hallmark of sound engineering. Instead of focusing on writing code, engineers must look at how the program should be organized at a higher level so that it will be easier to maintain. For example, software engineers working on the Cadre's Teamwork products several years ago spent four to five months "just thinking, figuring out how the products should work," Mazzucchelli said. Consequently, the implementation phase went smoothly because the architecture was sound, and even more time was saved when the company began to work on the second version of the products, he added.

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*Erin E. Murphy* Associate Editor

THE WHITE HOUSE  
Office of the Press Secretary

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For Immediate Release

June 28, 1991

EXECUTIVE ORDER

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EXTENSION OF THE PRESIDENT'S COUNCIL OF  
ADVISORS ON SCIENCE AND TECHNOLOGY

By the authority vested in me as President by the Constitution and the laws of the United States of America, and in order to extend the President's Council of Advisors on Science and Technology, it is hereby ordered that Section 4(b) of Executive Order No. 12700 is amended by deleting "June 30, 1991" and inserting "June 30, 1993" in lieu thereof.

GEORGE BUSH

THE WHITE HOUSE,  
June 28, 1991.

# # #

- 1 7 panels
- 2 Budget arm twisting
- 3 basic technologies - Crit. Tech. Report

#### 4 Facilities

Recent news accounts

- > Abuse of overhead recovery by univs.
  - > PLAST concerned about integrity of process for R+D and facilities
  - > Related issue: - pork barrel ~~earmarking~~ earmarking, big problem ~~at least \$810 M~~ at least \$810 M FY 91 by Congress
  - > Also fundamental problem of upgrading univs to carry out their responsibilities
- PLAST wants to be ~~helpful~~ helpful
- ~~integrity~~ integrity
  - earmarking
  - outdated facilities

How can we be most ~~helpful~~ useful?

- 5 Megaprojects
- 6 Anti-trust / Competitiveness
- 7 America 2000

As of May 1, 1991

**PRESIDENT'S COUNCIL OF ADVISORS  
ON  
SCIENCE AND TECHNOLOGY**

**MAY 2-3, 1991  
AGENDA**

**THURSDAY, MAY 2, 1991**

**OPEN SESSION 9:00 AM - 11:00 AM  
CONFERENCE ROOM  
COUNCIL ON ENVIRONMENTAL QUALITY  
722 JACKSON PLACE, NW**

<b>8:30 - 9:00</b>	<b>ARRIVAL AND COFFEE</b>	
<b>9:00 - 9:30</b>	<b>OPENING REMARKS</b>	<b>DR. BROMLEY</b>
<b>9:30 - 10:30</b>	<b>THE DECADE OF THE BRAIN</b>	<b>DR. PORTER</b>
<b>10:30 - 11:00</b>	<b>DISCUSSION</b>	
<b>11:00 -</b>	<b>CLOSING REMARKS</b>	<b>DR. BROMLEY</b>

Roger J. Porter, M.D.  
Deputy Director, National Institute of Neurological Disorders and Stroke

Born: April 4, 1942, Pittsburgh, PA

EDUCATION: B.S., Eckerd College, St. Petersburg, FL, 1964; M.D., Duke University School of Medicine, Durham, NC, 1968; University of California, San Diego, Straight Medical Internship, 1969; University of California, San Francisco, Resident in Neurology, 1971-1973; University of California, San Francisco, Chief Resident in Neurology, 1973-1974.

PROFESSIONAL HISTORY: Deputy Director, NINDS, 1987-present; Chairman, Subcommittee on Brain and Behavioral Research, OSTP, 1990-present; Chief, Medical Neurology Branch, and Chief, Clinical Epilepsy Section, NINCDS, 1984-1987; Clinical Epilepsy Section, NINCDS, 1980-1984; Acting Chief, Epilepsy Branch, Neurological Disorders Program, and Acting Chief, Clinical Epilepsy Section, NINCDS, 1979-1980; Assistant Chief, Epilepsy Branch, Neurological Disorders Program, NINCDS, 1978-1979; Senior Research Associate, Epilepsy Branch, Neurological Disorders Program, NINCDS, 1974-1978; Medical Officer, Commissioned Corps, PHS (Medical Director) 1974-present; Investigator, Diphenylhydantoin pharmacology project, University of California, San Francisco, 1972-1973; Staff Associate, Section on Epilepsy, NINCDS, 1969-1971; Fellow, Research Training Program, Duke University School of Medicine, 1966-1967 (9 months); Research Assistant, Department of Pathology, Metropolitan General Hospital, Cleveland, OH, 1965 (summer); Consultant-Lecturer in Neurology, National Naval Medical Center, Bethesda, MD, 1978-present; Clinical Professor of Neurology, Uniformed Services University of the Health Sciences, Bethesda, MD, 1980-present; Adjunct Professor of Pharmacology, Uniformed Services University of the Health Sciences, Bethesda, MD, 1982-present.

PROFESSIONAL ORGANIZATIONS: American Academy of Neurology, American Electroencephalographic Society, American Epilepsy Society (past president), American Neurological Association, American Society for Clinical Pharmacology and Therapeutics, American Society for Neurologic Investigation (Honorary Member), International League Against Epilepsy (Secretary-General), Society for Neuroscience.

HONORS, AWARDS: U.S. Public Health Service Commendation Medal, 1977; MacArthur Outstanding Alumnus Award, Eckerd College, 1977; Fulbright Distinguished Professor Award, 1985; President, Assembly of Scientists, NINCDS, 1985-1986, U.S. Public Health Service Meritorious Service Medal, 1986; Letter of Commendation, Commanding Officer, National Naval Medical Center, 1987; Letter of Commendation, Surgeon General C. Everett Koop, M.D., USPHS, 1988; Department of Defense Meritorious Service Medal, 1989; Distinguished Alumnus Award, Duke University Medical Center, 1989; United States Navy Commendation Medal, 1991.

PUBLICATIONS: Books--9; Articles and Chapters--139; Abstracts--90



## DECADE OF THE BRAIN, 1990 - 1999

*By the President of the United States of America*

### A Proclamation

The human brain, a 3-pound mass of interwoven nerve cells that controls our activity, is one of the most magnificent – and mysterious – wonders of creation. The seat of human intelligence, interpreter of senses, and controller of movement, this incredible organ continues to intrigue scientist and layman alike.

Over the years, our understanding of the brain – how it works, what goes wrong when it is injured or diseased – has increased dramatically. However, we still have much more to learn. The need for continued study of the brain is compelling: millions of Americans are affected each year by disorders of the brain ranging from neurogenetic diseases to degenerative disorders such as Alzheimer's, as well as stroke, schizophrenia, autism, and impairments of speech, language, and hearing.

Today, these individuals and their families are justifiably hopeful, for a new era of discovery is dawning in brain research. Powerful microscopes, major strides in the study of genetics, and advanced brain imaging devices are giving physicians and scientists ever greater insight into the brain. Neuroscientists are mapping the brain's biochemical circuitry, which may help produce more effective drugs for alleviating the suffering of those who have Alzheimer's or Parkinson's disease. By studying how the brain's cells and chemicals develop, interact, and communicate with the rest of the body, investigators are also developing improved treatments for people incapacitated by spinal cord injuries, depressive disorders, and epileptic seizures. Breakthroughs in molecular genetics show great promise of yielding methods to treat and prevent Huntington's disease, the muscular dystrophies, and other life-threatening disorders.

Research may also prove valuable in our war on drugs, as studies provide greater insight into how people become addicted to drugs and how drugs affect the brain. These studies may also help produce effective treatments for chemical dependency and help us to understand and prevent the harm done to the preborn children of pregnant women who abuse drugs and alcohol. Because there is a connection between the body's nervous and immune systems, studies of the brain may also help enhance our understanding of Acquired Immune Deficiency Syndrome.

Many studies regarding the human brain have been planned and conducted by scientists at the National Institutes of Health, the National Institute of Mental Health, and other Federal research agencies. Augmenting Federal efforts are programs supported by private foundations and industry. The cooperation between these agencies and the multidisciplinary efforts of thousands of scientists and health care professionals provide powerful evidence of our Nation's determination to conquer brain disease.

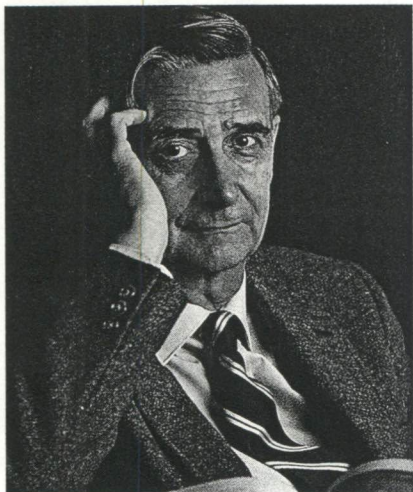
To enhance public awareness of the benefits to be derived from brain research, the Congress, by House Joint Resolution 174, has designated the decade beginning January 1, 1990, as the "Decade of the Brain" and has authorized and requested the President to issue a proclamation in observance of this occasion.

NOW, THEREFORE, I, GEORGE BUSH, President of the United States of America, do hereby proclaim the decade beginning January 1, 1990, as the Decade of the Brain. I call upon all public officials and the people of the United States to observe that decade with appropriate programs, ceremonies, and activities.

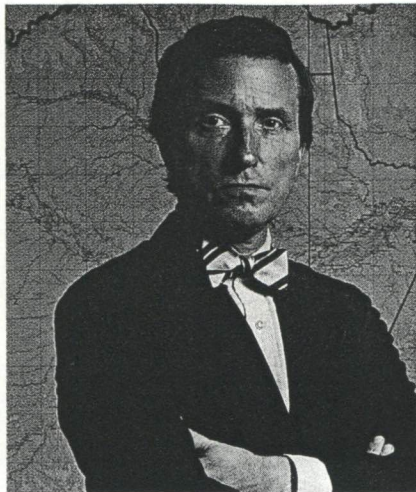
IN WITNESS WHEREOF, I have hereunto set my hand this seventeenth day of July, in the year of our Lord nineteen hundred and ninety, and of the Independence of the United States of America the two hundred and fifteenth.

*George Bush*

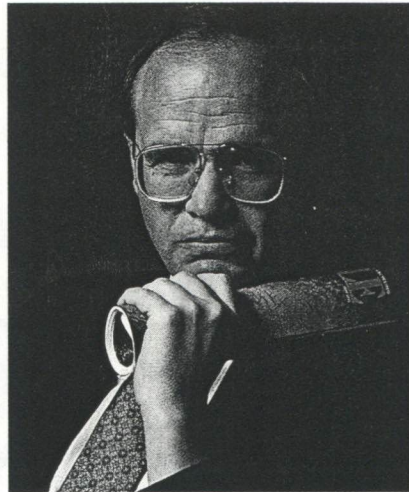
*E.O. Wilson  
Harvard University*



*Thomas Lovejoy  
Smithsonian Institution*



*James Gustave Speth  
World Resources Institute*

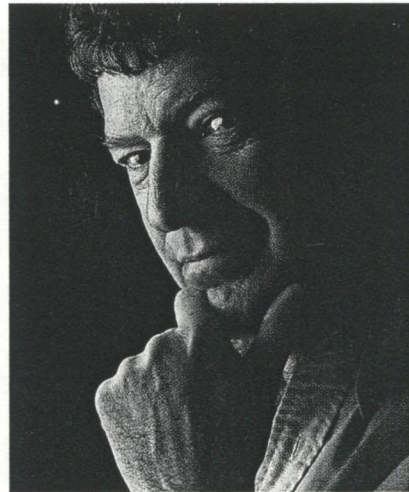
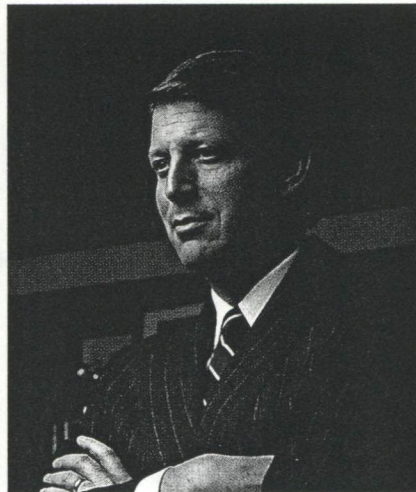
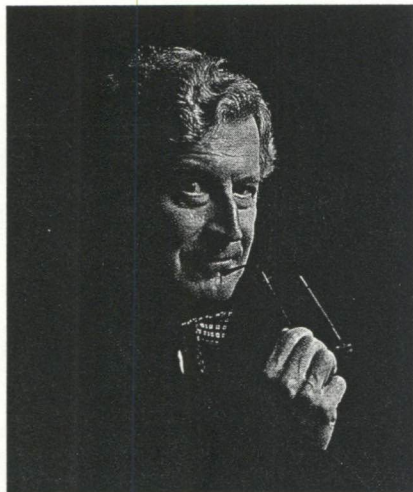


*David Rall*

*National Institute of Environmental  
Health Sciences*

*Albert Gore, Jr.  
U.S. Senator*

*Michael Glantz  
National Center for Atmospheric  
Research*



## Some of the crackpots predicting the world is coming to an end.

Recently, some of the foremost scientists and environmental experts from around the world met in the town of Boulder, Colorado.

The subject: the environment.

The conclusion: If something was not done quickly, these experts forecasted dire consequences for our planet.

According to computer projections, for example, the accumulation of carbon dioxide in the atmosphere from the burning of fossil fuels could increase the Earth's average temperature three to five degrees Fahrenheit. The result: Oceans will rise, causing massive flooding and the destruction

of millions of homes along the coast.

Because of the release of chlorofluorocarbons, the Earth's protective ozone layer has been dangerously eroded. As a result, scientists are predicting a dramatic increase in the incidence of skin cancer.

And the millions of tons of garbage and toxic waste produced annually threaten to contaminate precious drinking water supplies, and present a growing hazard to human health.

Fortunately, these experts also happen to have some suggestions on how we can prevent these things from ever happening.

Like reducing carbon dioxide pollution by cutting back on our use of coal and improving our energy efficiency. Enforcing a worldwide ban on ozone-layer-depleting chlorofluorocarbons. And putting greater emphasis on recycling wastes.

Of course, you could say these things are inconvenient.

But, then again, just consider the alternatives.

Please make a donation to help establish scholarships for environmental education. Send your contribution to The Environmental Challenge Fund, Radio City Station, P.O. Box 1138, New York, NY 10101-1138.