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Collection/Office of Origin: Science and Technology Policy, Office of (OSTP)
Series: Bromley, D. Allan, Files
Subseries: Presidential Priorities Files

OA/ID Number: 62087
Folder ID Number: 62087-002

Folder Title:
Executive Office of the President: Presidential Priorities [2 of 4] [1991]

Stack:

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Position:

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"CORRESPONDENCE TRACKING"

TYPE: PRESIDENTIAL PRIORITY DOCUMENT NUMBER: 9123951
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

FROM: DR. DAVID CARRIER

TO: JOHN SUNUNU

DATE OF
CORRESPONDENCE: 09/06/91

SUBJECT: UPDATE ON THE RECENT DEVELOPMENTS REGARDING HELIUM-3

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
Michelle Van Cleave
Dr. Wong
Dr. Phillips

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:
REMARKS:

OSTP RECEIVED: 09/09/91 FILE: P-EOP-PRESIDENTIAL PRIORITY
DEPT RECEIVED:

9/23951

T H E W H I T E H O U S E O F F I C E

REFERRAL

SEPTEMBER 6, 1991

TO: OFFICE OF SCIENCE AND TECHNOLOGY POLICY
ATTN: ALLAN BROMLEY

ACTION REQUESTED:
INFORMATION COPY - NO ACTION NECESSARY

DESCRIPTION OF INCOMING:

ID: 266235

MEDIA: LETTER, DATED AUGUST 20, 1991

TO: JOHN SUNUNU

FROM: DR. W. DAVID CARRIER III
 PRESIDENT
 BROMWELL & CARRIER, INC.
 POST OFFICE BOX 5467
 LAKELAND FL 38070

SUBJECT: UPDATE ON THE RECENT DEVELOPMENTS REGARDING
 HELIUM-3; FORWARDS A COPY OF THE LUNAR
 SOURCEBOOK

PROMPT ACTION IS ESSENTIAL -- IF REQUIRED ACTION HAS NOT BEEN
TAKEN WITHIN 9 WORKING DAYS OF RECEIPT, PLEASE TELEPHONE THE
UNDERSIGNED AT 456-7486.

RETURN CORRESPONDENCE, WORKSHEET AND COPY OF RESPONSE
(OR DRAFT) TO:
AGENCY LIAISON, ROOM 91, THE WHITE HOUSE, 20500

SALLY KELLEY
DIRECTOR OF AGENCY LIAISON
PRESIDENTIAL CORRESPONDENCE

THE WHITE HOUSE
CORRESPONDENCE TRACKING WORKSHEET

INCOMING

DATE RECEIVED: AUGUST 28, 1991

NAME OF CORRESPONDENT: DR. W. DAVID CARRIER III

SUBJECT: UPDATE ON THE RECENT DEVELOPMENTS REGARDING
HELIUM-3; FORWARDS A COPY OF THE LUNAR
SOURCEBOOK

ROUTE TO:		ACTION		DISPOSITION	
OFFICE/AGENCY	(STAFF NAME)	ACT CODE	DATE YY/MM/DD	TYPE RESP	C COMPLETED D YY/MM/DD
JOHN SUNUNU		ORG	91/08/28	IS	A 91/09/03 TC
<i>POSTP</i> <i>Allan Bromley</i>	REFERRAL NOTE: _____	I	91/09/06		C 1/1 TC
	REFERRAL NOTE: _____		/ /		/ /
	REFERRAL NOTE: _____		/ /		/ /
	REFERRAL NOTE: _____		/ /		/ /
	REFERRAL NOTE: _____		/ /		/ /

COMMENTS:

ADDITIONAL CORRESPONDENTS: MEDIA: L INDIVIDUAL CODES: _____

CS MAIL USER CODES: (A) _____ (B) _____ (C) _____

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*ACTION CODES:          *DISPOSITION          *OUTGOING          *
*                      *                      *CORRESPONDENCE:   *
*A-APPROPRIATE ACTION  *A-ANSWERED          *TYPE RESP=INITIALS *
*C-COMMENT/RECOM       *B-NON-SPEC-REFERRAL  *          OF SIGNER *
*D-DRAFT RESPONSE      *C-COMPLETED          *          CODE = A   *
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*R-DIRECT REPLY W/COPY *                      *                      *
*S-FOR-SIGNATURE       *                      *                      *
*X-INTERIM REPLY       *                      *                      *
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LETTER AT ALL TIMES AND SEND COMPLETED RECORD TO RECORDS
MANAGEMENT.

THE WHITE HOUSE
WASHINGTON

September 3, 1991

Dear Mr. Carrier,

Thank you for your recent letter and for sending me The Lunar Sourcebook.

I appreciate your sharing this with me.

Sincerely,

John H. Sununu
Chief of Staff

Mr. W. David Carrier, III, PhD
Post Office Box 5467
Lakeland, Florida 33807

26600

BCI

BROMWELL & CARRIER, INC.

P.O. Box 5467
Lakeland, FL 33807-5467
(813) 646-8591
FAX: (813) 644-5920

ENGINEERS • DESIGNERS • SCIENTISTS

August 20, 1991

JHS 9
Governor John Sununu
The White House
Washington, DC 20510

Dear Governor Sununu:

The purpose of this letter is to bring you up-to-date on recent developments regarding lunar helium-3:

1. Lunar helium-3 is slowly gaining recognition on the national agenda: It was included in the Synthesis Group report to the National Space Council issued in May. When Lt. Gen. Stafford, Chairman of the Synthesis Group, testified to a Congressional subcommittee a few weeks ago, Prof. Jerry Kulcinski (my colleague at the University of Wisconsin) was also invited to provide additional background on lunar helium-3. And now I hear that Senator Byrd is considering establishing a Lunar Helium-3 Institute (or some-such) in West Virginia.
2. The Lunar Sourcebook has just been published. I am one of the co-authors (see Chapter 9) and am pleased to enclose a copy for you. Helium-3 is discussed in portions of this book.
3. Finally, I am enclosing a recent paper by Edward Teller, A.J. Glass, T.K. Fowler, A. Hasegawa, and J.F. Santarius. The paper is about the potential use of lunar helium-3 to power fusion rockets for inter-planetary travel. For example, a helium-3 fusion rocket could carry people to Mars in just 90 days. As you will note, the paper was presented at an international conference in Moscow in late May.

I would also like to renew our offer: Jack Schmitt, Jerry Kulcinski, and I would be pleased to meet with you to discuss this critically important resource, and what the US needs to do in order to have commercial helium-3 power plants within two decades. Recall that the entire US electricity consumption for one year would require only 30 tons of helium-3: the equivalent of one shuttle payload. And at an equivalent cost of \$7 per barrel oil.

Sincerely,

BCI

W. David Carrier, III / cdm

W. David Carrier, III, PhD
President

WDC:cdm

"CORRESPONDENCE TRACKING"

TYPE: PRESIDENTIAL PRIORITY DOCUMENT NUMBER: 9123897
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

FROM: WHITELAW, Michael J.: IEEE

TO: PRESIDENT BUSH

DATE OF
CORRESPONDENCE: 09/04/91

SUBJECT: INFORMS THE PRESIDENT THAT D. ALLAN BROMLEY HAS BEEN
CHOSEN TO RECEIVE THE 91 IEEE UNITED STATES
ACTIVITIES BOARD DISTINGUISHED PUBLIC SERVICE AWARD,
OCT 23, 1991.

DIRECTORATE STAFF
ASSIGNED: DIRECTOR'S OFFICE ASSIGNED:

ACTION
REQUIRED: APPROPRIATE ACTION STAFF
ACTION:

SENDER'S DUE DATE: 09/17/91
OSTP DUE DATE: 09/11/91 STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley

WHITE HOUSE TRACKING #: CONTACT PERSON: SALLY KELLEY
PHONE: 456-7486 EXT:
REMARKS: The assignment is for the Director's Office for Damar Hawkins.
Cross reference with document #9123575.

9/9/91 - DAB is scheduled to meet w/ the group on Oct. 23, 1991,
m2

CLOSED

OSTP RECEIVED: 09/04/91
DEPT RECEIVED:

FILE: P-PRESIDENTIAL PRIORITY

3897
RECEIVED

SEP 3:27
THE WHITE HOUSE OFFICE

OFFICE OF THE
DIRECTOR REFERRAL

SEPTEMBER 4, 1991

TO: OFFICE OF SCIENCE AND TECHNOLOGY POLICY
ATTN: BROMLEY

ACTION REQUESTED:
APPROPRIATE ACTION

DESCRIPTION OF INCOMING:

ID: 265521
MEDIA: LETTER, DATED AUGUST 20, 1991
TO: PRESIDENT BUSH
FROM: MR. MICHAEL J. WHITELAW
CHAIRMAN
UNITED STATES ACTIVITIES BOARD
THE INSTITUTE OF ELECTRICAL AND
ELECTRONICS ENGINEERS, INC. (IEEE)
SUITE 1202
1828 L STREET, NW.
WASHINGTON DC 20036

SUBJECT: INFORMS THE PRESIDENT THAT D. ALLAN BROMLEY
HAS BEEN CHOSEN TO RECEIVE THE 91 IEEE UNITED
STATES ACTIVITIES BOARD DISTINGUISHED PUBLIC
SERVICE AWARD, OCT 23 91

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SALLY KELLEY
DIRECTOR OF AGENCY LIAISON
PRESIDENTIAL CORRESPONDENCE

THE WHITE HOUSE
CORRESPONDENCE TRACKING WORKSHEET

INCOMING

DATE RECEIVED: AUGUST 27, 1991

NAME OF CORRESPONDENT: MR. MICHAEL J. WHITELAW

SUBJECT: INFORMS THE PRESIDENT THAT D. ALLAN BROMLEY
HAS BEEN CHOSEN TO RECEIVE THE 91 IEEE UNITED
STATES ACTIVITIES BOARD DISTINGUISHED PUBLIC
SERVICE AWARD, OCT 23 91

ROUTE TO: OFFICE/AGENCY	(STAFF NAME)	ACTION		DISPOSITION	
		ACT CODE	DATE YY/MM/DD	TYPE RESP	C COMPLETED D YY/MM/DD
JEFF VOGT		ORG	91/08/27	TC	C 9/18/29 TC
OST - Bromley	REFERRAL NOTE:	A	9/10/91		
	REFERRAL NOTE:				
	REFERRAL NOTE:				
	REFERRAL NOTE:				
	REFERRAL NOTE:				

COMMENTS:

ADDITIONAL CORRESPONDENTS: MEDIA: L INDIVIDUAL CODES: 4900 4690

PL MAIL USER CODES: (A) (B) (C)

*ACTION CODES:	*DISPOSITION	*OUTGOING	*
*	*	*CORRESPONDENCE:	*
*A-APPROPRIATE ACTION	*A-ANSWERED	*TYPE RESP=INITIALS	*
*C-COMMENT/RECOM	*B-NON-SPEC-REFERRAL	* OF SIGNER	*
*D-DRAFT RESPONSE	*C-COMPLETED	* CODE = A	*
*F-FURNISH FACT SHEET	*S-SUSPENDED	*COMPLETED = DATE OF	*
I-INFO COPY/NO ACT-NEC		* OUTGOING	*
*R-DIRECT REPLY W/COPY			*
*S-FOR-SIGNATURE			*
*X-INTERIM REPLY			*

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IEEE

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Promoting Career and Technology Policy Interests of Electrical, Electronics & Computer Engineers

United States Activities Board August 20, 1991

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Communications &
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IEEE-USA Office
(202) 785-0017

"Information Line" Recording
(202) 785-2180

Facsimile
(202) 785-0835

The Honorable George Bush
President of the United States
The White House
Washington, DC 20500

Dear Mr. President:

It is my pleasure to inform you that D. Allan Bromley has been chosen to receive the 1991 IEEE United States Activities Board Distinguished Public Service Award. Dr. Bromley is being honored for his outstanding contributions to the development and implementation of Federal policy on science, engineering and technology. His activities have been directed toward the enhancement of the technology policy interests of the United States and thereby the interests of our U.S. members.

The plaque representing the award will be presented to Dr. Bromley in his office at 11:00 am, October 23, 1991.

The Institute of Electrical and Electronics Engineers (IEEE) is a transnational society directed toward the advancement of the theory and practice of electrical and electronics engineering and the related arts and sciences. There are approximately 320,000 individual members worldwide of which some 250,000 are in the United States. The United States Activities Board (USAB) of IEEE is responsible for the interests of the U.S. members.

Sincerely,

Michael J. Whitelaw
IEEE Vice President, Professional Activities and
Chairman, United States Activities Board

MJW:m1s

"CORRESPONDENCE TRACKING"

TYPE: PRESIDENTIAL PRIORITY DOCUMENT NUMBER: 9123625
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

FROM: JORDAN, Ms. Dinah: SCIENCE & TECHNOLOGY, THE LAND AND THE
LIVING SEAS

TO: PRESIDENT BUSH

DATE OF
CORRESPONDENCE: 08/28/91

SUBJECT: RE: THE 1990 ANNUAL REPORT OF SCIENCE AND
TECHNOLOGY, THE LAND AND THE LIVING SEAS.

DIRECTORATE STAFF
ASSIGNED: ENVIRONMENT ASSIGNED:

ACTION STAFF
REQUIRED: FOR DAB'S SIGNATURE ACTION:

SENDER'S DUE DATE: 09/09/91
OSTP DUE DATE: 09/04/91 STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
Damar Hawkins

WHITE HOUSE TRACKING #: CONTACT PERSON: SALLY KELLEY
PHONE: EXT:
REMARKS:

CLOSED

OSTP RECEIVED: 08/28/91
DEPT RECEIVED:

FILE: *P*-EOP-PRESIDENTIAL PRIORITY

Damar Mary Sue

Kara called — Sally
Kelley forward letter
for information only —
no response necessary.

Lise

3625
RECEIVED

91 AUG 28 A9:52

THE WHITE HOUSE OFFICE

OFFICE OF THE
DIRECTOR
REFERRAL

AUGUST 28, 1991

TO: OFFICE OF SCIENCE AND TECHNOLOGY POLICY

ACTION REQUESTED:

APPROPRIATE ACTION

DESCRIPTION OF INCOMING:

ID: 246954

MEDIA: REPORT,

TO: PRESIDENT BUSH

FROM: MS. DINAH JORDAN
PROJECT COORDINATOR / EDITOR
SCIENCE AND TECHNOLOGY
THE LAND AND THE LIVING SEAS

XX 00000

SUBJECT: 90 ANNUAL REPORT OF SCIENCE AND TECHNOLOGY
THE LAND AND THE LIVING SEAS

PROMPT ACTION IS ESSENTIAL -- IF REQUIRED ACTION HAS NOT BEEN
TAKEN WITHIN 9 WORKING DAYS OF RECEIPT, PLEASE TELEPHONE THE
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AGENCY LIAISON, ROOM 91, THE WHITE HOUSE, 20500

SALLY KELLEY
DIRECTOR OF AGENCY LIAISON
PRESIDENTIAL CORRESPONDENCE

ID # 246954WHITE HOUSE
CORRESPONDENCE TRACKING WORKSHEET☐ O - OUTGOING☐ H - INTERNAL☒ I - INCOMINGDate Correspondence
Received (YY/MM/DD)9/108/23

Name of Correspondent:

Dianah Jordan☐ MI Mail Report

User Codes: (A) _____

(B) _____

(C) _____

Subject:

1990 Annual Report of Science and Technology, The Land,
and The Living Seas

ROUTE TO:

ACTION

DISPOSITION

Office/Agency (Staff Name)

Action
CodeTracking
Date
YY/MM/DDType
of
ResponseCompletion
Date
YY/MM/DDEC Geis

ORIGINATOR

9/108/26C 9/108/26

Referral Note:

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Referral Note:

ACTION CODES:

A - Appropriate Action
C - Comment/Recommendation
D - Draft Response
F - Furnish Fact Sheet
to be used as EnclosureI - Info Copy Only/No Action Necessary
R - Direct Reply w/Copy
S - For Signature
X - Interim Reply

DISPOSITION CODES:

A - Answered
B - Non-Special Referral
C - Completed
S - Suspended

FOR OUTGOING CORRESPONDENCE:

Type of Response = Initials of Signer
Code = "A"
Completion Date = Date of Outgoing

Comments:

Not for President's Knowledge to the Congress.

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Prime Subject Code: _____		Secondary Subject Codes: _____	
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PRESIDENTIAL REPLY

Code	Date	Comment	Form
C	_____	_____	P.
DSP	_____	Time: _____	Media: _____

SIGNATURE CODES:

- CPn - Presidential Correspondence
 n - 0 - Unknown
 n - 1 - George Herbert Walker Bush
 n - 2 - George Bush
 n - 3 - George
 CLn - First Lady's Correspondence
 n - 1 - Barbara Bush
 n - 2 - Barbara
 n - 3 - Bar
 n - 4 - Mrs. Barbara Bush
 CBN - Presidential & First Lady's Correspondence
 n - 1 - Barbara & George Bush
 n - 2 - Barbara & George

- MEDIA CODES:
 B - Box/package
 C - Copy
 D - Official document
 G - Message
 H - Handcarried
 L - Letter
 M - Mailgram
 O - Memo
 P - Photo
 R - Report
 S - Sealed
 T - Telegram
 V - Telephone
 X - Miscellaneous
 Y - Study



THE LAND

PRESENTED BY
KRAFT GENERAL FOODS

Annual Report Science & Technology The Land and The Living Seas 1990



THE LIVING SEAS

PRESENTED BY

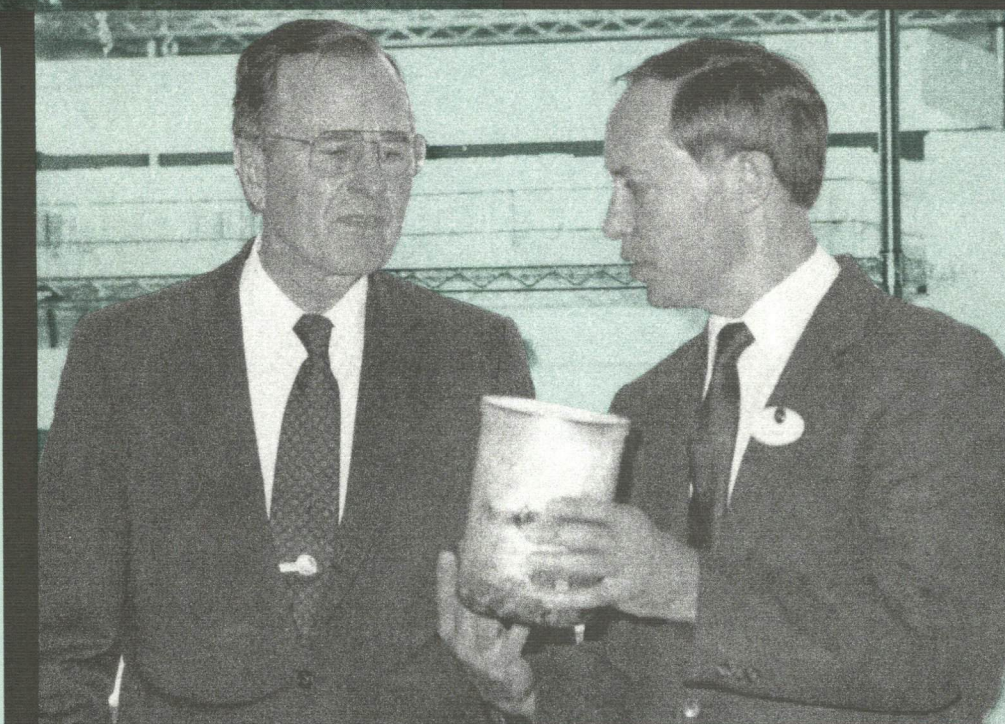


UNITED
TECHNOLOGIES

THE LAND

PRESENTED BY
KRAFT GENERAL FOODS

Annual Report Science & Technology The Land and The Living Seas 1990



8

Ron Geisler

Science and Technology Annual Report

The Land
Sponsored by Kraft General Foods

The Living Seas
Sponsored by United Technologies Corporation

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EPCOT Center Director: Greg Emmer

Project Coordinator/Editor: Dinah Jordan

Printing: WDW Print Services

Special Thanks: WDW Photography; Lynn Szymanski
WDW Print Services

Because Walt Disney World is a first name based company, second and subsequent references within each article for Disney cast members are first names.

Science and Technology

Ongoing research and technology development are major aspects of the shows at The Land and The Living Seas pavilions in Future World at EPCOT Center in the Walt Disney World Vacation Resort.

Because the facilities share common technologies and research goals, the Science and Technology group was formed, with Dr. Henry A. Robitaille as manager, in late 1989. The group was formed to achieve the most efficient use of resources and personnel in all research efforts at EPCOT Center.

The process of uniting the pavilions was gradual, and many changes took place in 1990. Several staff members who had worked exclusively in one pavilion branched out to work on challenges common to both.

One of the first efforts of the Science and Technology Group was the creation of the Chemistry Group, which has handled the chemical challenges of both pavilions, primarily those presented by the life support systems at The Living Seas.

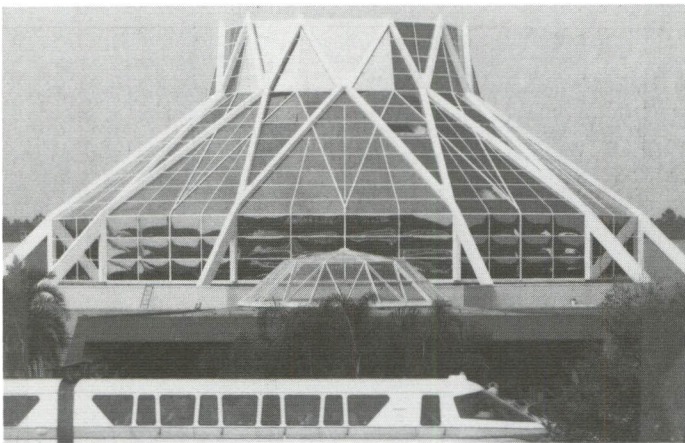
Publicity efforts were united under Peter Cook, the new Science and Technology Communications Coordinator. As such, his duties include working with Walt Disney World Publicity in hosting media and other guests on tours, and coordinating publicity and educational events.

The Biological Engineering Group was formed, joining the agricultural engineers at The Land and the life support technicians of The Living Seas. This group became responsible for the environmental, life support, and computer-related activities of both facilities.

Also, The Living Seas aquarists acquired the responsibility for the care of the aquatic systems and animals of The Land's aquacell.

The Land Overview

The Land pavilion was dedicated by Kraft, Inc., on October 6, 1982, at the same time EPCOT Center opened.



The Land is a communications, food production, and research facility which highlights many of the most important present and future world food crops. Guests learn about creative solutions to the problems of growing food — including aquaculture, integrated pest management, hydroponics, computer-controlled environments in greenhouses, intercropping, space agriculture, and biotechnology.

Objectives of The Land show include increasing public awareness of the major world crops, providing exposure to potentially important crops, and familiarizing them with concepts, technologies, and tools for agriculture in the future. It is the world's only major display of food and fiber crops from several major climate zones under one roof.

Attractions in the pavilion include "Symbiosis," a movie about man's relationship with the environment; "Kitchen Kabaret," an animatronic show about good nutrition; "Listen to The Land," a 20-minute boat ride through the green-

houses; and "Tomorrow's Harvest Tour," a 45-minute interactive walking tour through the greenhouses.

In December of 1988, Kraft became Kraft General Foods when Phillip Morris purchased Kraft, Inc. and combined the company with General Foods.

Some portions taken from "Listen to the Land," courtesy of Kraft, Inc. c. 1987.

The Living Seas

The Living Seas is sponsored by United Technologies Corporation. The pavilion opened in 1986.

The goal of The Living Seas is to give the public a better understanding of mankind's reliance on the seas, mankind's past relationship with them, and the role they will play in the future of humanity.

The facility includes a 5.7-million-gallon aquarium filled with man-made sea water, a simulated coral reef environment, and sea life ranging from sharks to rays to some of the smallest reef fish.

Guests travel through The Living Seas first through an informative queue area; then a short pre-show depicting the tools of technology; then to a 7-minute film "The Seas" about the ocean's mysteries; then through hydrolators and an omni mover to Seabase Alpha, where they view the coral reef environment.

A number of educational opportunities await the guests within Seabase Alpha, including a dive chamber lockout demonstration, dolphin research viewing, an endangered manatees exhibit, and maybe a fish-feeding session.



Manager of Science & Technology
Hank Robitaille
 Secretary: Lori Brasington

Land Manager
Fred Pettit
 Secretary: Dinah Jordan

Plant Science
 Mary Schon,
 Supervisor
 Ed Bell
 Dave Forehand
 Sandra Gerdes
 7 Students

Entomology
 Fred Pettitt,
 Supervisor
 Marian Coffey
 Rick Etzel
 Maureen Knop
 David Wietlisbach

Pathology
 Andrew Schuerger,
 Supervisor
 Bill Hammer
 Bret Norman

Biotechnology
 Lexie McKently,
 Supervisor
 (Open)

Living Seas Manager
Tom Hopkins
 Secretary: Gloria Burke

General Curator of Aquatic Systems
Bruce Miller
 Secretary: Marjorie Cianelli

Life Support
 Chris Logue,
 Supervisor
 Robert Boylan
 Rory Harvick
 Charles "Skip"
 Holzman
 Rodney Lick
 Bryan Schultz
 Chris Vega
 Jim Zurwell

Aquarium
 Michael Andrew,
 Curator
 Richard Boschen
 Joe Bycz
 Dave Clippinger
 Jane Davis
 Tom McHenry
 Jim Korzep
 Scott Martin
 Eric Rose
 Larry Rutherford
 2 Students

Dive
 Maryann Buehn,
 Supervisor
 John Ambrose
 Mark Barringer
 Paul Brown
 Jimmy Clarkin
 Ann Cleveland
 Robert Jones
 Nicole Nault
 Lynn Szymanski
 Debbie Weber
 Rodger White

Marine Mammal
 Conrad Litz,
 Assistant
 Curator
 Jane Capobianco
 Cathy Goonen
 Elaine Leslie
 Mary Monaco
 Tom Morris
 Kim Odell

Land WDI Funded Researchers:
 Ivey Burns
 Greg Kiker
 Bill Treharne

Biological Engineering
 Eldon Muller,
 Supervisor
 Bob Hines
 Bill Ham
 Sue Novak Morris

Chemistry
 Jeff Keaffaber,
 Supervisor
 Chris Coston

Communication /Education
 Peter Cook
 Laura Lacabra
 Nancy Rugh

Seas WDI Funded Researchers:
 John Gory
 Christine Johnson
 Mark Xitco

President Bush Visits Land and Seas



President George Bush saw first-hand some of the latest technologies in agricultural and marine sciences when he visited The Land and The Living Seas pavilions. On January 8, Bush addressed the American Farm Bureau Federation in Orlando, then requested a tour through the greenhouses of The Land and the marine environment of The Living Seas.

Hosted by Bob Matheison, Executive Vice President for Walt Disney World Parks, and guided by Dr. Henry Robitaille, the president viewed about 30 of the world's most important food and fiber crops grown in The Land. Also included in the tour were Florida Governor Bob Martinez, White House Chief of Staff John Sununu, and U.S. Representative from Florida Bill McCollum. Norm Doerges, Director of EPCOT Center, was also part of the tour. Tom Ricke, Kraft General Foods Senior Vice President for Corporate Affairs, made a special trip from Chicago for the event.

At The Land, Bush expressed the most interest in the Biotechnology Laboratory, where he peered into a microscope to observe asexually-propagated plantlets. At the same time, Dr. Lexie McKently briefed him on current research using recombinant DNA techniques to improve the quality of peanut oil.

In The Land's production greenhouse, Bush learned from Dr. Fred Petitt about integrated pest management (IPM). He was one of the first visitors to view the IPM Video, which showed micro-videography of biological control agents at work in The Land. Bush caught a glimpse of futuristic space agriculture in the Controlled Ecological Life Support System (CELSS) display.

At The Living Seas, Tom Hopkins and Bush visited Seabase Alpha, where his tour included a look at a marine mammal research module, where two endangered West Indian manatees reside; and a demonstration of current underwater communication techniques.

Science & Technology Research and Related Projects

Research is conducted at EPCOT Center both to maintain and enhance the show.

The Integrated Pest Management (IPM) work at The Land is an example of show maintenance-based research; no options exist for controlling show-destroying pests other than finding creative new solutions. Since biologically based shows are dynamic and constantly changing, this kind of research is never-ending.

Other research is done to develop new show ideas or enhance existing shows. These types of projects, such as the dolphin language projects at The Living Seas, add depth to shows and provides many educational and publicity opportunities.

Funds for the research conducted at The Land and The Living Seas come from two primary sources: Walt Disney World (WDW) and Walt Disney Imagineering (WDI).

Kraft General Foods (KGF) provides funds for the paddlefish research with the University of Arizona's Environmental Research Lab and most of the biotechnology research conducted at The Land. The National Aeronautics and Space Administration (NASA) and the Agricultural Research Service of the United States Department of Agriculture (ARS/USDA) provide non-monetary support via equipment loans, special expertise, and technical services.



Exhibits at The Land and The Living Seas, such as the Mariculture Lab at The Seas, combine education with entertainment.

Plant Science Projects

In 1990, the Plant Science Group was formed to enhance communication between the disciplines of the department that are directly involved in plant health and maintenance. Individuals from the plant nutrition, horticulture, entomology, plant pathology, and engineering disciplines are involved in a weekly greenhouse walk-through, in which the status of crops is discussed and crop scheduling decisions are made.

Nutrient Solutions

The first year of the plant nutrition program, coordinated by Dr. Mary Schon, resulted in significant changes in the formulation of the nutrient solutions feeding the plants. In the Desert and Tropic greenhouses, the addition of ammonium sulfate to the nutrient solution increased the acidity of the root zone. This made nutrients more available for plant uptake; eliminated micronutrient deficiencies in rice, cassava, and other crops; and allowed a 75% reduction in concentrations of nutrients delivered to the plants' roots in those greenhouses.

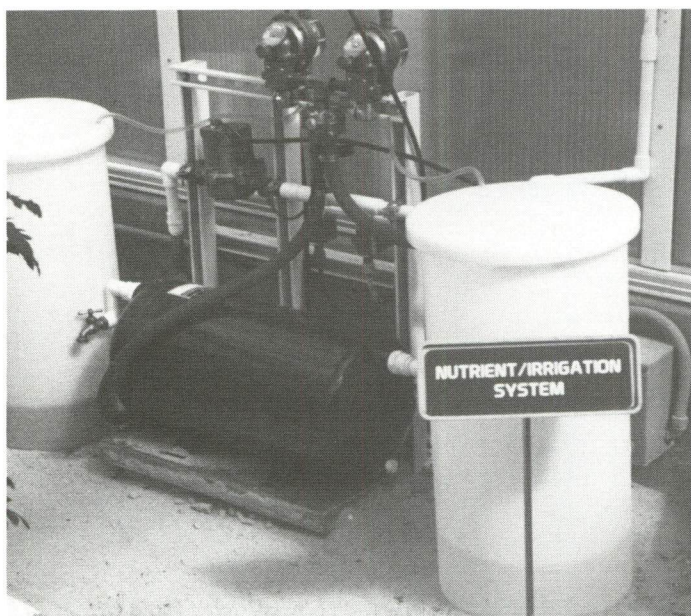
A primary objective of the plant nutrition program was to begin fine-tuning the hydroponic nutrient solutions at The Land. Nutrient solutions were fine-tuned for individual crop species and for specific growth stages of plants to enhance plant development with the most efficient use of fertilizer salts.



Dr. Mary Schon, Plant Nutritionist

Individual Injectors

The use of individual injector systems will allow each of the ten plots in the String House to be fertilized independently.



Individual Injector

This is critical for optimal efficiency of plant feeding, since crops have species-specific nutrient requirements. Two of the individual injectors were installed in 1990, and the rest will be installed in 1991.

Hydroponic plant nutrition can be adjusted with individual injectors by changing the concentration of nutrients as the growth stage of the crop changes. Dr. George Hochmuth, from the University of Florida Vegetable Crops Department, recommended a hydroponic solution for tomatoes grown in Florida greenhouses. It is a 5-step series of nutrient solutions which increases in nitrogen, potassium, calcium, and magnesium as the plant continues to mature and bear fruit.

The Land's plant nutrition staff modified Dr. Hochmuth's program into a 3-step progression of nutrient solutions that has produced good results with both tomatoes and peppers. Decreasing nitrogen fertilization by 66% during early plant growth phases resulted in less suckering and minimal early blossom end rot.

Plant Nutrition: Blossom End Rot (WDI)

The second major objective of the nutrition program was to alleviate blossom end rot — the most devastating nutritional disorder at The Land — in pepper and tomato fruit.

A calcium deficiency in the fruit causes blossom end rot. Research in 1990 examined the possible methods of alleviating blossom end rot: by applying calcium or “anti-

transpirants” — agents that prevent transpiration — directly to leaves or by injecting calcium directly into the fruit.

Preliminary studies indicated that anti-transpirant applications early in fruit development stimulated early fruit yields and increased total calcium movement into pepper fruits. Research in 1991 will continue in the show greenhouses to determine long-term effects of anti-transpirant applications on pepper yields and blossom end rot occurrence.

Horticulture: Crop Variety Trials (WDW)

Crop variety trials are conducted to evaluate new crop releases and to examine different horticultural practices and nutritional programs. Trials are usually conducted in the Support Greenhouse. Different varieties of bell peppers, tomatoes, and sugar cane were studied in 1990's trials.

The pepper trial, conducted in January through June, evaluated the effects of two nutrient solutions with different calcium/potassium ratios on fruit development and total yield. This study included eight varieties. Although harvestable yields were comparable, total yields were significantly different due to a higher percentage of fruit with blossom end rot in the formula with the lower calcium/potassium ratio.

A tomato trial was conducted in July through November. It evaluated eleven new varieties for their tolerance to high heat and high relative humidity. Growth habits, flowering, and fruit-setting potentials were examined under two different fertilizer solutions.

Plant growth in the lower nutrient concentration was not significantly different from plant growth on the higher nutrient concentration. This indicated the potential for considerable savings in fertilizer usage and costs. Poor fruit development and low crop yields on all varieties in the summer months, due to high temperatures and humidity, limit tomato production to cooler months.

Six varieties of sugar cane were tested in January through May. The United States Department of Agriculture Sugar Cane Field Station in Canal Point, Fla., supplied all the varieties. From this trial, a red-stemmed Florida variety with a vigorous growth habit was chosen to be included in the show.

Also in 1990, a few variety trials were incorporated into the show. For example, tipburn had become a problem on bibb lettuce grown in the heat of summer. A lettuce trial was conducted in the production house raceways from March through July. As a result, Oxford, a new variety from Holland, was chosen because of its greater heat tolerance and higher harvest quality. Oxford was favorably accepted by Walt Disney World chefs.

Engineering: Phenology Modeling Studies (WDI)

Greg Kiker, a University of Florida graduate student and researcher at The Land, has been developing a simulation model that uses greenhouse temperatures to predict important phenological dates (flowering and fruiting) and growth parameters (height and node addition). Knowledge of these parameters can aid in crop decision making, in order to schedule crop transplant and removal dates that will continuously maintain the highest possible show quality of plants in the greenhouses.

Another component of the study traces crop progress daily. Plant scientists can follow the daily progress of a plant's development and estimate the time until the next stage. Knowledge of the crop's phenological status can aid plant scientists in proper timing of nutrient solution changes to meet the plants' nutritional needs as the crop matures. Ultimately, this information should lead to greater efficiency in crop scheduling and plant production.



Cultivar trial for lettuce

Integrated Pest Management Projects

Integrated Pest Management (IPM) is an approach for managing the pests and diseases that affect crop plants, including those in The Land's greenhouses.

In IPM, careful monitoring is necessary to provide information about the level of damage the pest is likely to cause. Decision makers use this information to determine if treatments are required and what strategy to use. Compatible combinations of cultural, mechanical, physical, biological, and chemical control tactics are sought that minimize adverse effects on the environment.

The IPM staff faced several challenges in 1990, including new pests in the greenhouses and continued efforts to control pre-existing ones.

Tomato Spotted Wilt Virus (TSWV)

A WDW grant provided funds for the University of Florida to conduct research on tomato spotted wilt virus (TSWV), a new and potentially devastating plant disease in Florida that is transmitted by thrips. Several varieties of plants grown at The Land were tested for their reaction and resistance to the virus.

UF professors Dr. Gary Simone and Dr. Richard Christie and Division of Plant Industry (DPI) researcher Dr. Larry Brown conducted the research.

Several of the plant species tested in 1990 showed some resistance to TSWV. Cotton and bean cultivars were found to be immune, while the cucumber variety 'Vetomil' showed high resistance to systemic movement of the virus. All pepper and lettuce cultivars were highly sensitive to several TSWV strains.

Four tomato cultivars exhibited moderate degrees of resistance, depending on time of inoculation, temperature, and the strain of TSWV. Recently two new tomato cultivars have become available that show high degrees of resistance to TSWV in Hawaii and California. It is still unknown whether these cultivars will perform well in Florida greenhouses.

The results of this research have provided information on the potential severity of TSWV on plants in The Land's greenhouses and have given the staff at least a year's lead time on responding to the virus when it does occur in The Land. Continuing research in 1991 will include several new species of plants.

Thrips Exclusion (WDW)

The western flower thrips (*Frankliniella occidentalis*), the most common thrips in The Land's greenhouses, is an efficient vector of TSWV. While pesticides and beneficial insects, such as the predatory mite *Neoseiulus cucumeris*, can keep the thrips population low enough to prevent significant thrips feeding damage, it only takes one infected thrips to transmit the disease. Therefore, the best way to prevent an outbreak of TSWV at The Land is to prevent infected thrips from entering the greenhouses.

Thrips can enter the show greenhouses from several points, but the cooling pads represent the main entry point that can be controlled. All of the air in the greenhouses is exchanged every minute through these paper filters, which allows many species of tiny insects to enter.

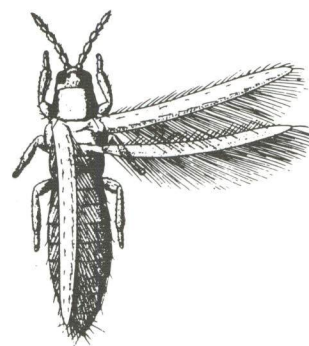
Tests in 1990 concentrated on determining the quantity of insects, especially thrips, that were actually pulled into the greenhouses through the cooling pads. Entomologists Rick

Etzel and Maureen Knop found that up to 500 thrips daily entered each of the two greenhouses tested. Since TSWV has been found on ornamental plants in EPCOT Center and elsewhere in Orange County, this number of thrips was seen as a serious potential threat to The Land crops.

Biological Engineer Sue Novak Morris and Maureen tested screen materials that showed promise in filtering out thrips, but they would produce too much air flow resistance to use with existing fans when dirty or wet. Keeping them clean would be too labor-intensive to be practical.

Sue then began working with Munter's Corp., the manufacturer of the cooling pads currently in use, to modify the pads to improve insect exclusion without appreciably increasing air resistance.

A chamber was built to test different pad modifications. Two modifications were tested in 1990 and tests will continue in 1991. The best option will be installed when testing is completed.



A thrips. Drawing enlarged, actual size 1.5 mm

Figure from *AN INTRODUCTION TO THE STUDY OF INSECTS*, Fourth Edition, by D. J. Borror et al., copyright ©1976 by Saunders College Publishing, reprinted by permission of the publisher.

Leafminer Biological Control (WDW)

One biological control tactic uses *Opius dissitus*, a tiny wasp that parasitizes *Liriomyza sativae*, a fly whose larvae tunnel through plant leaves. The wasps find the fly larvae and lay eggs in them. The immature wasp uses the fly larva as food as it develops. These wasps are reared and released at The Land.

In an effort to increase efficiency of our methods for producing the parasitic wasp, Fred Pettit and David Wietlisbach conducted studies to determine the number of healthy fly larvae that could develop on a single leaf. The research found that about 80 healthy fly larvae could be reared on a single lima bean leaf. When more than 80 were reared on a leaf, limited food supplies resulted in a lower average fly weight. As the weight of the flies diminished, so did the weight of the wasps that developed on them.

The researchers were able to reduce the number of lima bean plants used in the rearing process and to increase the number of the beneficial wasps produced.



Leafminer-Damaged Leaf

Location of Prey by Insect Parasitoids (WDI)

Fred and Steve Wolf, along with other Land entomologists David W. and Marian Coffey, worked with Ted Turlings of the USDA Insect Attractions Lab in Gainesville, Fla., to determine whether the female parasitoid *O. dissitus* finds leafminer larvae using her olfactory sense.

The study determined that chemicals released into the air by insect-damaged plants attract the wasp to the plants. The wasps used chemical signals in flight to differentiate between damaged and undamaged plants.

Additional studies showed that after a wasp laid an egg in a leafminer on a certain species of plant, the wasp increased its degree of preference for that plant species over another plant species. The wasps are apparently capable of associating airborne chemicals from a damaged plant with the positive experience of egg-laying.

This information has potential implications for biological control of insect pests. Insect predators and parasitoids may be given certain experiences before release in crop plants to increase their effectiveness in finding prey. This also may be used as a screening technique useful in quality control of laboratory-reared predators and parasitoids.

Rice Root Aphid (WDW)

The rice root aphid, *Rhopalosiphum rufiabdominalis* (Sasaki) was first collected at The Land from rice crops in 1985. Since then, it has infested the roots of squash plants in the creative house and caused sporadic damage there.

During the summer of 1990, it became a major pest on butternut squash roots. Populations were so dense that the root systems were discolored and rotting. During the summer, an



Rice Root Aphid

endemic fungus that attacks aphids became established in the greenhouse. During the last four months of 1990, natural infestations of the fungus were used to keep root aphids populations low enough to prevent significant root damage.

Samples of the fungus were sent for identification to Dr. Drion G. Boucias of the University of Florida Entomology and Nematology Department. He identified the fungus as *Verticillium lecanii*, which is commonly associated with aphid hosts. The fungus was then cultured in The Land's laboratory and placed in storage.

Whitefly Biocontrol (WDW)

Sweet potato whitefly (*Bemisia tabaci* Gennadius) is a serious pest of many crops grown at The Land. It also causes millions of dollars of damage to ornamental and vegetable crops each year.

This year marked the beginning of a cooperative project with Dr. Kim Hoelmer, a research entomologist with the USDA's Horticultural Research Laboratory in Orlando, to study the effectiveness of several biological controls of the whitefly. Beneficial insects introduced into The Land greenhouses in 1990 included the parasitoid wasps *Eretmocerus* sp., *Encarsia transvena*, and *Encarsia nigricephala*, and the predatory beetles *Delphastus pusillus* and *Nephaspis* sp.

These insects were reared with the cooperation of Dr. Lance Osborne at the IFAS Central Florida Research and Education Center in Apopka.

The results of this work will better enable the scientists at The Land to protect crops from whitefly injury. In turn, the knowledge gained at The Land will help ornamental and vegetable growers elsewhere to use these beneficials more effectively as part of their IPM program.

IPM Video

An unnarrated preliminary version of the Integrated Pest Management Videotape was completed in early 1990. It contains video microscopy work by plant pathologist Andrew Schuerger and entomologist Rick Etzel, who also edited it using facilities of Disney's Post-Production Group.

Microscopic scenes of several biological control agents, including a lady beetle attacking aphids and parasitoid wasps laying eggs in leafminer larvae, are included in the video.

President George Bush saw an excerpt of the IPM video during his tour. A portion of the tape was included in the "Florida Home Grown" show on WMFE-TV in January.

Other visitors to view the video included the following: IBM executives in January; the Prince of Monaco and a group of almost 200 editors and writers in September; Disney Dimensions, the Orlando Sentinel editorial board, and Eddie Albert in October; and the FCC Commissioner and the Kraft General Foods Crop Development group in November.

Tomato Mosaic Virus Control (WDW)

Plant viruses can be transmitted through the nutrient solution in recirculating hydroponic systems. Research began in early 1990 to investigate how rapidly tomato mosaic virus (ToMV) is spread and how temperature and the acidity (pH) of the nutrient solution influence disease development.

Results showed that warm temperatures, typically encountered during the summer months in Florida greenhouses, greatly increase plant-to-plant spread of ToMV. Temperatures cooler than 80°F slowed the spread of the virus. Root damage usually occurred between 14 and 21 days in warmer temperatures, but it took as many as 40 days in cooler temperatures.

Research in 1991 will use environmental control chambers to study the role of temperature and pH on symptom development.

Fusarium solani root pathology (WDI)

Fusarium solani is a fungal pathogen that can cause devastating damage to plant roots that eventually results in permanent plant wilt. Research studying the effects of temperature, pH, humidity and light quality on disease development on mung bean was completed in 1990.

High temperatures (greater than 80°F) allowed plants to resist the disease, while lower temperatures (around 68°F) caused plants to succumb to the disease. Even short periods of high temperatures killed the pathogen without affecting the plant.

Acidity of the nutrient solution also influenced disease development. Low pH (4.0) increased the number of fungal spores that attached to roots, which subsequently increased the severity of the disease.

Light quality studies used high pressure sodium, metal halide, and fluorescent lights. The lamp type used for these experiments had no effect on disease development and any one of the three lamp-types functioned well for plant studies.



Tomato Mosaic Virus studies on peppers in IPM greenhouse.

Several new pests were found in the greenhouses in 1990 and required control efforts. The introduction of these new pests emphasizes the importance of the insect exclusion project.

Common Name	Scientific Name	Host Plant(s)
Yellow sugar cane aphid*	<i>Sipha flava</i> (Forbes)	sugar cane, rice
Corn leaf aphid	<i>Rhopalosiphum maidis</i> (Fitch)	sorghum
Potato aphid	<i>Macrosiphum euphorbiae</i> (Thomas)	pepper
Rusty plum aphid	<i>Hysteroneura setariae</i> (Thomas)	rice
Cottony grass scale	<i>Pulvinaria elongata</i> Newstead	sugar cane
Long-tailed mealybug	<i>Pseudococcus longispinus</i> (Targioni-Tozzetti)	cassava
Papaya whitefly	<i>Trialeurodes variabilis</i>	papaya, cassava
Garden fleahopper*	<i>Halticus bractatus</i> (Say)	Nasturtium, oregano

* A reintroduction.

Plant Environment Control

Research efforts to update and improve methods for controlling the environment of plants within the greenhouses continued in 1990. The Biological Engineering Group did the primary work in this area.

Greenhouse Monitoring and Control (WDI)

The Land's greenhouses have had an environmental monitoring system (EMS) since 1984 to keep track of temperature, humidity, and other environmental parameters. The Land's computers record these data, which are used within The Land, as well as by Reedy Creek, WDW Engineering, and Landscaping.

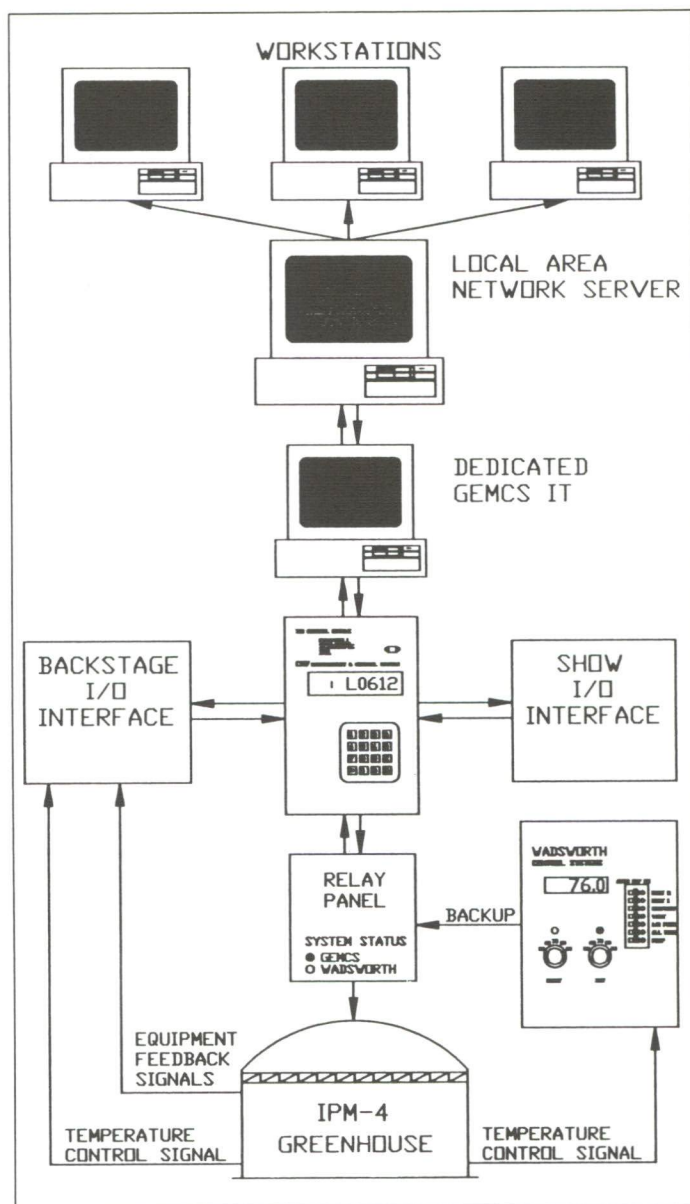
While environmental monitoring is important, an ultimate goal is to be able to automatically control the greenhouse environment using computers. Since 1986, The Land has worked with The Environmental Research Lab (ERL) of the University of Arizona, Tucson, to develop and test greenhouse environment and control software (GEMCS).

Sue Novak Morris worked with ERL personnel in 1990 (1) to improve data collection and data file output routines, (2) to improve the software to activate environmental controls at established temperature points, and (3) to add hardware and software to permit the original relay controls to be used as a back-up system.

Software testing began in a small backstage greenhouse. A computer in The Land office uses greenhouse temperature levels to control the greenhouse environment with its heaters, vent doors, fans and cooling pad water pump. Later, relative humidity will also be controlled using this system.

An important feature of GEMCS is two-way interaction: the computer knows immediately if the greenhouse hardware does not respond correctly to its command.

In preparation for the installation of GEMCS, improvements were also made to the EMS. Hardware was expanded to double its original capacity; a data base was developed to track sensors and enable GEMCS interaction; and new types of temperature and humidity sensors were evaluated for accuracy.



Irrigation Control (WDI)

Engineering Consultant Ivey Burns, Biological Engineer Eldon Muller, and Agronomist Ed Bell, developed the computerized weighing lysimeters at The Land. The weighing lysimeter produced several dramatic results from its inception.

Early tests, in which the weighing lysimeters controlled irrigation for peppers, demonstrated a significant reduction

in nutrient solution use and dramatically decreased nutrient solution discharge into the environment. In these preliminary tests, crop life lengthened considerably, with corresponding improvements in yield and show quality. Labor and related costs associated with more frequent crop cycling declined.

Irrigation Control (continued)

The weighing lysimeter control system was integrated into the control systems for all rockwool production in The Land greenhouses. Research continued on crop responses and system enhancement with additional greenhouse crops such as eggplant, tomato, and cucumber.



Weighing lysimeter in use at The Land.

Studies with sand culture demonstrated the ability to control irrigation precisely with sensor-based systems. Potential savings from increased efficiency are equally promising. Future research will focus on developing a unique real-time sensor-based system for this purpose. An early prototype is now being tested.

Walt Disney Imagineering has applied for a patent on the weighing lysimeter.

CELSS (WDW)

Installation of new computer control equipment for the National Aeronautics and Space Administration/Controlled Ecological Life Support System (NASA/CELSS) plant growing system was completed in 1990. Biological Engineer Bob Hines, in cooperation with NASA scientists Ralph Prince and Dennis Chamberland and Bionetics scientists Jim Bledsoe and Steve Godfrey, developed and installed new hardware and software for CELSS growing units.

The new system proved to be reliable; it independently maintained the nutrient solution pH, temperature, ion concentration, and liquid level for each of six plant-growing subsystems.

Discussions in late 1990 between NASA and EPCOT Center researchers identified several areas for joint research in the upgraded CELSS plant-growing system. Research in 1991 will study the compatibility of different plant species to

flourish when grown in the same recirculating hydroponic nutrient solution. Also, crop cultivars will be evaluated for use in space agriculture systems. These tests will include rice, bean, and herb cultivars.

Software Development (WDW)

The engineering group progressed in its efforts to upgrade and expand computer efficiency, both in control of systems and in user-end operations. One major change was the upgrade from an 80 megabyte hard drive to a 300 megabyte hard drive for The Land's Local Area Network (LAN).

During the year, several new software programs were installed at The Land. These were AutoCAD, Lotus 1-2-3, Foxbase, Current Contents on Disk, ProCite, ProSearch, and Turbo C++.

Other Projects

Researchers at The Land explored state-of-the-art technologies in improving plant and fertilizer quality.

Biotechnology

Dr. Lexie McKently continued WDI-supported research to improve the quality of plant vegetable oils through genetic engineering. The 'gene of interest' reduces saturated fats in the oil of engineered plants, while increasing monounsaturated fats. Both qualities make oils more healthful, and can reduce serum cholesterol levels in people.



This past year's efforts concentrated on developing the gene transfer protocol. The bacterial species *Agrobacterium tumefaciens* is the vehicle used to carry and transfer the gene into isolated plant cells. Once engineered, these treated cells grow and develop into whole plants that produce the improved oil.

In research supported by WDW, several plant species were propagated as "Teenie Greenies," which were sold in EPCOT Center merchandise locations. These plants included potato, cactus, jojoba, strawberry, banana, pineapple, cassava, and peach palm.

Plasma Torch Project (WDI)

Bill Treharne, visiting researcher, worked on a system to generate nitrogen fertilizer compounds from atmospheric air. The system uses an electric arc to ionize the nitrogen and oxygen, which recombine as nitric oxide compounds. These dissolve in water to make nitric acid, a nitrogen fertilizer.

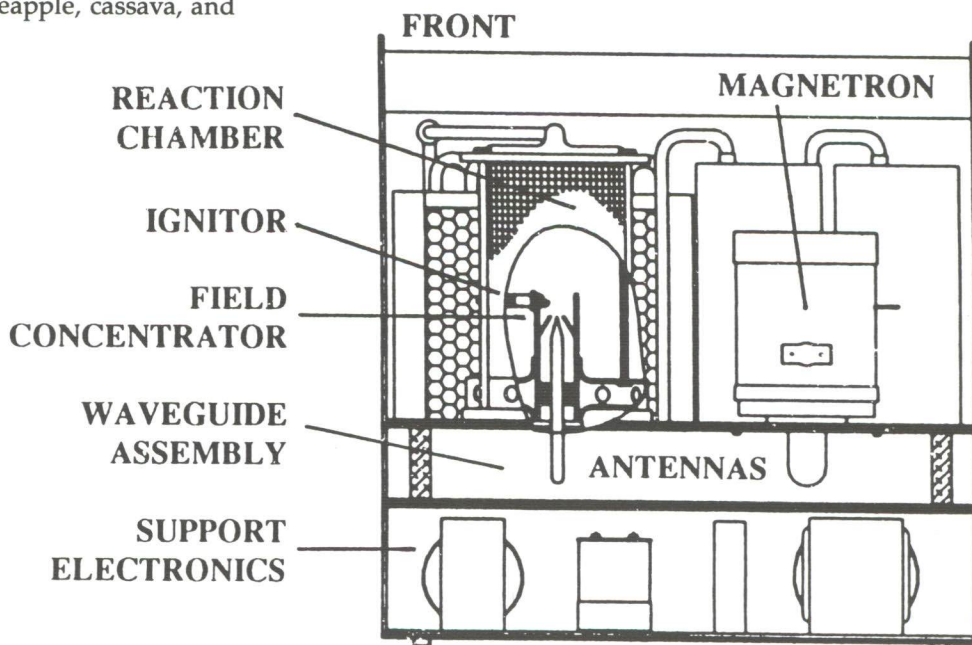
The arc method has limitations due to low electrical efficiency, contamination of the chemical process from electrode erosion, and the emission of a strong electrical noise.

Drs. Bill Atwill and Bob Martin of FuturLab are working with him to replace the electric arc with a plasma torch, which produces an "atomic flame" of charged particles from ordinary air. The flame floats on a reaction tube above the tip of the torch, without contacting any part of the device. Although flame temperatures can reach more than 27,000°F, the plasma releases little heat.

Air entering the reaction tube will be separated into its oxygen and nitrogen components, which will then recombine into the optimum concentration mix to maximize nitric oxide yields.

The plasma torch will be energized using an inexpensive magnetron from a microwave oven with solar photovoltaic panels as the energy supply.

MICROWAVE PLASMA NITROGEN FIXATION APPARATUS



Marine Mammals

One goal of The Living Seas is to increase our knowledge and understanding of marine mammals. Research studying dolphins and manatees, and improving the techniques used to study them, progressed in 1990.

Abstract Problem Solving In Bottlenose Dolphin (WDI)

Christine Johnson has studied dolphin behavior and problem solving abilities since June 1988. She earned a Ph.D. in psychology from Cornell University in August 1990.

Early studies tested the dolphin's ability to use the abstract concepts same and different. When presented with a pair of objects, the dolphin was required to touch one target if the objects were the same and another if they were different. The Living Seas' dolphins, Toby and Bob, succeeded at this task with a significant accuracy.

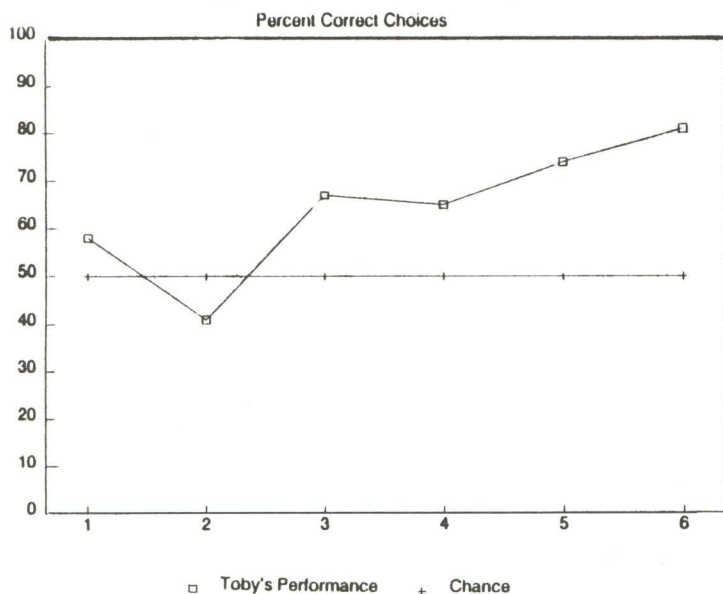
A more recent study involves an analogy. In this task, the dolphin is presented with a pair of objects which are either the same or different. He is also presented with two alternative pairs, one of which is the same and the other which is

different. His task is to select the alternative pair which represents the same relationship represented by the sample pair.

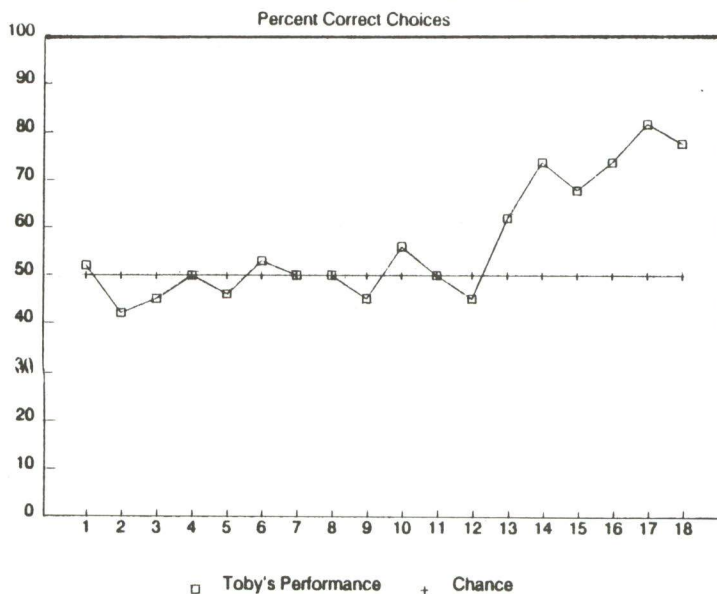
Choosing the analogous alternative requires that the dolphin recognizes whether or not the objects within a pair are the same, and that, for instance, two frisbees have something in common with two bowling pins: the abstract quality of "sameness."

The dolphins succeeded on this test using familiar stimuli -- objects they have worked with before. They were then tested with novel stimuli. The next phase of the problem-solving project will involve training the dolphins in a cooperative mimicry paradigm.

TOBY: One Alternative



TOBY: Two Alternatives



Dolphin Language Keyboard Project (WDI)

John Gory and Mark Xitco, two psychology Ph.D. candidates from Southern Methodist University in Dallas, Texas, have been studying another aspect of dolphin intelligence.

The Dolphin Language Keyboard Project, currently under development at The Living Seas, represents a sophisticated new approach for instructing dolphins in an artificial language system. A large, underwater keyboard will serve as a language medium between humans and dolphins, and between dolphins. Each key will be a unique multidimensional symbol referring to a particular word, such as an object or action.

Sentences will be created by activating sequences of keys according to a pre-determined grammar. Using the keyboard, dolphins and humans will be able to make requests, describe their environment, and ask questions.

Several generations of keyboard design have evolved with the assistance of WDI. After much research into materials and designs, the final design has been reached. A prototype keyboard is currently under construction at WDI, and will be completed and introduced to the dolphins in the coming year.

Other language projects are planned for the dolphins. John and Mark will test the dolphins to determine if they can learn to use tools by watching how humans use them and analyze the dolphins' ability to remember their spatial environment. As these studies progress, tools and other objects will be added to the keyboard, allowing more complex human/dolphin interaction.

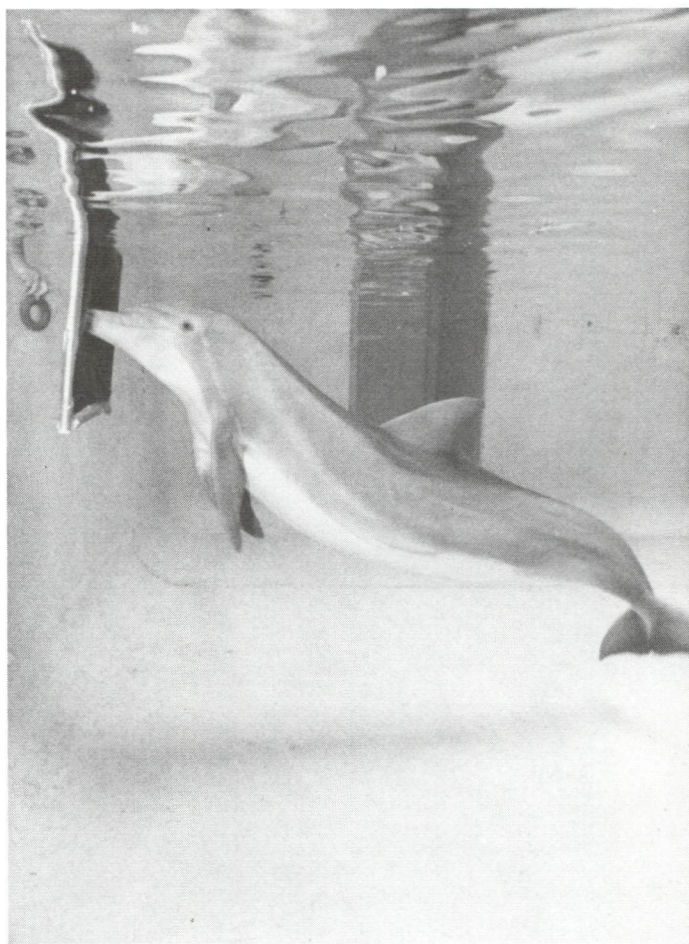
Dolphin Echolocation Studies (WDI)

At The Living Seas, investigation of the dolphin's biological sonar, or echolocation system, continued under the direction of Mark Xitco. During echolocation, dolphins produce a rapid series of clicking sounds, which create unique echoes as they strike objects in the distance. Dolphins learn about their environment by actively listening to those echoes.

Over the past year, the dolphins were tested using a large set of 3-dimensional objects as echolocation targets. The dolphins have become highly proficient on their echolocation task, and have proven themselves to be among the best trained echolocating dolphins in the world.

Throughout testing, the dolphins demonstrated the ability to reliably make discriminations on the basis of object shape, material composition, and internal structure. However, an analysis of the dolphins' errors revealed that when they did make mistakes their errors were influenced predominantly by the shape of the target object. These results will be used in future tests to examine the dolphins' capacity for integrating echolocation information into its overall perceptual and communicative scheme.

*a sophisticated
new approach
for instructing
dolphins*



A dolphin echolocates to study an object behind the screen.

Manatee Observations (WDW)

Manatees, which number between 1200 and 1500 in Florida, are an endangered species. Because of this, Living Seas scientists recognize the importance of communicating to the public the precarious status of these herbivorous mammals.

Jean Pierre (J.P.) and Lorelei, the manatees residing at The Living Seas, provide an opportunity for scientists to observe the manatees daily while educating the public about the manatee's only natural enemy — man. High mortality combined with a low reproductive rate has made the manatee's future uncertain.

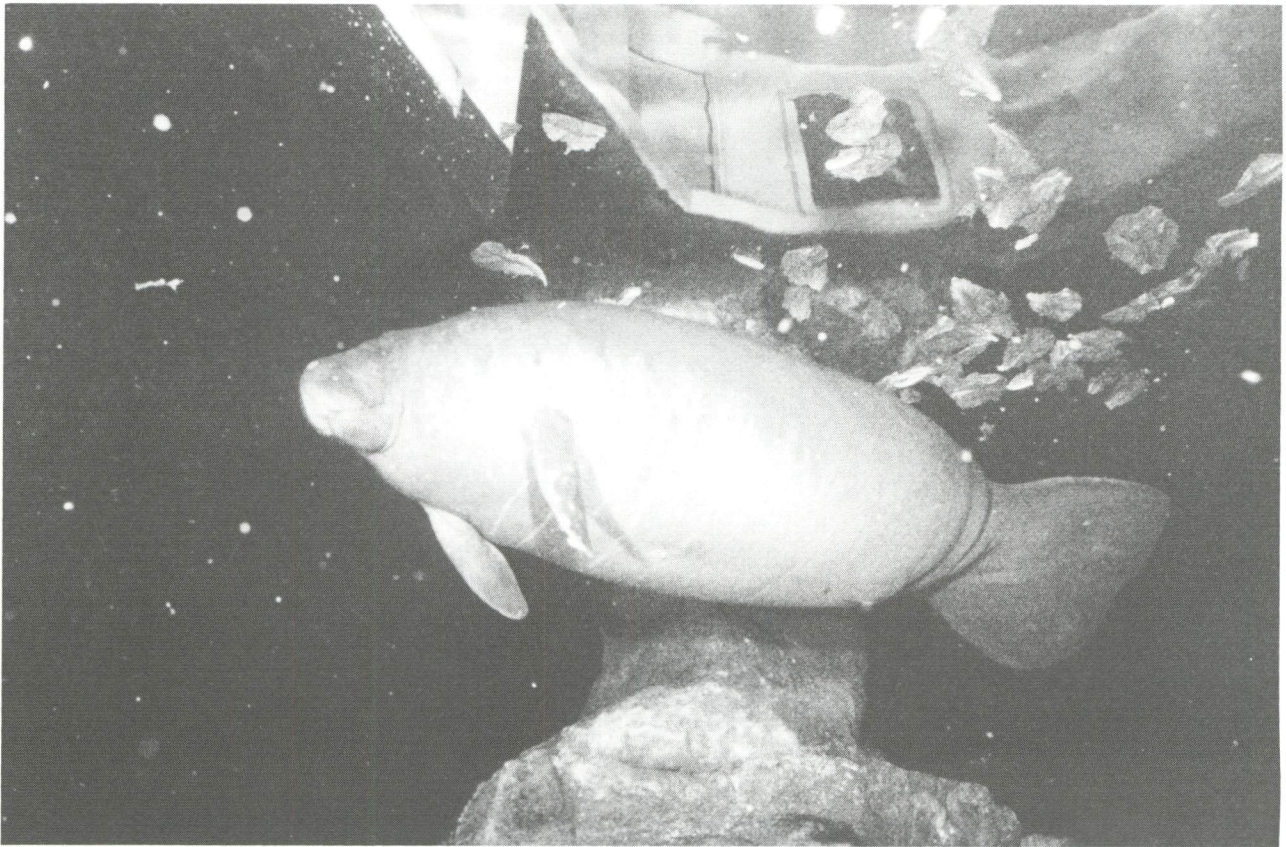
Manatees normally have one calf every three to five years, according to Conrad Litz, marine mammal specialist at The Living Seas.

Lorelei was the first manatee to be bred and born in captivity, at Miami's Seaquarium in 1975, while J.P. was found

orphaned in 1980 when he was two weeks old. The manatees arrived at The Living Seas in June of 1988.

In September of 1989, J.P. and Lorelei were observed breeding, and blood tests of hormone levels confirmed pregnancy in October. However, Conrad suspects she may have already been pregnant at the time. He explained that manatees have a gestation period of 12-14 months, and the stillborn calf Lorelei delivered in June 1990 was almost fully developed.

In September of 1990, the pair were observed mating again, and pregnancy was confirmed by checking hormones. This time, the scientists plan to monitor the pregnancy using ultrasound and Doppler techniques, as well as blood tests. The marine mammal staff is working with a Canadian company to develop a Doppler transducer that works for manatees.



A manatee at The Living Seas.

Manatees and Passive Integrated Transponder Tags

WDI is currently funding a Department of Natural Resources research project using passive integrated transponder (PIT) tags in a pilot study to test the potential of these tags for a long-term marking study of manatees. The PIT tag is inserted below the skin. Each glass-enclosed microchip is programmed with a unique identification code. Experts in

determining wildlife population levels have indicated that such permanent marking programs are essential to the development of accurate population estimates.

The project proposes using the tags on available manatee carcasses first to determine the best application sites and techniques. The second phase calls for the tagging of captive manatees throughout the state (including J.P. and Lorelei) and monitoring the animals for tag loss, failure, or migration.

Non-Mammal Aquatic Animals

Science and Technology work with non-mammal aquatic animals included sharks, Caribbean reef fish, clear-nose skates, and paddlefish.

Swimming Patterns of Sharks (WDW)

The swimming habits of three sharks in The Living Seas were observed for a nine-month period. The researchers, Sherri Seligson and Deborah Weber, studied a tiger shark, a bull shark, and a brown shark. When a second brown shark was introduced, the original brown shark's swimming habits changed dramatically to coincide with those of the new brown shark. The other two sharks also appeared to change their patterns to accommodate the new arrival.

In addition, researchers observed the sharks' reactions to a variety of other stimuli, such as divers, dolphins, and other items in the water. Sharks avoided dolphins and oriented toward the outer wall of the aquarium. Although they seemed to alter their patterns in response to divers, their response varied with the situation.



Sharks



Larval Rearing of Caribbean Reef Fishes (WDW)

Living Seas researchers Rodger White and Richard Hall worked on a project to document the embryology, larval development and spawning behaviors of several species of Caribbean reef fish.

The control species for the project is *Balistes vetula*, the Queen Triggerfish. To date, no one has successfully reared this species to maturation. Its larvae are hatched and reared in the lab. The fish reproduce in the Living Seas main aquarium, and average about 100,000 eggs produced per month. This high rate of specimen availability allows for virtually unlimited experimentation.

Prior to hatching, specimens are removed from the sites. Collected eggs are hatched and the free-swimming larvae are placed in specially-designed rearing chambers. In a trial experiment of the rearing system's efficiency, the larvae survived 145 hours after hatching, an increase of 33 hours over previous attempts.

The project will now center on determining the optimum food source in size and nutritional value for the larvae.

Clearnose Skate in Biomedical Research (WDI)

Biomedical researchers have found that sharks and their relatives exhibit an unusual resistance to cancer. Sharks, however, are difficult to study in the wild and do not usually breed in captivity.

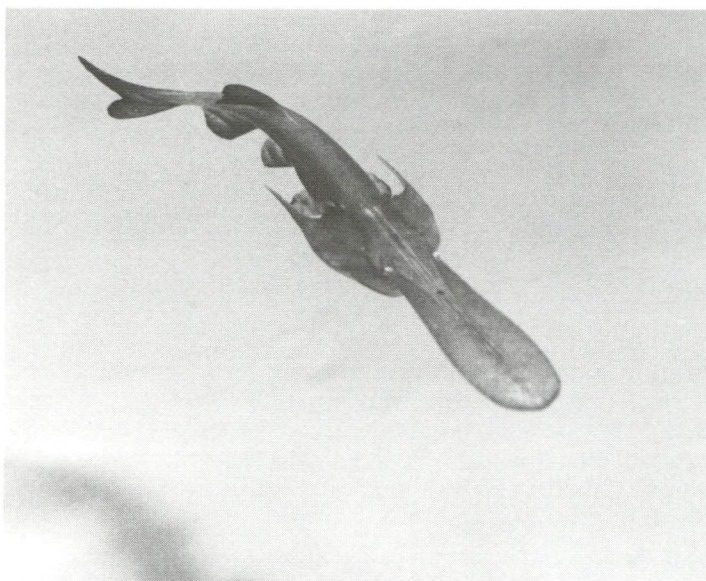
However, clearnose skates, which are related to sharks and rays, do reproduce in captivity. Current and future studies into the cancer-resistant characteristics of skates are dependent on the researchers' understanding the animals' reproductive habits.

Because skates lay eggs outside the body, embryos can be studied as they develop, without sacrificing the mother. In fact, researchers have been able to study skates in all stages of development.

WDI has been supporting the biomedical research conducted by Dr. Carl Leur's group at Mote Marine Laboratory in Sarasota, Fla. In return, Dr. Leur and his researchers breed skates for the Seas' mariculture exhibit, which creates an excellent opportunity for EPCOT Center guests to view the development of skate embryos.



Clearnose skate embryo



Paddlefish

Paddlefish Aquaculture Research (WDI)

Paddlefish raised in The Land's aquacell have not grown well because of inefficient feeding. Paddlefish normally feed continuously by filtering zooplankton from the water. Working with The Land, Environmental Research Lab researcher Chris Brand designed and studied a proposed modification to the aquacell that would improve feeding efficiency.

The first approach was to physically modify the culture tank (raceway) to produce a circulating water flow strong enough to maintain powdered manufactured feed in suspension, allowing paddlefish greater access to it. The benefit of the increased food consumption, however, was partially offset by increased swimming energy required of the fish during feeding.

The second approach was to develop a method and the hardware to produce and deliver live natural foods to the paddlefish. A suitable method of collecting wild zooplankton was developed to supply the required amount, and a plankton recovery option was developed in the tank to reduce loss through filters.

In full-size test raceways at ERL, paddlefish were fed freshly hatched brine shrimp, *Artemia nauplii*, and live zooplankton. The average weight gain in six months was equivalent to a year's weight gain in The Land's aquacell.

The experimental results suggest that further improvements should be made to the live food method. However, since artificial diets are usually more cost-effective and uniform in quality, further studies on the use of artificial diets and feeding methods are planned.

The Human Factor

Some of the research at The Living Seas is designed to improve man's ability to explore the marine environment. For example, three closely-related WDI projects are working to ensure the safety of Living Seas divers, who spend several hours per day in the water. This research has potential benefits for the rest of the diving industry as well.

Dive Computer Modification

The doppler research project, which was designed to determine the effects of frequent shallow diving on gas levels in the blood, required development of a method for exact profile recording.

Dive computers record the depth, time, tank pressure, temperature, and the time remaining of the dive. Most computers, however, only save the last dive. An Oceanic dive computer was modified to save up to ten dives, and to provide the capability to down-load to a PC.

In conjunction with Dudley Crosson, president and chief scientist of Delta P in Port St. Lucie, Fla., a software package is being developed that will easily store and analyze the physiological data collected.

Doppler Digitization

SCUBA diving causes nitrogen bubbles to form in the blood, which can cause decompression sickness — “the bends” — if a person ascends from deep waters too quickly. However, little is known about the effects of frequent shallow diving on blood nitrogen levels.

A Doppler Ultrasonic Bubble Detection Unit allows researchers to hear nitrogen bubbles in the blood. Researchers grade the bubbles in terms of frequency, percentage, and number of cardiac cycles. The process of grading doppler recordings is a time-consuming and subjective procedure.

In order to reduce time and standardize the procedure, the task of digitizing the ultrasonic bubble detection signal was initiated, using a computer to quantify the nitrogen bubbles in the blood.

One goal is to correlate bubble activity with dive profiles to evaluate the physiological effects of prolonged shallow diving.

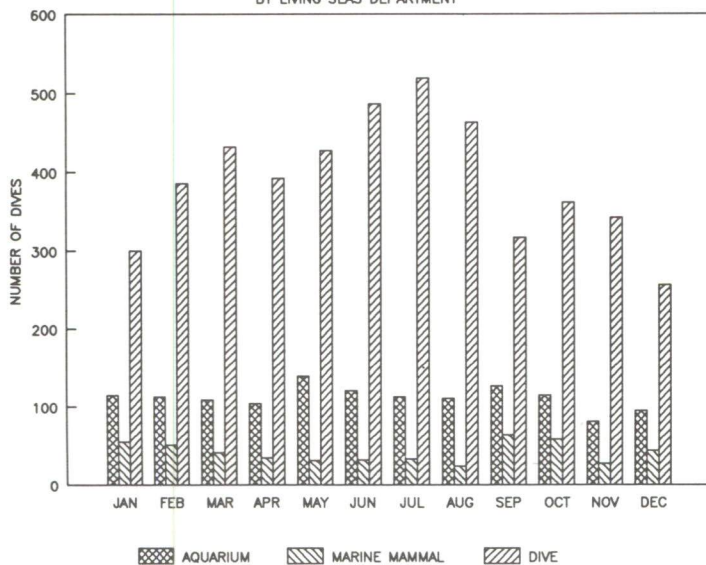
Partially-Closed Rebreather System

Delta P and Richard Fox of Fox Engineering are collaborating closely with The Living Seas divers to develop a new personal life support system based on partially closed rebreather technology. Living Seas divers currently use the same SCUBA technology that is available in the sports diving market.

Rebreathers, also known as closed-circuit SCUBA, recycle the nitrogen in the diver's breath. Although rebreathers have been used by the military for years, the military design specifications and low-volume manufacturing have made them prohibitively expensive for use by scientific divers.

The new design will be a nitrox rebreather. It will be constructed of off-the-shelf parts with emphases on safety, simplicity of operation and maintenance, comfort, and a futuristic appearance. It will provide Disney with advanced diving technology for the Living Seas divers.

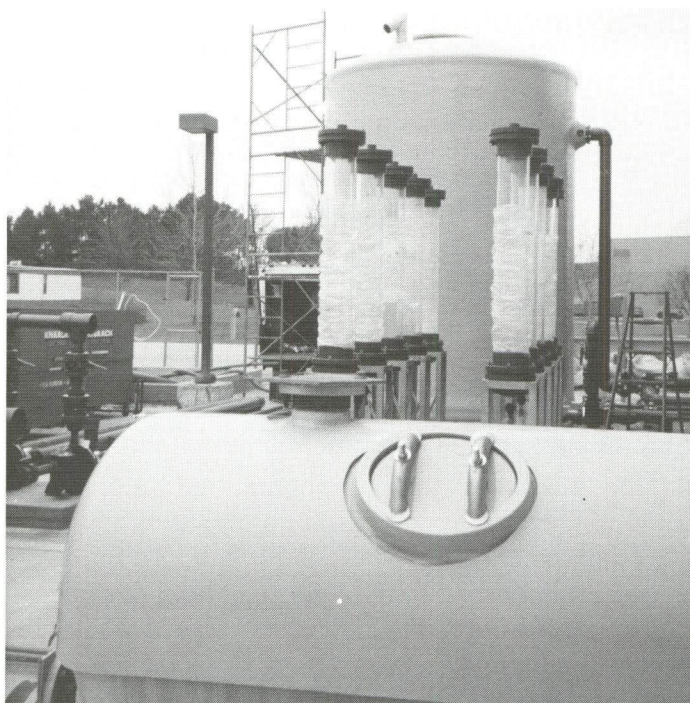
NUMBER OF DIVES IN 1990
BY LIVING SEAS DEPARTMENT



In 1990, Living Seas divers in the aquarium, marine mammal, and dive departments logged 5,429 hours of diving in 6,664 dives.

Marine Environment Controls

Researchers at The Living Seas worked diligently to understand and improve the aquatic environment within the six-million gallon aquarium. Efforts to reduce nitrate — a potentially toxic substance to marine animals - and to understand the effects of ozone — a seawater disinfectant — were emphasized.



Nitrogen removal system during construction.

Nitrate Removal System Development (WDW)

Rapid development of a nitrate removal system was required to prevent increasing nitrate levels in the Living Seas main tank from becoming toxic. Under the direction of Dr. Jeff Keaffaber, Bill Ham, and Chris Coston, denitrification research moved from the laboratory to a successful pilot plant during 1990. Late in the year, construction began on a full-scale facility.

The denitrification process separates a specified amount of seawater from the Living Seas main tank. The isolated seawater recirculates through a series of filters containing microorganisms that consume the nitrates. When all the nitrates are consumed, the seawater is returned to the main tank. The process requires 2-3 days to remove all nitrates from the batch of water.

The researchers prepared several publications on their research and applied for a patent on the system.

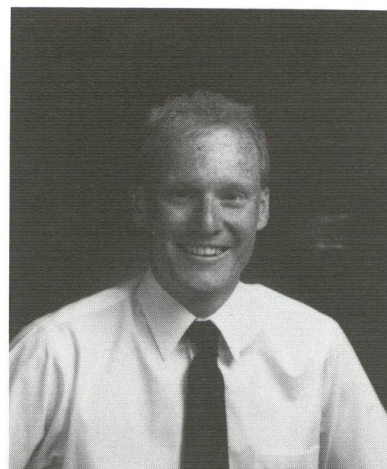
Ozonation/Oxidation Reduction

A project to understand the chemistry of ozone and its effect on recirculated marine and fresh water began in 1990. Ozone, a seawater disinfectant, is an aggressive chemical and little is known about its effect on synthetic seawater.

Although ozone is used to purify the water, it can potentially cause problems. For example, in synthetic seawater, two key ions, bromide and iodide, cannot be added because ozone converts them to potentially toxic materials.

To better understand ozonation, Jeff and Chris used chemical separation methods — gas and ion chromatography — to define the inorganic and organic composition of The Living Seas seawater. They developed new sample treatment procedures to separate the organic chemicals from the seawater before analysis.

Research will continue with the assistance of Dr. John Trefry and Gordon Grguric, chemical oceanographers from the Florida Institute of Technology.



Dr. Jeff Keaffaber

Material Study (WDW)

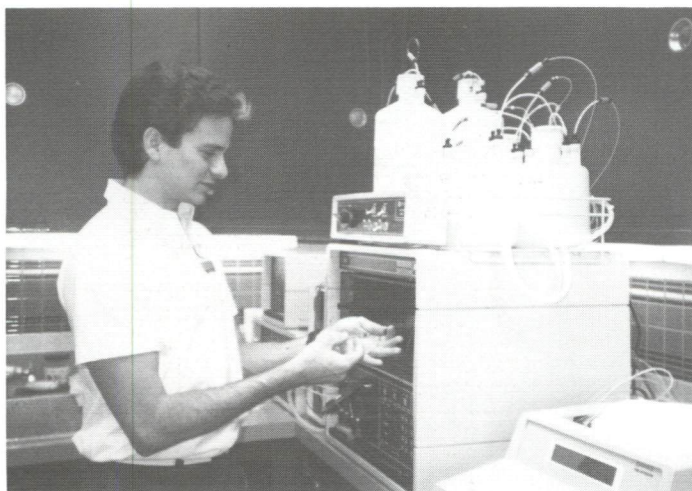
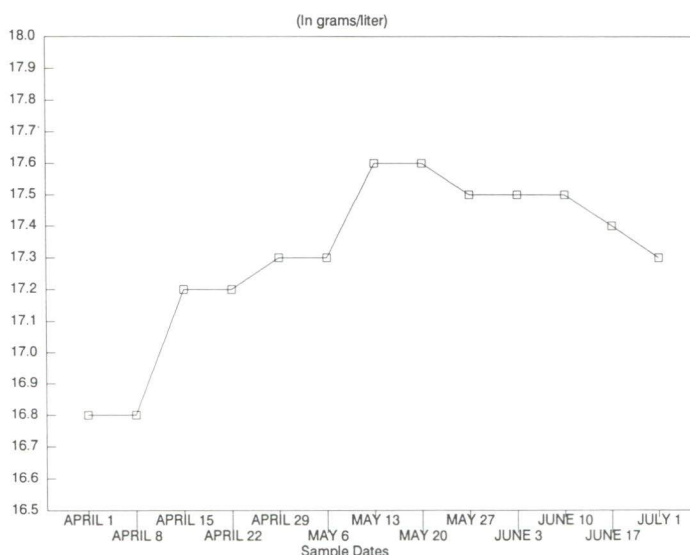
A study to determine the best material for reconstruction of The Living Seas artificial coral reefs took place in 1990. The environmental stability and longevity of several polymers were examined in the laboratory.

Organic contamination of the marine environment by these materials was a major concern. With results from gas chromatography tests, the urethane materials best suited were selected.

Chemical Balances (WDW)

Another joint collaboration with F.I.T. involved determining the chemical balance of major elements in the waters of The Living Seas. The concentration of major elements sodium, magnesium, potassium, sulfur and chlorine; and minor elements strontium, iron, manganese, cadmium, copper, nickel, lead, vanadium, and aluminum were determined. Also, a computer model of alkalinity — the seawater's buffer system — was developed.

Chloride Concentrations



Chemist Chris Coston injects a sample into an ion chromatograph, which separates and identifies salts in the seawater. The instrument was acquired in 1990.

Science and Technology Education Efforts

Exciting young people about careers in agriculture is one goal of the Science and Technology Group. Both The Land and The Living Seas offer opportunities for elementary and high school students to learn about the research conducted in each pavilion.

Land Education

Earth Shuttle, which is based in Boston, Mass., offers students in grades 3-12 the opportunity to visit EPCOT Center, the Kennedy Space Center, and Sea World, all of which offer a variety of learning experiences to their visitors.

The program began bringing students from around the country to the Orlando area in the middle of 1989. Students raise money to pay for the trips.

Almost 1,800 students toured The Land's greenhouses as participants in the Earth Shuttle program in 1990.

At The Land, Earth Shuttle students view the Symbiosis movie and are given a special tour through the greenhouses, where they learn about hydroponics, aquaculture, biotechnology, and other agricultural technologies.

Some educational groups other than Earth Shuttle are pre-signed for Harvest Tours through The Land office. Some of these are arranged through the teachers; 425 students visited in 1990 on teacher-arranged tours. Almost 420 people toured The Land as part of other educational groups, including university students, teacher groups, Girl Scouts, and honor groups.

Seas Education

Thousands of students visited The Living Seas during 1990 through the Seas Immersion Program (SIP).

SIP brings between 30 and 60 school children (K-12) -- almost every day -- to The Living Seas for three hours. So far, more than 12,000 students have been introduced to the wonders, mysteries and excitement of the ocean through SIP.

Students participating in the program watch "The Seas" movie, then they are given activity sheets -- geared to age group -- to guide them through the Sea Base Alpha exhibit. The students later hear a Living Seas technical staff member speak on his/her specialty.

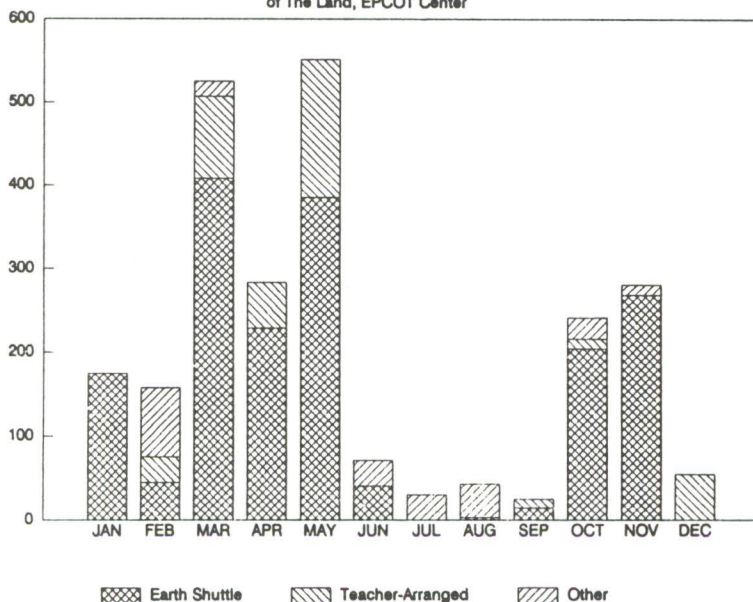
Another education program at The Seas is "World of Water." It involves 7th and 8th grade students from Florida who are selected to attend a University of South Florida camp. One hundred students participated in June and July of 1990.

This program includes researchers from The Living Seas marine mammal, aquarium, diving, and chemistry departments. It is an all-day experience for the students, and includes lunch hosted by United Technologies.

Laura Lacambra and Nancy Rugh coordinate the education program under the direction of the Disney University Seminars Department.

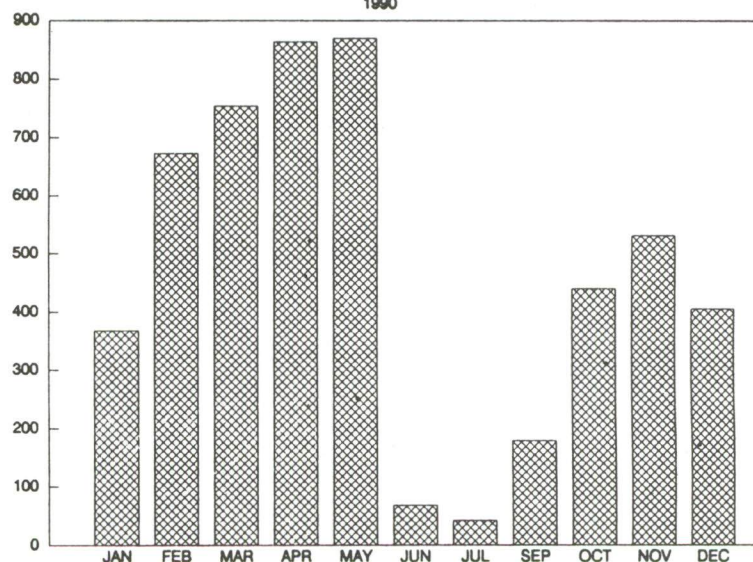
EDUCATIONAL TOURS

of The Land, EPCOT Center



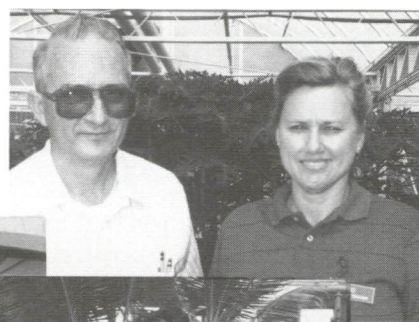
SEAS IMMERSION PROGRAM

1990



Student Programs

A major goal of the Science and Technology Group is education. Therefore, college internship programs are a natural extension of the efforts to educate young people about the career opportunities that exist in agricultural and marine sciences today.



The Land Student Program

The Land has had college interns since it opened, beginning with two horticulture students in 1982. Since then, the program has gradually increased to more than a dozen in a six-month term, including students in other disciplines. Recent student groups have seven or eight horticulture students and two aquaculture students. Other disciplines -- entomology, plant pathology, engineering, plant nutrition, and biotechnology -- also routinely have students who work on research projects.

The Land Agricultural Student Program provides horticulture or agronomy students an opportunity to work in the dynamic agricultural show greenhouses. The students' primary work is to grow and maintain the 30+ crops in the show. For all students, five or six hours weekly are spent conducting walking tours. Students also participate in discussion classes on areas of expertise at The Land, field trips to see Florida agriculture, and may do a research project which benefits both The Land and the student.

A new group of students arrived the last week of December 1989. Horticulture interns in the greenhouses were Christopher Alexander, Oklahoma State University; Chad Berghoefer, Iowa State University; Carol Cammack, New Mexico State University; Tim Cozort, Southwest Missouri State University; Michelle Malloy and Ann Naylor, Purdue University; and Tom Sawyers, Texas A&M University. The aquaculture students were Tom St. Clair, University of Washington, and Jeff Wielgus, University of Miami.

Working in the labs were plant pathology student Andy Hoetger, Iowa State; plant nutrition student Bob Pearson, Montana State University; and biotechnology student Melud Nabavi, Seminole Community College.

In June, the spring students departed and a new group of fall interns joined the staff for six months. The horticulture students were Mark Anderson, Virginia State and Polytechnic University; Jim Anthony, Southeast Missouri State University; Mona Corbett and Lisa Earnest, Texas A&M; Rob Dowd, Pennsylvania State University; Theresa Fay, Cornell University; Miguel Garces, University of Florida; and Cecilia Jimenez, University of Arizona. Robbie Roach, Texas A&M, and Eduardo Tjoa-Tan, University of Arizona, were the aquaculture students. In other areas: Jim Adams, University of Illinois, worked in plant pathology; Carolyn Finn, Iowa State University, worked in tissue culture; Christopher Rubino, Cornell, worked in plant nutrition; Tara Thiede, University of Wisconsin-Madison, worked in entomology; and Brad Wind, Colorado State University worked in agricultural engineering.

Seas Interns

The Living Seas' internship program began in the fall of 1989 with a single student. Seas students work only in the marine mammal area with the visiting researchers. The internships are available in the fall, spring, and summer terms with two or three students working per term.

In 1990, seven students participated in the internship program. The interns assisted the research staff in data collection and analysis, by participating in research sessions with dolphins and manatees, with constructing and deploying apparatus, by entering data for computer analysis, and by attending research planning meetings.

The internship provides the students an opportunity to observe the practical application of classroom knowledge and to gain experience in research design and implementation.

1990 students were Mark Barringer, University of South Florida; Trisha Southard and Kendra Lawrence, New College, Sarasota; Caryn Poll, Cornell University; Susan Baxter, University of Georgia; Wendy Dunlap, University of San Diego; and Monica Ross, Florida State University.

OCPS Summer In-Service Institute

Both The Land and the Living Seas are involved in a program that allowed local high school teachers to come backstage in the Science and Technology area to find out more about the daily operation of the pavilions, as well as ongoing research projects. The Orange County Public Schools (OCPS) Industry Study Program is part of Florida's Summer In-Service Institute. OCPS initiated the program to give teachers industry experience outside of the classroom.

Two teachers per pavilion participated in the program for two weeks in June.

Jo Bennett, from Winter Park High School, and Bob Smith, from Edgewater High School, learned about The Land with the new students and worked in the greenhouses during their term.

At The Living Seas, Walt Detwiler, from Jones High School, and Cynthia Smith, from Dr. Phillips High School followed the researchers through food preparation, fish feeding, and training of marine mammals.

The Land and Space Agriculture

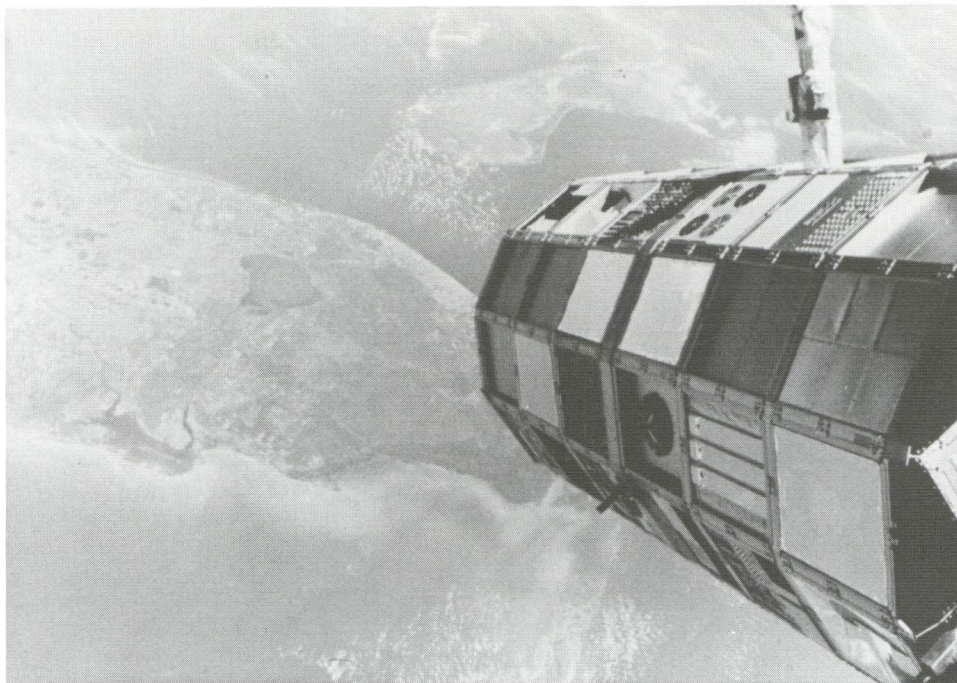
By Dinah Jordan

The Space Shuttle Challenger launched the Long-Duration Exposure Facility (LDEF) satellite into low Earth orbit in April 1984. LDEF was originally scheduled to orbit for about a year, but the Challenger accident in 1986 stretched its time in space to almost *six years*. It was retrieved by the Space Shuttle Columbia in January 1990.

The retrieval of LDEF created excitement and activity at The Land.

On LDEF were 57 experiments, including a U.S. Air Force experiment studying the effects of the space environment on electronic circuits, mirrors, laser rods, and plant seeds.

Land scientists were particularly interested in an aluminum alloy tube with about 150 seeds and several small radiation detectors. It was enclosed in a canister designed to open after several days in space and close within one year.



LDEF satellite in space.

Microbiology Studies

Andrew Schuerger, senior plant pathologist, and Bret Norman, technical specialist in plant pathology, studied the survival of microorganisms on seeds after long-term exposure to the space environment.

"As humans begin to colonize space and send unmanned spacecraft to the far reaches of the solar system, we need to realize that microorganisms will also make those trips," Andrew explained.

"How these small creatures will affect the health of humans, animals, and plants is critical to the success of human colonization of space," he added. "It is also important with unmanned missions because it may require that the robotic spacecraft be sterilized in order to prevent contamination of other planetary bodies."

With this in mind, Andrew set out to determine the survivability of certain microorganisms in space.

The experiment used several seed varieties: corn, pumpkin, sunflower, two strains of garden bean, bush lima bean, and pea. The LDEF tube and a control tube remaining on Earth each contained 16 seeds of each variety.

The seed experiment was removed from LDEF at NASA's Kennedy Space Center in March 1990. The seeds were taken to the laboratories at The Land; they were opened in April and examined under sterile conditions.

Andrew said he and NASA scientists were not sure what to predict, since it was the first experiment of its kind.

Still, they thought the increased radiation and harsh environment of space would cause a reduction in the population and diversity of fungi and bacteria on LDEF seeds. What they discovered was the exact opposite: microorganisms in space survived better than those remaining on Earth.

Andrew said they found 15% to 20% more microscopic organisms on seeds that had been in space. Apparently some microbial species that were on earth-bound seeds died, he explained.

"It is likely that bacteria in space survived better because of lower temperature," he analyzed.

Because LDEF would be exposed to extremes of temperature during its orbit — from -250°F to $+200^{\circ}\text{F}$ — scientists predicted that the temperature in space would average out to about room temperature. So earth-bound seeds were stored at room temperature.

Because cold temperatures preserve microorganisms, Andrew said, he and the other scientists suspected that the temperature of the canister in space was actually colder than expected.

Microbiological research isolated more than 30 species of bacteria and 15 species of fungi that survived the six-year voyage in space. Once the microbial studies were complete, experiments on the seeds themselves began. The corn seeds were planted and grown to maturity. Both space and earth seeds grew normally.

Tissue Culture Experiments

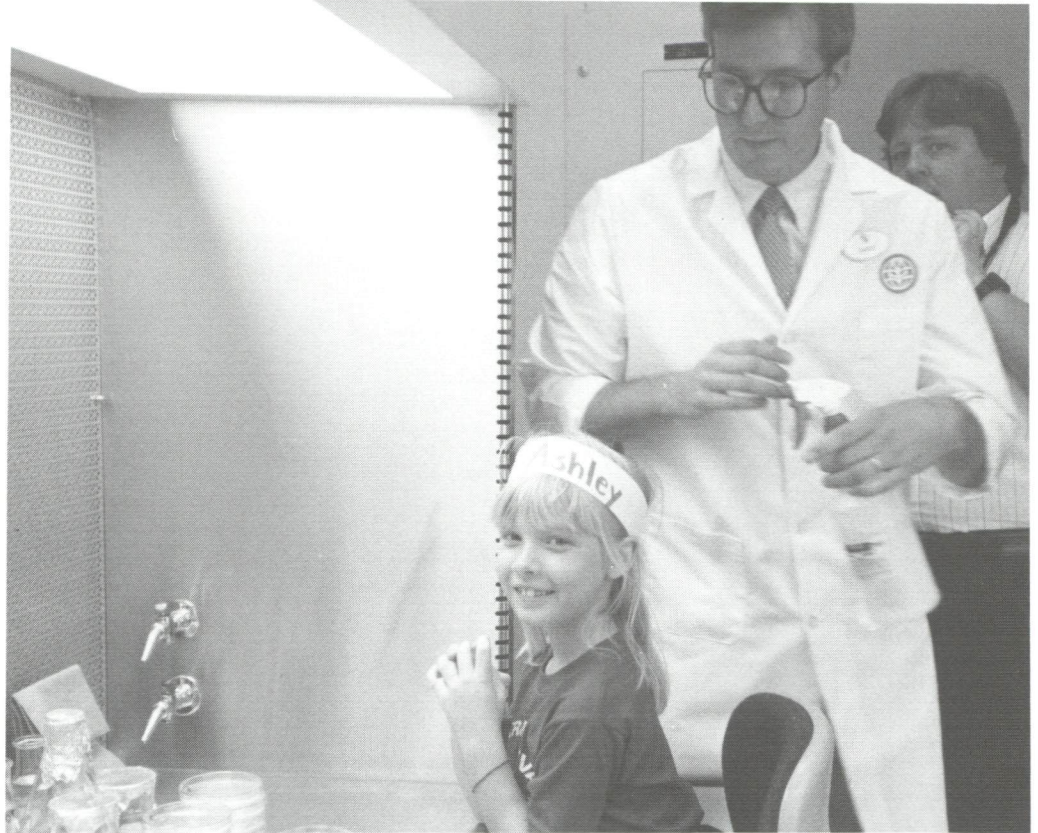
The rest of the seeds were given to Dr. Lexie McKently, plant biotechnologist, who studied the effects of space on the genetic material in the seeds themselves. Lexie's research utilized a variety of tissue culture techniques to look for genetic variation in the seeds.

Tissue culture involves using various tiny parts of plants — in this case seeds — and special growing media to produce new plants. This type of work allows more genetic mutations to be expressed than if the seed were simply planted.

"You normally see some variation (from the mother plant) in tissue culture," Lexie explained, "but we were looking for variations that are above and beyond the norm."

In these experiments, she placed seed parts in sterile petri dishes on agar-based media to stimulate growth of shoots, which can later be separated and grown into plants.

Preliminary results did not show any differences between shoots developed from the two types of seeds.



Merritt Island student, Ashley Zysko, learns about tissue culture with Land Horticulturist, David Forehand.

Teachers Visit For Seeds

Almost 200 teachers from around the United States traveled to Florida in February to learn about the Space-Exposed Experiment Developed For Students (SEEDS), one of the experiments on the LDEF satellite.

SEEDS was sponsored by National Aeronautics and Space Administration (NASA) and the George W. Park Seed Co. in Greenwood, S.C.

For the SEEDS experiment, about 12 million tomato seeds placed in sealed containers in one sector of the LDEF satellite and an equal number, a control group, was stored in sealed containers on earth. Packages of 50 seeds from each group were distributed in the spring to teachers nationwide for use in their classrooms.

NASA challenged students — from fifth grade to college — to grow the seeds that spent five years in space and report the results to the space agency.

One objective of SEEDS was to generate interest in science among young people. It was designed to involve a large number of students in experiments to determine the effects of

space — such as microgravity, cosmic radiation, and extreme temperatures — on seed growth.

The Land's staff hosted the teachers on tours that included an explanation of the SEEDS experiment, a discussion of the excitement of science, and a tour of The Land's greenhouses.

They heard about Andrew Schuerger's LDEF experiment on the effect of the space environment on microorganisms that are normally found on seeds. During a reception in the Kraft General Foods VIP Lounge, Dr. Lexie McKently showed the teachers tissue culture techniques for seeds.

Dr. Henry Robitaille commented on the motive for bringing the teachers to EPCOT Center:

"The connection is perfect because EPCOT Center represents tomorrow's technology and futuristic thinking," Hank said. "At The Land, we showcase agricultural technology, which includes space technology; and we're trying to emphasize educating our youth and stimulating them into careers in agriculture and science."

Elementary Students Experience Biotechnology

Penny Beers, a teacher from Gardendale Elementary School in Merritt Island, Fla., attended the SEEDS conference. With her guidance, the gifted 3rd-and 4th-grade students germinated both space and control seeds.

Ms. Beers was also excited about the novel technique of tissue culture she had seen Dr. Lexie McKently demonstrate.

Catching her enthusiasm, four of her top students came from their school in Brevard County to learn the tissue culture process in the sterile lab in The Land.

On May 11, the students brought the plants they had grown from LDEF seeds to The Land's biotechnology lab. With Lexie's direction, they went through the leaf tissue culture process: sterilizing surfaces, instruments, and themselves; cutting the leaf into tiny sections; and putting the leaf sections into petri dishes containing a shoot-inducing medium.

The students cut ten leaf tissue pieces each from plants grown from space seeds and from plants grown from control seeds.

Afterwards, the students returned to their classrooms to share with their classmates the tissue culture techniques they had learned.

The students left the dishes in The Land's sterile laboratory where they would grow under Lexie's watchful eye. About 45 days later, the tissue pieces developed shoots, which were separated and placed in rooting medium. The plants that developed were transplanted into The Land's greenhouses.

Lexie said that teaching the students tissue-culture techniques was a good way to enlighten young people about the excitement of science.



Dr. Lexie McKently and students, Austin Kamm, Ashley Zysko, Nerissa McCoy, Christopher Ramos.

EPCOT Center Poll Gauges Public Opinion on Space

The return of LDEF to earth placed the U.S. space program and space exploration in front of the public eye, but some people wondered how much the public really knows about space exploration.

To find out, The Land's Andrew Schuerger worked with Dr. Joe Angelo, director of advanced technology for Science Applications International Corporation in Melbourne, Fla., and Wallace Sears, of EPCOT Center Publicity, to create a questionnaire to be given to visitors of the EPCOT poll.

He also gathered video footage from NASA affiliates Kennedy Space Center and Johnson Space Center to produce a three-minute show about American space projects. A short questionnaire followed the presentation of the video.

The poll began in February, in conjunction with a Space Initiatives Conference that was held at The Living Seas, and ran for three months.

More than 4,800 people responded to the survey, and the results showed that 45% of Americans felt they knew a fair amount or a great deal about the U.S. space program and an equal percentage felt they knew only a small amount about space exploration. In addition, most Americans felt that NASA was moving either too slowly or about the right speed in exploring the solar system; only 6% of those surveyed felt the U.S. was moving too quickly in space exploration.

Many Americans also felt that studying the earth's environment should be a primary goal of the space program for the next 20 years.

Other results show that most people believed the government is spending about the right amount on space exploration; manned and unmanned flights should be emphasized equally by NASA; the space program has paid for itself with the new technology it has created; and that NASA should speed up the construction of Space Station Freedom.

1990 Happenings

January 4:

Mrs. Clayton Yeutter, wife of the U.S. Secretary of Agriculture, received a special tour along with 11 wives of agricultural ministers from other countries.

January:

The Living Seas hosted participants in the Eastern States Veterinarians Association.

January:

The clear wall enclosing the biotechnology lab was complete.

February 21:

Almost 40 space industry executives participated in the Space Conference held in Orlando. Many of them were given a special "breakfast on the sidewalk" tour of The Land's greenhouses.



Biological Engineer Bob Hines visits with Astronaut Joseph Allen during the "Breakfast on the Sidewalk" in The Land greenhouses.

February:

The Living Seas hosted members of a Marine Mammal Interest Group.

March 1:

The Land was mentioned twice in company-wide Salaried Update.

April 22:

Earth Day 1990 was recognized at The Land by distributing packets of slash pine seed to all guests. That week, an article about The Land's environmental efforts was in the Disney employee newspaper, Eyes & Ears.

April 26:

Official reorganization plan for Science and Technology Group (Land and Seas) was announced.

June:

A wall separating the Support Greenhouse into two sections to prevent spread of insects and diseases to seedlings was complete.

July 9:

Solar-powered car race began at EPCOT Center, with cars representing 34 colleges making the journey to Detroit, Mich.

September 14:

Writers and editors participating in the National Conference of Editorial Writers and National Association of Broadcast Editors visited EPCOT Center. Hank, Fred, Eldon, Peter, and Lexie gave the group of 175 a presentation on The Land's research. The same group made a similar presentation to the editorial board of the Orlando Sentinel in October.

September:

Members of the Manatee Recovery team met at The Living Seas.

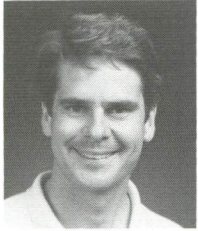
November:

Air conditioning was installed in the biotechnology laboratory.

1990 Cast Highlights

January

Bret Norman, plant pathologist, joined The Land in January. He has a bachelor's degree in crop protection and a master's degree in plant pathology, both from Kansas State University in Manhattan. He was a research assistant for seven years in the cereal pathology lab at KSU.



Bret Norman

On January 10, Fred Pettitt went to the University of Central Florida to recruit biology students to work in the entomology lab. Later in January, three UCF students, Ike Ansine, Shali Brown, and Carmen Hein, began working part-time at The Land. Ike and Carmen worked through the spring, and Shali worked through December.

Eldon Muller and Bob Hines went to Kennedy Space Center on January 18 to investigate using robotic wheat harvesters in The Land.

Fred was interviewed on January 24 for the local television program, "Florida Home Grown". The program also interviewed Dr. Lance Osborne, associate professor of entomology at the University of Florida, who often works cooperatively with The Land and its pest management program. The program was broadcast in February, in conjunction with a local meetings of the Southeastern Branch of the Entomological Society of America.

February

On February 8, Ginny Mann and Brian Shirley represented The Land at the University of Florida Career Day in recruiting for the student intern program. Also that weekend, part-time engineering consultant Greg Kiker used the traveling hydroponic display at the engineering fair at the University of Florida.

Tom Bonzi, a lead in Land Boat Operations who has a degree in agricultural education, began attending staff meetings as a liaison between the agricultural and operations staffs.

March

In March, Hank Robitaille was honored with a Distinguished Alumni Award from Michigan State University, where he received his master's and doctorate degrees in horticulture and plant physiology.

Following a trade show on sensor technology in California, Sue Novak went to the Environmental Research Lab in Tucson, Ariz., to consult with the scientists there on the progress of the Greenhouse Environmental Monitoring Control System (GEMCS).

April

Stephen Wolf, an Auburn University student who had been a Land intern in the spring and summer of 1989, returned to work as student assistant in the entomology lab through September.

On April 5, Peter Cook went to Harbor Branch Oceanographic Institute in Harbor Branch, Fla., to assist in hosting a teleconference on aquaculture. A segment of the telecon-

ference had been taped in The Land's aquacell on March 5 to be part of the nationally-televised program on educational TV.

The Southern Regional Biological Control Working Group met in Orlando in April. Some of The Land entomology group attended meetings and conducted the group of 40 through the greenhouses on April 6, emphasizing the integrated pest management program.

At The Living Seas, Joe Bycz was promoted from an aquarist to a senior aquarist.

May

Bill Ham, a life support specialist at the Living Seas, became part of the Biological Engineering Group. He has certifications in water treatment from Webster Adult Education and Seminole Community College; is licensed by the Florida Department of Environmental Regulation (DER) for potable drinking water; and has been a life support technician at The Living Seas for five years. He was promoted to Senior Life Support Specialist in July.

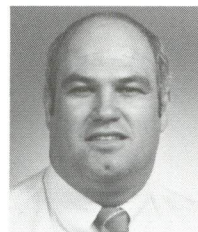
Also, Charles "Skip" Holzman, life support operator for The Living Seas, began working with the Biological Engineering group. He began working for Walt Disney World in 1976, and worked in the Contemporary Resort Marina and with the filtration system at River Country prior to transferring to The Living Seas in 1988.

Greg returned to The Land full-time WDI-funded phenology project when his school semester ended.

June

Ivey Burns returned as a full-time engineering consultant in June to continue work on the lysimeter research project. He has been a consultant since May 1988 while pursuing a bachelor of science in engineering degree from the University of Florida. He received his degree in May 1990.

Chris Coston became a cast member in June. He works with Jeff in the Seas chemistry laboratory. He received a bachelor's degree in chemistry in 1989 from the University of Florida.



Bruce Miller

July

Bruce Miller, curator of aquatic systems at The Living Seas, assumed new responsibilities over The Land's aquacell. He had been aquarium curator. Peter, who had been aquacell supervisor and The Land's publicity liaison, began devoting more time to the publicity and communication efforts of the Science and Technology Group.

At the Seas, Mike Andrew was promoted from assistant aquarium curator to aquarium curator; Conrad Litz was promoted from assistant marine mammal curator to marine mammal curator; and Debbie Weber was promoted from scientific diver to senior scientific diver.

During July, Stan Johnson, diving supervisor at The Living Seas, and Susan Schuerger, coordinator of education programs, left Disney to pursue other employment.

August

In early August, Hank traveled to California to discuss preliminary plans for a space pavilion at EPCOT Center with the people at Walt Disney Imagineering.

Brian left in early August to pursue a second bachelor's degree in landscape architecture at the University of Kentucky. He had been a student in Spring, 1989, then joined the staff full-time to fill a third-shift horticulture/entomology opening.

Later that month, Ginny, horticulturist and student coordinator, transferred to the resorts area of Walt Disney World to begin management training. She had been with The Land since 1982. When she left, Peter assumed the duties of student recruiting coordinator.

September

September brought a few reassignments of responsibilities. Jane Davis, senior aquarist at the Living Seas, became The Land's aquacell supervisor, under Bruce. She has a bachelor of science degree in environmental technology with an aquaculture option from Florida Institute of Technology. She started working for Disney as a technical specialist at The Land in 1983, then transferred to the Seas in 1985.



Jane Davis

Also, Dave Forehand, horticulturist who had been working in the biotech lab, became horticulturist/student coordinator in the greenhouses. Dave joined The Land staff in 1985 as third shift horticulturist, then became biotechnology technician in 1988. He received a bachelor of science degree in ornamental horticulture from Auburn University in 1984.

Ed, who had been irrigation specialist in the engineering Area, shifted his area of emphasis to the plant science area. He still maintained responsibility for facilities coordination of The Land. He has a bachelor's degree in agronomy from Murray State University in Kentucky, and has been with The Land cast since 1981.

While in Ithaca, N.Y., for Sue's wedding to Jeff Morris, Sue and Maureen Knop met with Arend-Jan Both, an agricultural engineering graduate student at Cornell University, to discuss thrips exclusion.

October

The week of October 23-27, Jeff participated in the Disney Way I classes sponsored by Walt Disney World.

At The Living Seas, Maryann Buehn was promoted to diving supervisor. She had been a senior marine specialist.



Maryann Buehn

Hank participated in a round-table discussion on science and technology at the EPCOT Center Electronic Forum. The audience included members of the Association of Science Technology Centers.

December

Late in December, Mary met with some of the participants in the Florida State Horticultural Society meetings that were held in Lake Buena Vista, Fla.

The Great Pumpkin Visits The Land



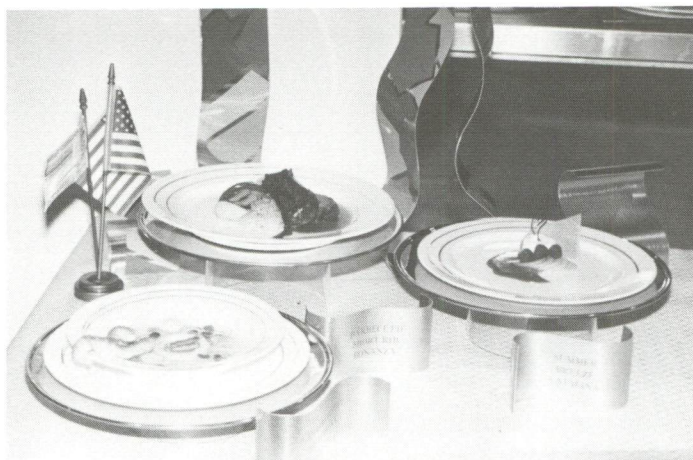
A 400 pound pumpkin, grown by Mr. Wayne Hackney of New Milford, Conn., was displayed in the front of The Land pavilion in October 1990. EPCOT Center Decorating and Operations personnel displayed it in a garden setting.

Each year, hundreds of pumpkins are grown for competition across the nation. This pumpkin is only half the size of the 1990 national pumpkin competition winner. When growing at its fastest rate it gained 15 pounds per day.

'Atlantic Giant' pumpkins are grown for their size, and not necessarily for shape or color. One pumpkin this size will make 400 pies.

Land Malabar Wins In International Competition

Malabar, a leafy vegetable similar to spinach, is grown at The Land and is available to EPCOT Center restaurants. In November, however, some of The Land's malabar was part of a menu that won an international cooking competition against culinary teams from 22 other countries.



Prize winning dish with malabar.

About 20 pounds of The Land's malabar was used to prepare the meal for 150 people, which included the six judges as well as other culinary experts who purchased tickets for the event.

Twenty-four boxes of freshly-harvested malabar were express-shipped to Luxembourg for the competition.

Team USA, a culinary crew managed by EPCOT Center Executive Chef Keith Keogh, prepared the prize-winning menu in Luxembourg for the 1990 Culinary World Cup. The team also includes chefs from West Virginia, Ohio, Michigan, and Pennsylvania.

The hot food entry menu included braised barbecued ribs, hot potato salad, and roasted baby corn on chayote squash. The malabar was sauteed with a Jamaican jerk seasoning as a part of the vegetable dish. Each plate included three 4-inch long malabar tips with the squash and baby corn on top.



Malabar growing on A-frames.

Land Recycles Used Items

Every year, The Land uses hundreds of flats and pots for growing seedlings. Six-inch pots are used primarily for growing lima beans used in entomology research, and flats are used for carrying potted plants. Horticulturists use 10-inch pots and other flats.

These containers are not reused at The Land because disinfecting them is costly and labor-intensive.

Rather than throw away the used items, they are distributed to the Walt Disney World Tree Farm and the Osceola Mental Health Society, a non-profit organization that operates a halfway house.

The halfway house has several greenhouses, in which mental health clients raise landscape plants to gain skills for future employment. A greenhouse burned down a few years ago, destroying all their equipment. The Land learned of their plight and began regularly donating these materials in January 1990.

Almost 1900 flats and 3750 pots were donated to the halfway house, while 650 flats and 2960 pots went to the Tree Farm. Liberty Middle School in Orlando also received more than 500 pots in a single donation.

Seas Staff Helps Turks and Caicos Dolphins

While the Living Seas concentrated on caring for and studying the dolphins in its own facilities, its staff also took the time to take care of an injured dolphin far away.

In the Turks and Caicos islands of the Caribbean, a wild dolphin named "JoJo" often plays with the local SCUBA divers. Early in 1990, a diver noticed an infection behind JoJo's dorsal fin that looked like a stingray barb. The diver was concerned the infection could penetrate to the internal organs and contacted someone at United Technologies.

United Technologies contacted Tom Hopkins, Living Seas manager, about the problem. In June, he and Dr. Bob Stevens, consulting veterinarian for the Seas, were flown to the islands to check up on the dolphin.

Tom and Bob examined JoJo, and found that it was in good health. They consulted with the divers and a local veterinarian, explaining to them what to look for and protocol for treating injured dolphins.

Collecting Site Relocates

Many species of fish can be found in The Living Seas, and most of them came from the ocean via a collection facility in the Florida Keys. 1990 began with a move to new collection quarters, located on Walker's Island.

The facility — including tanks, storage sheds, pumps, filters, and seawater supply line — was moved one-half mile from the east to the west side of the island. The new location pro-

vides quick access to deep water and a cleaner supply of seawater, as well as on-site living space for collecting teams. A genuine Seminole chickee hut shades the holding tanks.

During the 1990 calendar year, almost 4300 fish and crustaceans passed through the new facility on their way to The Living Seas, Typhoon Lagoon, and Ariel's Restaurant aquarium.

Sea Turtles Rescued

Below-freezing temperatures in the Florida peninsula during the 1989 Christmas season spelled danger to cold-blooded marine animals, which could become incapacitated, drown, or succumb to pneumonia in dramatically cooler waters.

One of those species was the Atlantic green turtle, an endangered species that frequents the shallow waters along Florida's east coast. When water temperatures dropped, National Marine Fisheries requested that the Living Seas provide shelter to some turtles for the duration of the cold snap.

The Living Seas responded to the request by hosting 82 turtles throughout its facilities. The isolation tank, dolphin holding pools, Shark Reef, and the greenhouse facility became temporary homes from December 28, 1989 through February 6, 1990, when water temperatures returned to normal.



Scott Martin, Seas aquarist, works with an Atlantic green turtle.

Harvests

The Land's greenhouses produced tons of fresh produce in 1990. Guests in EPCOT Center consumed much of this at the Farmer's Market, the Land Grille Room, and other eating establishments.

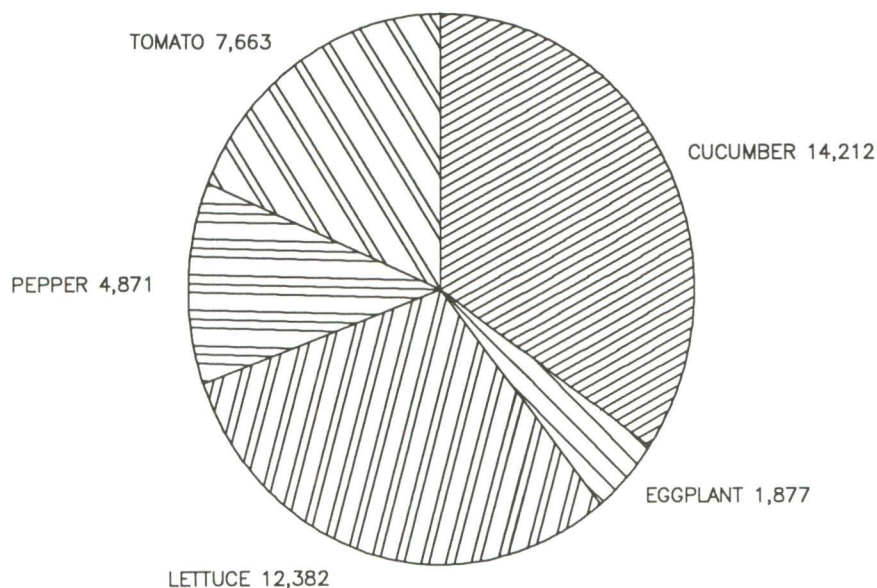
Cole crops include cabbage, broccoli, and kohlrabi; herbs include oregano, basil, chives, and Nasturtiums.

In the aquacell, tilapia and catfish were harvested occasionally and served in EPCOT Center restaurants as well. Totals are available for the second half of the year. More than 2,100 pounds of tilapia were harvested, but only 110 pounds of catfish were harvested in 1990.

HARVEST TOTALS 1990

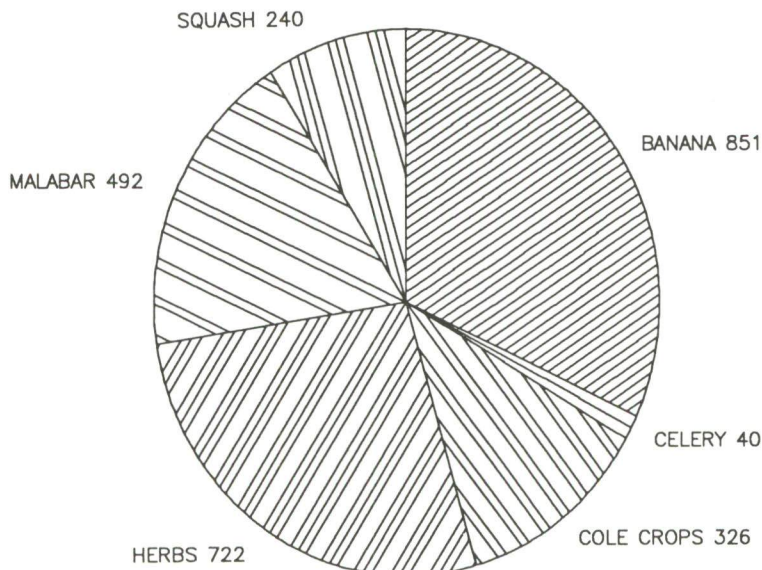
MAJOR CROPS

Quantities are in pounds.



HARVEST TOTALS 1990

MINOR CROPS



Abbreviations Used in Annual Report:

Ag	Agriculture or Agricultural
ARS	Agricultural Research Service
ASCD	Association for Supervision and Curriculum Development
Assoc.	Association
CCDS	Centers for Commercial Development of Space
CELSS	Controlled Ecological Life Support System
EC	EPCOT Center
ERL	Environmental Research Lab
ICBR	International Center for Biotechnology Research
Int'l	International
IFAS	Institute of Food and Agricultural Sciences
KGF	Kraft General Foods
KSC	Kennedy Space Center
LDEF	Long-Duration Exposure Facility
NASA	National Aeronautics and Space Administration
Sci.	Science
Tech.	Technology
ToMV	Tomato Mosaic Virus
TSWV	Tomato Spotted Wilt Virus
UCF	University of Central Florida
UF	University of Florida
Univ.	University
USDA	United States Department of Agriculture
WDI	Walt Disney Imagineering
WDW	Walt Disney World

The Land Agricultural Staff on January 8, 1990, following President Bush's tour. From left: Chris Alexander (S), Ann Naylor (S), Peter Cook, Michelle Malloy (S), Chad Berghoefer (S), Ginny Mann, Tom St. Clair (S), Carol Cammack (S), Hank Robitaille, Dinah Jordan, Jeff Wielgus (S), Sandra Gerdes, Fred Pettitt, Sue Novak, Mary Schon, David Forehand, Maureen Knop, Melud Nabavi (S), Bill Hammer, Tom Sawyer (S), Tom Cozort (S), Marian Coffey, Brian Shirley, Lexie McKently, and Andy Schuerger. (S) denotes student intern.



Visitor Overview

Throughout 1990, visitors from around the world came to see the science and technology exhibited at The Land and The Living Seas. They came from many backgrounds and with many interests and purposes.

The visitors to The Land included the president, a prince, and a former first lady; actors and actresses; foreign dignitaries and businessmen; Disney executives and stockholders; university professors and industry researchers; and writers and editors from around the world.

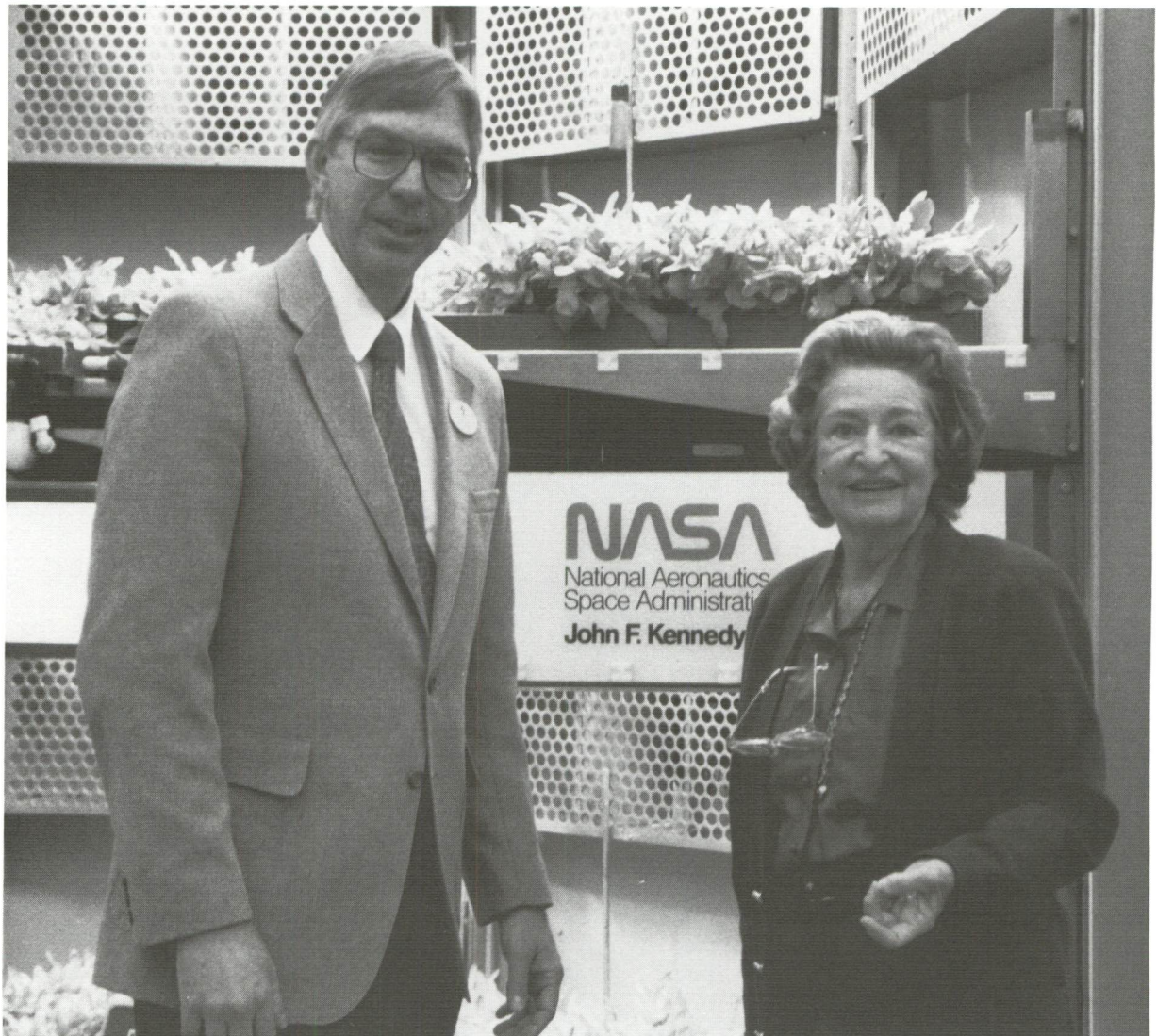
The Land kept records of guests who received pre-arranged tours, came backstage to see the facilities more in-depth, and were presigned by special request through its office.

More than 130 of the guests who visited The Land were from foreign countries. Almost 170 visitors were science, agricul-

ture, or education professionals. At least 50 media people helped to publicize the excitement of agricultural science to the masses. More than 250 people received tours from members of The Land's senior staff.

The Land's "Tomorrow's Harvest Tour" continued to be popular with guests, and more than a thousand guests were presigned to tours through The Land's agricultural office. This did not include educational groups presigned through Earth Shuttle or by request of their teachers. About 440 Kraft General Foods employees and their families were presigned.

The Land's efforts to inform the public also included 450 letters sent to individuals requesting information about The Land, primarily hydroponic technology.



Peter Cook and Lady Bird Johnson

Science and Technology Backstage Tours

DATE	NAME	TITLE, COMPANY	FROM	NO.
Jan 15	Deni Gorden	Marketing Account Manager, IBM	Orlando, FL	4
Apr 15	Gerald Eisner	Uncle of Disney CEO Michael Eisner		2
May 17	Group	SMH Swatch Tour		5
Jun 29	Judy Marino	Admission Counselor, Florida Institute of Technology	Melbourne, FL	8
Jul 12	Group	Directors, Florida Regional Planning Council	Florida	15
Aug 15	Mr. Wong	Minister of Trade, Peoples Republic of China	China	4
Aug 25	Lou Kompare	Executive, Disney Information Services	Lake Buena Vista, FL	2
Sep 11	Group	WDI Imagineers	California	16
Sep 14	Dr. Kumar Mahadevan	Executive Director, Mote Marine Laboratories	Sarasota, FL	45
Sep 17	Group	WDI Imagineers	California	10
Sep 24	Nancy Green	Architect Engineer, Olympic Hall of Fame	Colorado Spgs., CO	4
Sep 25	Group	WDI Imagineers	California	16
Oct 24	Mark Choper	Manager, Operational and Planning Analysis, WDW	California	1
Oct 26	Group	Disney Dimensions (Executive Orientation)		12
Nov 2	Stephen Soter	Asst. Director, Smithsonian Air & Space Museum	Washington, DC	1
Nov 5	Robert Tieman	Disney Archives		1
Nov 12	Group	WDI Imagineers	California	10
Nov 17	Group	Members, Rene Dubois Society		30
Nov 20	Dianna Morgan	Disney Administration	Lake Buena Vista, FL	1
Nov 20	Dick Nunis	President, Walt Disney Attractions	California	1
Nov 20	Jeff Smith	Disney Corporate Counsellor	California	1
Nov 20	Robert Hight	Chief Counsel, California State Lands Commission	California	1
Nov 27	Karen Bohlman	Disney, EC Display	Lake Buena Vista, FL	1

Land VIP Guests

DATE	NAME	TITLE, COMPANY	FROM	NO.
Jan 4	Mrs. Clayton Yeutter	Wife, U.S. Secretary of Agriculture	Washington, DC	12
Jan 6	Donald Mazankowski	Deputy Prime Minister Government	Canada	4
Jan 8	George Bush	President of the United States	Washington, DC	6
Feb 7	Dr. Charles Hess	Member, National Higher Education Council	California	12
May 1	Dr. Dean Plowman	Director, USDA/ARS	Beltsville, MD	8
May 17	Sid Bass	Disney Stockholder	Texas	24
Jun 3	E.G. Marshall	MGM Studio Star A Day		2
Sep 19	Eddie Albert	Actor, "Green Acres" TV Show	California	4
Sep 27	Prince Ranier	Prince of Monaco	Monaco	7
Nov 2	Dr. Martin Harwit	Director, Smithsonian Air & Space Museum	Washington, DC	2
Dec 6	Lady Bird Johnson	Former 1st Lady, United States	Texas	5

Science and Technology Professional and Group Visits

DATE	NAME	TITLE, AFFILIATION	FROM	NO.
Jan 2	Ronald Davis	Professor, State University of New York	Cobleskill, NY	1
Jan 4	Dr. Ruth Floyd	Professor of Fish Pathology, University of Florida	Gainesville, FL	4
Jan 5	Jerry Olstad	Meeting Planner, Evangelical Lutheran Church		10
Jan 9	Dr. Nyanoa Su	Entomologist, IFAS Research & Education Center	Fort Lauderdale, FL	1
Jan 10	Dr. Merle Jensen	Arizona Farm Bureau Group.	Tucson, AZ	30
Jan 11	Dennis Riggs	Info. Director, Champaign Co. Farm Bureau	Champaign, IL	44
Jan 12	Jerry Shireman	Head, University of Florida, Fish & Aquaculture Dept.	Gainesville, FL	3
Jan 15	Group	Attendees, Eastern States Veterinary Association		30
Jan 15	Alfred Prescod	Horticulturist Royal Botanical Gardens	Hamilton, Ontario, Canada	1
Jan 19	Sara Bolton	Prospective Intern, Georgia Technical University	New Smyrna Beach, FL	1
Jan 20	Dr. Clarence Scrivner	Soil Scientist/Retired Professor, Univ. of Missouri	Columbia, MO	2
Jan 22	Barry Gregoire	Parkson Corporation	Daytona Beach, FL	1
Jan 24	Den Gardner	Vice President, Ciba-Geigy	Bloomington, MN	44
Feb 2	Jenes Rystedt	Consultant, Dansk Erhvervsgartnerforening	Odense, Denmark	1
Feb 2	Niels Ehler	Horticulturist, Royal Vegetable & Agriculture University	Frederickberg, Denmark	1
Feb 2	Useld Frederiksen	Development Manager, DGT-Volmatic	Denmark	1
Feb 8	Dr. Bob Martin	Electrical Engineering Consultant, Actran	Orlando, FL	2
Feb 8	Dr. Marlin	NASA	Washington, DC	1
Feb 9	Stan Raspberry	Physicist, National Bureau of Standards		1
Feb 12	Dr. Dudley Crosson	Marine Physiologist, Delta-P	Port St. Lucie, FL	1
Feb 13	Dr. James Jones	Administrator, Sea-Grant		1
Feb 17	Nick Connerford	Soil Scientist, University of Florida	Gainesville, FL	10
Feb 18	Dave Barker	Tour Arranger 500, Tours Inc.	Indianapolis, IN	23
Feb 21	Dr. Collier	Nat'l Pesticide Group	Purdue, IN	12
Feb 21	Ken Koubek	NTIRS		12
Feb 22	Ann Leslie	IPM Researcher, EPA	Virginia	1
Feb 26	Mike Steskal	Technical Sergeant, U.S. Air Force	Patrick A.F.B., FL	1
Feb 28	Chris Webber	Tour Arranger, Holiday Travel Service	Eau Claire, WI	43
Mar 5	Dr. Kumar Mahadevan	CEO, Mote Marine Labs	Sarasota, FL	30
Mar 6	Group	Entomologists, Southern Regional Info Exchange Group		20
Mar 6	Dr. John Streeter	Agronomy Professor, Ohio State University	Wooster, OH	2
Mar 9	Susan Marcus	Coordinator, Earth Shuttle Program	Boston, MA	2
Mar 14	Dr. James Lang	Statistician, Math Dept., Valencia Community College	Orlando, FL	1
Mar 21	Christopher Rubino	Prospective Intern, Cornell University	Ithaca, NY	1
Mar 21	Frank Chapman	Assistant Professor, Fisheries & Aquaculture, IFAS	Gainesville, FL	1
Mar 21	Malcolm Lumsden	Vice President, Federated Farmers of New Zealand	Wellington, New Zealand	1
Mar 22	Carolyn Sedgwick	Prospective Intern, University of New Hampshire	New Hampshire	1
Mar 23	Bill Walker	Manager, Food Science Division, U.S. Borax	Chicago, IL	2
Mar 26	Dr. Bill Armiger	Biochem Technologies		1
Mar 30	Jim Pidgeon	Lunar Soil Technician, University of Minnesota	Minnesota	2
Mar 31	Group	Participants, Southern Regional Biological Control Group		20
Apr 6	Tim Kring	Coordinator, Interregional Project on Biocontrol S192		40
Apr 10	Janine Lehman	Prospective Intern, Valencia Community College	Plant City, FL	1
Apr 11	Steve Godfrey	Systems Engineer, Bionetics	KSC, FL	1
Apr 12	Dan Dalke	Prospective Intern, University of Miami	Miami, FL	1
Apr 16	Dr. Fred Davies	Professor, Texas A&M University	College Station, TX	3
May 7	Charles Hall	Engineer, Environmental Research Labs	Tucson, AZ	1
May 9	Valerie Ann Jones	Research Assistant, University of Florida	Gainesville, FL	1
May 9	Whit Chase	Agriculture Liaison, Senator Bob Graham's office	Tallahassee, FL	2
May 13	Dr. Robert McGraw	Agronomist University of Missouri	Columbia, MO	1
May 15	Dr. Gary Simone	Researcher, University of Florida	Gainesville, FL	4
May 23	Mike Kohler	Engineer, NASA/Bionetics	KSC, FL	5
May 25	Nelson Takahashi	Agronomist, Cooperative Agriculture	Sao Paulo, Brazil	1
May 25	Rideki Okamoto	Agronomist, Cooperative Agriculture	Sao Paulo, Brazil	1
May 25	Scott Johnson	Agronomist, Allied-Signal Inc.	Hopewell, VA	1
May 26	Ted Turlings	Entomologist, USDA	Gainesville, FL	2

Science and Technology

Professional and Group Visits (continued)

DATE	NAME	TITLE, AFFILIATION	FROM	NO.
May 31	Dr. Herb Roitblat	Dolphin Researcher, University of Hawaii	Hawaii	1
May 31	Dr. Stan Kuczaj	Human Psychologist, Southern Methodist University	Dallas, TX	1
May 31	Dr. Sue Savage-Rumbaugh	Chimp Psychologist, Georgia Tech	Georgia	1
Jun 7	David Riley	Graduate Student, University of Florida	Gainesville, FL	1
Jun 7	Dr. Kim Hoelmer	Entomologist, USDA/ARS	Apopka, FL	1
Jun 12	Kim Warneke	Co-op Supervisor, Tree Farm, WDW	Lake Buena Vista, FL	27
Jun 25	Bill Atwill	President, FuturLab	Orlando, FL	2
Jun 28	Stephen Crnko	Extension Agent, Seminole County	Sanford, FL	1
Jul 1	Dr. Rodrigo Tarte	Director General, CATIE	Turrialba, Costa Rica	1
Jul 3	Dr. Desmond Jimenez	Research Scientist, USDA-ARS Horticulture Lab	Orlando, FL	4
Jul 9	Kirk Collier	Systems Engineer, Florida Solar Energy Research Center	Cape Canaveral, FL	2
Jul 13	Bent Vestegard	Owner, BV Hydro Systems	Taastrup, Denmark	1
Jul 17	Group	Challenge Program, Disney University		17
Jul 20	Mr. Jan Dill	Vice President, Oceanic Hawaii	Hawaii	2
Jul 27	Steve Boyd	Consultant, Ivey Bennet Harris & Walls	Orlando, FL	1
Aug 14	Dr. George Hochmuth	Vegetable Specialist, University of Florida IFAS Extension	Gainesville, FL	2
Aug 17	Scott Korney	Hydroponics Society of America	Concord, CA	1
Aug 28	Kim Warneke	Intern Supervisor, Disney Tree Farm Interns	Lake Buena Vista, FL	10
Sep 6	Barbara Hand	Public Affairs Staff, National Geographic Society	Washington, DC	2
Sep 7	Deborah Claesgens	Orlando Science Center	Orlando, FL	1
Sep 12	Ian Gregory	Int'l Fertilizer Development Center	Alabama	19
Sep 12	Jack Fournie	Fish Pathologist	Pensacola, FL	1
Sep 14	Dr. Kumar Mahadevan	Executive Director, Mote Marine Laboratories	Sarasota, FL	45
Sep 17	Larry Bell	Director, Boston Museum of Science	Boston, MA	1
Sep 23	Tom Hall	American Oceans Campaign		1
Sep 27	Kelly Lewis	Manatee Researcher for Georgia Sea Grant	Georgia	1
Sep 29	Phil Cavits	National Wildlife Federation		1
Oct 1	Dr. Gus Turnbill	VP-Academic Affairs, Florida State University	Florida	3
Oct 3	Dennis Chamberland	Liaison, NASA	KSC, FL	2
Oct 6	Roger Akerblom	Skandus Tour & Travel		50
Oct 9	Phil Bolotta	Dive Supervisor, Columbus Zoo	Columbus, OH	1
Oct 12	John Moran	Inspector, Florida Game & Fresh Water Commission	Orlando, FL	2
Oct 12	Steve Gustavino	Bio Systems Engineer, McDonnell Douglas	California	2
Oct 16	Group	Association of Science & Tech Centers		40
Oct 17	Elaine McEwan	Educational Coordinator, Los Angeles Theatre Center	Los Angeles, CA	1
Nov 8	George Taylor	President, Ocean Power Technologies	New Jersey	1
Nov 14	Jim Bledsoe	Systems Engineer, Bionetics	KSC, FL	2
Nov 19	Bill Soucie	Vice President, Kraft General Foods	Glenview, IL	6
Nov 29	Stephen Smith	President, Aqua Engineering	Fort Collins, CO	1
Nov 30	Linda Nelson	Plant Physiologist, U.S. Army Corps of Engineers	Vicksburg, MS	1
Nov 30	Mike Netherland	Plant Physiologist, U.S. Army Corps of Engineers	Vicksburg, MS	1
Dec 3	John Centko	Professor, Valencia Community College	Orlando, FL	1
Dec 4	James Sims	Inspector, Florida Division of Plant Industry	Tallahassee, FL	2
Dec 6	Dr. Gary Gascho	Agronomy Professor, University of Georgia	Tifton, GA	2
Dec 7	Steve Somermeyer	Producer, International Cichlid Conference II	Indianapolis, IN	2
Dec 18	Hoagy Kim	Director, National Science Museum	South Korea	1
Dec 18	Sangseon Won	Assistant Director, National Science Museum	South Korea	1
Dec 19	Dr. Bob Hochmuth	Extension Agent, Multi-county Agriculture Extension	Live Oak, FL	1
Dec 19	Dr. Daniel Cantliffe	Chairman, University of Florida Vegetable Crops	Gainesville, FL	3
Dec 21	Zeb Jones	Co-owner, Hawaiian Hydroponics	Hawaii	2

The Land Foreign Visitors

DATE	NAME	TITLE	COMPANY	FROM	NO.
Jan 6	Donald Mazankowski	Deputy Prime Minister	Government	Canada	4
Jan 13	Renzo Franco	Member, Council of Agriculture	General Agreement for Tariffs & Trade (GATT)	Switzerland	2
Jan 15	Alfred Prescod	Horticulturist	Royal Botanical Gardens	Hamilton, Ontario, Canada	1
Feb 2	Niels Ehler	Horticulturist	Royal Veg & Ag Univ.	Frederickberg, Denmark	1
Feb 2	Useld Frederiksen	Development Manager	Dgtvolmatic	Denmark	1
Feb 2	Jens Rystedt	Consultant	Dansk Erhvervsgartnerforening	Odense, Denmark	1
Feb 6	French Agriculture Society	Unicat Personnel		France	21
Mar 10	Dr. Wang Ren	Biological Control	Chinese Academy of Agric. Sci.	Beijing, China	1
Mar 18	Ricardo Valdez	Agricultural Trade Leader		Dominican Republic	1
Mar 18	Yuiannis Drossos	Agricultural Trade Leader		Greece	1
Mar 18	Laszlo Balogh	Agricultural Trade Leader		Hungary	1
Mar 18	Sveinn Bjornsson	Agricultural Trade Leader		Iceland	1
Mar 18	Jennifer Owen-Williams	Agricultural Trade Leader		Jamaica	1
Mar 18	Elijah Bikundo Manyara	Agricultural Trade Leader		Kenya	1
Mar 18	Gwendolyn Adighibe	Agricultural Trade Leader		Liberia	1
Mar 18	Kamaludin Haji Othman	Agricultural Trade Leader		Malaysia	1
Mar 18	Petre Prisecaru	Agricultural Trade Leader		Romania	1
Mar 18	Michael Chee Swee	Agriculture Trade Leader		Singapore	1
	Cheong				
Mar 18	Nadine Keim	Agriculture Trade Leader		Sweden	1
Mar 18	Sabahattin Gazanfer	Agriculture Trade Leader		Turkey	1
Mar 21	Malcolm Lumsden	Vice President	Federated Farmers of New Zealand	Wellington, New Zealand	1
Mar 26	Abraham Fikoloma	Principal	Livingstone Teacher Training College	Livingstone, Zambia	4
Mar 27	Brian Dunsby	Principal	Perlex Consultants	N. Yorks, United Kingdom	1
Apr 13	Yoshiaki Kimura	Staff Editor, Travel Magazine	Nikkei Business Publications	Tokyo, Japan	1
Apr 28	Toshihide Hatakeyama	Associate Director	Construction Div./Oriental Land Co.	Japan (Chiba)	1
Apr 28	Kenichiro Kikutani	Manager	Facility Section/Oriental Land Co.	Japan (Chiba)	1
Apr 28	Masashi Oikawa	Architect	Kuhkan Sekkei	Japan (Chiba)	1
Apr 28	Paul Komer	Vice President	Project Management/Tokyo Disneyland	Japan (Chiba)	1
Apr 28	Yasuyuki Fujiwara	Manager	Construction Permit Dept	Japan (Chiba)	1
Apr 28	Yasuyoshi Hayashi	Chief Plan & Eng Dept	Keikaku Gijutsu Kenkyujo	Japan (Chiba)	1
Apr 28	Yasuhiko Kimura	Asst. Mgr., Const. Permit Dept.	Chiba Prefectural Government	Japan (Chiba)	1
Apr 28	Hiroyuki Nakao	Staff Member, Plan Engr. Dept.	Keikaku Gijutsu Kenkyujo	Japan (Chiba)	1
May 21	Steven Yan	Host, TV Program	"Wok With Yan" on Lifeline	Vancouver, BC Canada	3
May 25	Nelson Takahashi	Agronomist	Cooperative Agriculture	Sao Paulo, Brazil	1
May 25	Rideki Okamoto	Agronomist	Cooperative Agriculture	Sao Paulo, Brazil	1
Jun 15	Takagihi Shogo	Journalist	Mainichi Newspaper	Japan	1
Aug 4	Maurice Laouchez	General Manager	Credit Agricole	Martinique, France	2
Aug 5	Martin Buske	Hydroponic Grower		Hampshire, England	1
Aug 7	Dr. David Hall	Professor	West of Scotland College	Scotland	1
Aug 15	Mr. Wong	Minister of Trade	Peoples Republic of China	China	4
Sep 7	Dr. L.D. Koshta	Tree Physiologist		India	1
Sep 7	Dr. P.K. Ashokan	Tree Physiologist		India	1
Sep 24	Mr. Tam	Vice Chairman	Hong Kong Trade Union	Hong Kong	2
Sep 27	Prince Ranier	Prince	Monaco	Monaco	7
Oct 8		TV Crew	German Disney Club	Germany	6
Oct 9	Val Darkin	SCUBA Diver	Federation of Underwater Activities	Vladivostok, U.S.S.R.	1
Dec 18	Hoagy Kim	Director	National Science Museum	South Korea	1

Science and Technology Publicity Guests

DATE	NAME	TITLE, COMPANY	FROM	COMMENT
Jan 5	Paul Stern	Videographer, Vox Television Production	W. Newton, MA	Filmed nitrogen production facilities.
Jan 8	Randy Bray	Photographer, WPBF-25	West Palm Beach, FL	Was here to cover President Bush's visit.
Jan 8		Reporter, WESH-TV	Orlando, FL	Was here to cover President Bush's visit.
Jan 8	Louis Aguirre	News Reporter, WSCV-51	Miami, FL	Was here to cover President Bush's visit.
Jan 8	Vicki Vaughn	Reporter, Orlando Sentinel	Orlando, FL	Was here to cover President Bush's visit.
Jan 8		Reporter, WTVT Channel 13	Tampa, FL	Was here to cover President Bush's visit.
Jan 10	Sam Knipp	Mgr, Broadcast Svcs. Kansas Farm Bureau	Manhattan, KS	Conducted radio interview with Peter.
Jan 10	Tony Stedman	Mgr. Video Services Michigan Farm Bureau	Lansing, MI	Shot video piece in The Land on futuristic agriculture.
Jan 17		Film Crew, Kraft General Foods	Chicago, IL	Produced internal promotion video.
Jan 18		Reporter, WSBS-AM Radio	Massachusetts	Interviewed Ginny Mann.
Jan 25	Dorothy Wenzel	Freelance Writer	Minneapolis, MN	Worked on article about Lunar Soil.
Jan 29	Pat Duggins	Reporter, Public Radio	Orlando, FL	Conducted phone interview with Andy about LDEF.
Feb 7	Marty Young	Reporter, CNN	Atlanta, GA	Filmed at EPCOT. The Land supplied eels for focus on aquaculture.
Feb 7	Ruth Foster	Writer, Boston Globe	Boston, MA	Interviewed David Wietlisbach for info on IPM.
Feb 13	Tom Maccubbin	Freelance Writer, Orange Co. Extension Svc.	Orlando, FL	Interviewed Fred.
Feb 13	Dennis Wall	Photographer, Orlando Sentinel	Orlando, FL	Took pictures for Tom MacCubbin.
Feb 16	Jim Fisher	Reporter, Florida Grower & Rancher	Orlando, FL	Interview with Lexie.
Mar 5	Rita Zawisza	Assistant Editor, Purdue Alumnus Magazine	W. Lafayette, IN	Interviewed Ginny for Purdue Alumni magazine article.
Mar 5	Mike Miller	Videographer, Earl Miller Productions	Texas	Videotaped Aquacell for segment in nationally-telecast Aquaculture Teleconference.
Apr 13	Yoshiaki Kimura	Staff Editor, Nikkei Business Publications	Tokyo, Japan	Worked on article about Disney for a travel magazine.
Apr 17	Ben Aycrigg	Reporter/Anchor, Channel 6	Orlando, FL	Produced segment on Biological Control in conjunction with Earth Day. Interviewed Fred and used IPM Video footage.
Apr 18	John Biffar	Reporter, Long John Productions/WINK-TV	Ft. Myers, FL	Interviewed Andy for TV Show.
Apr 19	Tom Conrad	Writer/Director Lockheed Video/Film	Sunnyvale, CA	Was here to film for Space Exploration promotion.
May 11	Penny Beers	Teacher, Gardendale Elementary School	Merritt Island, FL	Brought four gifted 3rd & 4th grade students, Austin Kamm, Ashley Zysko, Merissa Mccoy, and Christopher Ramos to Biotech Lab for Lexie to demonstrate Tissue Culture techniques on plants grown from seeds that had spent time in space.
May 11	Jim Banke	Reporter, Florida Today Newspaper	Melbourne, FL	Covered Lexie's demonstration of Tissue Culture techniques to gifted students from Brevard County.
May 11	Lin Wright	Reporter, WESH-TV	Orlando, FL	Covered Lexie's demonstration of Tissue Culture techniques to gifted students from Brevard County.
May 18	Ken Pruitt	Reporter, Good Morning America (ABC)	New York, NY	Filmed Boat Ride and The Disney Approach to Quality Service.
May 21	Steven Yan	Host, Wok With Yan/Lifeline	Vancouver, BC Canada	Filmed The Land and other parts of EPCOT for cooking show.
May 22	Darrell Jones	Photographer, Kodak	Rochester, NY	Worked on project for EPCOT Forum.
Jun 15	Takagihi Shogo	Journalist, Mainichi Newspaper	Japan	Interviewed Hank.
June 20		Reporter, UPI		Interviewed Conrad Litz about manatee stillbirth.
June 22	Chip Powers	Reporter, Tampa Tribune	Tampa, FL	Interviewed Hank and Peter.
Aug 2	Jeanne Voltz	Cookbook Writer		Interviewed Hank.
Aug 13	Karen Ireland	Freelance Writer, Disney News	California	Interviewed Peter for article on EPCOT Center technologies.
Aug 14	David Chandler	Reporter, Boston Globe	Boston, MA	Conducted phone interview with Andy for article on space agriculture.
Aug 15		Reporter, Today Show	New York, NY	Filmed Disney's "Dreamers and Doers" on The Boat Ride.
Aug 16	Mark Bondurant	Writer, IFAS Publicity Dept./UF	Gainesville, FL	Conducted phone interview with Andy for statewide press release.
Oct 5	Art Sechrist	Reporter, Nat'l Assn. of Farm Broadcasters		Interviewed Peter about The Land.
Oct 19		TV Crew	Italy	Filmed in The Land.
Nov 5	Lori Smith	WDW Coordinator, TV Crew, WHAS-TV	Louisville, KY	Filmed A Garden Show in Greenhouses.
Nov 7		TV Crew, CFCF-TV	Montreal, Canada	Filmed in Greenhouses.
Nov 21	Ron Jones	Freelance Writer, German Magazine	England	
Dec 10		Film Crew, Weather Channel	Canada	Interviewed Miguel and filmed in Greenhouses.

Presentations by Science & Technology Staff

DATE	SPEAKER	SEMINAR LOCATION/AUDIENCE	SEMINAR TITLE/TOPIC
Jan 31	Eldon Muller	Land Seminar	"A Weighing Lysimeter For Evapotranspiration & Irrigation Control".
Feb 1	Eldon Muller	LBV, FL/Int'l Conference on Computers in Ag Extension Programs	"A Weighing Lysimeter For Evapotranspiration & Irrigation Control".
Feb 6	Fred Pettitt	Orlando, FL/Southeastern Branch, Entomological Soc. of America	"Responses of the Leafminer Parasitoid <i>Opius dissitus</i> to Host-related Airborne Semiochemicals".
Feb 13	Eldon Muller	Lake Alfred, FL/IFAS Research Station	Water Management in Greenhouses: Irrigation Monitoring and Control at The Land.
Feb 13	Fred Pettitt	Orlando, FL/Univ. of Central Florida Biological Science Dept.	"Biological Control of the Vegetable Leafminer <i>Liriomyza sativae</i> by <i>Opius dissitus</i> at The Land, EPCOT Center."
Mar 5	Jeff Keaffaber	Seas Seminar	"Biochemical Reduction: Nitrate to Nitrogen Gas in 4 Steps".
Mar 13	Jeff Keaffaber	Land Seminar	"Biochemical Reduction: Nitrate to Nitrogen Gas in 4 Steps".
Mar 28	Jeff Keaffaber	Orlando, FL/Univ. of Central Florida Chemistry Dept.	"Chemistry of Fluorinated Organic Systems" - Dissertation Research".
May 23	Peter Cook	Land Seminar	"Get Hooked on Aquaculture" Teleconference Videotape.
May 30	Peter Cook	Seas Seminar	"Get Hooked on Aquaculture" Teleconference Videotape.
Jun 7	Andrew Schuerger	Orlando, FL/Space Conference	Long-Duration Exposure Facility (LDEF).
Jun 14	Andrew Schuerger	Land Seminar	"Space Agriculture and LDEF".
Jun 19	Andrew Schuerger	Seas Seminar	"Space Agriculture and LDEF".
Jun 21	Bob Hines	Land Seminar	"A Thin Film Hydroponic System For Plant Studies".
Jun 21	Bob Hines	Columbus, OH/American Society of Agricultural Engineers	"A Thin Film Hydroponic System For Plant Studies".
Jul 25	Peter Cook	Raleigh, NC/NC Ag in Classroom Workshop	"The Land: A New Vehicle for Agricultural Communications".
Jul 26	Peter Cook	Rockford, IL/Dupont Press Event	"The Land: A New Vehicle for Agricultural Communications".
Aug 7	Andrew Schuerger	Grand Rapids, MI/American Phytopathological Society	"Effect of Temperature & pH on Spore Attachment of <i>Fusarium solani</i> on <i>Vigna radiata</i> ."
Aug 7	Peter Cook	Asheville, NC/NC Ag in Classroom Workshop	"The Land: A New Vehicle for Agricultural Communications".
Aug 17	Mary Schon	Guelph, Canada/Boron in Ag & Biological Systems Workshop	Dissertation Research/Boron Research at The Land.
Aug 22	Andrew Schuerger	Land Seminar	LDEF and Space Agriculture: An Update.
Sep 6	Stephen Wolf	Land Seminar	"Effects of Experience on Attraction of the Leafminer Parasitoid <i>Opius dissitus</i> to Host-related Airborne Semiochemicals".
Sep 14	Hank Robitaille	Editors & Writers Conference/EPCOT Center	Purpose, Philosophy, and Operation of The Land.
Sep 14	Lexie McKently	Editors & Writers Conference/EPCOT Center	Biotechnology.
Sep 14	Fred Pettitt	Editors & Writers Conference/EPCOT Center	Integrated Pest Management.
Sep 14	Eldon Muller	Editors & Writers Conference/EPCOT Center	Irrigation Control in Greenhouses.
Sep 17	Mary Schon	Gainesville, FL/Horticulture Dept.	"Physiological Roles of Boron in Plants."
Oct 5	Jeff Keaffaber	North Manchester, IN/Manchester College Chemistry Department	"Denitrification & Ozonation of Closed Recirculating Marine Systems".
Oct 19	Jeff Keaffaber	Seas Seminar	"Performance of the Pilot Scale Denitrification System".
Oct 21	Mary Schon	San Antonio, TX/American Society of Agronomy	Posters: "The Land Focuses the Public's Attention on Agriculture" and "Use of Anti-Transpirants to Redirect Calcium and Boron Movement in Plants".
Oct 30	Maureen Knop	Crossnore, NC/Ornamental Workshop on Disease & Insects	"Concerns about Tomato Spotted Wilt Virus and Western Flower Thrips at EPCOT".
Nov 4	Hank Robitaille	Tucson, AZ/American Society For Horticulture Science	Poster: "The Land Focuses the Public's Attention on Agriculture"; Also, Moderator For Administrators Breakfast: "Long-Range Planning".
Nov 9	Jeff Keaffaber	Bionetics/KSC, FL	"Denitrification & Ozonation of Closed Recirculating Marine Systems".
Nov 14	Ed Bell	Land Seminar	Greenhouse & Runoff Update
Nov 14	Ivey Burns	Land Seminar	Lysimeter & Irrigation Update and Project Summary
Nov 19	Lexie McKently	LBV, FL/ Kraft General Foods Biotechnology Meeting	Peanut Transformation Research Process.
Dec 5	Fred Pettitt	New Orleans, LA/Entomological Society of America	"Effects of Experience on Attraction of the Leafminer Parasitoid <i>Opius dissitus</i> to Host-related Airborne Semiochemicals".

Science and Technology Staff Trips

DATE	PERSON ATTENDING	LOCATION	CONFERENCE	TOPIC
Jan 4-5	Lexie McKently	Chicago, IL	Kraft Biotechnology Center	Biotechnology Update
Jan 29-31	Mary Schon	New Brunswick, NJ	Rutgers University Short Course	Greenhouse Design & Management
Jan 31-Feb 1	Sue Novak	Lake Buena Vista, FL	Int'l Conf. Computers in Ag Ext Programs	Computer Technology Update
Jan 31-Feb 1	Ivey Burns	Lake Buena Vista, FL	Int'l Conf. Computers in Ag Ext Programs	Computer Technology Update
Jan 31-Feb 1	Ed Bell	Lake Buena Vista, FL	Int'l Conf. Computers in Ag Ext Programs	Computer Technology Update
Jan 31-Feb 2	Maureen Knop	Homestead, FL	Sweet Potato Whitefly Workshop	Biological Controls
Jan 31-Feb 2	Fred Pettitt	Homestead, FL	Sweet Potato Whitefly Workshop	Biological Controls
Feb 4-8	Fred Pettitt	Orlando, FL	SE Branch, ESA	Annual Meeting
Feb 4-8	Rick Etzel	Orlando, FL	SE Branch, ESA	Annual Meeting
Feb 4-8	Maureen Knop	Orlando, FL	SE Branch, ESA	Annual Meeting
Feb 4-8	Marian Coffey	Orlando, FL	SE Branch, ESA	Annual Meeting
Feb 12-13	Sue Novak	Tavares, FL	Campbell Scientific Training	Engineering Applications
Mar 6-7	Dinah Jordan	Altamonte Springs, FL	Ventura Desktop Publishing Training	Computer Design
Mar 10-14	Sue Novak	Long Beach, CA	Sensors Expo Trade Show Conference	Sensor Technology
Apr 3-8	Mary Schon	Columbia, MO	Plant Physiology	Plant Biochemistry & Physiology
Apr 5	Fred Pettitt	Orlando, FL	So. Reg. Bio Control Work Group	Biological Control of Insects
Apr 18-19	Lexie McKently	Tarrytown, NY	General Foods Research Center	Biotech Planning Meeting
Apr 26-28	Eldon Muller	Orlando, FL	FL Section, Amer. Soc. Ag. Eng	Annual Meeting
Apr 26-28	Sue Novak	Orlando, FL	FL Section, Amer. Soc. Ag. Eng	Annual Meeting
Apr 26-28	Bob Hines	Orlando, FL	FL Section, Amer. Soc. Ag. Eng	Annual Meeting
May 7-10	Lexie McKently	Toronto, Canada	Allelix Plant Biotech Co.	KGF Technology Meetings
May 8	Mary Schon	Leesburg, FL	Agriculture Field Day On Squash	Cultivar Trials
May 8	Bret Norman	Leesburg, FL	Agriculture Field Day On Squash	Pathological Problems
May 12-19	Tom Hopkins	Vancouver, Canada	Int'l Assoc for Aquatic Animal Medicine	Aquatic Animal Medicine
May 15	Mary Schon	Live Oak & Lake City, FL	IFAS	Nutrient Solutions/Rockwool in Vegetable Production
May 15	Sandra Gerdes	Live Oak & Lake City, FL	IFAS	Tomato Nutrient Solutions/Rockwool in Vegetable Production
May 23	Sue Novak	Ft. Myers, FL	Yoder Brothers Greenhouses	Thrips Exclusion Design
May 23	Maureen Knop	Ft. Myers, FL	Yoder Brothers Greenhouses	Thrips Exclusion Design
Jun 10-14	Jane Davis	Halifax, Nova Scotia	World Aquaculture Society	Annual Meeting
Jun 10-15	Peter Cook	Halifax, Nova Scotia	World Aquaculture Society	Annual Meeting
Jun 11-12	Bill Hammer	Gainesville, FL	Univ. of Florida Workshop	Virus Inclusion Bodies
Jun 11-12	Bret Norman	Gainesville, FL	Univ. of Florida Workshop	Virus Inclusion Bodies
Jun 11-12	Andrew Schuerger	Gainesville, FL	Univ. of Florida Workshop	Virus Inclusion Bodies
Jun 14-17	Greg Charbeneau	Charleston, SC	American Elasmobranch Society	Annual Meeting
Jun 18-20	Tom Hopkins	Turks & Caicos Islands	Providenciales	
Aug 1-5	Peter Cook	Miami, FL	Florida Aquaculture Society	Annual Meeting
Aug 12-15	Mike Andrew	Athens, GA	Univ. of Georgia Fish Disease Seminar	Fish Diseases
Aug 19-25	Fred Pettitt	Chatauqua, NY	Chatauqua Int'l Conf On Environment *	Environment
Aug 26-31	Jeff Keaffaber	Washington, DC	American Chemical Society	Annual Meetings
Sep 5-11	Ed Bell	Pittsburgh, PA	Greenhouses And Runoff Conference	Environmental Concerns
Sep 11-14	Tom Hopkins	Alexandria, VA	Marine Mammal Interest Group	Marine Mammals
Sep 24-28	Tom Hopkins	Indianapolis, IN	Amer. Assoc. of Zoos, Parks, & Aquariums	Animal Care
Oct 3-7	Maryann Buehn	St. Petersburg, FL	Amer. Academy of Underwater Sciences	Underwater Science
Oct 3-7	Deborah Weber	St. Petersburg, FL	Amer. Academy of Underwater Sciences	Underwater Science
Oct 11	Bret Norman	Gainesville, FL	Univ. of Florida Workshop	Virus Identification
Oct 11	Andrew Schuerger	Gainesville, FL	Univ. of Florida Workshop	Virus Identification
Oct 22	Elaine Leslie	Myrtle Beach, SC		"Wild Hearts" Filming
Oct 26-Nov 2	Ivey Burns	Phoenix, AZ	Irrigation Symposium	Irrigation Technology Update
Oct 31-Nov 2	Sandra Gerdes	Jacksonville, FL	Amer. Ghse. Veg. Growers Assoc.	Horticulture Technology Update
Nov 15	Lexie McKently	Chicago, IL	Kraft General Foods	Biotech Business Meeting
Nov 26-30	Lexie McKently	Washington, DC	BIOTECH USA	Biotech Technology Update
Dec 2-6	Fred Pettitt	New Orleans, LA	Entomological Society of America	Bio Control Research
Dec 7	Ed Bell	Orlando, FL	Florida State Irrigation Trade Show	Irrigation Engineering
Dec 7	Ivey Burns	Orlando, FL	Florida State Irrigation Trade Show	Irrigation Engineering
Dec 7	Bob Hines	Orlando, FL	Florida State Irrigation Trade Show	Irrigation Engineering
Dec 7	Sue Morris	Orlando, FL	Florida State Irrigation Trade Show	Irrigation Engineering
Dec 7	Eldon Muller	Orlando, FL	Florida State Irrigation Trade Show	Irrigation Engineering
Dec 7	Brad Wind	Orlando, FL	Florida State Irrigation Trade Show	Irrigation Engineering

Visiting Speakers in Science & Technology

DATE	SPEAKER	COMPANY	FROM	SEMINAR TITLE/TOPIC
Feb 21	Dr. Dudley Crosson	Delta P	Port St. Lucie, FL	Mixed Gas Diving *
Mar 13	Dr. Dave Anderson	Ag Research & Education Center	Belle Glade, FL	"Association of Sugar Cane Rust With Soil and Plant Nutrient Conditions"
Mar 27	Brian Dunsby	Perlex Consultants	N. Yorks, United Kingdom	Perlex Growing Systems.
Apr 16	Dr. Peter Sharp	Texas A&M	College Station, TX	"Plant Production in Low Pressure Systems."
Apr 18	Chris Coston	University of Florida	Gainesville, FL	"The Preparation and Chemistry of High Temperature Superconductors."
Apr 20	Scott Davidson	Reedy Creek, WDW	Lake Buena Vista, FL	"Topics in Environmental Chemical Analysis."
May 30	Glen Byer	Florida Institute of Technology	Melbourne, FL	"Water Quality in Estuarine and Lagoonal Waters."
Jun 26	Bill Easterwood	University of Florida	Gainesville, FL	Lunar Soils.
Jun 27	Marvin Brown	Favrite Farms, Inc.	Dover, FL	"A New Vertical System of Growing."
Aug 7	Dr. David Hall	West of Scotland College	Scotland	"Perlite as a Substrate for Vegetable Production."
Aug 8	Bob Adolphe	Reedy Creek Env. Services	Lake Buena Vista, FL	"Solid Waste Management: Waste Reduction and Recycling".
Aug 14	Mr. Francis Ferguson	FAIRS, University of Florida	Gainesville, FL	Florida Agricultural Information Retrieval Service. *
Sep 18	Rick Martinez	Manatee Foods		"Mass Production of Alfalfa Sprouts and Grass Using Hydroponics."
Oct 9	Val Darkin	Federation of Underwater Activities	Vladivostok U.S.S.R.	SCUBA Diving in The U.S.S.R. *

* At Living Seas

Published Papers Science & Technology, EPCOT Center

Refereed

Dolbier, W. R. Jr., T. A. Gray, J. J. Keaffaber, L. Celewicz, and H. Koroniak. Kinetic and thermodynamic effects in the thermal electrocyclic ring-openings of 3-fluorocyclobutene, 3,3-difluorocyclobutene, and 3-(trifluoromethyl) cyclobutene. *J. Amer. Chem. Soc.* 112: 363-367.

Dolbier, W. R. Jr., J. J. Keaffaber, C. R. Burkholder, S. F. Sellers, H. Koroniak, and J. Pradhan. The thermal conversions of 6,6-difluorobicyclo [3.1.0] hex-2-enes to fluorobenzenes. An interesting dichotomy of mechanisms. *J. Amer. Chem. Soc.* [Accepted].

McKently, A. H., G. A. Moore, and F. P. Gardner. *In vitro* plant regeneration of peanut from seed explants. *Crop Science* 30(1): 192-196.

Petitt, F. L. Distinguishing larval instars of the vegetable leafminer, *Liriomyza sativae* (Diptera: Agromyzidae). *Fla. Entomol.* 73: 280-286.

Petitt, F. L., J. C. Allen, and C. S. Barfield. Degree-day model for vegetable leafminer (Diptera: Agromyzidae) phenology. *Environ. Entomol.* [Accepted].

Seligson, S. A. and D. J. Weber. Alterations in established swimming habits of carcharhinid sharks at the Living Seas Pavilion. *J. Aquaculture & Aquatic Sci.* V(4): 105-111.

Schon, M. K. and D. G. Blevins. Foliar boron applications increase the final number of branches and pods on branches of field-grown soybeans. *Plant Physiol.* 92: 602-607.

Schon, M. K., A. Novacky, and D. G. Blevins. Boron induces hyperpolarization of sunflower root cell membranes and increases membrane permeability to K⁺. *Plant Physiol.* 93: 566-571.

Other

Conrad, G. W. and C. A. Leur. Development of the cornea in the eye of the clearnose skate (*Raja eglanteria*). *Bull. Mt. Desert Is. Biol. Lab.* 29:13. [Research supported by WDI R&D funds.]

Easterwood, G. W., J. J. Street, J. B. Sartain, D. H. Hubbell, and H. A. Robitaille. Lunar Base CELSS--A Bioregenerative Approach. In W. Mendell (ed.) *Lunar Bases and Space Activities in the 21st Century*. Houston, Texas. [In press.]

Hines, R. L., R. Prince, E. R. Muller, and A. C. Schuerger. A thin film hydroponic system for plant studies. Paper # 90-4035. American Society of Agricultural Engineering, Columbus, Ohio.

Jordan, D. L. Food for the final frontier. *FFA New Horizons*. February/March: 20-21.

McKently, A. H. Plant regeneration via somatic embryogenesis in peanut. *In Vitro Cellular and Developmental Biology Abstracts* 26(3):45.

McKently, A. H. Regeneration of peanut and perennial peanut from cultured leaf tissue. *In Vitro Cellular and Developmental Biology Abstracts* 26(3):68.

Petitt, F. L. and M. K. Schon. EPCOT Center's "The Land" focuses the public's attention on agriculture. *Agronomy Abstracts*: 29.

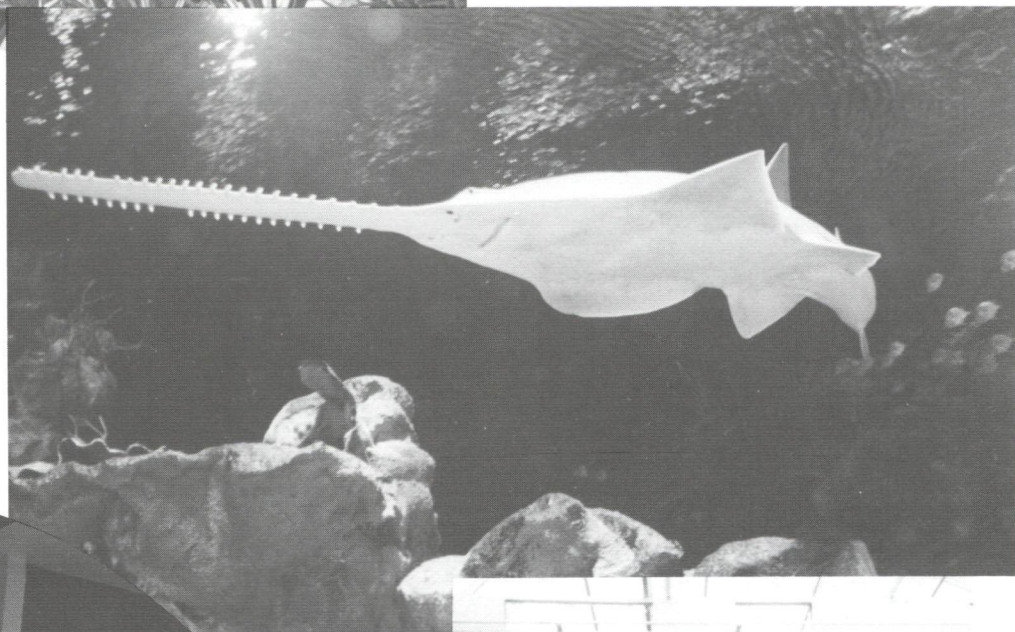
Schon, M. K. A Science Career: Working "The Land". In 1990 Yearbook of Agriculture. United States Department of Agriculture.

Schon, M. K., and B. A. Shirley. Use of anti-transpirants to redirect calcium and boron movement in plants. *Agronomy Abstracts*: 280.

Schuerger, A. C. and D. J. Mitchell. Effect of temperature and pH on spore attachment of *Fusarium solani* f. sp. *phaseoli* on *Vigna radiata* in hydroponic systems. *Phytopathology* 80(10): 971.



Clockwise from top: Guests ride through greenhouses on Land boat ride; Sawfish at Living Seas; Mickey and Land horticulturist Virginia Mann; Seas guests observe JIM suit.



"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

ORIGINATOR: 02

STATUS C

DOCUMENT NUMBER: 9123575

DIRECTORATE STATUS

FROM: WHITELAW, Michael J.: IEEE U.S. ACTIVITIES

TO: DR. D.A. BROMLEY

~~HE~~
~~AW~~

DATE OF
CORRESPONDENCE: 08/20/91

SUBJECT: A LETTER TO THE PRESIDENT INFORMING HIM THAT DR.
BROMLEY HAS BEEN CHOSEN TO RECEIVE THE 1991 IEEE
UNITED STATES ACTIVITIES BOARD DISTINGUISHED PUBLIC
SERVICE AWARD.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley FCCSET
DIRECTOR'S OFFICE
ALL ASSOCIATE DIRECTORS
PCAST

WHITE HOUSE TRACKING #: CONTACT PERSON:
REMARKS: PHONE: EXT:

*I think Dr. Bromley's office is the most appropriate
place for the meeting. (Oct 23)*

OSTP RECEIVED: 08/23/91
DEPT RECEIVED: FILE: P-EOP-PRESIDENTIAL*P-DAB-AWARD

*10/23/91 - DAB met with the IEEE Reps.
MA*



IEEE

UNITED STATES ACTIVITIES

RECEIVED

Promoting Career and Technology Policy Interests of Electrical, Electronics & Computer Engineers

91 AUG 23 AM : 15

United States Activities Board August 20, 1991

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DIRECTOR

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The Honorable George Bush
President of the United States
The White House
Washington, DC 20500

Dear Mr. President:

It is my pleasure to inform you that D. Allan Bromley has been chosen to receive the 1991 IEEE United States Activities Board Distinguished Public Service Award. Dr. Bromley is being honored for his outstanding contributions to the development and implementation of Federal policy on science, engineering and technology. His activities have been directed toward the enhancement of the technology policy interests of the United States and thereby the interests of our U.S. members.

The plaque representing the award will be presented to Dr. Bromley in his office at 11:00 am, October 23, 1991.

The Institute of Electrical and Electronics Engineers (IEEE) is a transnational society directed toward the advancement of the theory and practice of electrical and electronics engineering and the related arts and sciences. There are approximately 320,000 individual members worldwide of which some 250,000 are in the United States. The United States Activities Board (USAB) of IEEE is responsible for the interests of the U.S. members.

Sincerely,

M. J. Whitelaw

Michael J. Whitelaw
IEEE Vice President, Professional Activities and
Chairman, United States Activities Board

MJW:mls

BCC: E. Sumner
D. Bromley
M. Buckley
D. Brereton
E. Herz
L. Fanning
W. Anderson

"CORRESPONDENCE TRACKING"

TYPE: PRESIDENTIAL DOCUMENT NUMBER: 9123494
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

FROM: PEOPLES, John: FERMILAB

TO: PRESIDENT BUSH

DATE OF
CORRESPONDENCE: 08/09/91

SUBJECT: RE: A NEW INFORMAL PROFILE OF FERMILAB.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
PHYSICAL SCIENCES

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:
REMARKS: Enclosures to DAB.

OSTP RECEIVED: 08/15/91
DEPT RECEIVED:

FILE: P-EOP-PRESIDENTIAL*P-PS-ENERGY
Priority

THE WHITE HOUSE
WASHINGTON

September 19, 1991

Dear John:

Just a brief note of congratulations on your new report **Fermilab: Boundless Horizons**. The report is beautifully done, and is the sort of document that makes my job substantially easier.

Unfortunately our paths have not crossed as often as I would have liked in the recent past. Let me only wish you continuing success in your responsibilities at Fermilab.

With all best wishes,

Sincerely yours,



D. Allan Bromley
The Assistant to the President
for
Science and Technology

Dr. John Peoples
Director
Fermilab National Accelerator Laboratory
Post Office Box 500
Batavia, Illinois 60510



Fermilab

349d
Fermi National Accelerator Laboratory
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708-840-3211 FTS 370-3211

Director's Office

August 9, 1991

OSTP
George Bush
President
The White House
Washington, D.C. 20500

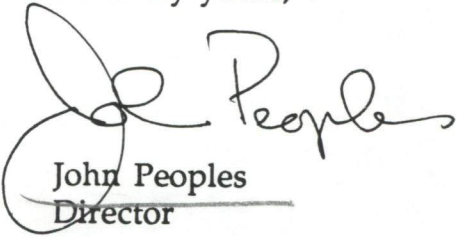
Dear Mr. President:

I am happy to present you with a new, informal profile of Fermilab, the largest, most active high-energy physics laboratory in the United States. *Boundless Horizons* conveys the essence of what we do, the spirit of our approach, and the values that over the years have shaped the Laboratory's contributions to science and to society.

Civic leaders of wisdom and foresight have helped Fermilab to become a national laboratory of the highest quality. We are grateful for your commitment to scientific excellence, to technical innovation, and to learning of many kinds.

I hope you share my pride in the vigor, excitement, and importance of our achievements and our aspirations.

Sincerely yours,



John Peoples
Director

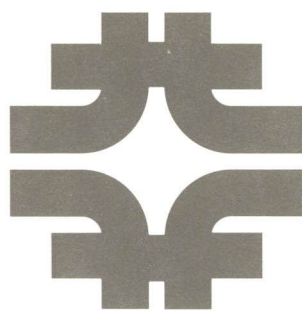
Enclosure
Boundless Horizons



FERMILAB: BOUNDLESS HORIZONS

RESEARCHERS FROM THE FOLLOWING INSTITUTIONS HAVE CHOSEN FERMILAB AS THE PLACE TO CARRY OUT THEIR WORK OF CONSTRUCTING A BETTER PICTURE OF THE UNIVERSE AND ITS UNDERLYING LAWS. AUSTRALIA: AUSTRALIAN NATIONAL UNIVERSITY; UNIVERSITY OF MELBOURNE; UNIVERSITY OF SYDNEY; UNIVERSITY OF TASMANIA. BELGIUM: UNIVERSITÉ DE L'ÉTAT A MONS; UNIVERSITÉ LIBRE DE BRUXELLES. BRAZIL: CENTRO BRASILEIRO DE PESQUISAS FÍSICAS; UNIVERSIDADE DE SÃO PAULO; UNIVERSIDADE FEDERAL DO RIO DE JANEIRO. BULGARIA: UNIVERSITY OF SOFIA. CANADA: ADVANCED TECHNOLOGY LABORATORIES-BELL NORTHERN RESEARCH; CANADIAN INSTITUTE OF PARTICLE PHYSICS; CARLETON UNIVERSITY; CHALK RIVER NUCLEAR LABORATORIES; MCGILL UNIVERSITY; UNIVERSITÉ DE MONTRÉAL; UNIVERSITY OF OTTAWA; UNIVERSITÉ DU QUÉBEC; UNIVERSITY OF TORONTO; UNIVERSITY OF WESTERN ONTARIO; VANIER COLLEGE; YORK UNIVERSITY. PEOPLE'S REPUBLIC OF CHINA: INSTITUTE OF HIGH-ENERGY PHYSICS, BEIJING; NANJING UNIVERSITY; SHANDONG UNIVERSITY. COLOMBIA: UNIVERSIDAD DE LOS ANDES. EQUADOR: UNIVERSIDAD DE SAN FRANCISCO DE QUITO. FEDERAL REPUBLIC OF GERMANY: ALBERT-LUDWIGS-UNIVERSITÄT, FREIBURG; INSTITUT FÜR THEORETISCHE PHYSIK, AACHEN; CHRISTIAN-ALBRECHTS UNIVERSITÄT ZU KIEL; MAX-PLANCK INSTITUTE; UNIVERSITÄT-GESAMTHOCHSCHULE WUPPERTAL. FRANCE: CENTRE D'ETUDES NUCLÉAIRES DE SACLAY; CENTRE DE RECHERCHES NUCLÉAIRES DE STRASBOURG; COLLÈGE DE FRANCE; LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE; LABORATOIRE DE PHYSIQUE DES PARTICULES; RENÉ BERNAIS LABORATOIRE; UNIVERSITÉ DE LYON; UNIVERSITÉ DE NANCY; UNIVERSITÉ DE PARIS VI; UNIVERSITÉ DE STRASBOURG. GERMAN DEMOCRATIC REPUBLIC: INSTITUT FÜR HOCHENERGIEPHYSIK. GREECE: NATIONAL AND CAPODISTRIAN UNIVERSITY OF ATHENS. HUNGARY: CENTRAL RESEARCH INSTITUTE FOR PHYSICS OF THE HUNGARIAN ACADEMY OF SCIENCES. INDIA: JADAVPUR UNIVERSITY; PANJAB UNIVERSITY; RAJASTHAN UNIVERSITY; TATA INSTITUTE OF FUNDAMENTAL RESEARCH; UNIVERSITY OF DELHI; UNIVERSITY OF JAMMU. IRELAND: UNIVERSITY COLLEGE, DUBLIN. ISRAEL: TEL-AVIV UNIVERSITY; WEITZMANN INSTITUTE OF SCIENCE. ITALY: ISTITUTO NAZIONALE DI FISICA NUCLEARE (FRASCATI, GENOVA, MILANO, PISA, ROMA, TORINO); UNIVERSITÀ DEGLI STUDI DI BARI; UNIVERSITÀ DEGLI STUDI DI BOLOGNA; UNIVERSITÀ DEGLI STUDI DI FERRARA; UNIVERSITÀ DEGLI STUDI DI FIRENZE; UNIVERSITÀ DEGLI STUDI DI LECCE; UNIVERSITÀ DEGLI STUDI DI MILANO; UNIVERSITÀ DEGLI STUDI DI PAVIA; UNIVERSITÀ DEGLI STUDI DI TORINO; UNIVERSITÀ DEGLI STUDI DI TRIESTE; UNIVERSITÀ DEGLI STUDI DI UDINE. JAPAN: AICHI UNIVERSITY OF EDUCATION; ASHIKAGA INSTITUTE OF TECHNOLOGY; AOYAMA GAKUIN UNIVERSITY; GIFU UNIVERSITY; HIROSAKI UNIVERSITY; HIROSHIMA UNIVERSITY; INSTITUTE FOR COSMIC RAY RESEARCH, UNIVERSITY OF TOKYO; INSTITUTE OF SPACE AND AERONAUTICAL SCIENCES, UNIVERSITY OF TOKYO; KANAGAWA UNIVERSITY; KINKI UNIVERSITY; KOBE UNIVERSITY; KONAN UNIVERSITY; KWANSEI GAKUIN UNIVERSITY; KYOTO SANGYO UNIVERSITY; KYOTO UNIVERSITY OF EDUCATION; NAGOYA UNIVERSITY; NATIONAL LABORATORY OF HIGH-ENERGY PHYSICS (KEK); OKAYAMA UNIVERSITY; OSAKA CITY UNIVERSITY; OSAKA SCIENCE EDUCATION INSTITUTE; SAITAMA UNIVERSITY; SHINSU UNIVERSITY; TOHO UNIVERSITY; TOHOKU GAKUIN UNIVERSITY; TOHOKU UNIVERSITY; UNIVERSITY OF OCCUPATIONAL AND ENVIRONMENTAL HEALTH; UNIVERSITY OF TOKYO; UNIVERSITY OF TSUKUBA; UTSUNOMIYA UNIVERSITY; WAYAKAMA MEDICAL COLLEGE; WASEDA UNIVERSITY; YOKOHAMA NATIONAL UNIVERSITY. REPUBLIC OF KOREA: CHONNAM NATIONAL UNIVERSITY; GYEONGSANG NATIONAL UNIVERSITY; JEONBUK NATIONAL UNIVERSITY; KOREA UNIVERSITY; SOOKMYUNG WOMEN'S UNIVERSITY; WON KWANG UNIVERSITY. MEXICO: UNIVERSIDAD DE GUANAJUATO. THE NETHERLANDS: KATHOLIEKE UNIVERSITEIT NIJMEGEN. NEW ZEALAND: UNIVERSITY OF AUCKLAND. POLAND: INSTITUTE OF NUCLEAR PHYSICS, KRAKÓW; INSTITUTE FOR NUCLEAR STUDIES, WARSZAWA. PUERTO RICO: UNIVERSITY OF PUERTO RICO. ROMANIA: CENTRAL INSTITUTE OF PHYSICS; INSTITUTE FOR ATOMIC PHYSICS. SINGAPORE: NATIONAL UNIVERSITY OF SINGAPORE. SPAIN: INSTITUTO DE FÍSICA CORPUSCULAR; UNIVERSIDAD DE BARCELONA; UNIVERSIDAD DE SANTANDER; UNIVERSIDAD DE VALÈNCIA. SWEDEN: LUNDS UNIVERSITET; STOCKHOLMS UNIVERSITET; UPPSALA UNIVERSITET. SWITZERLAND: EIDGENÖSSISCHE TECHNISCHE HOCHSCHULE, ZÜRICH; EUROPEAN LABORATORY FOR PARTICLE PHYSICS. TAIWAN: INSTITUTE OF HIGH-ENERGY PHYSICS, ACADEMIA SINICA. UNION OF SOVIET SOCIALIST REPUBLICS: INSTITUTE FOR THEORETICAL AND EXPERIMENTAL PHYSICS,

FERMILAB BOUNDLESS HORIZONS



UNIVERSITIES RESEARCH ASSOCIATION, INC.

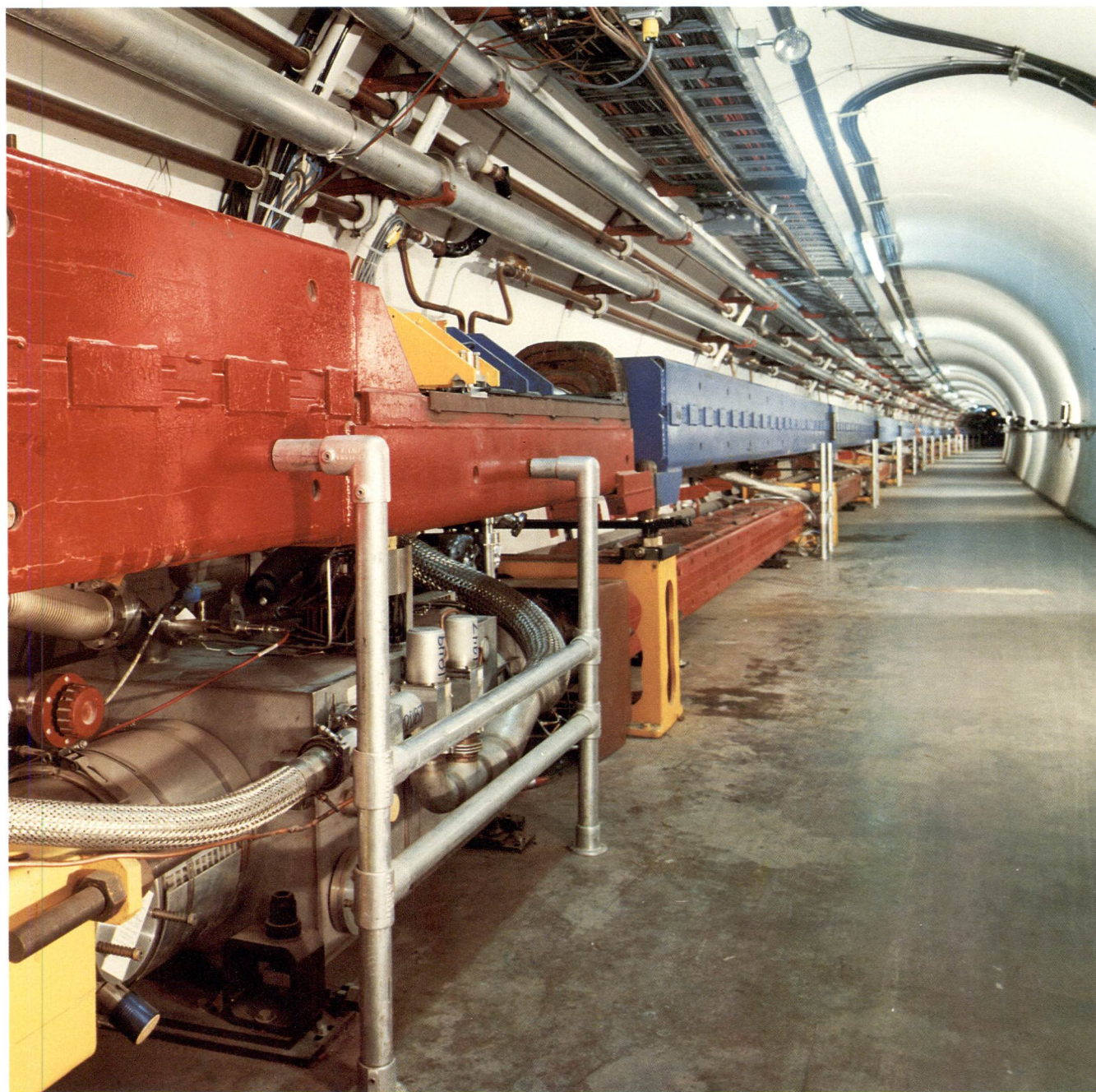
 ON A SIXTY-EIGHT-HUNDRED-ACRE EXPANSE OF ILLINOIS PRAIRIE, TWENTY-SEVEN MILES WEST OF CHICAGO, STANDS A REMARKABLE CREATION OF THE HUMAN MIND AND SPIRIT. FOR MORE THAN TWENTY

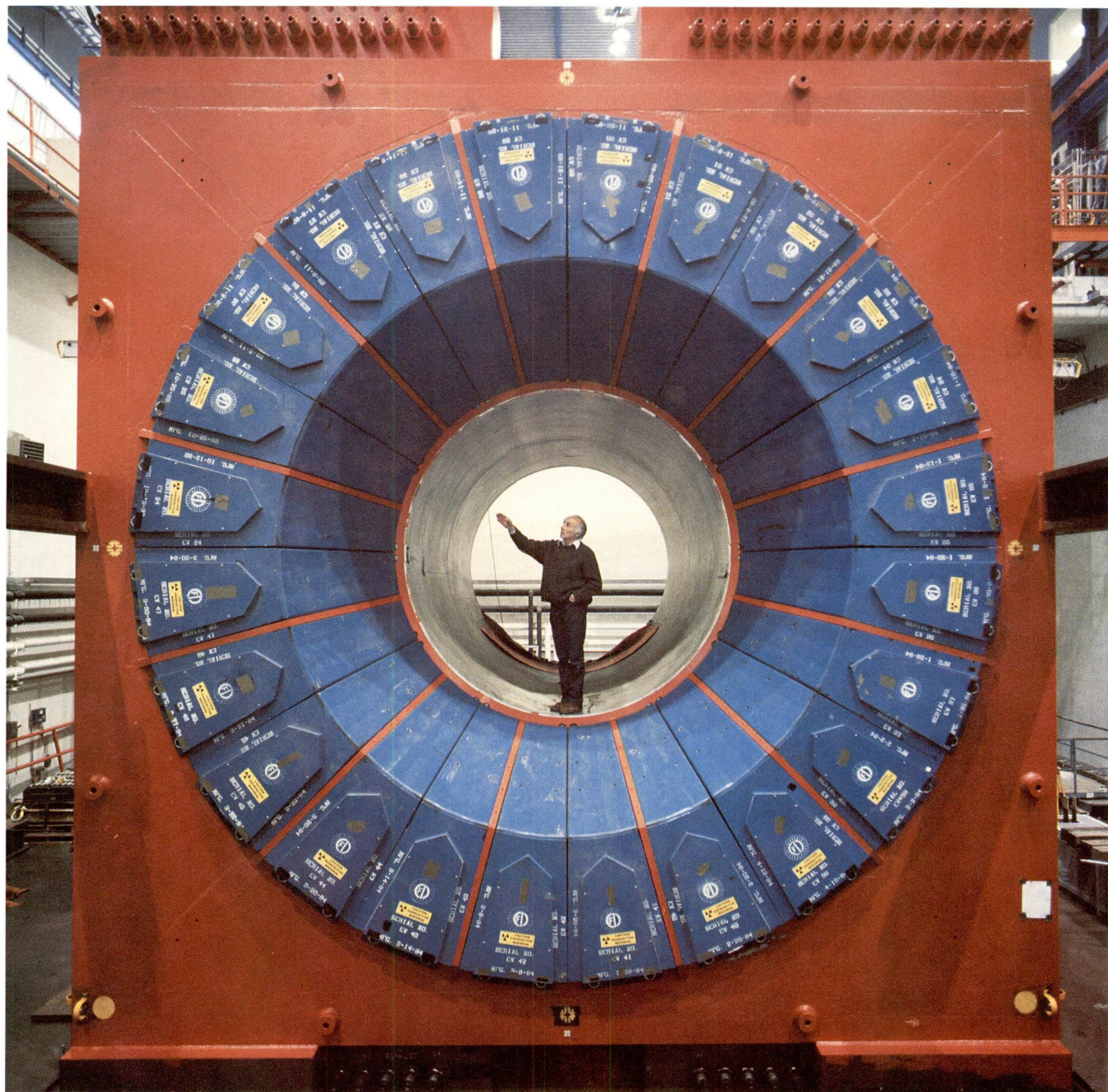
years, the Fermi National Accelerator Laboratory — Fermilab, to its friends — has been dedicated to revealing the mysterious beauty and evolution of the physical universe. By probing the subatomic world, scientists are forging the key that may unlock such cosmic riddles as why there is so much more matter than antimatter in the universe; why some things, like light, are massless when other things have mass; what the enigmatic unseen matter is that accounts for ninety percent of the mass in the universe. And, historically, the key to new knowledge has also opened possibilities for applying that understanding toward a better way of life.

Hundreds of explorers from scores of universities and more than thirty foreign countries come to Fermilab to chart their course, to invent and assemble their instruments of discovery, to record their sightings. Others come for different reasons: high school students and teachers to absorb the excitement of research at the frontiers of knowledge; leaders of industry to participate in technological advancements; medical researchers to study new approaches to treating cancer; residents of nearby communities to savor a leisurely bicycle ride, a morning's fishing, an evening at a concert or lecture, a stroll through the tall prairie grass.

Fermilab's role in unraveling the enigmas of the natural world begins underneath a circular ridge of earth four miles around, in a tunnel containing two hollow metal tubes about three inches in diameter, one above the other. This is the world's most powerful particle accelerator, the Tevatron. Bunches of subatomic particles zipping through the tubes are boosted to higher and higher energies until each second they make fifty thousand revolutions — a distance equivalent to seven times the circumference of the Earth. They are steered into collisions either with stationary targets or with antimatter particles speeding in the opposite direction. When the details of these collisions are observed and recorded by some of the world's most sophisticated electronic devices, they are on their way to becoming part of an all-encompassing understanding of matter, energy, space, and time.

RIGHT: A section of the Fermilab Tevatron, a particle accelerator that is enabling physicists from universities and laboratories around the world to better understand the fundamental laws of the physical universe. OVERLEAF: Part of the CDF detector, a collaboration of seventeen American, Italian, and Japanese institutions. A major focus of this experiment is to look for the top quark, the only one of the six quarks that has not yet been detected. Knowing the mass of the top quark is crucial to pinning down many of the predictions of the standard model of elementary-particle physics. If the top quark is too massive to be seen at Fermilab, that could be the first empirical evidence of physics beyond the standard model.





ONE OF HUMANITY'S OLDEST
AND NOBLEST ASPIRATIONS
HAS BEEN TO INVESTIGATE
AND MAP OUT THE WAY THE
UNIVERSE IS PUT TOGETHER.

Particle physics, the science of the universe at its most fundamental level, is one aspect of this quest. Increasingly, the only feasible way to conduct many investigations crucial to this branch of science is at laboratories like Fermilab that provide resources and services to an international community of researchers. The large particle accelerators and detectors, the computing capabilities, and the technical support that have enabled some of the field's most brilliant advances lie far beyond the means of one university or state.

Building an institution dedicated to basic research on this scale is a serious undertaking. A national laboratory as strong and vital as Fermilab did not come about through the desultory efforts of a few. It is the result of the sustained dedication of a significant group of people — citizens and statesmen, scientists and administrators, leaders of industry and education — who see Fermilab's contributions to society as a credit to their country, to the communities they represent, and to their own lives.

We are now engaged in examining Fermilab closely to determine how best to maintain and renew its strength. In focusing on our needs we must not lose sight of our assets. We should remember that the Fermilab Tevatron is the highest energy particle accelerator in the world, with a scientific potential unmatched by any accelerator in operation. We should remember that we are an essential resource not only for today's investigations but also for inspiring and preparing future generations of students to meet tomorrow's challenges. And we should remember that since this laboratory was founded, in 1967, others have looked to it as a model for harnessing innovative technologies, for promoting enlightened human rights policies, and for taking full advantage of the occasion to become an important educational, environmental, and cultural resource.

More people have contributed to our vitality than can be mentioned between the covers of a booklet. Some of our colleagues appear on these pages to provide a range of perspectives on physics and Fermilab, but our achievements reflect the talents and dedication of the entire Fermilab community — at the Laboratory, in Illinois, across the country, around the world. I am proud of, and grateful to, every member.

For as long as we can sustain Fermilab as a place that draws first-rate minds to address scientifically compelling questions, we will continue to uncover new opportunities for building a better world, we will help all of science achieve a higher standard, and the efforts of our supporters will continue to be gloriously rewarded.

JOHN PEOPLES, *Director*

SOLVING THE MYSTERIES OF THE UNIVERSE

NOWHERE on Earth does scientific research explore more extreme scales than at Fermilab. A particle theorist sits in her office, performing a calculation involving bottom quarks, particles that are smaller than 10^{-16} (0.0000000000000001) centimeters across and live for an unimaginably short time: a millionth of a millionth of a second. Across the hall her colleague, a cosmologist, is considering the origins of galaxies, which are scattered about the universe every 10^{24} (1,000,000,000,000,000,000,000,000) centimeters or so — a distance that takes light three million years to travel — and appear to be billions of years old.

There are other seemingly fundamental differences. The theorist's bottom quarks are, as far as anyone knows, elementary particles: indivisible specks of matter without internal structure. The behavior of the subatomic particles she analyzes can be understood in terms of three forces: The *strong interaction* binds quarks into protons and neutrons, and it also binds protons and neutrons into the nuclei of atoms. The *weak force* causes neutrons to be transformed into protons in the natural process of radioactivity. The *electromagnetic force* fixes the orbits of electrons around atomic nuclei, establishing the properties of the elements (whether they are conductors, insulators, or semiconductors, for example). On the other hand, the galaxies that fascinate the cosmologist are clearly composed of many constituents, and the behavior of matter on that scale is governed by a fourth force: *gravity*.

Is there any logical reason why the particle theorist and the cosmologist should work in the same place? It is far from immediately obvious, but the two actually share significant common ground.

First, although different forces predominate at different distances, the laws that govern all matter are the same. Ever since Newton realized that gravity was a universal phenomenon — that an apple falling to the ground obeys the same law of gravity as a planet orbiting the sun — scientists have never found a case where the laws of physics that apply on Earth failed to hold anywhere else in the universe.

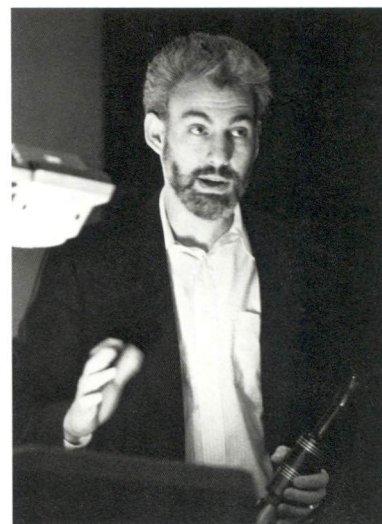
Second, the basic physical stuff is the same anywhere in the visible universe. The triplet of quarks that make up a proton in an atom in an ink molecule in the period at the end of this sentence is identical to the quark triplet inside a proton in a galaxy a million light-years away.

But perhaps the most unexpected reason for the two scientists to be working across the hall from each other at a high-energy physics laboratory is the exciting realization that understanding the behavior of the fundamental particles can be applied to learn more about the origin, evolution, and ultimate fate of the universe. Cosmologists now believe that the present universe is a direct consequence of interactions that took place — largely before the universe was one second old — among the elementary particles physicists study. The high-energy collisions of subatomic particles that physicists create at accelerator

laboratories like Fermilab to probe the smallest, most basic constituents of the physical world also replicate conditions of the very early universe, for a fraction of a second and on a tiny scale.

What actually happens when a proton and its antimatter counterpart, an antiproton, are accelerated to nearly the speed of light in the Fermilab Tevatron and collide head-on? A frequently invoked analogy compares colliding particles with smashing two watches together and watching their component springs, sprockets, and wheels fly out. Reality is much more exciting. When two particles collide, new particles are created that didn't even exist before the collision. Einstein's famous law $E = mc^2$ says that energy (E) and mass (m) are equivalent: one can be converted into the other (the c stands for the speed of light). So, the more energy there is, the more massive the particles that can be created. A better image is that out of the collision of two wristwatches fly an alarm clock, a stopwatch, and a pocket watch — and, occasionally, a grandfather clock.

Some of the particles created in the collision are perfectly ordinary, stable particles, like electrons. Others are so unstable that they don't exist for very long before they transform themselves into lighter particles. When physicists first saw some of these esoteric particles, their existence could not be logically accounted for. But over the past twenty years, a remarkable series of experimental discoveries and theoretical advances has led to a new coherence in the model of the fundamental structure of matter. Not only are there lots of data that describe the particles and the forces that act on them; physicists have constructed a theory that enables them to predict the behavior of matter under new conditions. Remarkably, no experiment has yet contradicted this theory, which physicists prosaically refer to as the standard model.



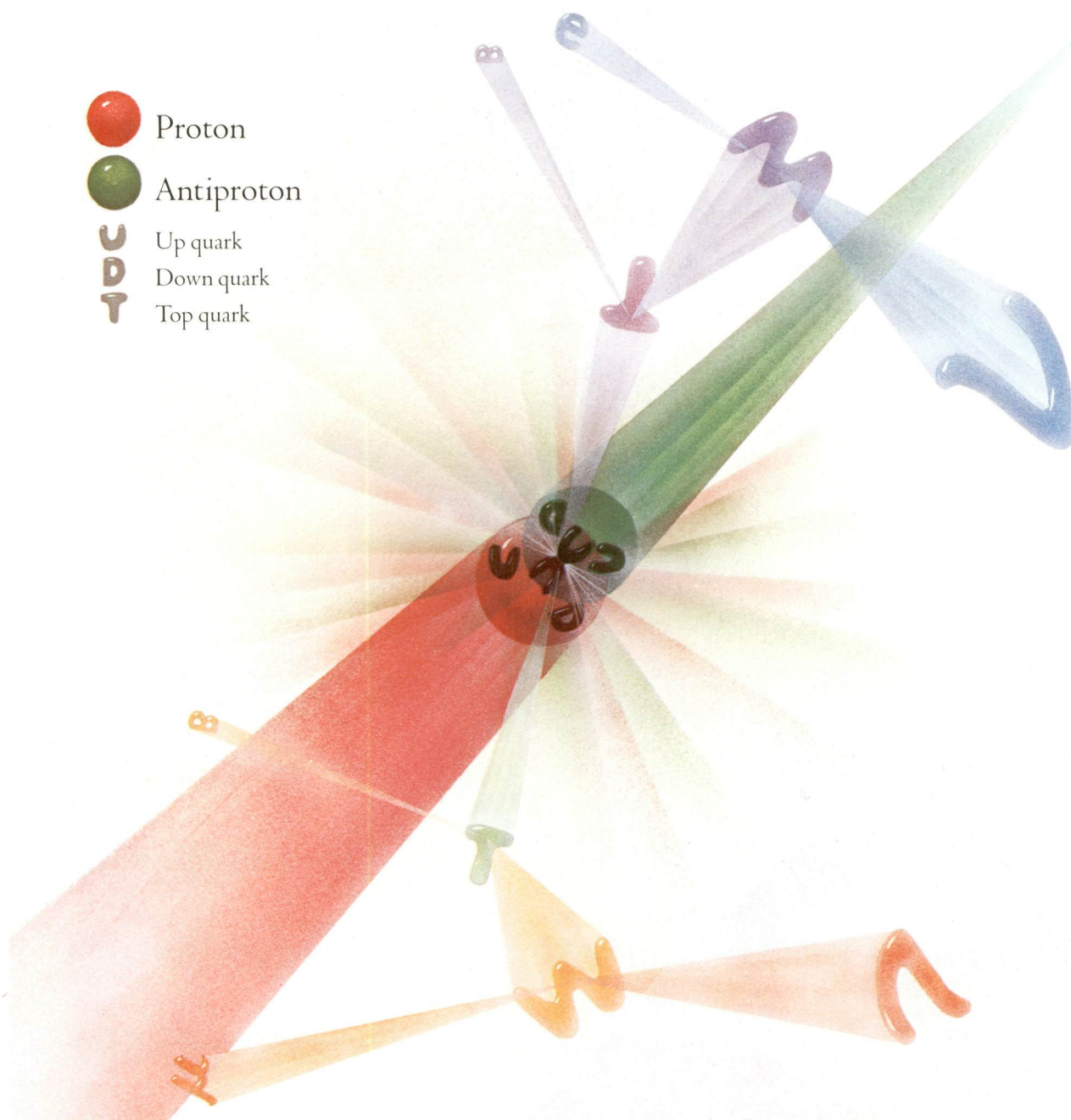
"High-energy physics grapples with the most fundamental questions about the origin of the universe. In most other branches of physics, and in chemistry and biology, they know what the laws are—it's a question of how the laws work themselves out: what kind of chemicals can you have, based on the laws of quantum mechanics? what kinds of biological systems could you have evolving under these conditions? But you don't question what the laws are. What I find so appealing about this kind of physics is that we're still trying to discover what the laws are. I've worked at Fermilab since 1973. I really like the place. Scientifically, it's a fantastic lab. It's the best lab that I've ever worked at, in terms of the quality of the people that you meet there. All the users eat together in the cafeteria, so there's a great exchange of information. If some other group has a good idea about how to solve a problem, everybody knows about it very quickly, and you can easily talk to them."

BRUCE WINSTEIN, *Professor of Physics*
University of Chicago



● Proton
● Antiproton

U Up quark
D Down quark
T Top quark



An Introduction to the Standard Model of Elementary-Particle Physics

Trying to understand nature is like trying to figure out a game such as chess without knowing any of the rules beforehand, without being able to see the board the entire time, without even being able to view the whole board when you do get to look at it. But after making some observations it is possible to start coming up with rules for how the game is played. Many of the rules that observers first come up with they later have to throw out, because they see something that doesn't make sense in terms of the rules they have conjectured. When something occurs that shows that the rule is deeper than they thought, the game appears even more complicated. But if the observers are clever enough to figure out the deeper rule, then everything looks simpler than it did before.

This is just what happened in particle physics during the last two decades. By looking at matter at higher energies, physicists were able to see more of the board, and they discovered many new particles with varied properties. Instead of looking simpler, the picture of matter looked more complicated.

Eventually, however, a certain pattern of simplicity emerged. Two classes of subatomic particles, *quarks* and *leptons*, were found to account for every kind of matter that physicists understand, from boys to boysenberries to Boise. In fact, just two kinds of quarks (called *up* and *down*) make up the nuclei of all atoms. Only two kinds of leptons are needed in addition to explain ordinary phenomena: the familiar electrons that orbit the nuclei of all atoms, and the electrically neutral, apparently massless neutrinos that are not found inside atoms but are created in certain radioactive processes.

LEFT: In a colliding-beam experiment at the Tevatron, bunches of protons are directed into bunches of antiprotons. Although there are billions of particles in each bunch, there is usually only one actual collision each time the bunches cross, because the particles have to be extremely close before they can interact. When that happens, it is really the constituents of the protons and antiprotons that act on each other.

Frustratingly, many of the most interesting and fundamental particles created in a collision exist for such a short time that they can't be directly detected before they transform themselves into more stable particles. Physicists have to calculate and recognize the characteristic patterns produced by the offspring of particles with fleeting lifetimes to deduce the presence of the parent particle. Here an up quark and an anti-up quark hit head on and annihilate, producing a top quark and an anti-top quark, each of which exists for an unimaginably brief time before transforming into other particles. These secondary particles themselves can travel just a short distance before turning into particles that live long enough to be detected.

However, experiments also turned up a surprise: the pattern of the first family of matter particles is repeated twice. The up quark, the down quark, the electron, and the electron neutrino, collectively known as the first generation, each have two replicas that are identical in every respect except mass and average lifetime. The second generation consists of the charmed and strange quarks and two leptons: the muon and the muon neutrino. The third generation comprises the bottom and top quarks and two more leptons: the tau and the tau neutrino. All the quarks and leptons have antimatter counterparts: particles with the same mass whose other properties, like electric charge, are reversed. While the second and third generations seemed mysterious, because the only place they appeared was in high-energy collisions of subatomic particles, they fit the pattern of the first generation so neatly that physicists were encouraged to try to understand them in terms of a few simple rules. And many of the particles that at first seemed so esoteric when they were made in accelerators turn out to be crucial for understanding how the early universe evolved.

Major theoretical advances accompanied these experimental discoveries. Theorists can now quantitatively describe the nature of the strong, weak, and electromagnetic forces and their effects on both quarks and leptons. Furthermore, because the theories of these forces are mathematically similar, it now appears plausible that they, and quite possibly gravity as well, are actually manifestations of a single force, just as more than a century ago lightning and the Earth's magnetic field were shown to be different manifestations of a single electromagnetic force. This intriguing possibility is very seductive to theorists, who believe that at the big bang there was just one unified force. In fact, a theory has been constructed and partially confirmed that unifies two seemingly unrelated forces, the weak and electromagnetic, into what is now called the electroweak force.

Providing Empirical Evidence

Fermilab is a laboratory built to advance our understanding of the most basic rules of the universe. These rules are most easily revealed in inconveniently located realms. The strong and the weak forces, for example, are only detectable on the scale of the atomic nucleus, a region as small compared with an atom as a single kernel of corn is compared with a baseball stadium.

The tools that permit people to investigate territories so far removed from our unaided senses are the culmination of hundreds of person-years of designing, inventing, building, and testing. None can be bought off the shelf with an instruction manual. Each requires meticulous design and engineering, vast expertise in computing, cryogenics, mechanical and electrical engineering, organization, and many hundreds of hours of tuning to operate reliably and efficiently.

Although the investigations are challenging to execute, their essence is simple. Because physicists can't directly examine subatomic particles to see what determines their properties, they have learned to deduce their essential qualities from patterns in their interactions.

Two variations on this approach can be performed at Fermilab.

In a fixed-target experiment, high-energy protons are smashed into a stationary target (a metal foil, a flask of liquid hydrogen, or a heavy metal cylinder), creating a spray of particles from the target atoms. (Sometimes, particles from the spray are even gathered and focused on a second target.) In this fashion, a variety of particles are created that can be used to investigate many different aspects of elementary-particle physics.

In a colliding-beam experiment, high-energy protons are smashed into a moving target: a beam of antiprotons traveling in the opposite direction.



The control room of the Tevatron in July 1983, the moment the beams first exceeded the design energy. The technological success of designing, assembling, and operating a four-mile-long ring of superconducting magnets and a complex cryogenic system of unprecedented scale has become a cornerstone of modern experimental physics.

Although in both types of experiment the energy of the collision is converted into new particles, the collision energy available with the colliding-beam technique is immensely greater, so more massive particles can be created than with the fixed-target method. On the other hand, fixed targets yield more collisions per second, so very rare processes can be studied. The issue under investigation determines the most appropriate approach.

A look at a colliding-beam experiment illustrates three of the most remarkable tools at Fermilab: the antiproton source, the accelerator, and a particle detector.

The Antiproton Source

Antiprotons, antimatter counterparts of the proton, are created at Fermilab by aiming high-energy protons at special targets. The antiprotons are kept in orbit at nearly the speed of light in a storage ring, where a sophisticated, computer-controlled system of magnets and radio-frequency accelerating devices squeezes them into tight, well-ordered bunches. In about fifteen hours, when enough antiprotons have been accumulated, they are shot into the Tevatron at the same energy, but in the opposite direction, as the protons.

The Accelerator

The Tevatron accelerates beams of protons and antiprotons to very high energies and focuses them into head-on collisions.

Accelerators work because subatomic particles with an electric charge, positive or negative, can be pushed by like charges and pulled by opposite charges. In addition, their paths can be bent into a closed loop by a magnetic field, so they can pass through the same accelerating stations over and over, getting boosted to a higher energy each time. The more energetic the particles, the higher the magnetic field required to keep them on track. To be useful to high-energy physicists, accelerators have to be able to boost particles to high enough energies to reveal new phenomena. They also have to orchestrate a high enough rate of particle collisions for unusual interactions to be observable.

The protons that are accelerated at Fermilab come out of a tank of hydrogen, the most abundant element in the universe. After gaining energy by riding radio-frequency waves in a series of accelerating stations built in a line (known as the *linac*, short for *linear accelerator*), the protons travel through a series of circular accelerators, analogous to different gears in a car, as they are pushed to higher energies.

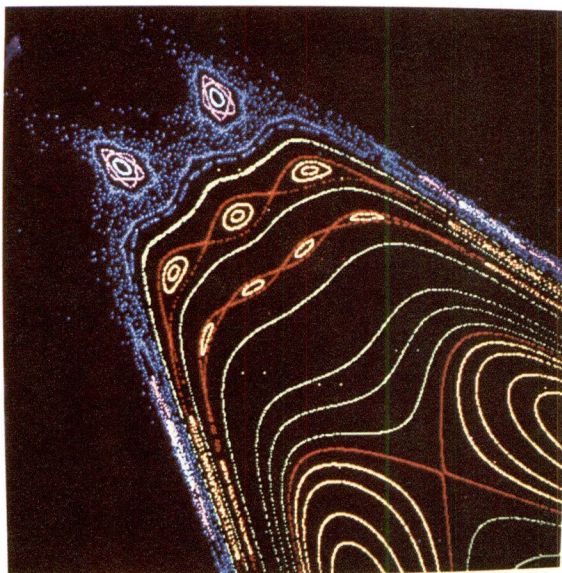
When the protons have enough energy, they are moved to the top tube in the four-mile ring, the original Fermilab accelerator. From there they are sent into the new superconducting accelerator, the Tevatron, below, where they are joined by antiprotons from the antiproton source. When the ring is full, it contains several bunches of protons and antiprotons. Each bunch is about a yard long and contains twenty to one hundred billion particles. Using particles and antiparticles meant that only one Tevatron ring had to be built to achieve



Part of the sophisticated stochastic cooling devices used in the complex process of producing and storing highly energetic, coherent bunches of antiprotons until enough accumulate to collide with protons about fifty thousand times a second in the Tevatron.



The main accelerator control room, where seven operators oversee the acceleration of a beam of protons and a beam of antiprotons to nearly the speed of light. When the beams are brought into collision, they create particles that cannot exist in more ordinary environments, providing new insights into the fundamental laws of nature.



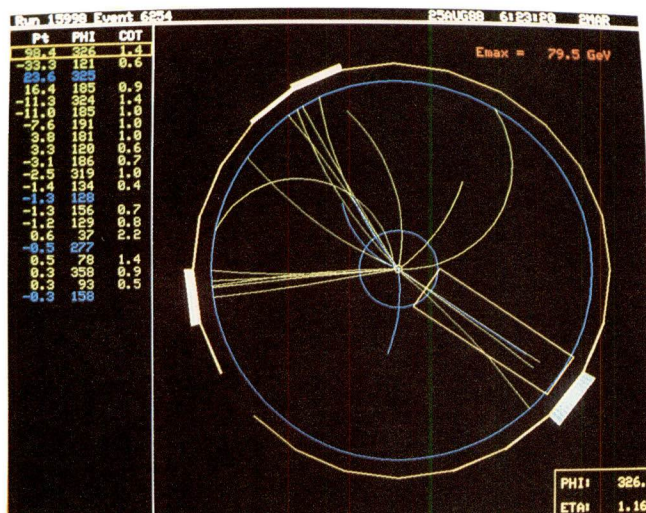
head-on collisions, because the protons and antiprotons are guided and accelerated in opposite directions by the same components.

It takes more than an hour to walk around the Tevatron ring. The protons and antiprotons circle the ring about fifty thousand times a second in opposite directions when they reach their final energy, about half an hour after the protons begin their journey. In a sequence of steps that rivals the launch of a space vehicle for complexity and precision timing, they are then brought into collision. (The beams continue to circulate in the Tevatron until the collision rate is too low to be productive, when the entire process begins again.)

A Detector

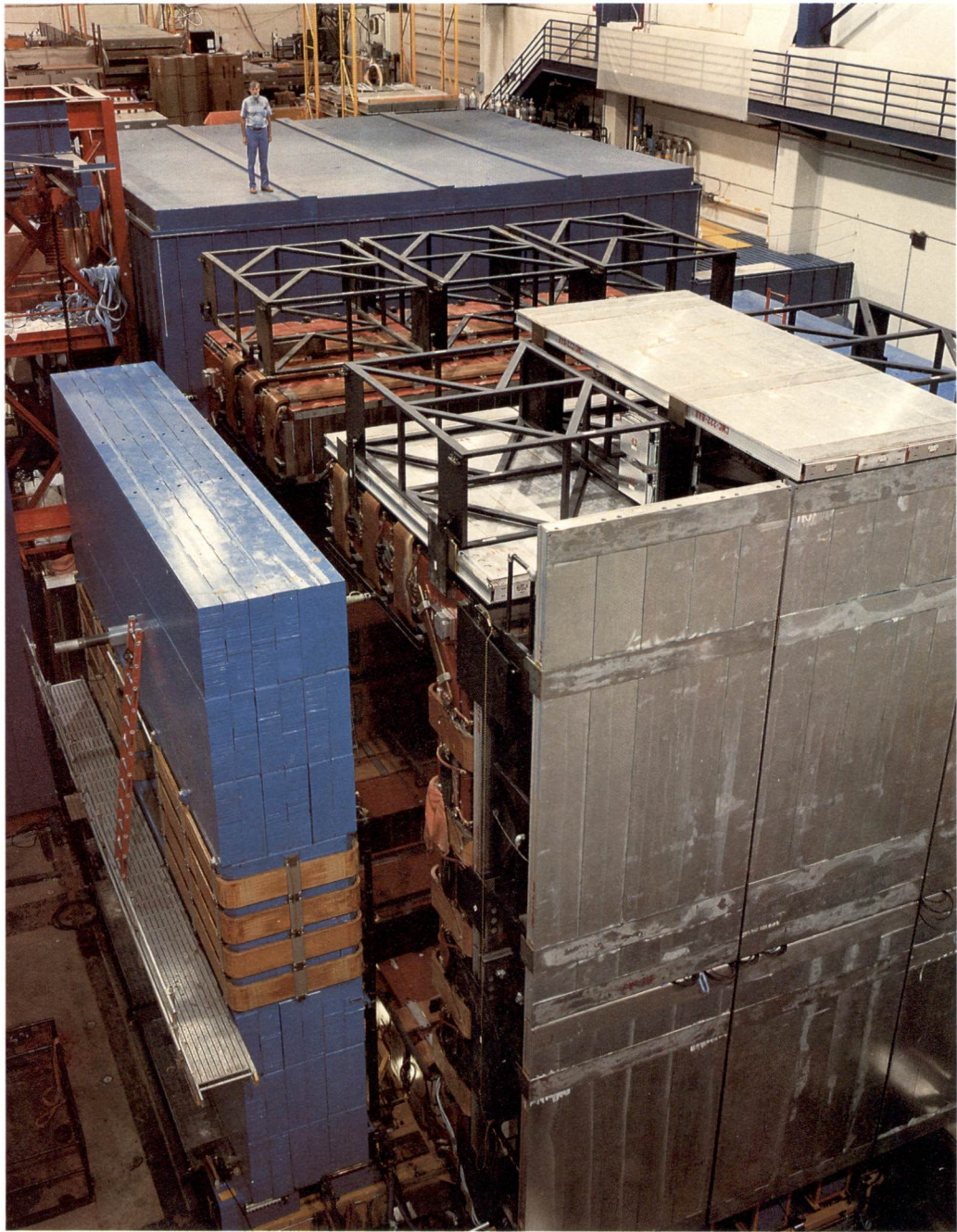
To understand nature at the most basic level, scientists try to test how things behave under new circumstances, to distinguish what is fundamental from what happens to be expressed in a particular situation. At Fermilab, the anti-proton source and the Tevatron create exotic conditions for studying particles and forces; detectors enable scientists to observe what happens.

The first task of the detector is to decide which of the more than fifty to one hundred thousand collisions that occur each second are interesting enough to record for later analysis. Even with the fastest techniques, only a few collisions can be recorded every second. The detector is



Computers are crucial to experiments at Fermilab. They control the beams of protons and antiprotons while they are accelerated and steered into head-on collision, record data on the new particles produced by the energy of the collision, and reconstruct the particles' paths and energies, enabling researchers to investigate the physical universe at the most basic level.

RIGHT: The D-Zero detector under construction. The detector is made up of many layers of material and electronics devised to recognize, track, and record different types of subatomic particles. Detector technology invented for particle physics experiments has been applied to many other problems, such as investigating the structure of materials in three dimensions, tracing the flow of oil in a jet engine, and revealing the flow of blood and the behavior of specific drugs in the body.





"Doing experimental high-energy physics is like taking a long hike in the mountains. You keep putting one foot in front of the other, and you are out of breath, and you are getting all sweaty, but it feels OK. Then there comes a moment when you turn the corner and you have this incredible view, and that is what you were on the hike for. ☐ People really want to come to Fermilab now: it's hot, it's the place to be. Really good people are coming directly from graduate school."

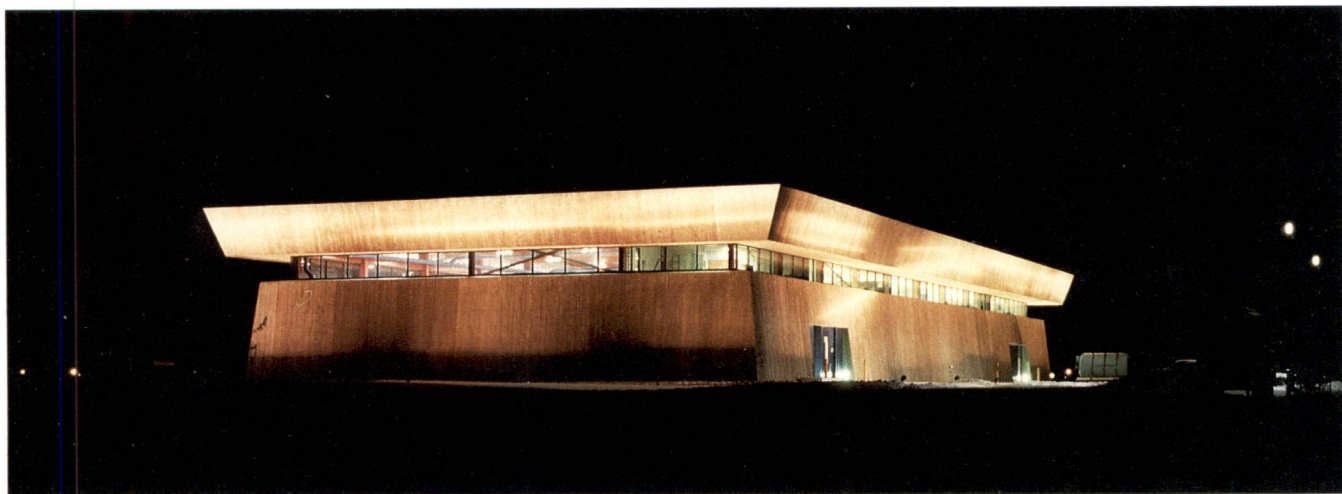
MELISSA FRANKLIN, *Professor of Physics*
Harvard University



designed to scan events quickly, compute whether an event looks like the kind that physicists want to study, record it, and look at the next event.

The second task of the detector is to measure as much information as possible about every particle in every event that is recorded — the particle's path, its energy, and its charge. Detectors take advantage of the distinctive behavior of different kinds of particles under different conditions. The trajectories of neutral particles, for example, aren't deflected by a magnetic field the way charged particles are, and while electrons rapidly lose their energy in lead plates, muons penetrate the lead easily, without significant energy loss. With layers of different kinds of materials, each designed to detect and record a specific type of information about the particles that interact with it, and with a fine enough grid in each layer to allow very closely spaced particles to be distinguished, the detector can build up a complete picture of an event.

To accomplish these tasks, the detector must have enough material for every particle to interact with and identify itself, and enough channels of electronics for a vast amount of information to be read to the computers. CDF (which stands for the Collider Detector at Fermilab) is as tall as a three-story building and weighs over twenty-four thousand tons. It took several years, \$70 million, and hundreds of physicists, engineers, technicians, and students to build. Collaborators from seventeen institutions in Italy, Japan, and the United States built many of the components and brought them to an underground hall at Fermilab next to the Tevatron, where the detector was assembled. Millions of lines of computer code were written for monitoring and controlling the detector and its support systems and for analyzing the data it collects. During the months that the detector spends taking data, it is operated from a control room by crews of seven scientists who take eight-hour shifts, twenty-four hours a day, seven days a week.



Part of Fermilab's fixed-target experimental complex at night. Both fixed-target and colliding-beam experiments explore the behavior of subatomic particles in collision to gain a deeper understanding of the structure of the universe.

Decoding the Data

Once data are recorded, analysis begins. The first step is to organize the collision information in a usable form. The raw data from each collision consist of discrete records of each place in the detector that any particle emerging from the collision interacted. Reconstructing the events essentially amounts to connecting a set of dots to depict the trajectories of each particle. Unlike the children's pastime of dot-to-dot, however, the dots in the event aren't numbered, so a computer must try all the geometrically plausible combinations of dots until it finds the correct combination. A typical CDF event generates tens of thousands of dots. Determining the correct trajectories of an event requires about a minute using a computer that carries out a million instructions per second. In 1989, the second year of full operation, CDF wrote five million events to tape. (Fermilab has exploited the techniques of parallel processing to speed up data

reconstruction in a highly successful collaboration with industry; see p. 35.)

After the trajectories and other information about the particles have been reconstructed, the properties of the events are compared with the properties predicted by theory and analyzed to establish their statistical significance. Certain interesting events have distinctive patterns, called signatures, but sometimes those signatures can be imitated by other processes, called background. To say that something really unusual has been seen, a physicist must show that it appeared significantly more often than it would in the background. Here the computing challenge is to look at the reconstructed events many times. It can take more than a month just for a computer to make a single pass through the reconstructed events from a single experiment, and many person-years before the data have been fully analyzed. More than a hundred graduate students participating in CDF will base their doctoral theses on data from this one experiment.

Looking for New Laws

Although the standard model makes many predictions that agree with experiment, in some important cases it gives only partial answers, impossible answers—or no answer at all.

For example, the standard model postulates that the masses of the quarks and leptons arise through their interaction with a hypothetical particle called the Higgs boson. However, there is nothing in the standard model that explains why a certain kind of quark or lepton happens to have the particular mass that experiments measure. Even more frustrating, while the standard model predicts the existence of the Higgs boson to explain the masses of the quarks and leptons, physicists cannot extract from the model a prediction of the mass of the Higgs boson itself.

Fermilab has an enormous potential to refine and improve our understanding of the structure of matter and energy, time and space. It may be where the next clues turn up to answer such compelling questions as:

- Why do some particles have different masses when others are massless?
- Is there, in addition to the quarks and leptons, a whole new kind of matter particles that make it possible to unify gravity with the three other forces?
- Why is there apparently so much more matter than antimatter in the universe, when laboratory experiments in which new matter is created always produce equal numbers of particles and their antiparticles?
- What is the mysterious “dark matter” that, according to current models, makes the universe ten times more massive than visible stars, planets, gas, and dust can account for?

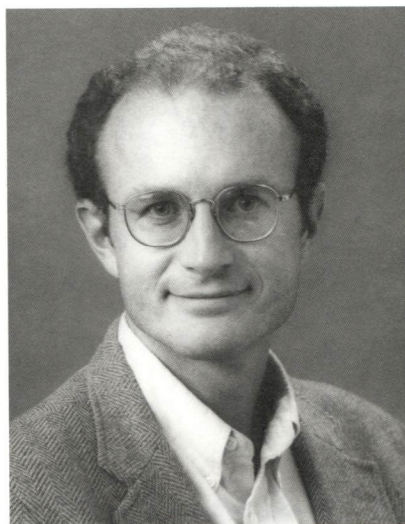


Some parts of an experiment are so sensitive that their fabrication and assembly require ultraclean conditions and operating-room precision. Here, scintillators are being made for the D-Zero detector. This colliding-beam experiment represents the combined effort of seventeen American universities, three American national laboratories, and laboratories in France and the Soviet Union.

"To really understand the fundamental nature of matter and the fundamental forces, you need to expand your horizons beyond the particles that are available in everyday life: the protons, neutrons, and electrons. There is simply not enough variation there for us to be able to understand the patterns. For example, we have been able to figure out that protons are made of quarks, and that is very important, but we need to look at the whole family of quarks to understand what is accidental about the ones we happen to have in a proton and what is fundamental to all the laws of physics. ¶ One of the biggest issues in physics now is, 'Where is the top quark?' We know that there must be six quarks there, we've seen the other five, but we still don't know even the mass of the sixth quark. That is not only a problem in itself; it turns out that everywhere else you go in physics, from studying bottom quark decays to looking for the Higgs, your predictions are tied to the top quark mass. Now our predictions have an enormous range of error, because we don't know the top quark mass. If the top quark mass is not too high, Fermilab is in the best position to see it. On the other hand, the top quark mass is so well constrained that, even if they say it is not in the range they can see, that already pins it down very precisely. It is not, of course, as satisfying as seeing it, but it is by no means no information.

¶ Fermilab is the largest and most active laboratory for high-energy physics in the U.S. now. Especially with the combination of the fixed-target program and the colliding-beam program, it is very important as a place to train graduate students and postdoc physicists. ¶ After spending many years running an experiment at Fermilab, I think the main thing that Fermilab has to offer a group of experimenters coming in is the spirit of the place and the willingness to get things done for an experiment, to get the experiment on the air—even when, in many cases, they don't really have the resources to do it. I think a lot of it is simply that the people at Fermilab are really very dedicated and work very hard to find some way of getting your experiment up and running."

MICHAEL WITHERELL, Professor of Physics
University of California, Santa Barbara

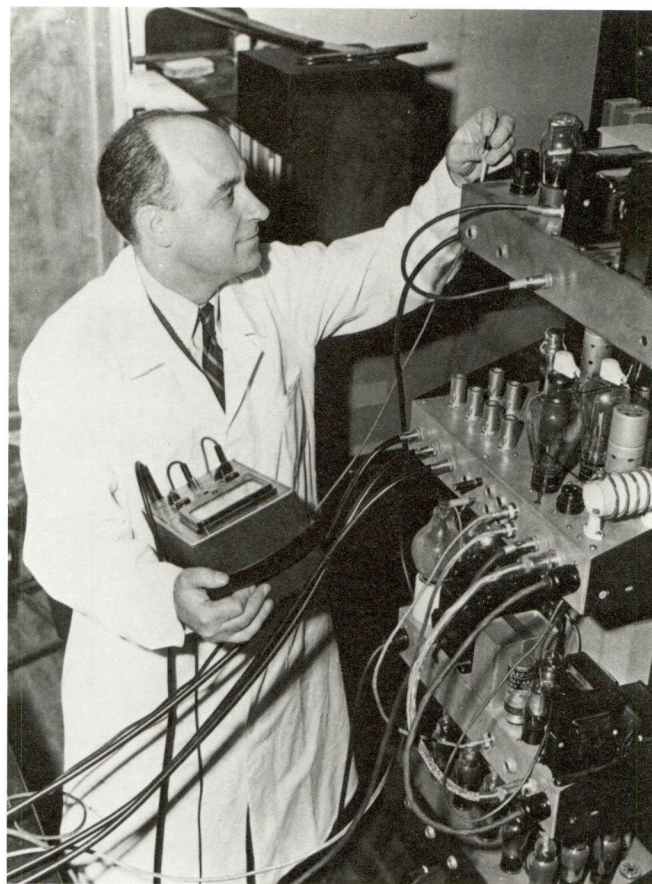


A HISTORY OF ACHIEVEMENT

In the Beginning: The Highest Energy Accelerator

In March 1972, in the middle of what had been an Illinois cornfield, a team of scientists, engineers, and technicians accelerated beams of protons to 200 billion electron volts of energy (giga-electron volts, or GeV), the highest energy particle beam that human beings had ever made. This historic accomplishment took place less than four years after President Johnson signed the congressional bill authorizing \$250 million for the construction of a new accelerator laboratory — two years ahead of the scheduled completion date. But work on the machine did not stop. In 1973, the accelerator reached 300 GeV. In 1974, it reached 400 GeV, twice the design energy. Fourteen beam lines were available for mounting experiments instead of the eight contemplated in the authorization. And \$6.5 million of the initial appropriation was returned to the United States Treasury.

The new institution was the first high-energy physics laboratory conceived as a truly national resource. It came into existence as the National Accelerator Laboratory and was later renamed the Fermi National Accelerator Laboratory in honor of Enrico Fermi, a physicist who reached the highest summits as both a theorist and an experimentalist. To ensure that the laboratory would be accessible and responsive to all qualified scientists, it was to be governed by a board of trustees with representatives from across the country. Most of the American scientific



Fermilab is named for Enrico Fermi (1901–1954), an Italian-born American physicist who was one of the outstanding scientists of modern times. His zest for science, his dedication to the utmost simplicity of ideas, his common sense, and his consummate abilities as both an experimenter and a theorist continue to nourish Fermilab's aspirations.



Bob Wilson (with shovel), Founding Director, set out in 1967 to build a laboratory with "a climate of mutual respect and responsibility." Under his leadership, Fermilab first achieved the distinction of having the world's highest energy accelerator.

community that would be involved in research at the laboratory had university appointments, so a group of leading research universities from across the United States and Canada was incorporated into the Universities Research Association (URA) to build and operate the new resource for the United States Atomic Energy Commission, the forerunner of the Department of Energy.

URA appointed Robert Wilson, in 1967 a self-described "carefree professor" at Cornell University who had championed high-energy, low-budget accelerator designs, as director of the Laboratory. The Atomic Energy Commission, with the help of a National Academy of Sciences committee, evaluated more than two hundred proposed sites in forty-six states. The final

choice, in northeastern Illinois, fulfilled the requirements of suitable geology for the underground series of accelerator tunnels, affordable power and water, room for expansion, convenient transportation, and a nearby metropolis with a strong university community and a well-developed industrial base.

Physicists from around the country, supported by their home institutions, attended a series of workshops Wilson organized in the summer of 1967 to work out a detailed design. At summer's end, about half of them joined the staff.

Even as the first newcomers unpacked, they began building a community as well as a laboratory. The Wilsons organized potluck suppers to make people feel at home. Laboratory staff members worked tirelessly to create an environment where respect for human rights was a paramount concern. Wilson wrote,

I envisaged the Laboratory as a utopian place where physicists coming from all parts of the country—and from all countries—would be doing their creative thing in an ambiance of well-functioning and yet beautiful instruments, structures, and surroundings that would reflect the aesthetic magnificence of their discoveries and theories. All of this [was] to be done in a scientific climate of mutual respect and responsibility.

An accomplished sculptor as well as a physicist, Wilson created a laboratory that is not only scientifically distinguished but also aesthetically striking.

With the successful construction of the first Fermilab accelerator, the Laboratory could get down to the business of doing physics—studying the properties of time, space, and matter at the most fundamental level. Experiments are chosen by the Director with the help of the Physics Advisory Committee (made up of a dozen physicists from outside the Laboratory), based on scientific and technical merit. Since 1972, more than three hundred experiments have been carried out—too many

to describe, or even to list. A few examples convey the richness and variety of the contributions Fermilab has made to our understanding of the basic laws of the universe. (See pp. 6–18 for background on the goals of particle physics.)

Discovery of the Upsilon

In the mid-1970s physicists were just getting used to the idea that, although the world around us could be constructed with just two kinds of quarks (plus an electron and its neutrino), there were actually four quarks. (The third and fourth quarks are produced only in collisions between subatomic particles of sufficient energy.) Then, in 1977, a team of researchers from Columbia University, Fermilab, and the State University of New York at Stony Brook, led by Leon Lederman of Columbia, announced the discovery of a new particle in an experiment they had performed at Fermilab. The particle's properties strongly implied the existence of a fifth quark (dubbed *bottom* or *b* for technical reasons). Because odd numbers of quarks don't fit easily into the standard model of elementary-particle physics, the discovery also suggested that there was a sixth quark (the *top* or *t*). The bottom and top together constitute a third generation of quarks, corresponding neatly with the three known generations of leptons (the electron and its two heavier cousins, and their accompanying neutrinos).

Besides being of enormous importance for building a better understanding of the fundamental universe, the experiment represented a breakthrough in being able to process enormous amounts of data: every second there were hundreds of millions of events. A sophisticated electronic data acquisition system was developed to scan the data and selectively record interesting events onto magnetic tape for later study.

A New Director, a New Technology

In 1978, Robert Wilson resigned and Leon Lederman assumed the directorship of Fermilab. He also assumed Wilson's dream of keeping Fermilab at the high-energy frontier by applying an innovative technology. Superconducting magnets, which use alloys of niobium and titanium cooled to about four degrees above absolute zero, had not been used in particle accelerators before, but they offered two important advantages over ordinary magnets: lower power costs (unlike ordinary conductors, electricity flows without loss in superconductors) and a higher magnetic field, which means that particles can be accelerated to higher energies and still be confined to the desired orbit. In 1979, Congress authorized Fermilab to install a second ring of magnets below the existing conventional magnets in the main ring. The Laboratory's pioneering use of superconducting magnets not only enabled protons to be accelerated to double the energy of any previous accelerator while cutting the power by more than two-thirds; it also showed that reliable superconducting magnets could be built using factory-style manufacturing techniques. That demonstration was a significant milestone in the development of superconducting magnets from laboratory curiosity to a practical component of modern technology.

High-Statistics Studies of Charm (Experiment E-691)

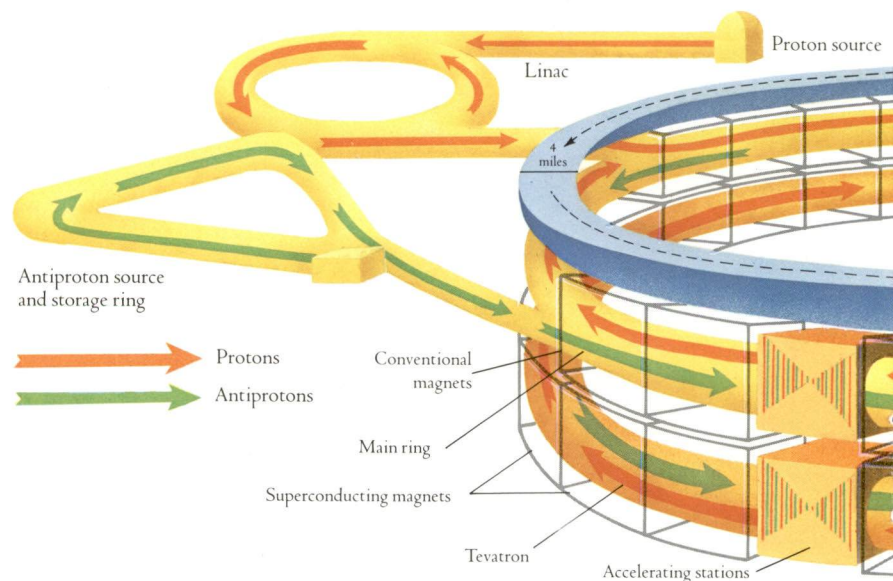
One of the experiments to make good use of the 800-GeV protons supplied by the new superconducting accelerator to fixed-target experiments was carried out by a team of thirty-five physicists from the University of California at



Under Leon Lederman, the Laboratory's second Director, the world's first superconducting accelerator was completed in 1984. The Tevatron reaches energies higher than any other existing accelerator.

Santa Barbara, the Brazilian Center for Particle Physics (CBPF), the Canadian National Research Council, Carleton University, the University of Colorado at Boulder, Fermilab, and the University of Toronto. In 1983 the collaboration proposed the experiment as a way of learning more about charm, one of the two quarks in the second generation. (One meaning of the word *charm* is something that wards off evil; charmed quarks were postulated to banish some serious inconsistencies in electroweak theory.) The combination of the high-energy accelerator and a new silicon-strip detector technology developed in Europe, which enabled extremely high resolution of particle tracks, was spectacularly rewarding. In five months of taking data, 100 million events were recorded, including at least ten times as many charmed particles as any previous experiment had obtained.

How does Fermilab work? A series of four accelerators, culminating in the four-mile-around Tevatron, boosts bunches of protons to almost the speed of light. Antiprotons are created and stored in the antiproton source before being injected into the Tevatron in the opposite direction from the protons. Powerful superconducting magnets, in which electricity flows without resistance, guide the particles around the Tevatron. Each time a bunch of particles passes through an accelerating station, radio-frequency waves increase the energy of the particles, until the bunches make nearly fifty thousand round trips each second. When the protons and antiprotons smash into each other, sophisticated electronic devices track, identify, and record the new particles that are made from the energy of the collision. Protons and antiprotons continue to circulate and collide until there are not enough particles left for efficient operation, and the process begins again.



But the staggering amount of data meant that another technological breakthrough was desperately needed: a vast increase in computing power. With the computers then available at Fermilab, six or seven years would have been required to convert all the recorded electronic signals from this detector alone into a usable form. Fermilab's Advanced Computer Program was founded in 1983 with the idea that parallel processing techniques could reconstruct data much more efficiently than the available main-frame computers. The Advanced Computer Program enabled the E-691 events to be reconstructed in just a year and a half, and also helped to launch a small revolution in commercial computer architecture.

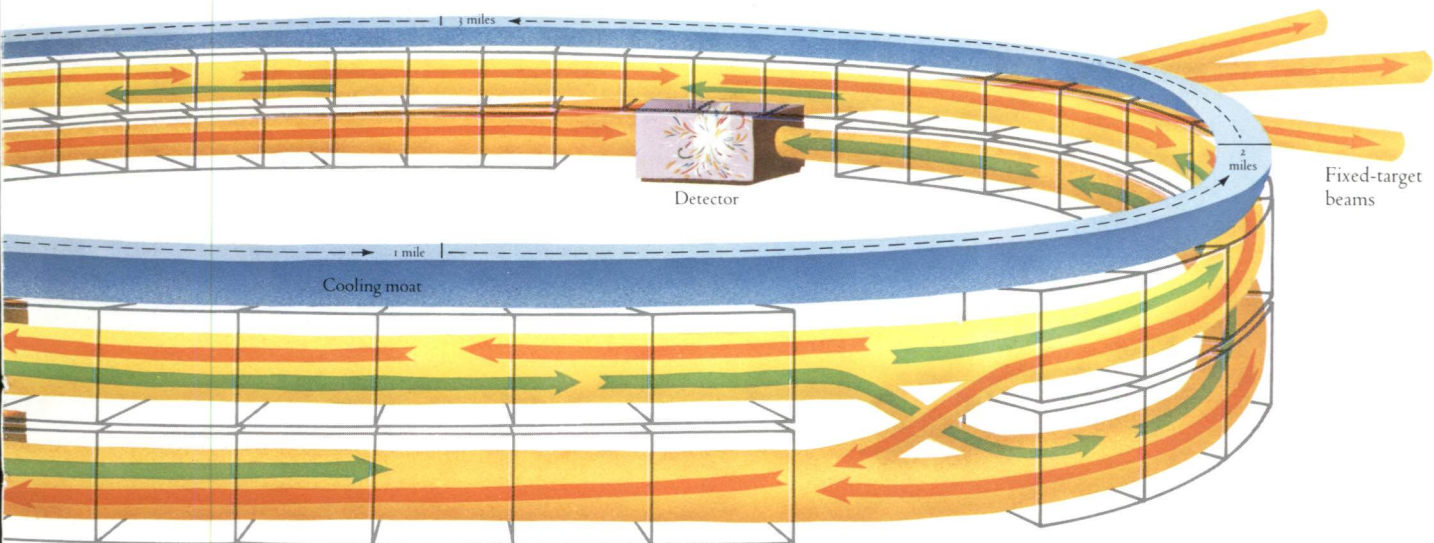
The experimenters were rewarded with the world's most precise measurements of the lifetimes of four particles and a substantially clearer picture of the behavior of

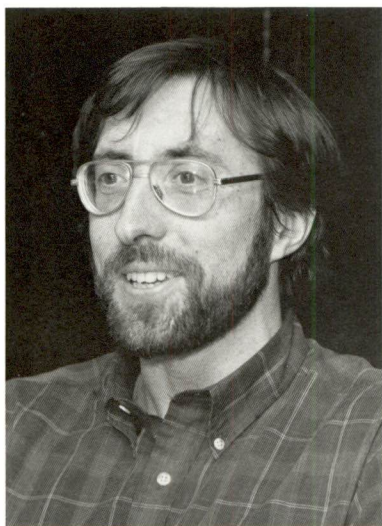
charmed particles, which in turn meant a better understanding of the weak interaction.

The experiment has been equally successful in helping to educate new physicists. By early 1990, five graduate students had earned their doctorates on this experiment, and at least three more Ph.D. theses will be based on further analysis of data from the single five-month run.

Probing the Difference between Matter and Antimatter (Experiment E-731)

Another fixed-target experiment at Fermilab, mounted in 1985 by collaborators from the University of Chicago, Centre d'Etudes Nucléaires-Saclay (France), Elmhurst





"Fermilab in the next ten years is probably going to have the best window on highest energy and shortest distance behavior anywhere in the world. You can't think of another laboratory that will be able to simultaneously do all the things that can be done here. I think that support of this kind of institution is a measure of the level of a culture. People built huge cathedrals in the Middle Ages, when there wasn't much surplus money to throw around. If you take a certain amount of pride in your culture you build pyramids or cathedrals or monuments. Of course, what is fundamentally different here is that, rather than just building some huge monument, you are actually learning something in the process."

JOHN HUTH, *Physicist*
Fermilab



College, Fermilab, and Princeton University, seeks to illuminate a startling observation: nature distinguishes between particle reactions that are identical except for the simultaneous interchange of particles and antiparticles and of right and left. Until 1964, physicists believed that any particle interaction and a mirror reflection of the same interaction among the corresponding antiparticles would occur at the same rate. But then, at Brookhaven National Laboratory, a team of experimenters from Princeton discovered that this cherished symmetry (called CP-symmetry) is not preserved in an interaction involving particles carrying the strange quark.

Understanding this tiny asymmetry in the behavior of matter and antimatter is crucial to explaining why there is so much more matter than antimatter in the universe, when they are produced in equal amounts in high-energy particle interactions like those that took place in the very early universe. Another important consequence of CP-symmetry violation is the corollary that the laws of physics are not symmetric under time reversal. One of the goals of experiment E-731 is to narrow the possibilities for the origin of CP-symmetry violation by measuring very precisely a quantity known as *the ratio of epsilon-prime to epsilon*. The standard model predicts that this quantity is very small: almost, but not quite, zero. A possible alternative to the standard model, which says that CP-symmetry violation is the manifestation of a new, barely noticeable force, predicts that the ratio of epsilon-prime to epsilon is zero. This measurement is extremely difficult to make. An earlier experiment at CERN, the European multinational particle physics laboratory, reported a value for the ratio of epsilon-prime to epsilon that appeared to rule out this alternative to the standard model. Subsequently, E-731 announced a measurement that implied that the alternative theory cannot be discarded



Part of Experiment E-691, designed to reveal more about one of the fundamental forces: the weak force, which governs the radioactive transformation of one element into another.



Part of the equipment for Experiment E-731, designed to investigate a phenomenon that has puzzled physicists for more than a quarter of a century: a slight difference in the behavior of matter and antimatter that has profound implications for the evolution of the universe.

after all. Further data taken by E-731 should help resolve the question of whether the cause of CP-symmetry violation can be explained within the framework of the standard model.

Matter Meets Antimatter

As the superconducting Tevatron accelerator opened new frontiers to fixed-target experiments, it also enabled colliding-beam experiments to explore new territory. With another innovative machine, the antiproton source, two beams of particles—protons and antiprotons—can be accelerated and brought into collision in the same ring of magnets, thus realizing substantial savings.

The antiproton source extracts protons from the accelerator and fires them at a copper target to produce antiprotons, which then have to be stored, in orbit, until enough have accumulated to be useful in experiments. When the antiprotons enter the storage ring, they are all moving at nearly the speed of light, but their energy and direction vary slightly. Hundreds of instruments—bending and focusing magnets, “kicker” magnets, radio-frequency accelerating devices—controlled with exquisite precision by computers, herd the antiprotons into coherent, ordered bunches. This complex process, based on technology pioneered at CERN, is known as *beam cooling*. Although the execution is difficult, the concept is elegantly simple: The ring in which the antiprotons are stored is shaped like a triangle. The energy and trajectories of a group of newly created antiprotons is monitored at one leg of the triangle, and electronic signals on how to cool them are flashed at close to the speed of light to instruments in the adjacent leg. By the time the group of antiprotons, which has been sent the long way round through the other two legs of the triangle, arrives at the cooling station, the instruments are ready.

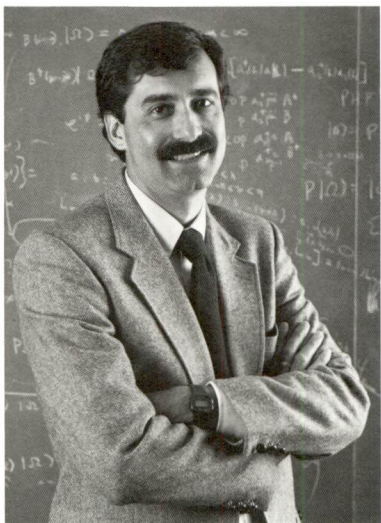
After about fifteen hours, when enough antiprotons have been gathered and ordered, they are shot into the Tevatron. Whirling in the same pipe, but in opposite directions, the beams of matter and antimatter are boosted to 900 GeV and, with precisely controlled magnets choreographing their positions, the two beams are guided into head-on collision.

Most of the time, although the beams are magnetically squeezed down to the diameter of a human hair to increase the probability of collision, they pass through each other like crossed beams of light from two flashlights. But about every tenth pass a quark inside one of the protons hits an antiquark inside one of the antiprotons, and the energy of the collision is transformed into a starburst of new particles, some of which haven't existed in nature since the universe was less than a millionth of a millionth of a second old.

Studying these subnuclear collisions for clues to the way the universe is put together requires an immense, complex arrangement of devices to identify the new particles, observe where they go and how fast they move, decide whether the event is interesting enough to study, and record the ones that are in exquisite detail. One of the machines that does this at Fermilab, known as CDF (Collider Detector at Fermilab), is the result of eight years of work by about 250 physicists, students, engineers, and technicians from seventeen institutions in Italy, Japan, and the United States.

The Search for the Missing Quark

CDF has obtained precise measurements of the masses of the *W* and *Z* particles, important for testing the theory that unifies the weak and electromagnetic forces. CDF is also searching for the top quark, the only known quark not yet observed. Because the top quark is so much more



"I often wonder what people in the next century will think of our attempts to understand the basic structure of the universe. However they judge our scientific efforts, I believe they will not find us lacking in boldness or imagination as we attacked problems previously thought to lie outside the realm of human comprehension. $\square$ Fermilab has a nurturing environment in which to pursue science that is not matched by very many places. There is an ambiance here that is important to a research institute. Such an atmosphere is something that is very precious and cannot be created overnight. No one knows how it happens, but it has developed here, and it is something that cannot easily be reproduced."

EDWARD KOLB, Astrophysicist
Fermilab and the University of Chicago



massive than any of the other quarks, the Tevatron is the only existing accelerator that might have sufficient energy to produce it. Determining the properties of the top quark is one of the most important goals of particle physics today. Should this quark be even more massive than the Tevatron can produce, that would actually be even more exciting: that result would reveal an unexpectedly deep mystery in the current model of how the universe is put together.

Once Again, the World's Highest Energies

The innovative technology of the Tevatron meant that Fermilab had again become the highest energy accelerator in the world. The total cost of the Tevatron and its accoutrements (such as the antiproton source and new and improved beam lines for experiments), including extensive research and development, was \$320 million. The second full-scale run, in 1988, exceeded the design luminosity (the intensity of the particle beams, an important measure of an accelerator's discovery potential), and accelerated both beams to 900 GeV, for a total energy of 1800 GeV, or 1.8 TeV (for tera-electron volts, hence the name Tevatron).

A Nobel Prize for the Director

The Laboratory took pride in Leon Lederman's 1988 Nobel Prize for an experiment carried out in 1961 at Brookhaven with two of his colleagues at Columbia University, Melvin Schwartz and Jack Steinberger. Their team discovered a particle that was to have far-reaching consequences for the construction of the standard model: a second kind of neutrino.

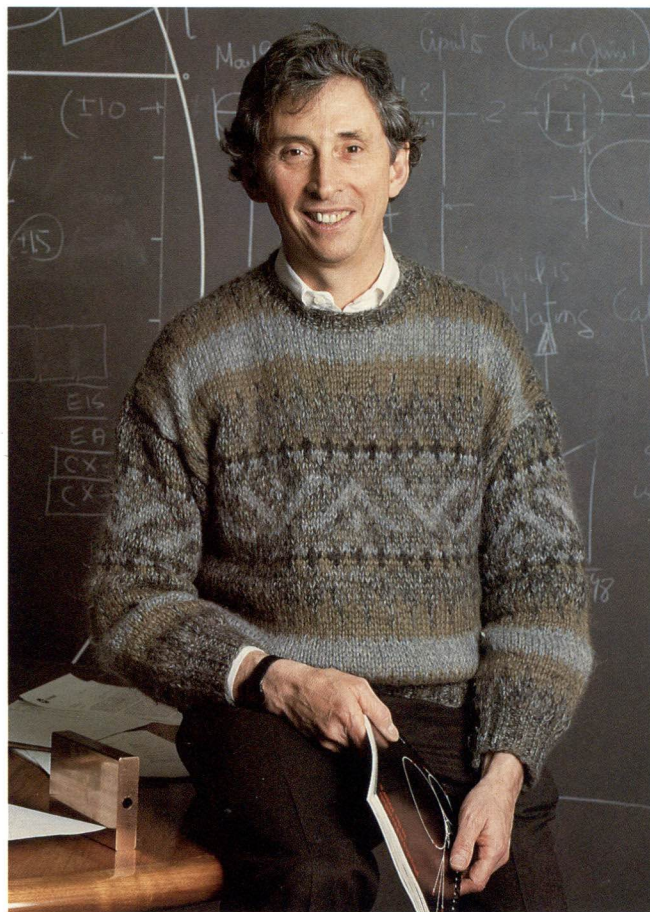
The Third Decade, the Third Director

In 1989 Fermilab's third director, John Peoples, took office. Peoples, who joined the Laboratory in 1972 from Cornell University, had filled several important positions, including project leader of the stunningly successful anti-proton source.

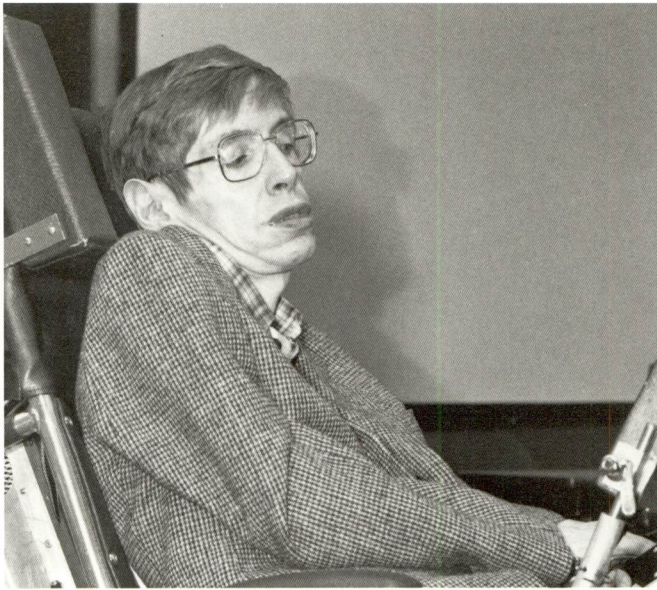
The Laboratory can continue to make a distinctive contribution to the region, to the country, and to the international scientific community. Fermilab's colliding-beam experiments and the Tevatron will continue to provide insights and experience for building the Superconducting Super Collider (SSC). At the same time, Fermilab has the potential to elucidate some of the most important issues in the field:

- What is the mass of the top quark?
- Can CP-symmetry violation be explained within the framework of the standard model, or is it a hint of what lies beyond?
- How can we refine and extend our current understanding of the strong and weak interactions and the three generations of matter particles?
- What is dark matter?
- How do galaxies form?

The frontiers of knowledge and technology have expanded in unforeseeable and wonderful ways since the Laboratory's beginnings. The future holds new challenges and opportunities, and we are ready to meet them.



John Peoples became Director of the Laboratory in 1989.



Many distinguished visitors bring new ideas to the Fermilab community each year. Steven Hawking and I. I. Rabi are among those who have inspired our audiences.

CONNECTIONS

NOT every scientist who comes to Fermilab performs an experiment at the Tevatron.

As an international center for high-energy physics, Fermilab seeks to develop — in addition to new tools for carrying out experiments — new ways of thinking about science. One powerful influence on the intellectual life of the Laboratory, and on the worldwide community of particle physicists, is Fermilab's Theoretical Physics Department.

The laboratory setting has proven particularly fertile. Experimenters need theoretical models to guide them in designing experiments and analyzing data; theorists rely on experiments to determine whether their theories are plausible views of the universe. The two approaches are not rival parties trying to reach the summit of understanding by different routes; they are more like two climbers inching their way up a steep cleft, with their feet on different walls but their backs braced against each other. The tools are allied, the impulse is one.

In addition to influencing the course of experimental research and receiving guidance and inspiration from experiments, Fermilab also has been home to much significant theoretical work that, while remote from today's experiments, expands the boundaries of what is thinkable.

The abilities and diversity of the theoretical group have enabled it to illuminate a broad spectrum of issues, including the search for and interpretation of charmed particles, the interpretation of the upsilon particles and the properties of the bottom quarks, the consequences of the theory of strong interactions, and the agenda for supercollider physics.

A vigorous visitors' program has been an important component of theoretical physics at Fermilab from the beginning. Scientists from across the country and around the world—including growing numbers of Fermilab "alumni"—bring their ideas to the Laboratory and return home stimulated by the experimental and theoretical work they encounter.

The tools of theoretical physics are no longer limited to pencil, paper, chalk, and blackboard. Computers are used extensively for symbolic manipulation, numerical evaluation of theoretical expressions, and simulation of the consequences of theoretical models. Recently, theorists have joined with the team that developed Fermilab's parallel processing capabilities to build a versatile array of computing engines dedicated to the study of the gauge theories of the strong, weak, and electromagnetic interactions.

One group of Fermilab theorists is dedicated to studying the largest and longest-running particle physics experiment: the universe itself. In the early 1980s, by establishing the first group of astrophysicists to work in an experimental high-energy physics setting, Fermilab led the way in forging new links between particle physics and cosmology, which find common ground in conditions that prevailed in the early universe and are replicated in microcosm in high-energy collisions. The NASA–Fermilab Theoretical Astrophysics Group investigates a variety of issues, from the origin of dark matter—the enigmatic stuff that seems to be different from observable objects in the cosmos and may turn out to be a completely new form of matter—to the formation of large lumps of matter, like galaxies, that were created in a universe that was once uniform in every direction.

Frequent exposure to fresh ideas and to new experimental results stimulates scientific progress. Fermilab makes a special effort to bring distinguished thinkers to the Laboratory to give lectures, seminars, and colloquia to

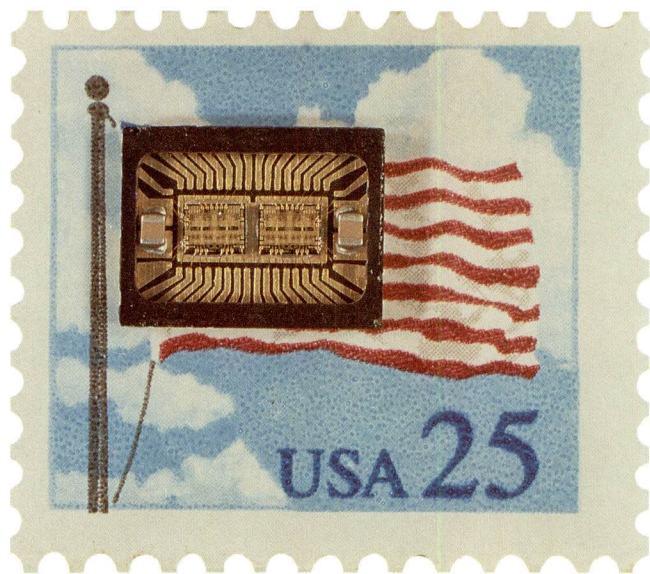


Scholarship of many kinds flourishes at Fermilab. Here a theorist works on a book that has become a standard text on the theories of the strong, weak, and electromagnetic interactions.

which the public is warmly invited. About two hundred speakers a year have graced our stage, including Bruno Bettelheim, Lewis Branscomb, Jane Goodall, Stephen Jay Gould, Stephen Hawking, I. I. Rabi, and Steven Weinberg. The Laboratory also sponsors and cosponsors extended visits for workshops, conferences, round-table discussions, and resident scholarship to encourage communication among universities, national laboratories, federal agencies, and private industry on a spectrum of topics from quantum cosmology to new technologies for the SSC.

NURTURING TECHNOLOGY

ALTHOUGH its primary mission is to carry out fundamental scientific research, Fermilab also stands as a symbol of our nation's technological achievement. As one of our leading scientific institutions, it brings together exceptionally skilled, educated, and creative people from across the country and around the world. They come to address not only compelling scientific questions, but also the challenges of developing the technology needed to answer those questions. The rewards of an approach to research that is perhaps best described as "if you need it and can't buy it, invent it" include developments and innovations applicable to cost-effective high-speed computing, to medical imaging and therapy, and to other sciences.



Experiments at Fermilab frequently require technology that is more advanced than that commercially available. Fermilab's Electrical Engineering Department designed this application-specific integrated circuit and its chip carrier. The chip, fabricated by Tektronix, contains four high-speed, high-gain, low-noise amplifiers. Two identical chips are shown mounted in the custom chip carrier.

1989 National Medal of Technology

In recognition of an exceptional contribution to the nation, President Bush presented four Fermilab scientists with the 1989 National Medal of Technology for their achievements in the bold development and application of superconducting and cryogenic technologies to the Tevatron. These innovations made it possible to double the energy of the accelerator while cutting the Laboratory's power consumption by two-thirds. The four scientists — Helen Edwards, Richard Lundy, J. Richie Orr, and Alvin Tollestrup — were the first National Medal of Technology recipients associated with a national laboratory.

RD-100 Awards

By 1989, Fermilab had won a dozen RD-100 Awards, presented by *Research & Development* magazine each year for the one hundred most technologically significant new products. The awards were received for

- The Tevatron's superconducting dipole magnet, which provides a uniform vertical magnetic field to bend the trajectory of the beam of protons (1980)
- The negative hydrogen-ion source, which substantially increased the intensity of the accelerator beam (1980)
- The electron cooling system to increase the density and cohesiveness of proton or antiproton beams in storage rings (1981)
- The Tevatron helium transfer line, a major advance in field-welded vacuum-jacketed helium pipes for cryogenic systems (1983)
- The ECL CAMAC ultrahigh-speed computer, whose processing speed for special applications surpassed by several times the most sophisticated mainframe computers on the market at a relatively low cost (1983)
- The slip-ring stepping motor, which quickly and reliably delivers high torque operation in a higher magnetic field (three thousand gauss) than any other stepping motor on the market (1983)
- The precision electric current sensor, which measures, with more accuracy and less noise than existing products, the magnitude of a direct current flowing in a conductor without touching it (1983)
- The spectrographic nitrogen detector to monitor low levels of nitrogen, water, or hydrocarbon contamination in helium (1984)
- The magnetic wire position transducer, an inexpensive device for surveying inaccessible objects that was devel-

oped to align magnets ten to twenty meters long to within tenths of a millimeter when conventional laser surveying proved too expensive (1985)

- The Advanced Computer Program (ACP) microprocessor system, the first large-scale parallel processor to be applied intensively to research (1986)
- The Video Data Acquisition System (VDAS), which can instantly convert video images into digital data (1986)
- The Advanced Computer Program multi-array processor system (ACP MAPS), which at peak performance provides floating-point calculational power at a cost-performance ratio nearly two orders of magnitude better than existing supercomputers (1989)

Faster, Less Expensive Computer Processing

Nature yields her secrets most readily to a combination of good ideas and technology. One of the most vexing problems faced by high-energy physicists is analyzing the vast amounts of data from experiments.

To improve the efficiency of data analysis, a Fermilab team developed a new parallel computer processing system using the best commercially available thirty-two-bit microprocessor chips ganged together. A local electronics firm and member of the Fermilab Industrial Affiliates group, the Omnibyte Corporation, supplied printed circuit boards for the Advanced Computer Program.

In parallel processing, an array of computers simultaneously work on different parts of a task, in contrast to conventional computers, which tackle problems by carrying out separate instructions sequentially. The ACP was



Programmers and engineers in the Advanced Computer Program have designed both hardware and software for advanced parallel processing. The group has worked closely with a local electronics firm to develop the computing capability to perform a large number of independent tasks simultaneously, at a relatively low cost.

among the first of a new genre of local-memory parallel processors, which have proven to be superb tools for solving many complex problems in science and engineering. When it was first used at Fermilab, the ACP made it possible to reconstruct the raw electronic data gathered in an experiment into a useful form in less than a quarter of the time it would have taken on all the Laboratory's other computers combined.

The first-generation ACP, which debuted in 1985, was substantially more cost-effective than any commercially available device, and national laboratories and universities

in Brazil, France, Switzerland, and the United States quickly placed orders.

Subsequent improvements combined new higher performance processors with more powerful and flexible software, called Cooperative Process Software. This software, together with "farms" of commercially available reduced-instruction-set computers, provides an inexpensive path to vast computational power. The Laboratory and Universities Research Association have licensed Omnibyte to produce and market a second-generation processor.

Advancing Health-Care Technologies

The industrial-scale technology base developed to supply the Tevatron with enough reliable superconducting magnets to fill a tunnel four miles long is one of the cornerstones of commercial development of superconducting magnets for magnetic resonance imaging (MRI). MRI creates images of soft tissues, invaluable for locating tumors and soft tissue damage that x rays reveal only faintly. It is estimated that development of superconducting wire for the Tevatron advanced commercialization of MRI technology by at least a year, bringing the benefits of this diagnostic technique to about a million additional patients.

Fermilab's experience with accelerators has also found more direct application. Under a work-for-others agreement with the Loma Linda Medical Center in California, Fermilab designed and built a 250-million-electron-volt proton synchrotron. The use of a proton beam for cancer therapy was first proposed by Robert Wilson, the Founding Director of Fermilab, in 1946. Because the energy, location, and intensity of a proton beam can be precisely controlled, protons offer the hope of killing cancer cells without damaging adjacent healthy tissue, a drawback of x-ray therapy. The most precise and flexible proton treatment instrument ever attempted, the Loma Linda accelerator is designed to treat one thousand patients a year. The new cancer center will be a worldwide resource for research on proton-beam therapy.

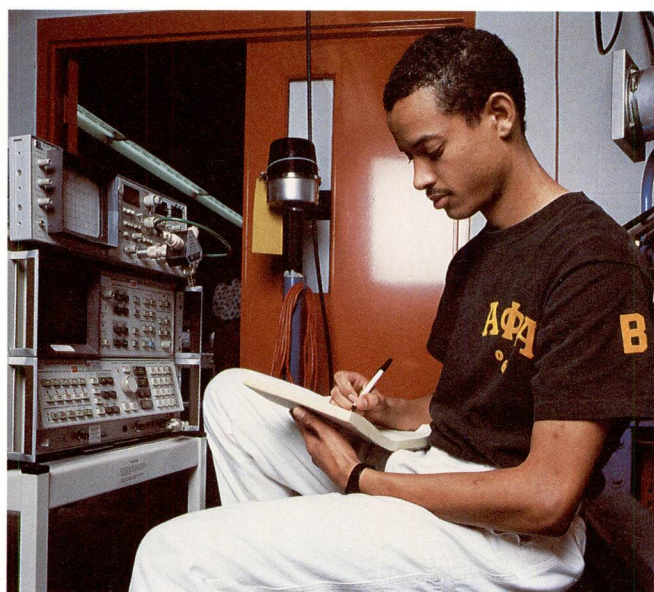
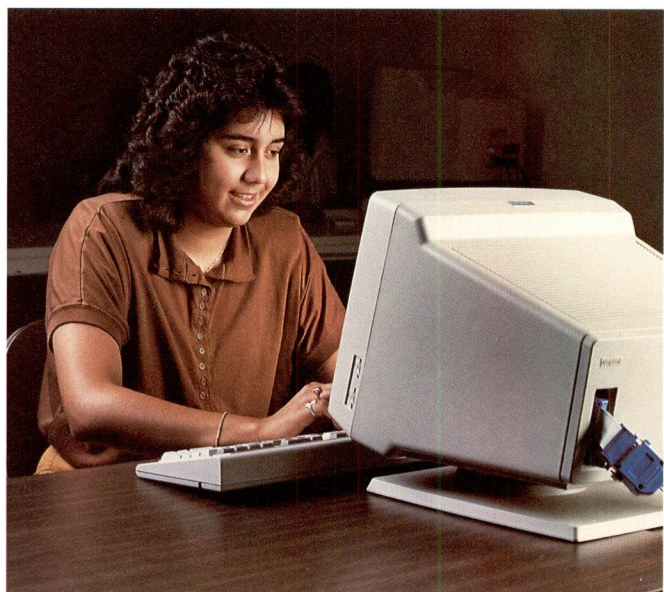
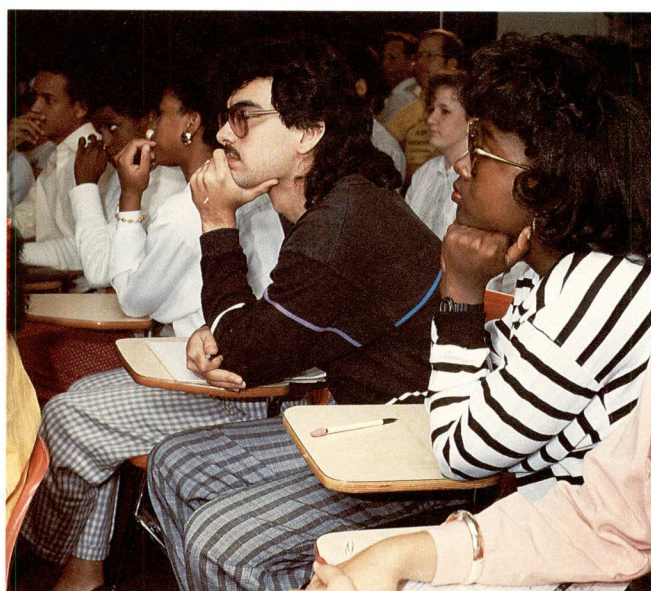
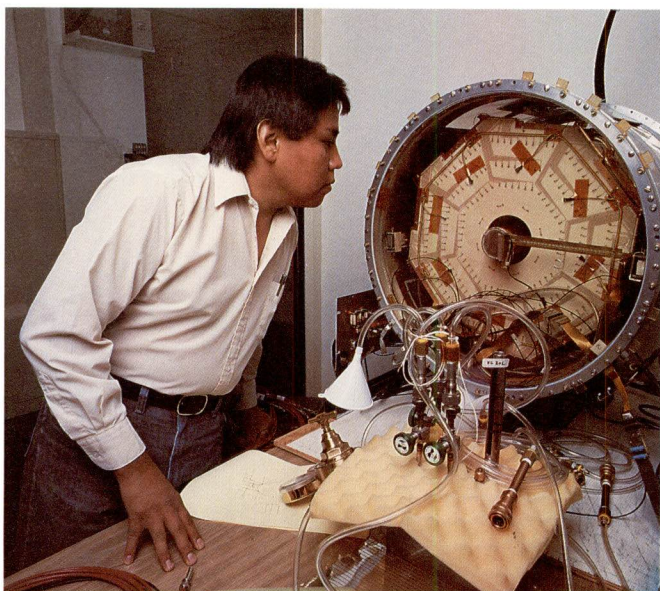
Fermilab and Future Research

Fermilab is an invaluable source of expertise for future high-energy physics research. Innovative techniques and

technologies developed and matured at Fermilab will help support the SSC, a high-energy superconducting accelerator laboratory that is being built in Texas by Universities Research Association and its industrial partners. Fermilab is making available test beams for SSC detector research and development. The Tevatron provides the opportunity to study how the SSC's 20-TeV proton beams will behave in their fifty-four-mile orbit. Fermilab's extensive experience in cryogenics has resulted in an innovative design for a strong, very-low-heat-leak cryostat to maintain the SSC magnets at about four degrees above absolute zero. Experience with detectors—including silicon microstrip detectors, laser holography, high-resolution optics, hybrid emulsion spectrometers, and scintillating fibers—and computers at Fermilab experiments is directly relevant to technology for future high-energy experiments at many institutions. And the discoveries that are made by both theorists and experimenters at Fermilab will help shape the program of high-energy physics research for years to come.

The Fermilab Industrial Affiliates Program

Formed in 1980, the Fermilab Industrial Affiliates program is designed to enhance communications on technology development between the academic and industrial research communities. More than forty corporations, major players in the world marketplace as well as small start-up companies, participate. Annual meetings have considered such topics as "Industrial Participation in Large Science Projects," "Supercomputer Developments in the Universities," and "Applications of Particle Physics: Out on the Limb of Speculation."



Fermilab's educational programs help thousands of students every year from local schools and from around the country develop an interest in and appreciation for science. Students at Fermilab are exposed to the latest questions that are being asked, the technology that helps answer them, the importance of rational inquiry and independent thought and intellectual honesty, and the joy of uncovering something no one has ever known about the way the universe is put together.

FERMILAB AND EDUCATION

ANIMATED by a deep respect for people, for nature, and for learning, Fermilab's many educational programs have inspired students and teachers at all levels and set a standard for serious commitment to science education by a national laboratory.

The Laboratory has long welcomed others to the excitement and intellectual integrity of a place where science is done, where new knowledge of the world is revealed. Having a model for the free and open exchange of ideas and independent thought is as important for the future as proficiency in science and mastery of technology.

Friends of Fermilab, a not-for-profit organization, was founded in 1983 to make use of the Laboratory's unique resources to develop precollege education programs. Their programs have been supported by grants and gifts from the National Science Foundation, the Department of Energy's Office of Energy Research, the State of Illinois, the Bersted Foundation, the Aurora Foundation, and other private foundations and individuals. In 1989 alone, more than three thousand students and six hundred teachers participated in science and mathematics programs at Fermilab.

Precollege Education:

Reaching Out to Our Neighbors . . .

In 1979 the Laboratory invited seventy nearby high schools to nominate students to attend ten lectures on modern physics given by experimental and theoretical physicists on the Fermilab staff. Over three thousand students have since attended the lecture series, which is repeated three times a year.

In a six-week apprentice research program, gifted minority high school students work side by side with a scientific, engineering, or technical mentor in the mornings and attend classes and carry out research in the afternoons. Two hundred fifty students, most from schools in Chicago, have completed the program.

In 1983 Director Leon Lederman and the Friends of Fermilab began work on the curriculum for what became the Illinois Mathematics and Science Academy. The three-year public school offers resident students accelerated and enriched programs in science, mathematics, languages, and the humanities. In 1985 a bill authorizing the Academy was passed by the Illinois State Legislature and signed by Governor Thompson. The Academy's doors opened in 1986, and in 1988 its senior class received the highest number of National Merit Scholarship awards in the state. Fermilab scientists serve this landmark institution as lecturers and advisors.

To stimulate the teaching of modern physics in northeastern Illinois high schools, a group of high school teachers and Fermilab physicists worked together to develop videotapes and a resource book for teachers and trained a cadre of master teachers.

Friends of Fermilab has produced a manual to introduce teachers at all levels to science classroom resources available in northern Illinois. The same organization sponsors networks for local high school physics and chemistry teachers to promote the exchange of teaching strategies and materials. To give students direct experience with science and technology, Friends of Fermilab has developed interactive science activities for elementary schools in the area. Other classroom materials are provided to local teachers free of charge or at cost.



Science and mathematics teachers from across the country visit Fermilab each summer and participate in research at the frontiers of particle physics, an invaluable means of transmitting the excitement and rewards of math and science to their students.

. . . and to the Nation

Sixty high school teachers of biology, chemistry, mathematics, and physics are selected annually for an intensive four-week summer institute at Fermilab. The program, initiated in 1983, offers lectures by Fermilab scientists and college faculty members, meetings with master teachers, and four follow-up sessions held in each discipline during the subsequent academic year.

Fermilab also participates in the Department of Energy Teacher Research Associates Program, a summer program for outstanding junior high and high school teachers. Twenty teachers from around the country have the opportunity to assist scientists and engineers at Fermilab. They return to their classrooms able to give their students a better sense of the outstanding issues in particle physics today and of the instruments and methodologies used at the frontiers of research.

Gifted high school students from across the country are exposed to world-class research in particle physics at Fermilab under the Department of Energy's High School Honors Research Program. The students spend two weeks at Fermilab attending seminars led by staff scientists, visiting different parts of the site, and working with physicists and graduate students on experiments.

Fermilab's commitment to science education will be crowned by a new science education center, which will comprise a resource center for teachers, space for hands-on science activities, and office space for the Laboratory's Education Office. Secretary of Energy James Watkins and Congressman Dennis Hastert participated in the October 1989 ground-breaking ceremony for the building, which will be funded by the Department of Energy.

Graduate Education

Hundreds of Ph.D. theses have grown out of work at Fermilab, underscoring the role of the Laboratory as the branch campus of more than a hundred of the nation's universities—a special resource that enables students and faculty members to participate in research at the frontiers of science that no single university could afford to undertake alone. Roughly a quarter of the members of a collaboration, on average, are graduate students. Even on the largest experiments, people tend to work in small groups that preserve the traditional and valuable graduate school experience of learning from close associates over time, within a framework that offers an exceptionally wide range of opportunities to develop different skills. Students can work with experts from many fields on a variety of tasks: designing, constructing, installing, and commissioning mechanical, electronic, and cryogenic support systems; writing software for design studies, systems monitoring and control, data reconstruction, and data analysis; designing, building, and operating extremely sophisticated devices; performing calculations with some of the world's most advanced software. Frequently students have the chance to collaborate with experts from industry.

However, graduate and postgraduate students in high-energy physics are not the only people that have received a crucial part of their education working at the Laboratory. Many engineers, computer scientists, and technicians who master the challenges of their disciplines in the high-energy physics environment go on to make important contributions to research and industry in other settings.



"Science is really international now. Even when you are working by yourself in a university, you know what other people are doing, you use the numbers that somebody else has measured or calculated. ¶ While I was working on my Ph.D. in Italy, two years ago, I came to Fermilab for seven months. I graduated last summer, and I'm now working on an experiment here with three Italian universities and four American institutions, because it's the only laboratory in the world where it can be done. ¶ When I first came here, all the people were really helping us, trying to make us feel at home. We could use the labs any time, during the day, during the night, on weekends. I like the way that you have everything at your disposal, that you can go to the stockroom whenever you need to. If you need to talk to somebody in the Lab you can just go and talk, even if he is the Director; it's not as formal as in Europe. ¶ When you go to a lab to do an experiment, you want to find people there that know things, that have already developed techniques, and the kind of organization that works. A lot of experiments depend on knowing things like which is the right sealant, or the right gas, to use. Fermilab is a place where people have the expertise and can help you when you need them. You don't have to reinvent everything."

NADIA PASTRONE, Postdoctoral Researcher
Italian National Institute of Nuclear Physics
(INFN)—Torino





Wildflowers and native grasses tall enough to hide a person on horseback flourish on more than three hundred acres inside the largest accelerator ring, part of a project to restore the tallgrass prairie that last existed here in Abraham Lincoln's youth. (Photo © Thomas Nash)

CARING FOR THE ENVIRONMENT

FERMILAB has always taken seriously its responsibility to the environment entrusted to its care.

The concern reflected in the physician's oath "First, do no harm" is preeminent. The Laboratory acts to ensure that its operation does not pose a threat to people, animals, or the natural surroundings. Air, water, and soil samples from around the site are continually monitored to make sure that Fermilab is functioning safely. The Laboratory, which must comply with both local and fed-

eral health and safety regulations, in many cases imposes even stricter standards. New construction reflects the latest advances in environmental design and energy efficiency; existing buildings, equipment, and fixtures are quickly brought up to date. The Laboratory's health physics, industrial hygiene, occupational medicine, safety management, industrial safety, fire protection, and emergency preparedness programs have been rated good to excellent by the Department of Energy.

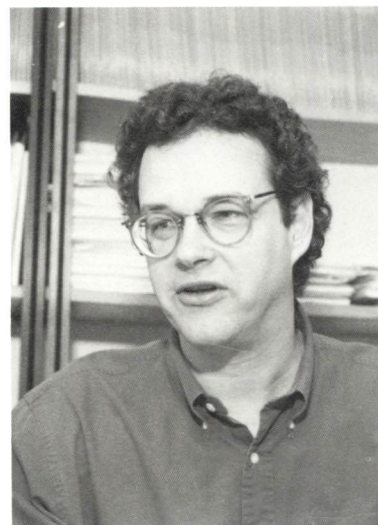
Restoring a Lost Ecosystem

All three of Fermilab's directors and a host of volunteer staff members have supported the Fermilab prairie restoration project. Begun in 1974 by the Nature Conservancy, the plan is to reestablish a lost ecosystem, the tall-grass prairie, on a large scale. Above the Tevatron, which gives scientists a look at conditions of the very early universe (see p. 6), the clock is being turned back in a different way. The 455 acres within the ring have been planted with seeds from nearly extinct plants and are now crowded with eight-foot-tall native grasses, prairie dock, coneflowers, goldenrod, and rosinweed. It is the largest area of restored prairie in the United States.

In 1985 the prairie restoration project — which was founded by Robert Betz, a biologist at Northeastern Illinois University, with the assistance of Ray Schulenberg, curator of the Morton Arboretum, and scores of volunteers from both inside and outside the Laboratory — expanded outside the ring. An interpretive trail circling part of the new acreage is open to the public — as is most of the Fermilab site for birdwatching, bicycling, cross-country skiing, and other forms of recreation.

In addition to a variety of wildlife — the endangered upland sandpiper, prairie songbirds, herons, red-tailed hawks, meadow voles, minks, foxes, and even coyotes have found their way to the site — the prairie project supports a diverse population of researchers. Soil scientists from Argonne National Laboratory, an ornithologist from the Chicago Academy of Sciences, and an entomologist from Northeastern Illinois University have already gleaned invaluable information from this unique living laboratory.

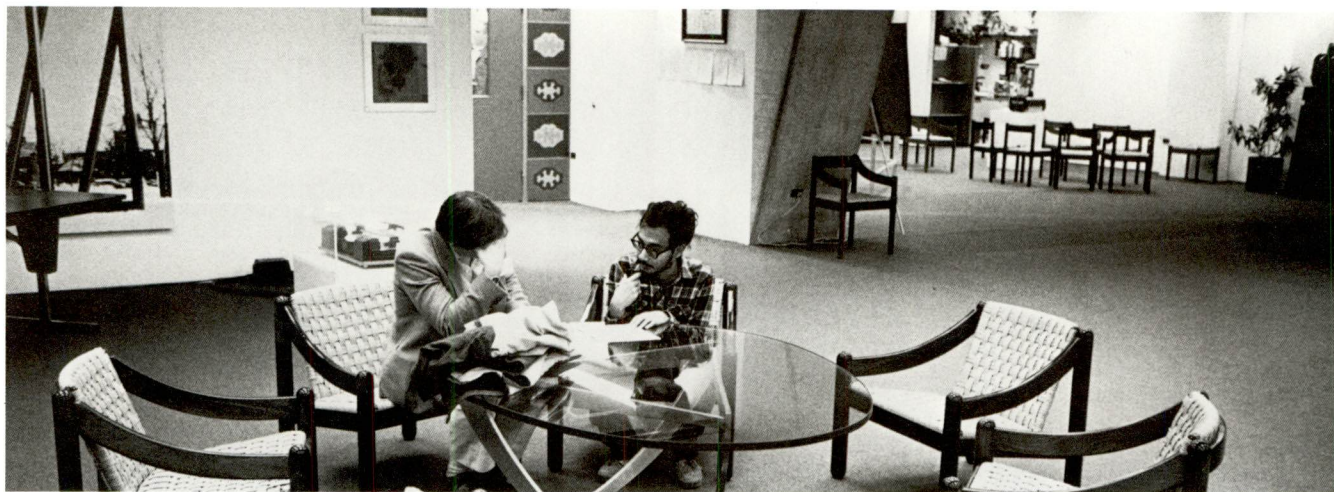
In 1989, the Department of Energy designated the Fermilab site the nation's sixth National Environmental Research Park, an outdoor laboratory for studying ecological relationships.



"One important issue in any experimental search for new physics is the expected rate of normal physics events that might mask a signal for new physics. If you have predictions for such background processes at SSC energies, you gain confidence if you can measure them at Fermilab, at the highest energy now available anywhere in the world, and check that they agree with the theory. This preparatory phase may, in fact, discover something, but even if it doesn't, it sets up the framework in which discoveries will be made. ¶ Being here has made it possible for me and other people in the theory group to do some very exciting work on the theory of the strong interaction. Our usual analytic techniques don't work at all for low energies. We have to use numerical methods, which require many trillions of computations. Because there is a tremendous experimental effort at Fermilab, we had the right people and the right atmosphere to build a machine to do these computations. We obtained a tremendous amount of computing power at very little cost — about a hundred times better than you could get commercially at the time we started. This type of innovation, which is hard to do at a university, was a much easier task here because of our resources."

ESTIA EICHTEN, Physicist
Fermilab





Fostering the exchange of information and ideas among scientists from around the world is one of Fermilab's most important missions.

AN INTERNATIONAL LABORATORY

SCIENCE is a truly universal human enterprise. The questions, the methods, and the language of science transcend national, racial, and political differences. Scientific research, which withers without the free exchange of ideas, open-minded thinking, and unrestricted access to knowledge, has traditionally been intercultural. Ideas are strictly tested, but on the basis of their agreement with experiment, without regard to national origin.

Fermilab has been proud to carry out this tradition, out of a deeply held conviction that such diversity both adds to intellectual richness and contributes to better comprehension of foreign assumptions and values. One hundred fifty-one foreign institutions from thirty-four nations have been actively involved in research at

Fermilab. And, consistent with our commitment to excellence, the Laboratory has both benefited from and contributed to the international exchange of people, equipment, and ideas.

Promoting Growth of Latin American Physics

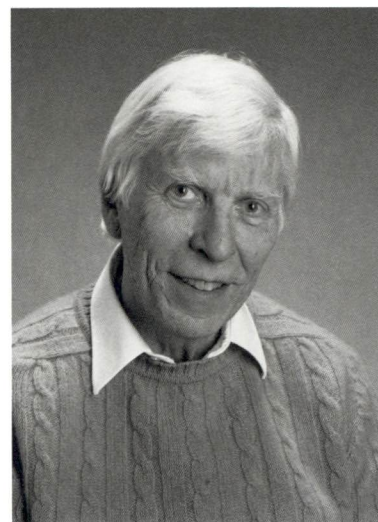
In the early 1980s, Fermilab began a series of meetings with high-energy physicists in the developing nations of Latin America to consider how best to collaborate with them. These discussions were motivated both by a desire

to advance physics and by the recognition that a strong scientific infrastructure is necessary for a country to advance technologically.

Leon Lederman, then Director of the Laboratory, says, "Often in Latin America, people say to me, 'What good is particle physics to Colombia? In Colombia we're interested in problems like coffee rust and corrosion.' My answer is, yes, high-energy physics isn't going to do much for coffee rust and corrosion in the next ten years. But coffee rust and corrosion are not the kind of things that are going to capture the imagination of a ten-year-old. Black holes, antimatter, neutrinos, the kind of stuff we do at Fermilab is what draws kids into science. Later, when they are mature scientists, they will turn to coffee rust and corrosion. Half of the physics Ph.D.'s that have come out while Fermilab has been in existence ultimately go into other fields, which means our export level is very valuable."

One element of the Fermilab program is aimed at redressing the effects of hard-currency shortages in Argentina, Brazil, Chile, Mexico, and Venezuela. Grants from the National Science Foundation and the Department of Energy have been used to purchase subscriptions to journals published in the United States for libraries in Latin America and to cover page charges for journal articles by Latin American authors, to buy spare parts and small pieces of equipment for physics laboratories, and to provide per diem support for Latin American physicists on short visits to this country. All the money has been spent in the United States.

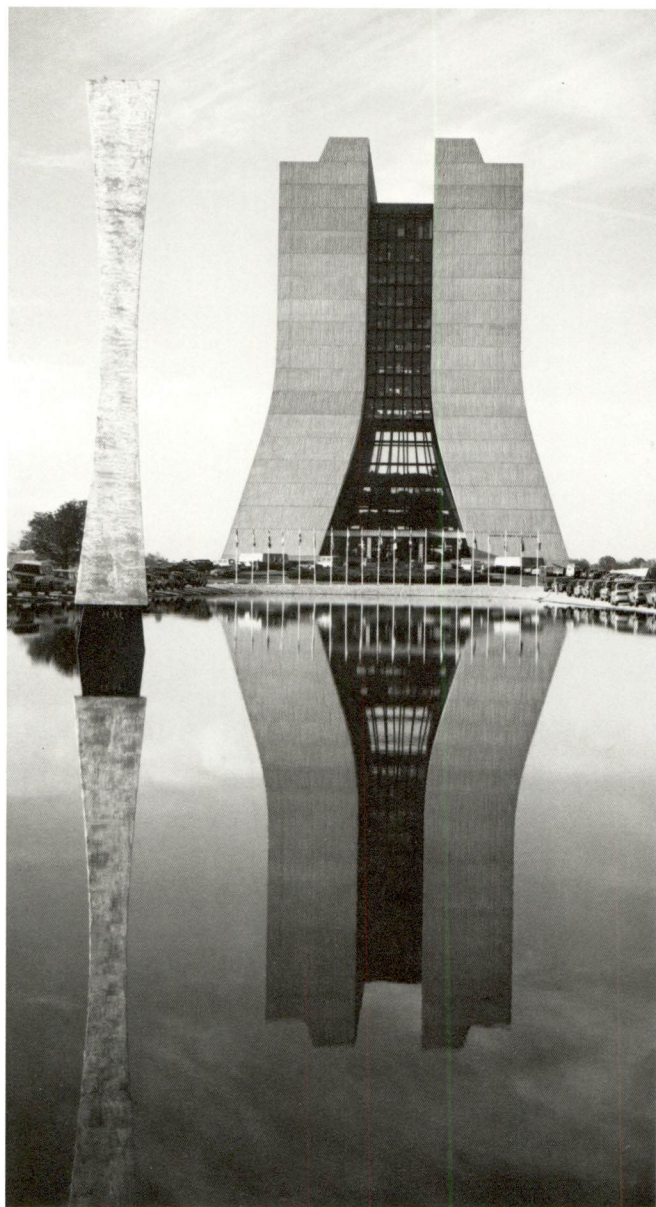
Today Fermilab has about fifty visitors from Latin America. Some have proposed experiments; others take advantage of the opportunity to become familiar with one of Fermilab's state-of-the-art technologies, such as superconductivity, control systems, and new computer architecture, and then return home to share and employ their new expertise in their home institutions. Fermilab, for its part, has benefited from their talents and enthusiasm.



"One of the most important things we've done is pushed the whole technology of superconducting magnets and cryogenics. CEBAF [the Continuous Electron Beam Accelerator Facility], RHIC [the Relativistic Heavy Ion Collider], the LHC [a large hadron collider under consideration in Europe], and the SSC [Superconducting Super Collider] are all direct results of the work on superconducting magnet technology and cryogenics that folks here started. I think if that hadn't been done, the whole history of this field would have been different. ☞ The technology that goes along with detectors here will also have a direct impact on the SSC. It's incredible how important this base is for that step forward."

ALVIN TOLLESTRUP, *Physicist*
Fermilab





Robert Rathbun Wilson Hall, named for the Founding Director. The library, cafeteria, auditorium, seminar rooms, and the offices of the Director and many staff scientists are all under one roof, to encourage the dissemination of ideas.

A LEADER IN HUMAN RIGHTS

FROM its beginning, Fermilab and the consortium of universities that operates the Laboratory for the Department of Energy (Universities Research Association) have been dedicated not only to contributing to the intellectual and technological growth of society but, at the same time, to affirming the principles of human rights and dignity.

It is a point of special pride to Founding Director Robert Wilson that he is descended from John G. Fee, an abolitionist preacher who before the Civil War founded interracial Berea College in Kentucky. Wilson considered it a "family obligation" to support the American civil-rights movement, and he took full advantage of his position to instill a profound respect for human rights at Fermilab.

The Laboratory's human rights policy that Wilson and his deputy director, Edwin Goldwasser, enunciated in 1968 remains basically unchanged:

In any conflict between technical expediency and human rights, we shall stand firmly on the side of human rights. This stand is taken because of, rather than in spite of, a dedication to science. . . . Our support of the rights of members of minority groups in our Laboratory and its environs is inextricably intertwined with our goal of creating a new center of technical and scientific excellence. The latter cannot be achieved unless we are successful in the former.

The Laboratory moved swiftly to become what an article in *Science* (June 5, 1970, p. 1185) called "clearly one of the more vigorous proponents of racial justice in the Chicago environs."

The Illinois State Legislature had refused to pass an open-housing statute when Fermilab was founded. The Laboratory directorate appeared at town council meetings in neighboring communities to support the swift adoption of local open-housing legislation.

Wilson established an Equal Opportunity Office and appointed Kennard Williams, leader of a local chapter of the NAACP, to head it. Pilot programs successfully recruited and trained young inner-city residents as operating engineers, machinists, drafters, and mechanical and electrical technicians. Williams also sought out minority-owned contractors and suppliers. For the largest contracts, where relatively few minority-owned businesses existed who were willing to take on the job, the Laboratory required bidders to submit proposed affirmative action programs for hiring and training minorities. An unsatisfactory plan was sufficient reason to reject a bid; a plan that was not implemented was grounds for a breach-of-contract suit. "When Bob Wilson tells [the contractors] what he expects," said Kennard Williams in a 1970 interview, "and says that if they don't think they can do the job under these conditions then they should go away, that makes all the difference."

As new opportunities for advancing human rights have arisen, the Laboratory and Universities Research Association have responded enthusiastically. Recognizing that lack of good child care could discourage people, especially women, from pursuing careers, in 1979 Universities Research Association provided seed money and the Laboratory set aside space for the Fermilab Children's Center. The Fermilab program became an innovative model of employer-sponsored, on-site day care, setting a standard that many of the nation's most prestigious research institutes and corporations have still to achieve.



A center for many aspects of creative thought, Fermilab's gallery and auditorium offer the public art exhibits, concerts, dance performances, and films.

A VISION FOR THE FUTURE

WE HAVE YET TO ANSWER THE DEEPEST QUESTIONS OF MATTER AND ENERGY, SPACE AND TIME. WE MAY NOT EVEN KNOW ALL THE RIGHT QUESTIONS TO ASK. NEVERTHELESS, OUR COMMITMENT TO exploring the unknown has been rewarded with great strides in the understanding of the fundamental structure of the universe. In the coming years, Fermilab holds the promise of making incisive, historic contributions to a more complete comprehension of nature's most basic laws. Part of Fermilab's role in a diverse, healthy program of high-energy physics research in the United States can be clearly delineated:

- Given our current understanding of the standard model, we anticipate that the only expected quark that has not been seen, the top, will be revealed at the Tevatron. If the top does not appear there, that itself will be a tantalizing hint of phenomena beyond the standard model.
- We expect other experiments at the Tevatron to help illuminate the issue of whether the imperfection of CP-symmetry, an occurrence that helps account for the preponderance of matter to antimatter in the universe, lies within the standard model or is a clue to something beyond.
- More generally, the Laboratory will enable physicists to extend tests of the standard model and to look for guidance to more-encompassing theories. The knowledge of physics and technology that emerges from our work will be invaluable for the efficient design and construction of future experiments, and possibly for applications that today have not even been dreamt of.

Most important, we at Fermilab will reaffirm our commitment to serving society responsibly by nurturing analytical, imaginative, and humane thinking — a source and a symbol of what the human mind can create at its best.

MOSCOW; INSTITUTE OF HIGH-ENERGY PHYSICS, SERPUKOV; INSTITUTE OF PHYSICS AND TECHNOLOGY, UKRANIAN ACADEMY OF SCIENCES; JOINT INSTITUTE FOR NUCLEAR RESEARCH; KAZAKH S. M. KIROV STATE UNIVERSITY; MOSCOW M. V. LOMONOSOV STATE UNIVERSITY; PHYSICAL TECHNICAL INSTITUTE, TASHKENT. UNITED KINGDOM: IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY, AND MEDICINE; RUTHERFORD APPLETON LABORATORY; UNIVERSITY COLLEGE, LONDON; UNIVERSITY OF BIRMINGHAM; UNIVERSITY OF BRISTOL; UNIVERSITY OF CAMBRIDGE; UNIVERSITY OF LIVERPOOL; UNIVERSITY OF OXFORD. UNITED STATES OF AMERICA: ABILENE CHRISTIAN UNIVERSITY; UNIVERSITY OF SOUTH ALABAMA; UNIVERSITY OF ALABAMA; ARGONNE NATIONAL LABORATORY; UNIVERSITY OF ARIZONA; BALL STATE UNIVERSITY; BRANDEIS UNIVERSITY; BROOKHAVEN NATIONAL LABORATORY; BROWN UNIVERSITY; CALIFORNIA INSTITUTE OF TECHNOLOGY; UNIVERSITY OF CALIFORNIA, BERKELEY; UNIVERSITY OF CALIFORNIA, DAVIS; UNIVERSITY OF CALIFORNIA, IRVINE; UNIVERSITY OF CALIFORNIA, LOS ANGELES; UNIVERSITY OF CALIFORNIA, RIVERSIDE; UNIVERSITY OF CALIFORNIA, SAN DIEGO; UNIVERSITY OF CALIFORNIA, SANTA BARBARA; UNIVERSITY OF CALIFORNIA, SANTA CRUZ; CARNEGIE-MELLON UNIVERSITY; CASE WESTERN RESERVE UNIVERSITY; UNIVERSITY OF CHICAGO; UNIVERSITY OF COLORADO AT BOULDER; COLUMBIA UNIVERSITY; CORNELL UNIVERSITY; DEPAUW UNIVERSITY; DUKE UNIVERSITY; ELMHURST COLLEGE; EMMANUEL COLLEGE; FLORIDA A&M UNIVERSITY; FLORIDA STATE UNIVERSITY; UNIVERSITY OF FLORIDA; GENERAL ELECTRIC R&D CENTER; GEORGE MASON UNIVERSITY; HANSCOM A.F.B. GEOPHYSICS LABORATORY; HARVARD UNIVERSITY; HARVEY MUDD COLLEGE; UNIVERSITY OF HAWAII AT MANOA; UNIVERSITY OF HOUSTON; UNIVERSITY OF ILLINOIS AT CHICAGO; ILLINOIS INSTITUTE OF TECHNOLOGY; UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN; INDIANA UNIVERSITY; IOWA STATE UNIVERSITY; UNIVERSITY OF IOWA; JOHNS HOPKINS UNIVERSITY; JOHNSON SPACE CENTER; UNIVERSITY OF KANSAS; LAWRENCE BERKELEY LABORATORY; LAWRENCE LIVERMORE NATIONAL LABORATORY; LEHIGH UNIVERSITY; LOS ALAMOS NATIONAL LABORATORY; LOUISIANA STATE UNIVERSITY; UNIVERSITY OF MARYLAND; UNIVERSITY OF MASSACHUSETTS; MASSACHUSETTS INSTITUTE OF TECHNOLOGY; MICHIGAN STATE UNIVERSITY; UNIVERSITY OF MICHIGAN; UNIVERSITY OF MINNESOTA; MISSISSIPPI STATE UNIVERSITY; UNIVERSITY OF MISSISSIPPI; NATIONAL SCIENCE FOUNDATION; UNIVERSITY OF NEW MEXICO; STATE UNIVERSITY OF NEW YORK AT ALBANY; STATE UNIVERSITY OF NEW YORK AT BUFFALO; STATE UNIVERSITY OF NEW YORK AT STONY BROOK; NEW YORK UNIVERSITY; UNIVERSITY OF NORTH CAROLINA; NORTHEASTERN UNIVERSITY; NORTHERN ILLINOIS UNIVERSITY; NORTHWESTERN UNIVERSITY; NOTRE DAME UNIVERSITY; OAK RIDGE NATIONAL LABORATORY; OHIO STATE UNIVERSITY; UNIVERSITY OF OKLAHOMA; PENNSYLVANIA STATE UNIVERSITY; UNIVERSITY OF PENNSYLVANIA; UNIVERSITY OF PITTSBURGH; PRAIRIE VIEW A&M UNIVERSITY; PRINCETON UNIVERSITY; PURDUE UNIVERSITY; RICE UNIVERSITY; UNIVERSITY OF ROCHESTER; ROCKEFELLER UNIVERSITY; RUTGERS UNIVERSITY; SAN FRANCISCO STATE UNIVERSITY; SANDIA LABORATORIES; SUPERCONDUCTING SUPER COLLIDER CENTRAL DESIGN GROUP; SUPERCONDUCTING SUPER COLLIDER LABORATORY; UNIVERSITY OF SOUTH CAROLINA; STANFORD LINEAR ACCELERATOR CENTER; STANFORD UNIVERSITY; STEVENS INSTITUTE OF TECHNOLOGY; SUFFOLK UNIVERSITY; UNIVERSITY OF TENNESSEE, KNOXVILLE; TEXAS A&M UNIVERSITY; UNIVERSITY OF TEXAS AT AUSTIN; TUFTS UNIVERSITY; UPSALA COLLEGE; VALPARAISO UNIVERSITY; VANDERBILT UNIVERSITY; VIRGINIA POLYTECHNIC INSTITUTE; UNIVERSITY OF VIRGINIA; WASHINGTON NATURAL PHILOSOPHY INSTITUTE; WASHINGTON UNIVERSITY; UNIVERSITY OF WASHINGTON; COLLEGE OF WILLIAM AND MARY; UNIVERSITY OF WISCONSIN-MADISON; YALE UNIVERSITY. YUGOSLAVIA: UNIVERSITY OF BELGRADE.

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This booklet was written by Kate Metropolis. Except where credited otherwise, photographs were provided by the Fermilab

Audio-Visual Services Department. Artwork by Leon Bishop. Design, typography, and production by

Wilsted & Taylor, Oakland, California. Text and display type is Centaur with Arrighi italics.

Printing by Phelps/Schaefer Litho-Graphics Company, Inc., Brisbane, California.



The last centuries of science have been marked by an unabating struggle to describe and comprehend the nature of matter, its regularities, its laws, and the language that makes it intelligible. The successes in this struggle, from the sixteenth century until our own day, have inspired the whole scientific enterprise, and lighted the world of technology, and the whole of man's life. ROBERT OPPENHEIMER

"CORRESPONDENCE TRACKING"

TYPE: PRESIDENTIAL PRIORITY DOCUMENT NUMBER: 9123394
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

FROM: THE HONORABLE DON RITTER: HOUSE OF REPRESENTATIVES

TO: JOHN SUNUNU

DATE OF
CORRESPONDENCE: 08/09/91

SUBJECT: WRITES REGARDING GLOBAL WARMING AND THE NAS STUDY

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: INFO COPY ONLY ACTION:
NO ACTION NECESSARY

SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: Carl Bretscher
ENVIRONMENT
D. Allan Bromley

WHITE HOUSE TRACKING #: CONTACT PERSON: SALLY KELLEY
PHONE: EXT:
REMARKS:

OSTP RECEIVED: 08/09/91 FILE: P-PRES PRIORITY*SUNUNU TRACKIN
DEPT RECEIVED:

RECEIVED

91 AUG 9 10:09 WHITE HOUSE OFFICE

REFERRAL

OFFICE OF THE
DIRECTOR

AUGUST 9, 1991

TO: OFFICE OF SCIENCE AND TECHNOLOGY POLICY
ATTN: ALLAN BROMLEY

ACTION REQUESTED:

INFORMATION COPY - NO ACTION NECESSARY

DESCRIPTION OF INCOMING:

ID: 257970

MEDIA: LETTER, DATED JULY 23, 1991

TO: JOHN SUNUNU

FROM: THE HONORABLE DON RITTER
U.S. HOUSE OF REPRESENTATIVES

WASHINGTON DC 20515

SUBJECT: WRITES REGARDING GLOBAL WARMING AND THE NAS
STUDY

PROMPT ACTION IS ESSENTIAL -- IF REQUIRED ACTION HAS NOT BEEN
TAKEN WITHIN 9 WORKING DAYS OF RECEIPT, PLEASE TELEPHONE THE
UNDERSIGNED AT 456-7486.

RETURN CORRESPONDENCE, WORKSHEET AND COPY OF RESPONSE
(OR DRAFT) TO:
AGENCY LIAISON, ROOM 91, THE WHITE HOUSE, 20500

SALLY KELLEY
DIRECTOR OF AGENCY LIAISON
PRESIDENTIAL CORRESPONDENCE

THE WHITE HOUSE
CORRESPONDENCE TRACKING WORKSHEET

INCOMING

DATE RECEIVED: JULY 29, 1991

NAME OF CORRESPONDENT: THE HONORABLE DON RITTER

SUBJECT: WRITES REGARDING GLOBAL WARMING AND THE NAS
STUDY

ROUTE TO:		ACTION		DISPOSITION	
OFFICE/AGENCY	(STAFF NAME)	ACT CODE	DATE YY/MM/DD	TYPE RESP	C COMPLETED D YY/MM/DD
JOHN SUNUNU		ORG	91/07/29	JS	A 91/08/05 TC
OSTP Allan Bromley	REFERRAL NOTE: ✓	I	910809		C 1/1 TC
	REFERRAL NOTE:				
	REFERRAL NOTE:				
	REFERRAL NOTE:				
	REFERRAL NOTE:				

COMMENTS:

ADDITIONAL CORRESPONDENTS: MEDIA: L INDIVIDUAL CODES: 1240

CS MAIL USER CODES: (A) (B) (C)

*ACTION CODES:	*DISPOSITION	*OUTGOING	*
*	*	*CORRESPONDENCE:	*
*A-APPROPRIATE ACTION	*A-ANSWERED	*TYPE RESP=INITIALS	*
*C-COMMENT/RECOM	*B-NON-SPEC-REFERRAL	*OF SIGNER	*
*D-DRAFT RESPONSE	*C-COMPLETED	*CODE = A	*
*F-FURNISH FACT SHEET	*S-SUSPENDED	*COMPLETED = DATE OF	*
I-INFO COPY/NO ACT NEC		*OUTGOING	*
*R-DIRECT REPLY W/COPY *			*
*S-FOR-SIGNATURE *			*
*X-INTERIM REPLY *			*

REFER QUESTIONS AND ROUTING UPDATES TO CENTRAL REFERENCE
(ROOM 75, OEOB) EXT-2590
KEEP THIS WORKSHEET ATTACHED TO THE ORIGINAL INCOMING
LETTER AT ALL TIMES AND SEND COMPLETED RECORD TO RECORDS
MANAGEMENT.

THE WHITE HOUSE

WASHINGTON

August 5, 1991

Dear Don,

Keep fighting the good fight! Your help really makes a difference.

Sincerely,

A handwritten signature in dark ink, appearing to read "John".

John H. Sununu
Chief of Staff

The Honorable Don Ritter
U.S. House of Representatives
Washington, D.C. 20515

257970



CONGRESS OF THE UNITED STATES
HOUSE OF REPRESENTATIVES
WASHINGTON, D. C. 20515

DON RITTER
FIFTEENTH DISTRICT
PENNSYLVANIA

July 23, 1991

Dear John,

THE CHIEF of STAFF
has seen

Yours truly couldn't
attend the S, S, & T Comm
hng. on Global Warming
but am unearthing
some pretty good stuff
on the NAS report
(Gore - Wirth!).

We'll also ask for
a Full Comm. hng. on the
Science / Just the Science. 
encl.

[This is a typed version of the attached memo; comments or additions in brackets]

MEMORANDUM

TO: J.E. (Joel Eisen — Minority Counsel to Environment Subcommittee)
FROM: Don Ritter, Ranking Republican Member, Subcommittee on Environment (House Science, Space, and Technology Committee)
RE: Global Warming: NAS Report; Observations following the July 21, 1991 Woods Hole Conference [weekend retreat for SS&T Members with NAS scientists]

- (1) The "Report" appropriation was requested by guess who? GORE & WIRTH.

Action: I believe it was in Senate HUD-Independent Agencies Appropriations Bill — please locate exactly and locate exact language of "what was to be done." (Key flaw as I see it was major focus on the "What if's" rather than the science itself; still very debatable. The "what if's" really dominated the activities, the volume, etc.)

- (2) Dinner conversation [at Woods Hole] indicated to me that "favorably disposed" (to global warming) outnumbered skeptics [on the panel] big time.

Action: Please investigate where the scientists stood on global warming prior to the study ("where you stand depends on where you sit"). Joel: Dr. Press [of NAS] was quite uncomfortable with my line of questioning.

- (3) Whatever happens in (1) and (2), I believe it is essential to the national debate that our Republican Minority on the Science Committee (all signed on) call for a comprehensive full Committee hearing on the pros and cons of the science!!

- (4) The NAS caters to an enormous scientific constituency [of] nice social scientists who see this as the Big Buck Bonanza for research — economic impacts, psychological, sociological, political impacts, etc. There seems to be [a] real predisposition toward this as [a] funding fount.

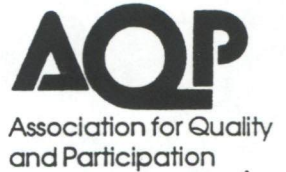


JOEL B. EISEN
REPUBLICAN COUNSEL
SUBCOMMITTEE ON ENVIRONMENT

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE,
SPACE AND TECHNOLOGY

HOUSE ANNEX II, RM. 388
WASHINGTON, D.C. 20515
(202) 226-6993

LEADING THE WAY TO TOTAL QUALITY:
MAKING THE LEAP FROM RHETORIC TO REALITY



7/23/91
To: V.E. (Joel Eisen - Minority Counsel)
From: Don Ritter, Ranking Rep. b. (Envir. Subc. SSIT)
Re: Global Warming: NAS Report: Observations
following 7/21 Woods Hole Conf.

1. The "Report" ^{appropriation} was requested by guess
who? GOPE + WIRTH.

Action I believe it was in Senate
Hud Indep. Agencies Appropri. Bill - Pls.
locate exactly and locate exact
language of "what was to be done"

Key flaw as I see it was major focus on
the "What ifs" rather than the science itself
still very debatable. The what ifs really
dominated the activities, the volume, etc.

2. Dinner Conversation indicated to me that
"favorably disposed" (+ Global Warming)
outnumbered skeptics big time.

Action: Pls. investigate where the
Scientists stood on ~~the~~ G.W. prior to
study (where you stand depends on where you sit)
and "D. P..." quite uncomfortable with (over)

my line of questioning.

③ Whatever happens in ① and ②, I believe it is essential to the nat'l. debate that our Republican Minority on the Sci. Comm. (all signed on) call for a comprehensive full Comm. hearing on the pros and cons of the science!!

④ The NAS caters to an enormous Science Constit. incl. Social Scientist who see this as the Big Buck Bonanza for research -- econ. impacts, psychological, sociological, political ~~impacts~~ impacts, etc. There ~~is~~ seem to be a real predisposition towards this as funding fount.

~~_____~~
~~_____~~
~~_____~~

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9123456

ORIGINATOR: 02

STATUS C

DIRECTORATE STATUS

FROM: TOLMIE, George S.

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 08/08/91

SUBJECT: A LETTER TO THE EDITORS OF SCIENTIFIC AMERICA
QUESTIONING THEIR SENSE OF VALUES IN SELECTING
LETTERS FOR PUBLICATION.

DIRECTORATE

STAFF

ASSIGNED:

ASSIGNED:

ACTION
REQUIRED:

STAFF
ACTION:

SENDER'S DUE DATE:

OSTP DUE DATE:

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
Steve Olson

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE:

EXT:

REMARKS:

OSTP RECEIVED: 08/13/91
DEPT RECEIVED:

FILE: P-EOP-PRESIDENTIAL CORRESPONDE

3452

RECEIVED

91 AUG 12 1991

August 3, 1991
159 South Whitney Street
Hartford, Connecticut 06105

OFFICE OF THE
DIRECTOR

Editors, Scientific American
415 Madison Avenue
New York, New York 10017

Dear Editors:

Please refer to the attached article taken from page two of The Hartford Courant, of this date: Scientists say it may be possible to make Mar's atmosphere Earthlike.

Some time ago you had featured an article in your journal on Mars and immediately upon reading of the conditions on Mars, a letter was sent to you suggesting the use of plant life introduced near the polar ice caps, for water; to change the carbon dioxide atmosphere to oxygen.

This letter was never printed; but, strangely to NASA researchers now are finding newsprint and space in the British journal Nature to state the exact same idea.

I am questioning your sense of values in selecting letters for publication.

Furthermore, I am questioning whether sending letters to your magazine makes any sense at all.

Please respond; as the novelness of ideas always brings credit to the originator; and, in this situation your magazine denied itself credit for publishing the idea; as well as denied myself some credit for thinking.

Sincerely yours,



George S. Tolmie

copy: NASA
President George Bush
Nature

Los Angeles Times

Scientists say it may be possible to make Mars' atmosphere Earthlike

With a poisonous atmosphere and

temperatures that can plunge to 220 degrees below zero, Mars is an inhospitable place where any unprotected creature from Earth would die instantly.

But a team of National Aeronautics and Space Administration scientists, noting that the atmosphere of Earth has changed dramatically throughout history — and apparently is still changing because of human activities — has concluded that it just might be possible to change the atmosphere of Mars so that it could

support life.

It would all have to be done with resources on Mars, and the researchers say it is too early to know whether the raw materials are even there.

But if they are, it may be that one day, say 100,000 years from now, humans will walk among the trees and flowers they have cultivated on Mars, breathing fresh Martian air that they have altered radically.

That scenario comes from a team of experts on the possibility of extraterrestrial life. Two of the researchers work at NASA's Ames Research Center in Mountain View, Calif., and

the third is at Pennsylvania State University.

The scientists, who are publishing their ideas in today's issue of the British journal *Nature*, acknowledge that none of this may come to pass because Mars may not have the materials needed to do the job.

"We're just trying to encourage some serious thinkers to think about it," said Brian Toon, one of three authors of the report. The others are Christopher P. McKay of Ames, one of the world's leading researchers in exobiology — the study of life on other planets — who is in Siberia looking for primitive life forms in-

side rocks, and James F. Kasting of Penn State.

The scientists see a scenario in which the planet could be changed enough to support plant life. Once that was accomplished, the plants would produce oxygen, changing the atmosphere of Mars just as plant life transformed the atmosphere of Earth. Eventually, it just may be possible that animals could survive there — perhaps even people — but that goal would be far more difficult to achieve.

The only possibility, they conclude, is to use materials that are already there, but no one knows for

sure whether Mars has what would be needed, such as water frozen at its polar caps or beneath the soil, and prodigious amounts of carbon dioxide that could be released into the air to make the thin atmosphere denser and the planet warmer.

Atmospheric pressure on the surface of Mars is equivalent to the pressure 100,000 feet above the Earth, and that is so thin that "if you stepped out your blood would boil," Toon said.

So three things must be done: the atmospheric pressure must be raised substantially, the planet must

be warmed and the chemical composition of its atmosphere must be changed.

"This is not something that is going to happen quickly," Toon said.

All of the speculation could come to a quick halt if Mars is found to be uncooperative. It could turn out, for example, that most of the carbon dioxide needed to warm the atmosphere is not frozen in the soil and ready to burst forth with a slight warming. It may be that it is buried in limestone instead.

"Then you are in trouble," Toon said.

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION DOCUMENT NUMBER: 9123344
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

FROM: HEAD, Marcy L.: PRESIDENT'S COMMISSION ON WHITE HOUSE
FELLOWSHIPS

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 08/02/91

SUBJECT: CONFIRMATION OF THE ASSIGNMENT OF JOSEPH BROZ TO
OSTP BEGINNING 09/03/91.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
Ken Yale
ADMINISTRATION

WHITE HOUSE TRACKING #: CONTACT PERSON:
REMARKS: PHONE: EXT:

OSTP RECEIVED: 08/07/91 FILE: P-EOP-WH CORR.*P-ADM-PERSONNEL
DEPT RECEIVED:

*Document and
note of appreciation
Marcy for all her
help.
DAB*

THE WHITE HOUSE
WASHINGTON

August 15, 1991

Dear Marcy:

Thank you for your recent note confirming our good luck at having Joe Broz select OSTP for his assignment as a White House Fellow this year. We are looking forward eagerly to his starting next month.

I especially want to extend my personal appreciation to you and your staff for all your efforts on our behalf. We were a bit delayed getting into the interview process as I recall and your staff was very helpful in last minute arrangements. I do appreciate the extra attention.

Again, we couldn't be more pleased about Joe's decision. Hope you are enjoying a good summer. My best wishes,

Sincerely,



D. Allan Bromley
The Assistant to the President
for
Science and Technology

Ms. Marcy L. Head
Director
President's Commission on White House
Fellowships

"CORRESPONDENCE TRACKING"

TYPE: PRESIDENTIAL PRIORITY DOCUMENT NUMBER: 9122378
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

FROM: TUBA, I.S.: INTERNATIONAL TECHNOLOGY INSTITUTE

TO: PRESIDENT BUSH

JUL 19 1991

DATE OF
CORRESPONDENCE: 07/18/91

SUBJECT: REQUESTS THAT THE PRESIDENT INITIATE LEGISLATION
WHICH WOULD ADOPT THE HOFEST SYSTEM NATIONWIDE IN
THE U.S.

DIRECTORATE STAFF
ASSIGNED: INDUSTRIAL ASSIGNED:

ACTION STAFF
REQUIRED: FOR DAB'S SIGNATURE ACTION:

SENDER'S DUE DATE: 07/30/91
OSTP DUE DATE: 07/22/91 STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
Damar Hawkins
INTERNATIONAL/POLICY

WHITE HOUSE TRACKING #: CONTACT PERSON: SALLY KELLEY
PHONE: 456-7486 EXT:
REMARKS:

CLOSED

OSTP RECEIVED: 07/18/91 FILE: EOP-
DEPT RECEIVED: P1-~~456~~-PRESIDENTIAL PRIORITY

THE WHITE HOUSE OFFICE

REFERRAL

JULY 18, 1991

TO: OFFICE OF SCIENCE AND TECHNOLOGY POLICY

ACTION REQUESTED:

DIRECT REPLY, FURNISH INFO COPY

DESCRIPTION OF INCOMING:

ID: 254482

MEDIA: LETTER, DATED JULY 9, 1991

TO: PRESIDENT BUSH

FROM: DR. I. S. TUBA PH.D.
EXECUTIVE DIRECTOR
INTERNATIONAL TECHNOLOGY INSTITUTE
7125 SALTSBURG ROAD
PITTSBURGH PA 15235

SUBJECT: REQUESTS THAT THE PRESIDENT INITIATE
LEGISLATION WHICH WOULD ADOPT THE HOFEST
SYSTEM NATIONWIDE IN THE U.S.

PROMPT ACTION IS ESSENTIAL -- IF REQUIRED ACTION HAS NOT BEEN
TAKEN WITHIN 9 WORKING DAYS OF RECEIPT, PLEASE TELEPHONE THE
UNDERSIGNED AT 456-7486.

RETURN CORRESPONDENCE, WORKSHEET AND COPY OF RESPONSE
(OR DRAFT) TO:
AGENCY LIAISON, ROOM 91, THE WHITE HOUSE, 20500

SALLY KELLEY
DIRECTOR OF AGENCY LIAISON
PRESIDENTIAL CORRESPONDENCE

THE WHITE HOUSE
CORRESPONDENCE TRACKING WORKSHEET

INCOMING

DATE RECEIVED: JULY 16, 1991

NAME OF CORRESPONDENT: DR. I. S. TUBA PH.D.

SUBJECT: REQUESTS THAT THE PRESIDENT INITIATE
LEGISLATION WHICH WOULD ADOPT THE HOFEST
SYSTEM NATIONWIDE IN THE U.S.

		ACTION		DISPOSITION	
ROUTE TO:		ACT	DATE	TYPE	C COMPLETED
OFFICE/AGENCY	(STAFF NAME)	CODE	YY/MM/DD	RESP	D YY/MM/DD
OFFICE OF SCIENCE AND TECHNOLOGY POLIC		ORG	91/07/16		/ /
REFERRAL NOTE:			/ /		/ /
REFERRAL NOTE:			/ /		/ /
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REFERRAL NOTE:			/ /		/ /
REFERRAL NOTE:			/ /		/ /

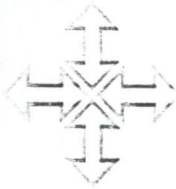
COMMENTS: ENCLOSURES
HOFEST (HALL OF FAME FOR ENGINEERING,
SCIENCE AND TECHNOLOGY)

ADDITIONAL CORRESPONDENTS: MEDIA:L INDIVIDUAL CODES: 4690 4660

MI MAIL USER CODES: (A) (B) (C)

*ACTION CODES:	*DISPOSITION	*OUTGOING	*
*	*	*CORRESPONDENCE:	*
*A-APPROPRIATE ACTION	*A-ANSWERED	*TYPE RESP=INITIALS	*
*C-COMMENT/RECOM	*B-NON-SPEC-REFERRAL	*OF SIGNER	*
*D-DRAFT RESPONSE	*C-COMPLETED	*CODE = A	*
*F-FURNISH FACT SHEET	*S-SUSPENDED	*COMPLETED = DATE OF	*
I-INFO COPY/NO ACT NEC		*OUTGOING	*
*R-DIRECT REPLY W/COPY *			*
*S-FOR-SIGNATURE			*
*X-INTERIM REPLY			*

REFER QUESTIONS AND ROUTING UPDATES TO CENTRAL REFERENCE
(ROOM 75, OEOB) EXT-2590
KEEP THIS WORKSHEET ATTACHED TO THE ORIGINAL INCOMING
LETTER AT ALL TIMES AND SEND COMPLETED RECORD TO RECORDS
MANAGEMENT.



International Technology Institute

7125 Saltsburg Road, Pittsburgh, PA USA 15235-2297
(412) 795-5306 Telex: 4933348

July 9, 1991

The President
The White House
Washington, DC 20500

Dear Mr. President:

Congratulations on the successful "Desert Storm."

I am sure you realize that a great part of winning with the remarkable low casualty rate was made possible only by the contribution of large numbers of engineers, scientists and technologists, who do not get their proper recognition by society at large at this time. During and after Desert Storm the media never made mention of them.

Of course, there exists the National Medal of Science and National Medal of Technology programs which are great to honor the top tip of the iceberg. However, there is a worldwide honor system in place which should be used to reach down and honor the so called "foot soldier heroes" of the technical community.

The Hall of Fame for Engineering, Science and Technology (HOFEST) is an ideal system, all in place, to perform the function. Already, those who are recipients of the National Medal of Technology are the ones who are elected and inducted into the USA National Level of HOFEST.

We are requesting you to initiate legislation or other appropriate government actions, which would adopt the HOFEST system in the USA, nationwide, on all levels.

Of course, engineers, scientists and technologists prefer to be utilized in their principal role of creating the ways and means by which new, real, tangible wealth can be generated for society at a higher rate than it was ever possible before. Furthermore, they are proud of their influential and dominating role in creating the possibilities of higher and higher quality of life for society, through health, education, entertainment and practically all aspects of human activities where real advances are made.

Attached are limited and outdated reference material. However, I volunteer my time to provide more information and ideas for appropriate implementations.

The President

Page 2

Your consideration of the above subject is greatly appreciated. I am awaiting your positive response, or at least an expression of willingness to explore the issues further.

Respectfully,

I. S. Tuba
I. S. Tuba, PhD, PE
Executive Director

IST/rg
Enclosures

Letter to: Honorable James A. Baker
Honorable Dick Cheney
Gen. Colin L. Powell
Gen. N. Norman Schwarzkopf

**HALL OF FAME
FOR
ENGINEERING, SCIENCE AND
TECHNOLOGY**

— HOFEST —

Purposes . . .

HOFEST is a unified, worldwide system with numerous electing units — its purposes being to:

- recognize individuals, and the organizations to which they belong, for their contributions in the fields of engineering, engineering science and technology,
- provide recognition on a broad spectrum — local, national, international, academic, industrial, government, corporate and society,
- provide recognition on a broad scale, applicable to as small a group as a section or department within a corporation, all the way to selecting only one individual per year from the entire world into the World Supreme. There are eight additional levels in between.

International Technology Institute serves as the Secretariat for HOFEST.



HOFEST

is a broad-based

Honorary Organization for Engineers, Scientists, Technologists

and it is also the

Hall of Fame for Engineering, Science and Technology

Invitation

We wish to recognize one or more of your past or present Engineers, Scientists or Technologists as electees into the appropriate levels of (International System of) the **Hall of Fame for Engineering, Science and Technology** during the next International Congress on Technology and Technology Exchange.

Kindly submit your nominations to HOFEST at the address below as soon as possible. Please include a black and white photo and biographical information on each of your nominees, reasons for selection and the number of engineers, scientists and technologists currently employed by your organization.

Although the acceptance of your nominees into HOFEST is **independent** of your financial support, HOFEST's ability to continue to provide dignified and meaningful recognition to electees depends on your financial support of the whole cause.

HOFEST
International Technology Institute
7125 Saltsburg Road
Pittsburgh, PA 15235

Award and Honor Systems and the Hall of Fame for Engineering, Science and Technology

I. Stephen Tuba. *International Technology Institute, Pittsburgh, Pennsylvania*

1.0 INTRODUCTION

Human needs are often displayed in the form of a pyramid with numerous levels. Beginning with the most elemental need — survival — at the base of the pyramid, man ascends to each level successively. When all basic needs are satisfied, he strives to fulfill those near or at the top of the pyramid. One of these is ego satisfaction.

Ego satisfaction is an extremely powerful motivator in all fields of human endeavor. At various times in history, progress of the human race depended more on the activities of one segment of society than on others.

There was a time when farming was the principal occupation of the majority of the population. As a result of the industrial revolution, the proportion was drastically altered. Efforts of factory workers dominated progress and changed most people's lifestyles.

The future of society depends on its ability to produce enough to meet the rising expectations of its members and to provide for future population growth. The increased productivity needed today must be achieved by engineers, scientists, and technologists; therefore, this group must be encouraged to perform.

Our standard of living, even with unemployment and economic difficulties, is higher today than it has been at any time in history. Many people talk about the "quality of life." That, too, is higher than it has ever been before. And who knows, who asks, what made this high standard of living and high quality of life possible? What could it be, if not the work of engineers, scientists and technologists?

1.1 Public Perception

From a visibility point of view, engineers, scientists and technologists are shortchanged. Actors have their Oscars and Emmys. Musicians have their Grammys. Athletes have their gold medals. Here in America, we know sports figures and entertainers. We are tuned in when they appear on TV, and they give us a great deal of pleasure. On the other hand, the computer whizzes lampooned in the late comic strip *Doonesbury*, are bloodless robots. The basis of science fiction is often an experiment gone wrong. And the mad Dr. Strangelove has come to symbolize the dangers of the nuclear age.

Doctors, lawyers, policemen and firemen are frequent subjects of movies and TV programs, and, as a rule, they are treated sympathetically.

But scientists are rarely portrayed; and when they are, they're usually portrayed as being a menace to humanity. Some people object to these unsympathetic portrayals and plan to do something about it.

1.2 Existing Award Systems

The technical community has its own award system. In fact, there are more award systems than organizations, because many organizations have more than one award. What then is the problem? The problem is that most of these award systems are extremely parochial. They are very meaningful to a narrow group of experts in a specialized subject worldwide, or to a small local geographic area. But the world's average citizens are uninformed and, therefore, uninterested in the great accomplishments of their next door neighbors.

1.3 Sampling of Award Systems

To have a better understanding of existing award systems, 50 systems were selected at random for study in Ref. 3. These systems are highly reputable and established by highly reputable organizations. Awards are extremely important to the organizations awarding them and to their recipients.

Award systems not only honor those who receive the honor, but also those for whom the award is named, or by whom the award is granted. These systems should not be tampered with lightly. In many cases, their traditions are deeply rooted.

It would be ideal, however, if a simple system could be superimposed on the countless award systems which would unify them in some way and provide them all with a higher degree of identification and visibility. Each, however, should maintain its own identity and tradition, without interference from anyone else.

Such a system, The Hall of Fame for Engineering, Science and Technology (HOFEST), is described in this study.

This is a reduced version of Ref. 3, presented here for the convenience of the reader.

Ref. 3 presents a survey and analysis of 50 major award and honor systems, which represent an arbitrarily selected list of awards and honors. The selection was made in such a way that major awards, organizations and criteria of selection were included; but an attempt was also made to provide a list of lesser known awards and organizations. The purpose was to illustrate both the major award systems and the great variations that exist in awards and awarding criteria.

A great number of scientific disciplines and fields of technology are represented in the sample of awards in Ref. 3.

Awarding organizations are generally professional societies in particular fields of science, engineering, technology and management. These societies make up one or several awards on the basis of specific award criteria. In some cases, awards are cosponsored by corporations or foundations with a special interest in an individual award.

2.0 HALL OF FAME FOR ENGINEERING SCIENCE AND TECHNOLOGY (HOFEST)

This paper contains the summary for the unified, world-wide system for honoring members of the technical community for their contributions to engineering, engineering science and technology fields.

2.1 Purpose

The purpose of the HOFEST is several fold:

1. To recognize individuals and the organizations to which they belong, for their contributions in the fields of engineering, engineering science, and technology.
2. To provide recognition on a broad spectrum — local, national, international, academic, industrial, governmental, corporate and society.
3. To provide recognition on a broad scale, applicable to as small a group as a section or department within a corporation, all the way to selecting only one individual per year from the entire world and eight additional levels in-between.

2.2 HOFEST Classification

Table I contains the recommended classification criteria for the ten levels of HOFEST. How units are established is discussed below.

2.2.1 Levels 1 through 5

The leadership of any organized group of EST may register

The prominence and size of awarding professional societies show a great deal of variety. In most cases, they are national (U.S. or Canadian) societies in major fields of science and engineering. The engineering societies usually claim large memberships of over 100,000.

The procedures for making awards follow fairly consistent patterns. Most societies maintain awards or honors committees, selection committees or committees for particular awards. These committees administer the award regulations, select candidates and make recommendations to the society board of directors and executives. The awards are bestowed in a public ceremony, usually at annual meetings of societies. The awards and those honored receive extensive publicity both within the society and through the national media. Annual meeting programs list past and present recipients, award criteria and information on the significance of the awards to be made.

with the Secretariat their desire to elect some of their members into the HOFEST. The registration must be accompanied by the following:

- a. A demonstrated evidence for the number of EST in the group.
- b. The method by which the Group intends to nominate up to the allowable number of individuals into the appropriate level of HOFEST.
- c. A yearly fee, established for the particular level, in order to cover the costs of operation of HOFEST.

The Secretariat on the basis of the Policies and Procedures, will review the application and issue a Permit to the Group for the election. In unusual situations, the Secretariat will utilize the guidance of rulings of the Policy Board and the Judiciary Board, or even that of the Board of Governors prior to issuing a permit.

2.2.2 Levels 6 and 7

Any nation or group of nations may apply to the Secretariat for the right to elect some of their citizens into the appropriate levels of HOFEST.

Procedure is similar to that discussed under Section 2.2.1 above.

2.2.3 Levels 8 through 10

To these levels, election is possible only on the world level by the HOFEST World Electorate, which is established according to the Policies and Procedures of HOFEST.

TABLE I		
Level	Electing Unit	Number Electable Per Year
10	The World	Supreme Level
9	The World	Superior Level
8	The World	World Level
		1
		10
		100
7	Any Nation or Group of Nations with 100,000,000 or More Population	1/Ten Million Population
6	Any Nation or Group of Nations with 10,000,000 or More Population	1/Ten Million Population
5	Any Group of 100,000 or More EST People	5/unit
4	Any Group of 10,000 or More EST People	4/unit
3	Any Group of 1,000 or More EST People	3/unit
2	Any Group of 100 or More EST People	2/unit
1	Any Group of 10 or More EST People	1/unit

2.3 Existing Award Systems

Many organizations have award systems which were established many years ago. Naturally, these award systems will not be affected by HOFEST. Each award, however, may receive a HOFEST Level Classification as appropriate. The organization making the award may request a Classification from the Secretariat by filing the required information.

2.4 HOFEST Facilities

Initially HOFEST will be an institution, existing in the minds and records of the technical community and of society. Awards will be displayed at the awardees' place of employment and at some regionally appropriate major institutions.

After HOFEST is conceptually accepted, a Foundation will be established for the purpose of collecting funds so that eventually a suitably distinguished World Hall can be constructed. In due time, regional Halls could be established as well. These Halls would contain material properly recording the accomplishments of awardees at or above a given level of classification.

2.5 Government

The Government of HOFEST is ultimately in the hands of the world's technical community, irrespective of political, economic, or any other boundaries. For administrative purposes, however, a HOFEST Government Network is required.

2.5.1 Board of Governors

A Board of Governors will have the highest level of authority in administrative matters of HOFEST.

2.5.2 Policy Board

The Policy Board is responsible for establishing Global Policies which control the operation of HOFEST. The Policy Board reports to the Board of Governors.

2.5.3 Secretariat

An international organization should act as the world secretariat for the HOFEST. Currently it is International Technology Institute.

2.5.4 Judiciary Board

The Judiciary Board will decide, when needed, whether HOFEST is operating within its Constitution.

2.6 Examples

2.6.1 The Mechanics Department of Designs, Inc. has 120 engineers. They may elect two (2) engineers per year to Level 2 of HOFEST.

2.6.2 The entire corporation of Designs, Inc. has 1,500 EST people. They can elect a maximum of three (3) of their people to Level 3 of HOFEST, some of whom may be from their Mechanics Department.

2.6.3, ASME has over 100,000 Mechanical Engineers as members. They may elect up to five (5) of these to level 5 of HOFEST per year. Some of these may come from the Mechanics Department of Designs, Inc..

2.6.4 The USA has 224,000,000 population, so it can elect up to 22 of their citizens to Level 7. Some of these may be members of ASME.

2.6.5 The World Electorate can elect one (1) person per year to Level 10 of HOFEST. That person may be one of the engineers from the Mechanics Department of Designs, Inc., who is also a USA citizen, Member of ASME, and, of course, is employed by Designs, Inc.. With this election,

the Department, Corporation, Technical Society, and the Country are all honored.

2.6.6 Organizations can display in their promotional material the number of HOFEST people they have at different levels.

For example, General Robotics Corporation may have the following HOFEST members on their staff:

1 Level 7
1 Level 5
3 Level 2
10 Level 1

3.0 RECOMMENDED PROCEDURES FOR HOFEST

Application for a Permit to establish an Electing Unit should be submitted to the HOFEST Secretariat, International Technology Institute, on official letterhead of the applicant. The application should contain the following information:

1. Name of Unit.
2. Principal Location of Unit.
3. Type of Unit, i.e., Local Section of a Technical Society, Corporation, State, University, etc.

4. Number of Engineers, Scientists and Technologists (EST's) as of a given date.
5. Who will act as Secretariat for the Unit, i.e., for local arrangements and for contact with HOFEST Secretariat.
6. Year to be covered.
7. Short description of the procedure to be used by the Unit for its selection. An application fee must be included, according to the appropriate schedule. The permit will be issued shortly after the accuracy of the submitted form is confirmed by the HOFEST Secretariat.

* * * * *

HALL OF FAME FOR ENGINEERING, SCIENCE AND TECHNOLOGY Recommended Permit Fee Schedule for Electing Units

Level	Minimum Number of EST's	Number Electable	Fee/EST *
1	10	1/10	\$0.50
2	100	2/100	\$0.40
3	1,000	3/1,000	\$0.30
4	10,000	4/10,000	\$0.20
5	100,000	5/100,000	\$0.10
Minimum Population			Fee/Population
6	10 Million	1/10 Million	\$0.001
7	100 Million	1/10 Million	\$0.001
8	World	100	N.A.
9	World	10	N.A.
10	World	1	N.A.

* The maximum fee for each level will not exceed the minimum fee for the subsequent level.

Permit fees are used to help defray administrative and record keeping expenses. The funds will also be used, if available, for further promotion of HOFEST. It is hoped that eventually enough funds will be collected for the construction of an actual facility to house an international HALL OF FAME for Engineering, Science and Technology.

Permit for Election
into the
HALL OF FAME
for
Engineering, Science and Technology

Issued to Electing Unit _____

With Principal Location at _____

Type of Unit _____

Number of EST's _____ As of (Date) _____

Secretariat for Unit _____

Electable to Level _____ Number _____

For the Year _____

The application and related documentation are filed by the
HOFEST Secretariat under No. _____

Permit Granted By
HOFEST Secretariat

By _____ Date _____

4.0 CONCLUSIONS

There are many award and honor systems in existence. These work very well within certain professional groups but fail to promote globally the engineering, science and technology professions to the society as a whole.

By superimposing a unified worldwide system for honoring members of the technical community for their contributions to engineering, science and technology, such as the HOFEST system, on existing systems, major advances are possible:

This paper was first presented and discussed during the International Congress on Technology and Technology Exchange, which was held in Pittsburgh, Pennsylvania, on May 3 to 6, 1982. Since that time the paper has also been presented at major international conferences in San Francisco, California and Berlin, West Germany, and numerous other locations. It is now considered a reality, which will be implemented. Written comments are welcome.

- (1) Engineers, scientists and technologists will be encouraged to achieve the best they can. This will help the whole world population in achieving a higher standard of living.
- (2) EST's will strive to reach higher and higher levels, which means they will want to become members of various technical societies. This will help the technical societies to attract new members.
- (3) When more and more organizations and individuals refer to the same system, awareness of the general population to accomplishments and importance of the profession will rise.
- (4) Mass ceremonies and banquets will be possible by regional groups to honor their electees, similar to the "Dapper Dan Banquets" for sports fans.
- (5) When awards are made at the higher levels, such as national or world levels, media coverage can be very helpful. It can become a matter of national or international interest, like the question of who will win the most gold medals in the Olympics. People will be concerned: Will that one person elected into the level 10 be an American? What if he or she is not?

5.0 ACKNOWLEDGEMENT

In 1982, at the time of the first publication of the HOFEST concept, the Rockwell Foundation — the Rockwell family's private charitable trust — has awarded a total of \$50,000.00, i.e., \$10,000 per year for five years, to International Technology Institute so it can act as the promoter and Secretariat of the HOFEST movement.

REFERENCES

- (1) I. S. Tuba, Hall of Fame for Engineering, Science and Technology, Paper No. HOF-1.0, presented at the International Congress on Technology and Technology Exchange, May 3-6, 1982, Pittsburgh, PA.
- (2) Publications of organizations listed in Section 6 in the 1981-1983 period.
- (3) I. S. Tuba and P. Body, Award and Honor Systems and the Hall of Fame for Engineering, Science and Technology. Proceedings 1984 International Congress on Technology and Technology Exchange, pp. 259-268.

An alternate view of HOFEST . . .

You may think about HOFEST as a collection of giant to small bulletin boards, distributed around the world, on which all organizations (electing units) may display the awards they bestow on their members, according to their own rules, allowing others to display their own also.

No organization is told how to run their own business — or how to select their heroes.

HOFEST provides a unified system by which others, outside of the particular organization, may recognize and appreciate the achievements of those they do not normally associate with.

In that respect, the entire EST community should join forces to promote itself to the general public. Public perception of Engineering, Science and Technology should be influenced by this movement.

HALL OF FAME FOR ENGINEERING, SCIENCE AND TECHNOLOGY

NAME/ORGANIZATION/EXPERTISE	COUNTRY	ELECTED	INDUCTED
WORLD SUPREME LEVEL — Posthumous Only			
Leonardo daVinci (1452-1519)	Italy	1989	1989
Sir Isaac Newton (1642-1727)	England	1989	1989
Albert Einstein (1879-1955)	Germany & USA	1990	1990
WORLD SUPERIOR LEVEL — Posthumous Only			
George Eastman (1854-1932) Eastman Kodak Co.	USA	1988	1988
Chester Carlson (1906-1968) Xerox Process	USA	1988	1988
George Westinghouse (1846-1914) Westinghouse Electric Corp./Air Brake Co.	USA	1989	1989
Alexandre Gustave Eiffel (1832-1923) Civil and Aeronautic Engineer	France	1989	1989
Thomas Alva Edison (1847-1931) Inventor	USA	1990	1990
Henry Ford (1863-1947) USA Automobile Manufacturer	USA	1990	1990
WORLD LEVEL			
Willard F. Rockwell, Jr. Astrotech International Corp.	USA	1982	1982
Dr. Allen E. Puckett Hughes Aircraft Corp.	USA	1984	1984
Dr. Hans List List Institute of Technology	Austria	1984	1984
Dr. Robert C. Seamans, Jr. Aerospace Corp. Massachusetts Institute of Technology	USA	1985	1985
Dr. Janos Prohászka Technical University of Budapest	Hungary	1986	1986
Dr. Luis W. Alvarez University of California	USA	1986	1986
Dr. Genichi Taguchi American Supplier Institute, Inc.	Japan	1986	1986
Dr. Chauncey Starr Electric Power Research Institute	USA	1988	1988
Dr. James C. Fletcher National Aeronautics and Space Administration	USA	1988	1988
Dr. John K. Hulm Westinghouse Electric Corp.	USA	1988	1988
Dr. Ralph E. Gomory IBM Corporation	USA	1988	1988
Joseph P. Sweeney AMP Incorporated	USA	1988	1988
Dr. Roald Z. Sagdeev Soviet Academy of Sciences	USSR	1988	1989
Dr. Robert Klapisch CERN/European Research Laboratory	France	1989	1989
Dr. Hsue-Shen Tsien (Hsueh-Shen Chien) Technical Leader in Rocket and Space Program	PRC	1989	1989
Dr. Edward Teller Lawrence Livermore National Laboratories Hoover Institution/Stanford University	USA	1989	1989
Dr. Richard M. Cyert Carnegie Mellon University	USA	1990	1990

USA NATIONAL LEVEL

(NMT - National Medal of Technology Recipient)
(NEP - Normal Election Procedure)

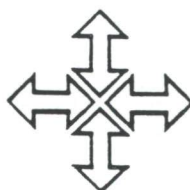
NAME/ORGANIZATION/EXPERTISE	COUNTRY	ELECTED	INDUCTED
Dr. D. Bruce Merrifield U.S. Department of Commerce	NEP	1988	1988
Dr. Paul M. Pan Westinghouse Electric Corp.	NEP	1988	
Dr. Robert K. Grasselli The Standard Oil Co.-BP America	NEP	1988	1988
Joseph P. Sweeney AMP Incorporated	NEP	1988	1988
Dr. George B. Cvijanovich AMP Incorporated	NEP	1988	1988
Richard T. Begley Westinghouse Power Systems Co.	NEP	1988	1988
Raymond Damadian FONAR Corp.	NMT	1988	1988
Dr. Sheldon Weinig Materials Research Corp.	NEP	1990	1990
Clarence Johnson Lockheed Corp.	NMT	1988	1988
Paul C. Lauterbur University of Illinois	NMT	1988	1989
Herbert W. Boyer University of California/SF	NMT	1989	
Stanley H. Cohen Stanford University Medical Center	NMT	1989	
Helen Edwards	NMT	1989	
Richard A. Lundy	NMT	1989	
J. Richie Orr	NMT	1989	
Alvin Tollestrup Fermi National Accelerator Laboratory	NMT	1989	
Robert R. Everett	NMT	1989	
Jay W. Forrester The MITRE Corp.	NMT	1989	
John L. Atwood Rockwell International	NMT	1988	
Arnold C. Beckman Beckman Industries	NMT	1988	
Paul M. Cook Raychem Corp.	NMT	1988	
Robert H. Dennard IBM Corporation	NMT	1988	
Harold G. Edgerton EG&G Corporation	NMT	1988	
Edwin H. Land Polaroid Corp.	NMT	1988	
David Packard Packard Co.	NMT	1988	
Joseph V. Charyk Communications Satellite Corp.	NMT	1987	
W. Edward Deming Private Consultant	NMT	1987	
John E. Franz Monsanto Corp.	NMT	1987	
Robert N. Noyce Intel Corp.	NMT	1987	
Bernard Gordon Analogic Corp.	NMT	1986	
Reynold B. Johnson IBM Corporation	NMT	1986	
William C. Norris Control Data Corp.	NMT	1986	
Frank N. Piasecki Piasecki Aircraft Corp.	NMT	1986	
Stanley D. Stookey Corning Glass Works	NMT	1986	
Francis VerSnyder United Technologies Corp.	NMT	1986	
AT&T Bell Telephone Laboratories, Inc. Ian M. Ross, President	NMT	1985	
Frederick P. Brooks, Jr.	NMT	1985	
Erich Block	NMT	1985	
Bob O. Evans IBM Corporation	NMT	1985	
Steven P. Jobs	NMT	1985	
Stephen Wozniak Apple Computer, Inc.	NMT	1985	

NAME/ORGANIZATION/EXPERTISE	COUNTRY	ELECTED	INDUCTED
Marvin M. Johnson Phillips Petroleum Co.	NMT	1985	
Ralph Landau Halcon-Scientific Design Group	NMT		
Ralph T. Parson	NMT	1985	
Frank L. Stulen John T. Parsons Co.	NMT	1985	
Harold A. Rosen	NMT	1985	
Allen E. Puckett Hughes Aircraft Co.	NMT	1985	
Joseph P. Sutter Boeing Commercial Airplane Co.	NMT	1985	
NIGERIA NATIONAL LEVEL			
Dr. Gabriel A. Makanjuola Federal Secretariat	NEP	1988	
Dr. Ifedayo O. Oladapo Ondo State University	NEP	1988	
Dr. Philip A. Kuale University of Benin	NEP	1988	
CENTRAL EUROPEAN			
Dr. Erno Pungor Technical University of Budapest	Hungary	1990	1990
CONNECTICUT STATE LEVEL			
Dr. Joseph A. Fisher Multiflow Computer, Inc.	NEP	1989	1989
UTAH STATE LEVEL			
Dr. Sy-Hwe Chen Norton Christensen, Inc.	NEP	1988	1988
PENNSYLVANIA STATE LEVEL			
Dr. Emil W. Deeg AMP Incorporated	NEP	1988	1988
Stanley G. Shaffer Duquesne Light Co.	NEP	1989	1989
Central Pennsylvania			
Dimitry G. Grabbe AMP Incorporated	NEP	1988	1988
Dr. Howard R. Peiffer AMP Incorporated	NEP	1988	1988
Western Pennsylvania			
William A. Conwell Duquesne Light Co.	NEP	1988	1988
MIDDLE EAST LEVEL			
Dr. David Salzmänn Soreq Nuclear Research Center	Israel	1989	1989
MONTANA STATE LEVEL			
Dr. Stewart Way Westinghouse Electric Corp.	NEP	1989	1989
HUNGARIAN NATIONAL LEVEL			
Prof. Dr. Lajos Fodor Technical University of Budapest	NEP	1989	1989
Prof. Dr. Sandor Gal Technical University of Budapest	NEP	1989	1989
Dr. Tibor Konkoly Technical University of Budapest	NEP	1990	1990
DISCIPLINARY			
Niel-Kanth J. Shen-d'ge SDG Enterprises, Inc. Solar Energy for India	India & USA	1990	1990
S. Pal Asija Synergy Consultants Computer Software Protection	India & USA	1990 1990	1990 1990
M. Fernand Roger Les Dessins Drummond Inc. Canadian Technicians & Technologists	Canada	1990	1990
Dr. Vladimir Dvorkovitz Dr. Dvorkovitz & Associates Technology Transfer	Poland & USA	1990	1990
ITI INTER-DISCIPLINARY			
Dr. Edward G. Fischer Westinghouse Electric Corp.	USA	1989	1989

*... for excellence
in technology*

The
**WILLARD F. ROCKWELL, Jr.
MEDAL**

Awarded by
International Technology Institute



The WILLARD F. ROCKWELL, JR. Medal

Established in 1982 by International Technology Institute, the Willard F. Rockwell, Jr. Medal is ITI's highest award. The medal is named in honor of its first recipient, Willard F. Rockwell, Jr., chairman of the board and chief executive officer of Astrotech International Corporation, which is headquartered in Pittsburgh, Pa. Mr. Rockwell is former chairman of the board of Rockwell International.

The medal is awarded to a maximum of three individuals each year . . . for excellence in technology. In particular, it recognizes the recipient's contributions toward the generation, transfer and application of technology for the betterment of mankind.

Recipients of the award must be persons of extremely high stature in the international technology community, electable to the World Level of the Hall of Fame for Engineering, Science and Technology which is the highest level into which any living person can be elected.

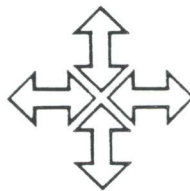
Nominations are invited from anywhere in the world. Recipients of the medal need not be members of International Technology Institute. However, all awardees will automatically become Honorary Members of ITI.

Naturally, others can be elected into the World Level of HOFEST along with the Rockwell Medal Recipients.



RECIPIENTS TO DATE

1982	Willard F. Rockwell, Jr.	USA
1984	Allen E. Puckett	USA
1984	Hans List	Austria
1985	Robert C. Seamans, Jr.	USA
1986	Janos Prohaszka	Hungary
1986	Luis W. Alvarez	USA
1986	Genichi Taguchi	Japan
1988	James C. Fletcher	USA
1988	Chauncey Starr	USA
1988	Roal'd Z. Sagdeev	USSR
1989	Edward Teller	USA
1989	Hsue-Shen Tsien	PRC
1989	Robert Klapisch	France
1990	Richard M. Cyert	USA





Willard F. Rockwell, Jr. USA

Presented May 5, 1982

1982 International Congress on
Technology and Technology Exchange
Pittsburgh, Pennsylvania

Willard F. Rockwell, Jr. is chairman of the board and chief executive officer of Astrotech International Corporation. He led its transformation from an investment company, then known as Cyprus, to an operating company, now known as Astrotech, with a number of subsidiaries.

Rockwell retired as chairman of the board of Rockwell International in 1979 after having held that position for 11 years. He remained on the board of directors of the firm until July 1984.

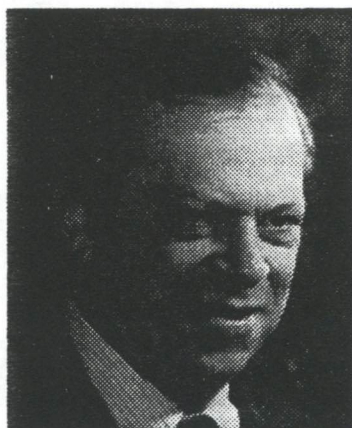
Following the 1967 merger of Rockwell Standard Corporation and North American Aviation, he was elected chairman of North American Rockwell Corporation, which became known as Rockwell International in 1973. He served as president of Rockwell Manufacturing Company from 1947 to 1964, vice chairman and chief executive officer from 1964 to 1971, and was named chairman in 1971. Rockwell Manufacturing merged into Rockwell International in 1973.

Rockwell was born on March 3, 1914 in Boston, Massachusetts. A registered professional engineer in Pennsylvania and California, he received a bachelor's degree in industrial engineering from Pennsylvania State University in 1935, where he also earned the technical degree of industrial engineer in 1955.

First employed by Pittsburgh Equitable Meter Company, he joined Timken Detroit Axle Company in 1936. He returned to Pittsburgh Equitable Meter in 1938, became vice president and controller and was elected a director in 1940. The firm's name was changed to Rockwell Manufacturing Company in 1945. During World War II Rockwell served as a captain in the U.S. Army. From 1945 until 1947, he served as vice president and general manager of Rockwell Manufacturing when he was elected president.

Rockwell is author of numerous articles on management subjects including the book *The Twelve Hats of a Company President*. He is a member of a half dozen professional societies, and he has served on the board of a number of professional and civic organizations. He is the recipient of five honorary degrees.

Rockwell has received numerous awards, including the AAS Lloyd V. Berker Award, AMA/ASME Henry Lawrence Gant Medal, PSPE Distinguished Service Award, World Trade Association Award, Pittsburgh Jaycees Man of the Year in Business and Man of the Year.



Allen E. Puckett USA

Presented October 9, 1984

1984 International Congress on
Technology and Technology Exchange
Pittsburgh, Pennsylvania

Dr. Allen E. Puckett, chairman of the board and chief executive officer of Hughes Aircraft Company, has been in key management positions with the company for more than three decades. Today, Puckett holds a position of national prominence in the aerospace industry.

He joined Hughes in 1949, where he served as president from March 1977 until November 1978 when he was named chairman. Over the years he progressed through various management positions in Hughes' guided missile, research and development, weapons systems development, and systems development laboratories. He held senior management positions in the aerospace engineering division and aerospace group prior to being named president.

Puckett was born on July 25, 1919 in Springfield, Ohio. In 1939 he received a bachelor's degree, and in 1941 a master's degree from Harvard University. In 1949 he received a doctorate degree from the California Institute of Technology.

He has authored numerous technical papers on high-speed aerodynamics; he co-authored *Introduction to Aerodynamics of a Compressible Fluid* and was co-editor of *Guided Missile Engineering*.

Puckett has served on numerous advisory boards concerned with the role of science in the nation's defense and space efforts and with the management of high technology industry in today's society. These include the Army Scientific Advisory Panel, Defense Science Board, Army Ballistic Research Laboratories Scientific Advisory Committee, Naval Aviation Industrial Council, and NASA's Subcommittee on Automatic Stabilization and Control, Committee on Aerodynamics and Space Program Advisory Council.

He has held leadership positions in numerous technical societies and is a member of the board of more than a dozen corporations, educational institutions and non-profit organizations.

Among the honors presented to him are the AIAA Lawrence Sperry Award, ASA Lloyd V. Berkner Award, California Manufacturer of the Year, Aerospace and Electronics Industries Humanitarian Award, IEEE Frederik Philips Award, Polytechnic Institute of New York Award for Creative Technology, Los Angeles C of C Kitty Hawk Memorial Award, and Britain's Institution Production Engineers 1983 International Award, and EIA Medal of Honor.



Hans List Austria

Presented September 4, 1984

15th International Conference of
Bus and Coach Experts
Budapest, Hungary

Dr. Hans List is founder of the List Institute of Technology in Graz, Austria which specializes in the development of diesel engines. He is a principal in Chicago-based AVL of North America, consultants to engine manufacturers in the United States and around the world.

He was born in Graz, Austria on April 30, 1896, where he received his technical education at the Graz University of Technology. In 1922 he received the title of Diplom-Ingenieur and in 1924 attained the degree of Doctor of Technical Science. He worked at the University and at the Grazer Waggonfabrik AG in Graz.

In 1926 he assumed the position of lecturer in thermal engines at the State University of Tungchi in China, where he specialized in internal combustion engines and was responsible for the engineering laboratory and thermal power station.

In 1932 he assumed the Chair of Thermodynamics and Internal Combustion Engines at the Graz University of Technology, where he succeeded Professor Dr. J. Magg. Under his supervision a number of works were produced on research in the area of two-stroke engines, injection processes in diesel engines and gas generators.

In 1941 List succeeded Dr. A. Nagel, the old master of German diesel engine research at the Technical University of Dresden. Under his leadership, the Research Institute grew considerable, and new methods of systematic engine development were established.

After the war, List returned to Graz and in 1948 opened an engineering office for the development of diesel engines. This later became the institute that is named for him.

List has written many significant works, including one on gas generators. He persuaded the Vienna publishers, Springer Verlag, to publish a 13 volume comprehensive reference series, *Die Verbrennungskraftmaschine*, which List wrote or coauthored with others.

His memberships include the Austrian Academy of Sciences; the German Engineers Association; Society of Automotive Engineers, USA; Institute of Mechanical Engineers, Great Britain; and the Societe des Ingenieurs de l'automobile, France. List has been honored with 18 prizes and awards, primarily from Austria and Europe.



Robert C. Seamans, Jr. USA

Presented June 25, 1985

10th Annual Meeting & Symposium
Technology Transfer Society
San Francisco, California

Dr. Robert C. Seamans is chairman of the board of trustees of Aerospace Corporation, a non-profit research corporation specializing in space systems and related technologies. He is also senior lecturer, department of aeronautics and astronautics, Massachusetts Institute of Technology.

He served as Henry R. Luce Professor of Environment and Public Policy at MIT from July 1977 until his retirement in July 1984, at which time he assumed his present position. He served as dean of engineering from July 1978 until September 1981.

Seamans was born in Salem, Mass., on October 30, 1918. He received a bachelor's degree from Harvard University in 1940, and a master's degree in 1942, and a doctorate degree in 1951, both from MIT.

In December 1974 he became first administrator of the Energy Research and Development Administration, after serving as president of the National Academy of Engineering since May 1973. From February 1969 until 1973 Seamans was secretary of the Air Force. From September 1960 until December 1965 he served as associate administrator of the National Aeronautics and Space Administration, then as deputy administrator until 1968.

From 1941 to 1955 Seamans held teaching and research positions at MIT where he worked on aeronautical developments for instrumentation and control of airplanes and missiles. He joined Radio Corporation of America in 1955, and in 1958 became chief engineer of their missile electronics and control division, a position he held until he joined NASA in September 1960. After more than seven years at NASA, he returned to MIT in January 1968.

In addition to Aerospace Corp. Seamans serves on 10 boards. He is a member of more than a dozen professional organizations, and he holds honorary degrees from 10 colleges and universities.

He has received numerous awards including the AIAA Lawrence Sperry Award, ASME Ralph Coats Roe Medal, Robert H. Goddard Memorial Trophy, NASA Distinguished Service Medal, General Thomas D. White USAF Space Trophy, USAF Space Trophy, USAF Academy Thomas D. White National Defense Award, the Aero Club of New England Godfrey L. Cabot Award, DOD Distinguished Public Service Medal, NSPE Achievement Award, Naval Ordnance Development Award, and the USAF Exceptional Civilian Service Award.



Janos Prohaszka Hungary

Presented August 4, 1986

Magyar Forum
Budapest, Hungary

Dr. Janos Prohaszka is a professor and director of the Institute of Mechanical Technology and Materials Science, Technical University of Budapest, a position he has held since 1977. He had served as deputy director since 1972, when the Institute was first established.

He was born in Budapest, Hungary in 1920. In 1950 he earned a diploma in mechanical engineering at the Technical University of Budapest, where he then taught fundamental subjects in mechanical engineering, mechanics and mathematics.

In 1953 he investigated the heat treatment of steels in the Institute for Ferrous Research, together with Laszlo Gillemot. He earned a doctorate degree as a result of his paper, "Action of Ti on Carbon Diffusion and on Steel Carburization," in 1956.

From 1957 Prohaszka conducted research in plastic deformation and heat treatment technology of tungsten in the Research Institute for Technical Physics, affiliated with the Tungfram Electric Bulb Factory and supervised by the Hungarian Academy of Sciences.

In 1964 he joined the department of materials science in electrical engineering, and in 1976 was appointed head of the department. In 1972 the department joined the department of mechanical technology of the faculty of mechanical engineering to form an Institute. He served as deputy director until 1977 when he was named director.

Prohaszka's activities in the field of science and technology have been acknowledged both by the Hungarian government and by the Hungarian Academy of Sciences. He has received numerous government decorations and was awarded a prize by the Hungarian Academy of Sciences in 1982. He was elected a corresponding member of the Academy in 1969 and a regular member in 1982.

He was elected a member of the presidency of the Hungarian Academy of Sciences twice for eight years. He has held leadership positions in several professional organizations, such as the theoretical technological committee of the Hungarian Academy of Sciences, for nine years. Currently he is co-president of the academic committee for materials science and technology and head of the professional group for mechanical engineering and metallurgical sciences. He is head of the technological committee of the Scientific Society of Mechanical Engineers of METESZ.



Luis W. Alvarez USA

Presented October 7, 1986

1986 International Congress on
Technology and Technology Exchange
Pittsburgh, Pennsylvania

Dr. Luis W. Alvarez is professor of physics, emeritus, at the Radiation Laboratory of the University of California at Berkeley, where he has worked since 1936. He is also senior research physicist at Lawrence Berkley Laboratory in California.

He was born in San Francisco, California on June 13, 1911. He attended the University of Chicago from 1928 to 1936, where he received his undergraduate and graduate degrees.

Alvarez joined the Radiation Laboratory of the University of California in 1936. From 1940 to 1943, he was on leave at the Radiation Laboratory of the Massachusetts Institute of Technology. Then he worked at the Metallurgical Laboratory of the University of Chicago from 1943 to 1944, and at the Los Alamos Laboratory of the Manhattan District from 1944 to 1945.

Early in his scientific career, Dr. Alvarez worked concurrently in the fields of optics and cosmic rays. He is credited with many discoveries including: co-discoverer of East-West effect in cosmic rays; radioactivity of tritium — a source of thermonuclear energy; helium 3, K-electron capture by nuclei, measured neutron magnetic moment; radar systems (blind landing system); muon catalysis of nuclear fission; proton linear accelerator; strange baryon and meson resonant states; neutron time of flight spectrometer; charge exchange accelerator; hydrogen bubble chambers; bubble chamber film measuring systems; variable focus thin lens; and stabilizing image in hand-held cameras and viewing devices.

Alvarez is the recipient of six honorary degrees. In addition, he was a member of the President's Science Advisory Committee from 1972 to 1973. He was also associate director at large at Lawrence Berkeley Laboratory from 1954 to 1959 and 1975 to 1978. He has been a director of Hewlett-Packard Company and also board chairman of Optical Research and Development since 1960.

He is a member of a number of professional societies and is the recipient of numerous scientific awards. Some of the most notable are the Collier Trophy, California Scientist of the Year, John Scott Medal and Prize, Pioneer Award of AIEEE, Einstein Medal, National Medal of Science, Michelson Award, Nobel Prize in Physics, National Inventors Hall of Fame, University of Chicago Alumni Medal and the Wright Prize.



Genichi Taguchi **Japan**

Presented October 7, 1986

1986 International Congress on
Technology and Technology Exchange
Pittsburgh, Pennsylvania

Dr. Genichi Taguchi is executive director of the American Supplier Institute, Inc. in Dearborn, Michigan, the sole training center for the Taguchi Methods in the United States. He is also director of the Japan Industrial Technology Institute and an independent consultant.

He was born in Japan in 1924. He graduated from Kiryu Technical College and received his doctorate in science from Kyushu University. Taguchi is honorary professor at Nanjing Institute of Technology in the People's Republic of China.

Taguchi joined the Electrical Communications Laboratory of Nippon Telephone and Telegraph Company in 1949 and worked there until 1961 to improve the productivity of research and development activities. Methods he developed for designing experiments, and the resultant commercial benefits, earned him the prestigious Deming Prize in 1960 for his individual contribution to Quality.

In 1962 he came to the United States and was a research associate at Princeton University. He returned to Japan and was a professor at Aoyama Gakuin University in Tokyo until 1982, during which time he trained thousands of engineers in industry while serving as a consultant to major Japanese corporations.

Taguchi's major contribution has involved combining engineering and statistical methods to achieve rapid improvements in costs and quality by optimizing product design and manufacturing processes. His methods represent one of the major advances in the history of manufacturing industries.

Taguchi's methods were introduced in the United States in 1980 with AT&T Bell Labs, Ford and Xerox as the pioneers. He helped found the American Supplier Institute to facilitate broader dissemination of his methods and ideas, which are now being adopted and implemented by hundreds of U.S. industrial firms.

A member of a number of Japanese associations for quality, statistics or engineering, Taguchi has also been chief editor of the journal, *Quality*, as well as chairman of the quality control research group of the Japanese Standards Association. He has written over 20 books and several hundred papers and articles. In addition to his 1960 Deming Prize for application of quality, he has received three other Deming Prizes for literature on quality.



James C. Fletcher USA
Presented October 19, 1988
1988 International Congress on
Technology and Technology Exchange
Pittsburgh, Pennsylvania

Dr. James C. Fletcher, Administrator of NASA, is the first man to head the nation's civilian space agency on two separate occasions. He was the fourth NASA Administrator from April 1971 to May 1977 and became the seventh head of the agency in May 1986.

Upon leaving NASA in 1977 after his first term as Administrator, Fletcher accepted the William K. Whiteford Professorship of Energy Resources and Technology at the University of Pittsburgh, where he remained until May 1986. During this period, he also was head of his own consulting firm, James C. Fletcher and Associates.

Fletcher began his career in 1940 as a research physicist with the U.S. Navy Bureau of Ordnance. In 1941 he became a special research associate at Cruft Laboratory, Harvard University and, in 1942, was an instructor at Princeton University.

In 1948, Fletcher joined the Hughes Aircraft Company where he served for six years. Later he joined Ramo-Wooldridge Corporation's Guided Missile Research Division, which later became Space Technology Laboratories. In July 1958, with an associate, Fletcher organized and was first president of the Space Electronics Corporation at Glendale, California, which developed and produced the Able Star Stage of the Thor-Able space carrier. After merger with a portion of Aerojet, Fletcher became president and then chairman of the newly formed Space General Corporation. Later he served as Systems Vice President of Aerojet General Corporation. In 1964 he became the eighth president of the University of Utah, a post which he held for seven years.

As a research scientist, Fletcher has developed patents in sonar devices and missile guidance systems. He has been associated with the President's Science Advisory Committee and has served on several Presidential Task Forces and many other government-industry committees.

He is a Fellow of the IEEE, AIAA, AAAS, AAS and was elected to the National Academy of Engineering. He was a recipient of the first Distinguished Alumni Award of the California Institute of Technology and holds honorary doctorates from several colleges and universities.



Chauncey Starr USA

Presented October 19, 1988
1988 International Congress on
Technology and Technology Exchange
Pittsburgh, Pennsylvania

Dr. Chauncey Starr was founding President and Vice Chairman of the Electric Power Research Institute. He is now serving as President Emeritus.

From 1967 to 1973 he served as Dean of the UCLA School of Engineering and Applied Science, following a 20-year industrial career during which he was Vice President of Rockwell International and President of its Atomic International Division.

Dr. Starr received an electrical engineering degree in 1932 and a Ph.D in physics in 1935 from Rensselaer Polytechnic Institute, New York. He then became a research fellow in physics at Harvard, working in the field of high pressures. From 1938 to 1941, Dr. Starr was a research associate in cryogenics at MIT. He has received honorary doctorates from Rensselaer, the Swiss Federal Institute of Technology and Tulane University.

He became associated with the Manhattan District in its early days at the Radiation Laboratory of the University of California, Berkeley, and later at Oak Ridge. Following World War II, while at Rockwell International, he pioneered in the development of nuclear propulsion for rockets and ramjets; in miniaturizing nuclear reactors for space; and in developing atomic power electricity plants. Subsequent activities included energy systems of all types. For his work in the peaceful uses of atomic power he received the Atomic Energy Commission Award in 1974, the Walter H. Zinn Award in 1979 and the Henry D. Smyth Award in 1983. As a pioneer in the field, he received a Distinguished Contribution Award from the Society of Risk Analysis in 1984.

In addition to numerous professional memberships, Dr. Starr is a member and past Vice President of the National Academy of Engineering and a founder and past President of the ANS. He is also a member and past Director of the AAAS, a foreign member of the Royal Swedish Academy of Engineering Sciences and an officer of the French Legion of Honor.

Roal'd Z. Sagdeyev USSR

Presented June 29, 1989

1989 International Congress on
Technology and Technology Exchange
New York, New York

Roal'd Sagdeyev who is a renowned physicist, became a key adviser to the Soviet leadership on space issues while serving as Director of the Space Research Institute (IKI) during 1973-1988.

He created the Analytical Center at IKI, a think tank for problems of international cooperation, security and arms control.

Sagdeyev has been involved in disarmament forums. He is Vice Chairman of the Soviet Committee of Scientists in Defense of Peace and Against the Nuclear Threat, leading his country's delegations to meetings of the joint committee of the U.S. and Soviet Academies of Sciences that deal with disarmament questions. Served as General Secretary Gorbachev's technical expert on SDI issues. A proponent of international cooperation in the space sciences he laid much of the groundwork for the US-USSR Space Cooperation Agreement of the 1987 Summit.

He was born in Moscow of Tatar origin in 1932. Graduated from Moscow State University in 1956, worked in nuclear and plasma physics at the Kurchatov Atomic Energy Institute and then served in Novosibirsk as Deputy Director of the Institute of Nuclear Physics. In 1970, he returned to Moscow and worked at the High Temperatures Institute until becoming IKI Director.

Sagdeyev holds a Doctorate in Physical Mathematical Sciences; became a full Academician at age 35. He holds a Lenin Prize for work on thermonuclear toroidal plasmas. Received two Orders of Lenin — one on his 50th birthday and one for directing a multinational space project that explored Venus and Halley's Comet.

Past member of the Supreme Soviet. Elected on an Academy slate to the Congress of People's Deputies in April 1989. Sagdeyev speaks fluent English and French.



Edward Teller

USA

Presented June 29, 1989

1989 International Congress on
Technology and Technology Exchange
New York, New York

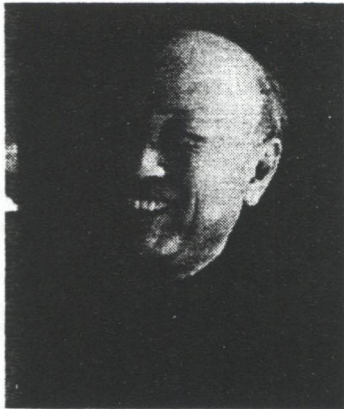
Dr. Teller is best known to the public for his work on the development of nuclear explosives and for his advocacy of a strong defense for America. He is also a noted physicist with more than 100 technical publications, several books, some patents and numerous articles in the popular media.

Born in Budapest in 1908, Dr. Teller worked at the University of Leipzig as a graduate student under Werner Heisenberg and received his Ph.D. in physics in 1930. From 1931 to 1933, he worked at the University of Goettingen with James Frank. With the rise of the Nazis he left Germany, worked in London and in Copenhagen at the Niels Bohr Institute. In 1935, Dr. Teller was appointed Professor of Physics at the George Washington University in Washington, D.C. He became a citizen of the United States in 1941.

Prior to 1939 and the announcement to the scientific community of the discovery of fission, Dr. Teller was engaged as a theoretical physicist working in the fields of quantum, molecular, and nuclear physics. The possibilities of fission, together with the menace of Nazi Germany, led him to work on the Manhattan Project. At an early stage, the possibilities of releasing energy via nuclear fusion became apparent and much of his attention was subsequently devoted to this development.

After World War II he became Professor of Physics at the University of Chicago where he remained until the threat of Soviet technological developments motivated him to return as Assistant Director to Los Alamos Scientific Laboratory. In 1952, at the time of the first test of the hydrogen bomb, Dr. Teller joined the University of California at Berkeley and started work at the newly founded Lawrence Livermore National Laboratory. In 1954 he was Associate Director and from 1958 to 1960, Director. In 1960, he became University Professor of Physics at the University of California while retaining the position of Associate Director at Livermore. He retired from these positions in 1975 and has since held the positions of Director Emeritus at Livermore and Senior Research Fellow at the Hoover Institution.

Dr. Teller has served our nation in many capacities, some of which are: member of the General Advisory Committee of the U.S. Atomic Energy Commission; chairman of the first Nuclear Reactor Safeguard Committee, member of the USAF Scientific Advisory Board; on the President's Foreign Intelligence Advisory Board; and as a board member of the Defense Intelligence School. In 1982 he was appointed a member of the White House Scientific Council and is presently on the National Commission on Superconductivity.



Hsue-Shen Tsien CHINA

Presented June 29, 1989

1989 International Congress on
Technology and Technology Exchange
New York, New York

Dr. Tsien Hsue-Shen is President of the China Association for Science and Technology and from 1982-1987 he served as Vice-Chairman of the Science and Technology Committee - within the Commission of Science, Technology and Industry for National Defense.

He was born in Shanghai, China on December 11, 1911. He graduated from Chiaotung University with a degree in Mechanical Engineering in 1934. He left China the next year to study aeronautical engineering at the Massachusetts Institute of Technology (MIT) where he gained his Masters degree. Afterward, he attended the California Institute of Technology (CIT) and in 1938 obtained his Doctorate in aerodynamics.

Dr. Tsien remained at CIT and became head of the Supersonic Research Lab. During World War II, he served as Director of the Rocket Section in the U.S. National Defense Scientific Advisory Board. In 1946 he was a Professor at MIT and then after a return trip to China became a Professor at CIT in Pasadena. From 1949 until 1955 he served as Director of the Guggenheim Jet Propulsion Laboratory.

Upon returning to his homeland in 1956, he began a second career as President of the Academy of Rocket Research until 1964. Dr. Tsien was Vice-Minister of the Commission of Science and Technology for National Defense, prior to his present government positions.

As a student at CIT he became a favorite of Prof. Theodore von Karman who interested him in jet propulsion and supersonic aircraft design. In his study of rocket design, he introduced the *Tsien Formula* in the development of jet propulsion.

Dr. Tsien has been the technical leader in China's pioneering rocket and space programs. He has made great and path-paving contributions to space technology and to systems science and engineering.

Since his return to the Chinese mainland, he has written numerous articles for publication.



Robert Klapisch FRANCE

Presented June 29, 1989

1989 International Congress on
Technology and Technology Exchange
New York, New York

Dr. Robert Klapisch is a physicist and currently is Adviser to the Director-General at CERN, the European Research Laboratory for Particle Physics based in Geneva, Switzerland. From 1981 to 1987 he held the position of Director of Research.

A French citizen, he was born near Paris on December 26, 1932. He studied in Paris where he graduated, first with a degree in Physics Engineering at the Ecole Supérieure de Physique et Chimie and then a Doctorate at the University of Paris - Orsay in 1966.

Except for a period in 1960-62 when he served in the French Army (Algerian War) and in 1968-69 when he was Research Associate at Princeton University, he has been with the French Center for Scientific Research. He presently holds the rank of Professor (Directeur de Recherche de Classe Exceptionnelle) and has been on special leave of absence since he joined CERN in 1981.

The early part of his scientific career was devoted to developing high-sensitivity mass spectrometers. There followed applications to Astrophysics (the nucleosynthesis of light elements) and to Nuclear Physics. He was a pioneer in combining mass spectrometers and lasers with particle accelerator beams to study short-lived new isotopes. This essentially gave birth to a new and lively branch of Nuclear Physics to which he contributed by co-authoring some 50 scientific publications. In the early 1970's, with his colleagues at Orsay, he developed a high-intensity ion implanter of which an industrial version is still marketed today.

At CERN his interests switched to Particle Physics. He directed both the Fixed Target and Proton-Antiproton Collider research programs and is credited for having launched two novel programs — the Low Energy Antiproton Ring (LEAR) is the only facility in the world devoted to the study of Antimatter; and The Relativistic Heavy Ions beams are a possible way of discovering a new state of matter called the Quark-Gluon Plasma. More than 1,000 research physicists from all parts of the world are active in these programs today.

Klapisch serves on a number of Scientific Advisory Committees in Europe, the United States and Canada.



Richard M. Cyert **USA**

Presented November 8, 1990

1990 International Congress on
Technology and Technology Exchange
Champion, Pennsylvania

Richard M. Cyert, president emeritus of Carnegie Mellon University and president of the Carnegie-Bosch Institute, is internationally recognized for his work in economics, behavioral science and management.

He became Carnegie Mellon University's (CMU) sixth president in July 1972 and retired from this presidency in June 1990 and now heads the Carnegie-Bosch Institute to study and improve international management.

Through his leadership, CMU became financially solvent, strengthened its educational programs and significantly expanded its research and enhanced its reputation as one of the nation's leading educational and research institutions. After three years as President, he was described by the New York Times as "the archetype of the new breed of leaders in American universities... an economist and management theorist."

A director and consultant for numerous businesses, state and federal governments, and nonprofit associations, he was head of a statewide group selected to review Pennsylvania's tax laws and has been honored frequently for his leadership role in the economic revitalization of western Pennsylvania.

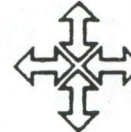
He joined the CMU faculty as an instructor of economics in 1948; rose through the ranks to professor of economics and industrial administration; and appointed dean of the business school in 1962. Under his direction the "management game" for business education was developed and expanded. It is now a model for other schools and used extensively throughout the USA, Europe and Middle East. He was appointed the University's president after 10 years as dean of CMU's Graduate School of Industrial Administration.

Prior to joining Carnegie Mellon, Dr. Cyert was an officer in the U.S. Navy in World War II and an instructor at the University of Minnesota and the City University of New York. He has authored or co-authored 10 books and written more than 100 articles for professional journals in the fields of economics, behavioral science and management.

Dr. Cyert has been a consultant in economics and management science in Belgium, Germany and Australia. He has received honorary doctorates from the University of Gothenburg, Sweden, the University of Leuven, Belgium, and from several colleges in the USA. A Fellow of the Econometric Society, the American Association for the Advancement of Science, and the American Statistical Association, Dr. Cyert has also received a Ford Foundation Research Fellowship and a John Simon Guggenheim Memorial Foundation Fellowship.



Rockwell Medal Recipients
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INTERNATIONAL TECHNOLOGY INSTITUTE

*This Institute is dedicated to the transfer and exchange of technology
across academic, governmental, technical society and industry lines and
across international boundaries. ITI advocates the recognition of technology as a
resource and its utilization for the betterment of the human race and of its members.*



Given this 29th day of June 1989

I. S. Tuba

Executive Director

Anthony Booth

President

International Technology Institute, 7125 Sakaburg Road, Pittsburgh, PA 15235 USA

THE WHITE HOUSE
WASHINGTON

July 26, 1991

Dear Dr. Tuba:

Thank you for your recent letter to President Bush suggesting the adoption of the Hall of Fame for Engineering, Science and Technology (HOFEST) as a national program. As you pointed out, the National Medal of Science and National Medal of Technology programs already honor those who are truly outstanding. In addition, individual Federal agencies have their own awards such as the Department of Energy's Fermi and Lawrence Awards, the National Science Foundation's Waterman Awards, and the Agricultural Research Service's Hall of Fame and Scientists of the Year honors.

In the private sector, the National Academies of Science and Engineering, and the Institute of Medicine give recognition to an even larger number of U.S. and foreign scientists and engineers.

I appreciate your interest in supporting science and technology in this country, but I believe there are enough government and private award programs to give recognition to the most deserving. It is commendable that more private sector organizations are interested in honoring the "foot soldier heroes of the technical community" as you put it, but more action by the Federal government in this regard is not warranted.

Sincerely,

A handwritten signature in black ink, appearing to read "D. Allan Bromley". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

D. Allan Bromley
The Assistant to the President
for
Science and Technology

Dr. I.S. Tuba
Executive Director
International Technology Institute
7125 Saltsburg Road
Pittsburgh, PA 15235

"CORRESPONDENCE TRACKING"

TYPE: PRESIDENTIAL PRIORITY DOCUMENT NUMBER: 9122378
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

FROM: TUBA, I.S.: INTERNATIONAL TECHNOLOGY INSTITUTE

TO: PRESIDENT BUSH

DATE OF
CORRESPONDENCE: 07/18/91

SUBJECT: REQUESTS THAT THE PRESIDENT INITIATE LEGISLATION
WHICH WOULD ADOPT THE HOFEST SYSTEM NATIONWIDE IN
THE U.S.

DIRECTORATE STAFF
ASSIGNED: INDUSTRIAL ASSIGNED:

ACTION STAFF
REQUIRED: FOR DAB'S SIGNATURE ACTION:

SENDER'S DUE
OSTP DUE DATE: 07/22/91
DATE COMPLETED: 7/19

COPIES TO: D. Allan
Damar Ha
INTERNAT

WHITE HOUSE TRACKING #
REMARKS:

*To AD's
Comments please!
See attached a plan to get
done short draft!
DAB*

OSTP RECEIVED: 07/18/91
DEPT RECEIVED:

FILE: ^{EOP} ~~PH-BAC~~-PRESIDENTIAL PRIORITY

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

July 22, 1991

MEMORANDUM FOR ALLAN BROMLEY

FROM:


D.A. HENDERSON

SUBJECT:

INTERNATIONAL TECHNOLOGY INSTITUTE

I have never heard of this outfit. It may be a wholly respectable enterprise but, as I read the information, it sounds like a marvelous mechanism for the care and feeding of Dr. I.S. Tuba (and an opportunity for him to toot his own horn -- pardon the pun).

There are so many schemes now operative to toot collective horns to the greater financial benefit of their sponsors that I have become deeply suspicious. This should not be supported absent a thorough investigation.