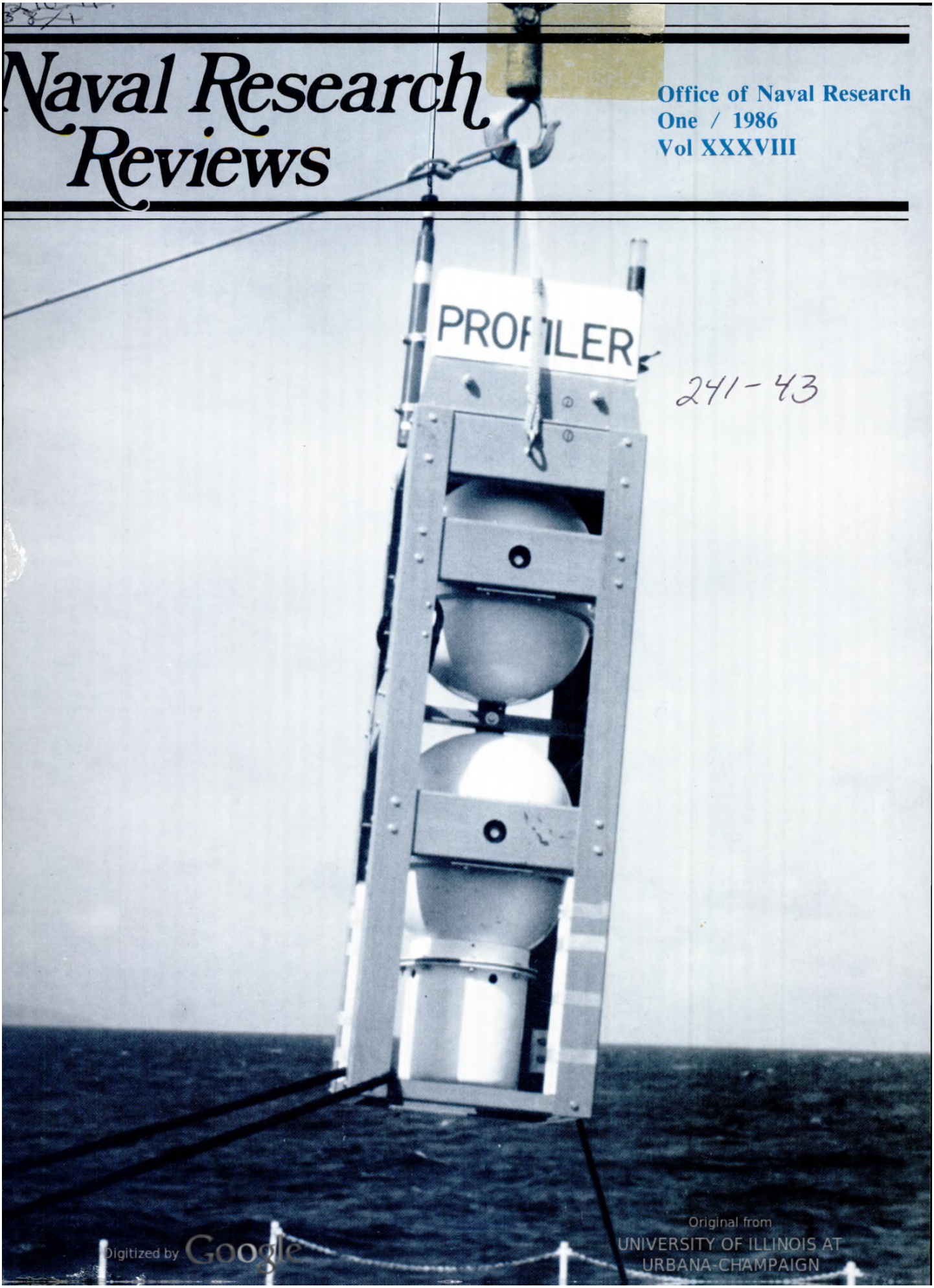
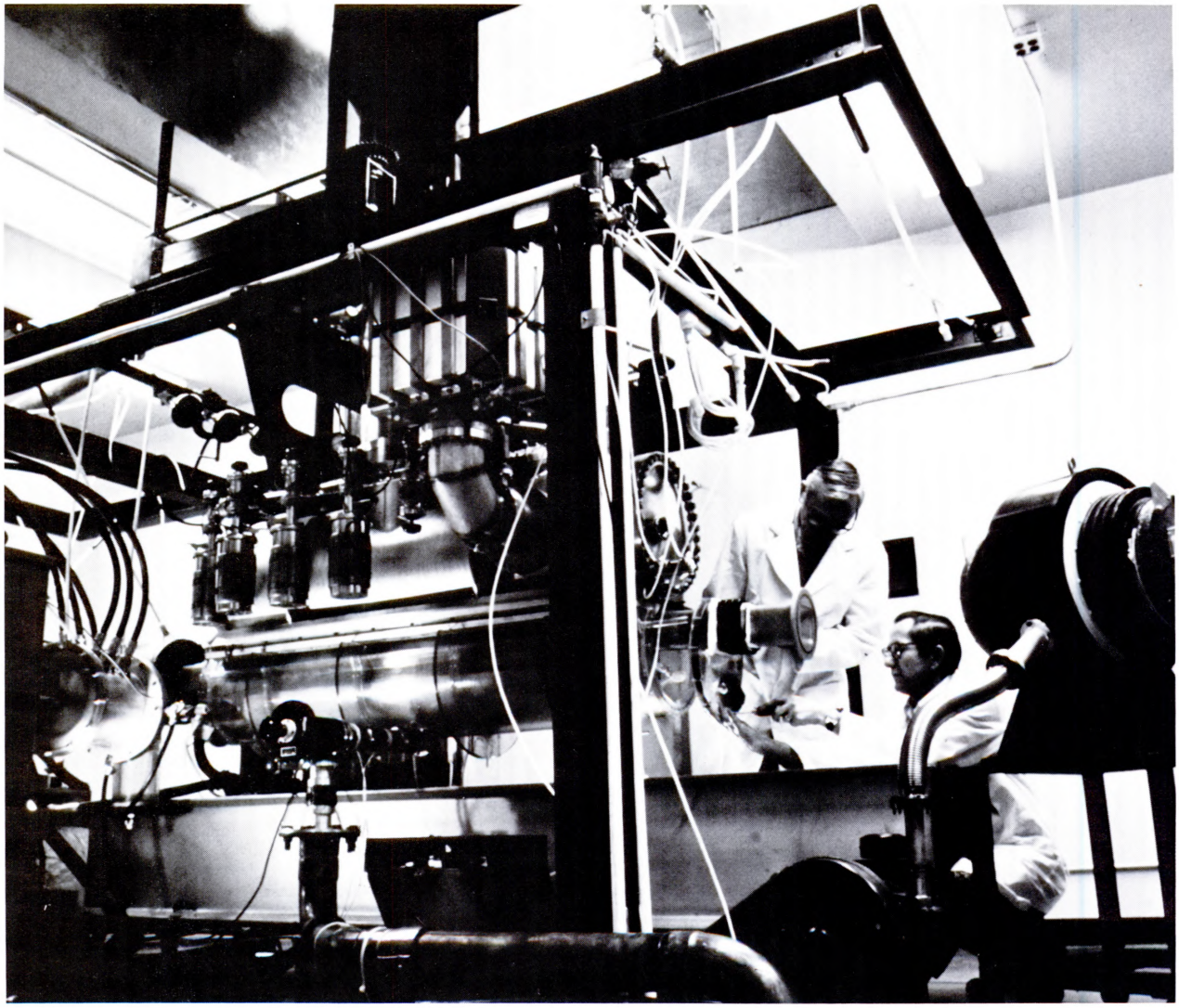
Naval Research Reviews

Office of Naval Research
One / 1986
Vol XXXVIII



Electron Beam Stabilized Electric Discharge Lasers



The first high energy electron beam stabilized carbon monoxide electric discharge lasers (CO EDL) were developed at the Northrop Research and Technology Center with support from the Advanced Research Projects Agency and the Office of Naval Research in 1968. At the time, sixty percent efficiency was attained, making the CO EDL the most efficient directly excited laser system. As a result of this program, major advances were made in critical areas of technology such as high precision gas conditioning, electron guns, and infrared optics.

Naval Research Reviews

Office of Naval Research
One / 1986
Vol XXXVIII

Articles

Departments

About the Cover

The vertical profiler designed and built at the Naval Ocean Research and Development Activity (NORDA) is a general purpose oceanographic and acoustic sensor system which can profile up to and through the air-sea interface, which makes it ideal for measurements in this high-energy exchange. With its internal timing controls, the profiler can be preprogrammed to descend and ascend at specified times. Its deepest diving depth is 1,000 meters, and uses lithium battery packs to drive its internal ballasting pump. See page 15.

Naval Research Reviews publishes articles about research conducted by the laboratories and contractors of the Office of Naval Research and describes important naval experimental activities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code OPARI, Office of Naval Research, Arlington, Va. 22217-5000. Requests for subscriptions should be directed to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. *Naval Research Reviews* is published from appropriated funds by authority of the Office of Naval Research in accordance with Navy Publications and Printing Regulations. NAVSO P-35.

WOMEN I

The Struggle Continues

by Janice S. Randall,
Radcliffe College

The Problem

In 1874, the brilliant mathematician Sonia Kovalevsky (also Sonya or Sofia Kovalevskaia), who formulated the now-famous Cauchy-Kovalevsky theorem on partial differential equations, received the doctorate in mathematics from the University of Gottingen—the first woman in history to be so honored. The degree was granted *in absentia,* however, as women were not allowed to study at universities in either Russia, Kovalevsky's native land, or in Germany. Ten years later she accepted an appointment at Stockholm University and became the first woman in modern times to hold a university post. She received no salary the first year and was not granted a permanent position for another five years, despite the fact that she had been awarded the prestigious Prix Bordin of the French Academy of Sciences in 1888. The Prize, awarded for her solution to the problem of determining the path of rotation of a solid body about a fixed position, was judged to be so outstanding that its monetary value was nearly doubled from 3,000 to 5,000 francs. (*The Dictionary of Scientific Biography,* Vol. 7, New York: Charles Scribner's Sons, 1973, p. 478.)

Today, few would suggest that talented women face the overwhelming social and economic barriers that confronted Kovalevsky in the patriarchal societies of 19th Century Europe. In the last hundred years, women have gained access to and recognition in a variety of professions, and within the last decade a few have taken dramatic steps forward: the first woman in space, the first woman to be named dean at Harvard University, the first woman judge to be appointed to the Supreme Court, the first woman to be nominated by a major political party to run for the office of Vice-President of the United States.

Despite these achievements, career prospects continue to lag behind those of men, and particularly for

women in science. A recent study by the National Research Council's Committee on the Education and Employment of Women in Science and Engineering shows:

- If women earned their PhD's more than 20 years ago, their chances of now being full professors are only 73 percent of those of men with the same experience.
- If they earned their degree 5 to 10 years ago, their chances of having tenure are only 67 percent of those of men.
- Their salaries, on average, are 5 to 18 percent lower than those of men with the same degree or experience.
- The difference in career prospects for men and women scientists following postdoctoral training start to emerge early in academic traning. Although women are more likely to receive postdoctoral fellowships, they have traditionally received fewer prestigious awards and lower stipends.
- Following postdoctoral training, women tend to receive a higher proportion of teaching appointments as opposed to pure research appointments.

Among other factors are women's presumed larger investment of time and energy in marriage and parenting, as well as restricted geographical mobility.

The results of such studies, both national and international, are controversial. Blatant sex discrimination within various scientific fields, limited access to informal communication between scientists, attitudes of parents and teachers and society in general toward science education, even the old argument of innate biological differences are some of the reasons advanced for women's continued underrepresentation in science. However, women today represent significantly more than a small fraction of the scientific community for the first time in history.

The Bunting Institute

"Crucial in turning these statistics around is the support given to women scholars through fellowships and grants from various government agencies, private corporations, and foundations," said Dr. Elizabeth McKinsey, newly-appointed director of the Mary Ingraham Bunting Institute of Radcliffe College. "We are grateful to the Office of Naval Research (ONR) for their contribution to the successful Science Scholars program at the Institute."

The Bunting Institute, founded in 1960 as the Radcliffe Institute for Independent Study during the presidency of Mary Ingraham Bunting, was renamed in her honor in 1978. It is a multidisciplinary program dedicated to professional and scholarly work by and about women. Throughout its twenty-five year history, it has provided opportunities for nearly 1,000 gifted women from a variety of fields, making available to them the time, space and support necessary for completion of a major research, artistic or writing project. Creating opportunities for women in science has been a particular interest at the Institute. Dr. Bunting, a well-known microbiologist who taught at Harvard University from 1960 to 1972 and served on a number of national science boards and councils, (Commissioner, Atomic Energy Commision, 1964) is aware of the unique barriers confronting women in science. Her continuing efforts "to create a climate of expectation" for women have had a significant effect on Institute programs.

Mary Bunting Smith, microbiologist, former President of Radcliffe College and founder of the Mary Ingraham Bunting Institute of Radcliffe College. (Photo by Martha Stewart)

ONR Support

Since 1980 ONR has provided $706,643 in grants to support the research of 19 women scholars who have participated in the multidisciplinary program at the Bunting Institute, allowing each to contribute to her field and to enhance her career. A four-year renewal grant effective in July 1985 will continue this support for an additional 16 postdoctoral science Fellows.

The ONR grant provides that each scholar selected for a one- or two-year appointment be in residence at the Institute, where she undertakes independent research or affiliates with a laboratory or research group at a major university in the Boston area. Research is conducted in areas of interest to the Office of Naval Research, including the physical sciences, mathematical and information sciences, biological sciences, psychological sciences, arctic and earth sciences, material sciences, and ocean science and technology. The program is open to women who have received their doctorate at least two years prior to appointment as Institute Fellows. They may be faculty members or researchers in industrial or academic laboratories. Each scholar receives a stipend of $20,000 and additional funds for research expenses.

While at the Institute, Science Scholars participate in a number of events. They present their work-in-progress at public colloquia, getting feedback from colleagues as well as from women in other fields. The Annual Science Scholars Colloquium features a distinguished scientist and allows the Institute to highlight the Science Scholars program and the accomplishments of other outstanding women scientists. In addition, by participating in a number of programs and luncheons at Radcliffe College, fellows provide important role models for young women in the Radcliffe/Harvard community who may be considering a career in science.

"I think the most important aspect of being a Science Scholar at the Bunting Institute for many of the recipients is that they are no longer 'the token woman' in an academic department or research center of men," said Dr. Ann Bookman, assistant director at the Institute. "Being in a community of accomplished women has allowed many women scientists to stop fighting battles for acceptance and turn their full attention to science. They bloom, and the scientific results are impressive."

To promote the program, the Institute has launched an effective outreach campaign to colleges and universities throughout the United States and abroad. Fellowship information is also distributed to scientific and professional associations, and advertisements are placed in appropriate newsletters and scientific and educational journals. The Institute is interested in supporting women of all ages, from all racial and national backgrounds, and from every kind of institution.

Selection of Fellows

The selection process has expanded greatly to meet the demands of a diverse applicant pool. It is a rigorous, sophisticated procedure based on the quality of the four-page proposal submitted, an evaluation of whether or not the proposed research will make a significant contribution to the field and the importance of the fellowship to the applicant's career.

In the first stage, each application is read by one and in some cases two reviewers in the appropriate field. Two ratings, "Encourage Funding" and "Discourage Funding," are used. Statistics from the last five years indicate that funding is encouraged for approximately 50 percent of the proposals submitted.

In the second stage, all "Encourage Funding" proposals in science are reviewed by a committee of distinguished tenured scientists from Boston area universities, covering all fields specified by ONR.

In the third and final stage, a Final Selection Committee, relying on the expert judgment of all the disciplinary panels, considers foremost the quality of the proposed research. Other factors such as geography, age, institutional affiliation, field, and minority representation are also considered in choosing the recipients. The 1985-1986 roster of 41 scholars, artists, and writers includes four science scholars.

"The Science Scholars Program has provided opportunities for talented women scientists to enter the mainstream in their various fields," said Radcliffe College President Matina S. Horner. "For the participants in the program, the fellowships at the Bunting Institute made possible by the Office of Naval Research grant, now splendidly renewed, have often been the critical factor enabling these women to advance in fields of science, where the participation of women has been significantly less than that of men."

Examples

Many of the first group of ONR scholars who completed residencies in 1983 have been named to important positions of leadership in teaching and research. Susan Cook is now education director for the Bermuda Biological Station for Research; Nanette Orme-Johnson is assistant professor of biochemistry and pharmacology at Tufts Medical School; and Susan Brawley was promoted to assistant professor of general biology at Vanderbilt University.

Brawley, who recently completed a five-months research project at the Institute of Oceanology, Qingdao, under the auspices of the National Academy of Sciences and the Committee on Scholarly Communication with the People's Republic of China, studied the interaction of endogenous electrical currents and the cytoskeleton during cell polarization while at the Institute.

"The independence that I had during my fellowship appointment as an investigator was critical. It was mostly a psychological advantage—but that made all the difference in my success," she said.

Dr. Susan Cook, currently Education Director and Research Associate at the Bermuda Biological Station for Research, reports: "My fellowship made it possible for me to collect data from two of the four years for which I currently have information on the patterns of reproduction, growth and survival for limpet populations. As a direct result of my fellowship, I have been awarded a research grant from the Environmental Protection Agency to study the effects of oil and other stress on limpet reproduction. This work would not be possible without the information I have already collected on normal fluctuations in limpet population. In addition, I was able to make a transition from behavioral work to longer-term ecological work. This kind of switch is especially difficult, because ecological work must go on for several years before publication of results is possible."

The research conducted by Dr. Laurie Rohde Godfrey, 1983-85, Associate Professor of Anthropology at the University of Massachusetts at Amherst, focuses on sized-related variation in the bones of extinct and extant Malagasy lemurs.

Dr. Laurie Rohde Godfrey, Associate Professor of Anthropology at the University of Massachuestts, Amherst, working here on the variation in the size of bones of extinct and extant Malagasy lemurs at Harvard's Museum of Comparative Zoology.

"In addition to allowing me time to work on a major research project involving data collection around the world and the benefits of a research base at Harvard's Museum of Comparative Zoology, I have been fortunate to have been incorporated into the Protocol of Collaboration for Paleontological Research by the Universite de Madagascar, the Duke University Primate Center, and the Duke University Department of Anatomy," Godfrey said. "Thus I have become a member of a working international community of scholars, including new researchers from the third world. This affiliation would not have been possible without the freedom afforded me by my Bunting Fellowship".

The diversity within the Bunting community is unique, allowing for intellectual interactions with scholars from a variety of fields. Dr. Ellen Bassuk, Associate Professor of Psychiatry at Harvard Medical School, commented:

"I designed and implemented a clinical research study of homeless adult individuals who had been staying at a representative shelter in Boston. This was the first clinical study of this group in Massachusetts. The study had important and immediate policy implications. The ONR program gave me the time and place to conduct the clinical project and has been pivotal in helping me to change career directions—from a hospital-based clinical practice to a more research oriented/health policy emphasis as advocate, researcher, and policy consultant. Clearly, the support of Bunting fellows from other disciplines, as well as from science, was extremely valuable in this project."

Donella Joyce Wilson, a molecular biologist who just completed her fellowship appointment, was recently featured as one of the ten "future-makers" (and the only woman) in a special issue of *Ebony* ("Blacks and the Future: Where Will We Be in the Year 2000?" August 1985). She has been appointed to a faculty position at Meharry Medical College in Nashville, Tennessee. While at the Institute, Dr. Wilson conducted research in the laboratory of Dr. Harvey Lodish at the Whitehead Institute at the Massachusetts Institute of Technology. Her recently isolated clone of a red blood cell membrane protein may be glycophorin, a protein suggested to play a role in malarial parasite invasion of red blood cells.

So far, science scholars from the Bunting have published numerous articles in professional journals and six books, and attended and/or presented papers at over thirty professional meetings and conferences in the United States and Europe. Dr. Sai Hyun Lee, who returned in 1984 to the School of Civil Engineering at the Georgia Institute of Technology, was the first woman to receive the American Water Works Association Academic Achievement Award. Her work on alternative methods for measuring the microbiological quality of drinking water received enthusiastic support at a recent national conference on water quality technology. Also, the results of the research of palynological consultant Sarah Pierce Damassa were presented as posters at the Third International Conference on Modern and Fossil Dinoflagellates at Egham, Surrey, U.K., in August and will form the basis of a manuscript to be submitted for publication in 1986.

"The greatest personal benefit derived from this fellowship has been the opportunity to collaborate with Dr. Andrew Knoll of the Herbarium at Harvard University," Damassa said. "Professionally, the sense of belonging to a group and a place after four years in relative isolation has been most gratifying. I expect my studies of Late Precambrian microplankton assemblages from central and southern Australia, which involve the Geological Survey of Canada, ARCO Oil and Gas Company and Amoco Production Company, to produce significant results from which both the participants and the general paleontological/geological community will derive considerable benefit."

Dr. Sai Hyun Lee, civil engineer from the Georgia Institute of Technology. Dr. Lee is shown here with her fluorescent microscope at the Engineering Science Laboratory, Harvard University. (Photo by Martha Stewart)

Conclusion

Margaret McKenna, newly-appointed president of Lesley College in Cambridge, Massachusetts, and former director of the Bunting Institute, oversaw the Science Scholars program in its initial stages.

"The success of the program and its participants is well-documented," McKenna said. "Beyond the scientific benefits, I recall scholars' comments on the 'intangibles' of their time at the Institute. Several scientists came from laboratories or departments in which they were the only women and appreciate the opportunity to interact on a regular basis with their female colleagues in science. Others have commented on the personal enrichment fostered by their association with peers in the humanities and social sciences. It is clear that there is a continuing need for this program."

Llewellya Hillis-Colinvaux, a well-known marine biologist professor at Ohio State University and current Bunting Institute Science Scholar, was recently interviewed on her return from three months in China as a National Scholar of the United States Academy of Sciences. She spoke with candor to a reporter's questions about the status of women scientists and women faculty members in the U.S.

"It was a 10-year fight to be recognized. No recognition has come to me as easily as it has to my male counterparts," she said. "Lots of women were trained in the biological sciences who could have been role models from as long ago as the 1920s and 1930s. If you look at the biology departments in U.S. universities, the women are not there . . . it's straight prejudice. However, the progress that has been made is now so firmly entrenched that it will be hard to dismantle it completely. I am optimistic, and I am also particularly grateful to the Office of Naval Research without whose enlightened support of a female planning to dive on coral reefs more than a dozen years ago much of the framework of my research would not have been possible."

The battle for women in science continues, but with the support and success of programs like the Offfice of Naval Research Science Scholars program at the Bunting Institute, new opportunities are created and the potential of talented women scholars is nurtured so that women may take their rightful place in the scientific community.

A complete list of the Science Scholars, their fields, and the titles of their project proposals follows:

Science Scholars at the Institute from 1983-1985. Shown here chatting with Richard Wilson, Harvard's Mallinckrodt Professor of Physics, L. to R. Mary Beth Ruskai, Professor Wilson, Gudrun Brattstrom, Pamela Coxson, and Donella Wilson. The photo was taken at a reception at Greenleaf House, the residence of Radcliffe College President Matina S. Horner. (Photo by Lilian Kemp)

Science Scholars 1981-1987

GRETCHEN GLODE BERGGREN, International Health
"Critical Evaluation of Accurately Documented Community Health, Population and Nutrition Programs in Rural Haiti"

SUSAN HOWARD BRAWLEY, Cell and Developmental Biology
"Polar Axis Fixation in the *Fucus* Embryo"

SUSAN BLACKFORD COOK, Marine Biology
"Pool and Ledge Limpets: An Experimental Analysis of the Consequences of Aerial Exposure"

MARY AMY HOOD, Aquatic Microbial Ecology
"The Role of Estuarine Organisms in the Distribution of *V. cholerae* in the Estuary"

BETTY RUTH JONES, Parasitology and Biological Ultrastructure
"Histochemical, Biochemical, and Ultrastructural Cytochemical Studies on Oxidative and Hydrolytic Enzymes in the Oncospheres of *Hydatigera Taeniaeformis*

NANETTE ORME-JOHNSON, Biochemistry
"ACTH Induced Molecular Changes Which Regulate Adrenal Corticosteroidogenesis"

BARBARA WALLNER PHILIPP, Biochemistry and Molecular Biology
"Characterization of the Human Albumin and Alpha-Fetoprotein Genes"

PRISCILLA FENN ROSLANSKY, Neuro-molecular Biology
"Cytoskeleton of Neurons"

PRAHBA KUMBHARE TEDROW, Physics/Electrical Engineering
"Design and Build an LPCVD Reactor to Deposit Transition Metal Silicide Films"

S. MERIC BARKAN, High Energy Experimental Physics
"Development and Test of New Detectors for SLC"

ELLEN L. BASSUK, Psychiatry/History of Science
"The Care of the Chronically Mentally Ill: Historical Perspectives 1880-1980"

GUDRUN BRIGITTA BRATTSTROM, Arithemtic of Elliptic Curves
"p-Adic Heights on Elliptic Curves"

PAMELA GAIL COXSON, Mathematics-Dynamic Systems
"Reduced Order Models of Large Scale Systems by Aggregation"

SARAH PIERCE DAMASSA, Paleontology/Palynology
"The Early Fossil Record of Plankton"

LAURIE ROHDE GODFREY, Primatology and Evolutionary Biology
"The Evolution of Scale in Malagasy Primates"

NAOMI JOCHNOWITZ, Algebraic Number Theory—Modular Forms
"Modular Forms and the Study of the Hecke Algebra"

SAI HYUN LEE, Civil Engineering
"Application of a New Microbiological Quality Measurement, the Fluorochrome DAPI Direct Count Method in Drinking Water Microbiology"

MARY BETH RUSKAI, Mathematical Physics
"Problems in Mathematical Physics"

DONELLA JOYCE WILSON, Molecular Biology
"The Expression of Developmentally Regulated Genes in Friend Cells"

LLEWELLYA HILLIS-COLINVAUX, Marine Biology
"Biogeography and Systematics of Calcareous Green Reef-building Algae"

KAY KINOSHITA, Physics
"Heavy Particles: Search and Study"

MARCIA McNUTT, Earth Science
"The Relationship Between the Mechanical Strength of Continents and the Formation of Mountain Belts"

BARBARA R. PESKIN, Mathematics
"An Examination of Quotient-Singularities in Characteristic p"

About the Author

As a member of the Bunting Institute staff, Janice Randall coordinates Institute publicity, edits the Institute Newsletter, and researches and writes grant proposals. She holds a B.S. in education from Bridgewater State College and an M.A. in English from the University of Massachusetts at Amherst. Before coming to the Institute, Janice taught English at Fisher Junior College and coordinated a writing skills program at Lesley College, Cambridge, Massachusetts.

Profiles in Science

Dr. Frank Herman, who is a theoretical solid state physicist at the IBM Research Laboratory, San Jose, California, has been a principal investigator of the Office of Naval Research (ONR) for many years. Currently, he is studying semiconductor heterostructures and metallic multilayers with ONR support as well as investigating the electronic and magnetic properties of interfacial systems that play a key role in microelectronics. Dr. Herman's research has elucidated the nature of localized electronic interface states at Ge/GaAs heterojunctions, at silicon surfaces passivated by its native oxide, and at interfaces between crystalline and amorphous silicon.

Early in his career, Dr. Herman went to work for RCA Laboratories, Princeton, New Jersey, where he carried out pioneering studies of the electronic structure of semiconductors for which he received world-wide recognition. He was also among the first to use electronic computers to solve major scientific problems.

In 1962, he joined the Lockheed Research Laboratory in Palo Alto, California, continuing his theoretical research on semiconducting crystals and alloys. He is perhaps best known for his 1963 book co-authored with Sherwood Skillman, "Atomic Structure Calculations," based on research conducted at RCA and Lockheed supported by ONR.

Dr. Herman has served as a consultant to the National Science Foundation, the National Research Council, and the Department of the Army. He is a Fellow of the Institute of Electronic and Electrical Engineers and a Fellow of the American Physical Society.

THE TOOLS OF OCEAN RESEARCH DEVELOPED AT NORDA

Clifford R. Holland,
Naval Ocean Research and Development Activity

Introduction

It has been said that we learn by measuring, and that our knowledge is limited only by our ability to measure. This ability to measure is determined by science, which is our combined understanding of the laws of the universe. Within the known existence of man, the ability to make measurements has been brief and is always associated with advancing societies.

With modern technology, it appears that we can measure, understand, and control a large variety of phenomena for the betterment of all. We in the Ocean Technology Division of the Naval Ocean Research and Development Activity are proud to be a part of developing and applying this technology to solving critical Navy problems. In the next few pages, we would like to tell you about some of our recent work and how it is helping to build a stronger Navy. The discussion concentrates on the measurement of acoustics, oceanography, and the characteristics of the seafloor.

Acoustic Systems

The Naval Ocean Research and Development Activity is heavily involved with acoustic research, and the Ocean Technology Division is providing a number of measurement systems that improve both the quality and the quantity of the required data.

Shallow Water Research System

The Shallow Water Acoustic Measurement Instrumentation System (SWAMI) is an example of a next-generation, high frequency, acoustic research tool. SWAMI will provide data for statistical studies of surface, bottom and volume backscatter, forward scatter, reverberation, and transmission path stability.

Figure 1 illustrates the Seagoing Advanced Acoustic Array (SA^3) portion of the SWAMI System which consists of two stable, yet portable, bottom-mounted towers with associated projectors, receivers, and data telemetry links. Each tower is brought to a convenient seaport near the targeted acoustic test area on flat-bed trailer trucks, where it is quickly assembled for surface tow to the test site. Once on site, the catamaran hulls and center trunk are flooded, which sends each tower to the bottom so that it will provide stable, precise support to the acoustic instrumentation at its apex.

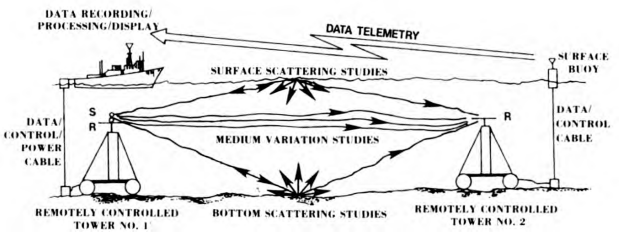
On one tower, two parametric sources provide a narrow beam of energy over the entire frequency range from 10 kHz to 200 kHz. Also atop this projector tower is a modified Mill's Cross 15-hydrophone array, which is 20 feet long by 3 feet high, to receive backscatter signals. The projector tower is connected to a moored surface ship from which it receives projector power, instrumentation power, and pointing angle control signals. The second receiving tower has an identical 15-hydrophone array to receive direct path, forward, or out-of-plane scattered signals. This second tower is battery powered and uses a radio frequency (R.F.) telemetry link from a surface buoy to transmit data and receive pointing angle commands.

The towers can be deployed from a few hundred to several thousand yards apart in shallow (50-300 feet deep) water and then "calibrated" for projector/receiver bore-sight by adjusting for maximum direct arrival signal level. Once bore-sighted, off-axis signals can be examined by commanding each tower to individually adjust to the desired relative angle in terms of azimuth, pitch, and roll angles. Projector power levels and frequencies can be altered at will to explore the acoustic characteristics of signals, noise, and reverberation in shallow or restricted coastal areas.

Relatively recent attempts to extrapolate deep ocean techniques to shallow water have been disappointing, thereby demonstrating the need for SWAMI data to develop reliable shallow-water acoustic data bases and models that will support shallow-water weapons systems development, performance prediction, and operational forecasts. The SWAMI data base and derived models will permit system developers in the mine, mine countermeasures, and torpedo communities to overcome the present environmental barriers to improved weapon system performance. These barriers have arisen because of the very sophisticated nature of modern acoustic systems for detecting, classifying, and localizing enemy targets. Sophistication results in greater sensitivity to small changes or variations, and a number of environmental parameters must now be known in tactical situations to realize optimum weapon systems performance. SWAMI will be instrumental in providing acoustics understanding needed for successful naval conflicts in the shallow-water coastal areas of the world.

Figure 1

Seagoing Advanced Acoustic Array



Lightweight Array Technology

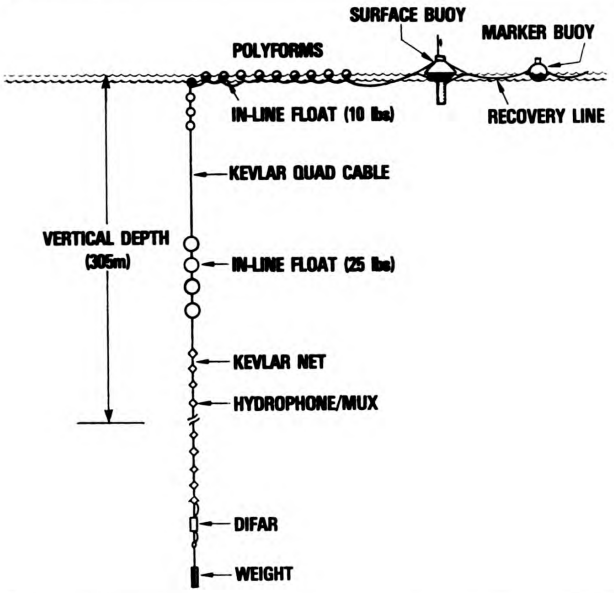
The use of deep-water acoustic hydrophone arrays has for many years meant large, bulky, and relatively stiff oil-filled hoses that required large equipment for deployment, recovery, and storage. Since the mid 1970s, NORDA's Ocean Technology Division has been developing a new modular concept for deep water arrays—one that uses free-flooding Kevlar cables for fabricating the hydrophone arrays. The first system to use this concept was called VEKA (Versatile Experimental Kevlar Array). Figure 2 illustrates a typical lightweight, near-surface deployment for a VEKA system with R.F. telemetry of data via a surface buoy.

The VEKA concept capitalizes on the strength, flexibility, and light weight of Kevlar aramid fibers to create an array where the hydrophones can be positioned (or repositioned) with relative ease, compared to an oil-filled hose. The final assembly can be easily deployed and recovered manually or with lightweight equipment from smaller, less expensive ships.

VEKA is a truly modular acoustic array assembly concept in that hydrophone components, strength members, and electrical wiring can be combined in endless variety to produce receiving systems that can be connected to a variety of signal transmission modules for R.F. telemetry, multi- or single-cable transmission, or fiber optic cable transmission. These systems can be deployed shallow or deep, free drifting or moored, vertical or horizontal, or laid on the bottom as necessary.

Figure 2

VEKA II-22



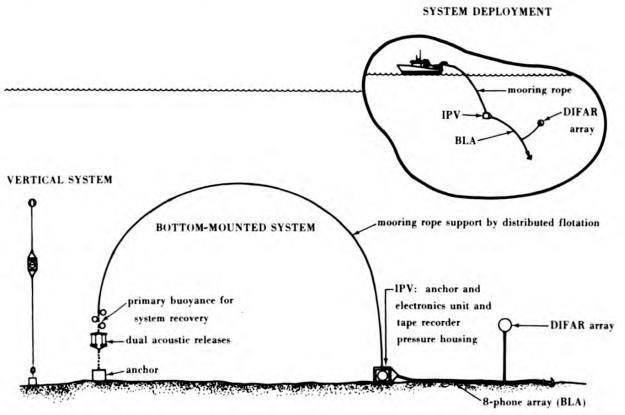
Self-Contained Data Acquisition System

The Versatile Experimental Data Acquisition Buoy System (VEDABS) is a second ocean acoustic tool resulting from application of Kevlar array technology and early VEKA experimentation. VEDABS is a self-recording analog system (see Figure 3) that has provided a number of important acoustic measurements for the Navy since 1982, as shown in Figure 4. The VEDABS electronics can accommodate up to 24 channels of acoustic data in the 5 Hz to 1 kHz band, with greater than 60 dB of signal-to-electronic noise ratio. It can record continuously for up to 8 days and contains internal timers to control initial start time and on/off time. The VEDABS Instrument Pressure Vessel (IPV) can be deployed to depths of 20,000 feet using array lengths approaching 10,000 feet. Deployment and retrieval times are on the order of 1 hour in reasonably good weather.

VEDABS has been used to produce a spectrum of acoustic data products including omni-directional ambient noise as a function of depth, propagation loss measurements, bottom interaction effects, and array performance data. VEDABS has proved to be of enormous value to the Navy over the past 2 years and will continue to earn its keep for a number of years to come.

Figure 3

VEDABS



Acoustic Navigation System

All the acoustic systems developed by the Ocean Technology Division are not for data collection. At least one, the Under-the-Hull Diver Location System (UHDLS), is designed to improve the performance of Navy salvage and hull inspection work. The UHDLS, illustrated in Figure 5, is designed to accurately locate an inspection diver under the hull of a large ship and vector him to desired inspection points. The system is being designed to be very portable so that it can be air transported rapidly anywhere in the world and quickly set up on a wide variety of ships.

Because of the highly reverberant acoustic environment, UHDLS requires redundant acoustic tracking sensors to compute location by more than one method and "reasonableness test" algorithms to determine rationality of the final computed position prior to display.

UHDLS will provide the Navy diving and salvage teams with a new capability that will make their jobs quicker and safer, and will produce more accurate inspection results. This improvement means more ships inspected more accurately with a given inspection team and an extended out of dry-dock interval for all Navy ships.

Oceanographic Systems

In addition to developing important new acoustic tools, the Ocean Technology Division has been active in improving oceanographic measurement systems. In the following paragraphs, a few recent accomplishments will be briefly discussed.

Figure 4

NORDA, Major Acoustic Measurements, Past Two Years

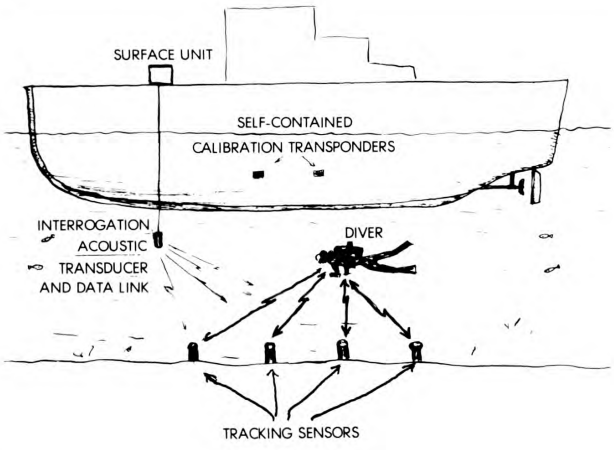
Exercise	System	Array configuration (No. of hydrophones)	Deployments (Water depth)	Acoustic data avg.
1. Outpost Encore (Apr/May 82)	VEDABS	Vertical (5) Horiz. bottom (13)	2 (180 m ea.) 2 (180 m ea.)	100%
2. Outpost Creole (Jul/Aug 82)	VEDABS	Vertical (8) Vertical (5) Horiz. bottom (14)	2 (2300 m ea) 1 (1300)m 1 (800 m)	75%
3. Outpost Grande (Mar/Nov 83)	VEDABS	Vertical (8)	3 (5700 m)	100%
4. CONTRACK VI (Aug/Sep 83)	VEKA	Vertical (32)	1 (3700 m)	100%
5. Outpost Reprise I (Oct/Nov 83)	VEDABS	Vertical (14) Horiz. bottom (12)	1 (2500 m) 1 (2500 m)	50%
6. Outpost Reprise II (May/Jun 84)	VEDABS	Vertical (14) Horiz. bottom (12)	2 (2600 m) 2 (2600 m)	80%
7. AEAS Pacific	VEDABS	Vertical (11)	2 (1400 m)	100%
TOTAL			**20**	**91%**

Notes:

1. Bottom-laid array of Outpost Reprise II also had two DIFARS attached.
2. Sound sources also moored in Outposts Creole, Reprise I and II exercises.
3. VEDABS Characteristics: self-recording, analog system, continuous or intermittent data taking, typically subsurface.
4. VEKA Characteristics: FDM system and R.F. telemetry capability available.
5. Both VEDABS and VEKA use Kevlar array technology developed at NORDA.
6. VEKA development completed Jun 83.

Figure 5

Under the Hull Diver Location System (UHDLS)



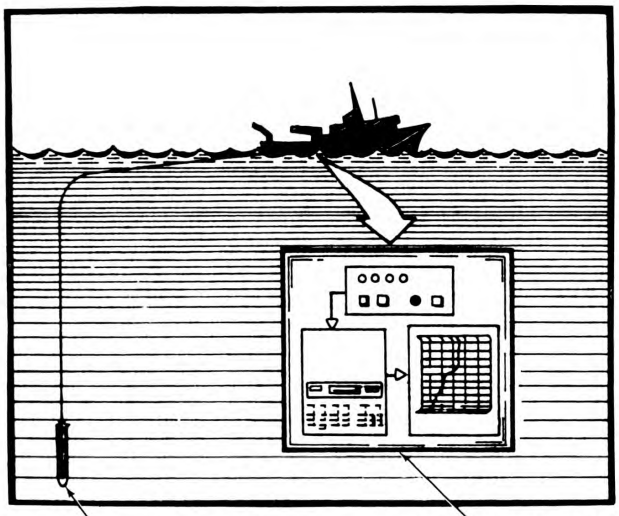
Expendable Probes System

In recent years, the oceanographic community has turned more and more to the use of such expendable sensors as the expendable bathythermograph (XBT) for temperature profiling; the expendable sound velocimeter (XSV) for sound velocity profiling; the expendable conductivity, temperature, depth (XCTD) probe for salinity and density profiling; and most recently, the expendable current profiler (XCP) for shear current profiling. Not long ago, the principal instrument for collecting and displaying expendable probe data was the strip chart recorder, a marvel of mechanical ingenuity but woefully lacking in accuracy and resolution. Today, a variety of computer-based, all-electronic acquisition, digitizing, processing, and display systems for the various types of probes are available. In response to the need for a highly accurate, user-friendly, general-purpose data acquisition and processing system we developed the Expendable Probes Data Acquisition System (EPDAS) for ocean scientists about 3 years ago (see Figure 6).

EPDAS consists primarily of a modular interface box and a desk-top computer. The interface box accepts plug-in printed circuit cards that permit interconnection of the computer to each type of commercial probe. The interface can be configured for up to three probes simultaneously. Computer software has been developed to produce in near real-time "waterfall" profile plots for operator interactive analysis. EPDAS is capable of processing tens of samples per second for each probe with resolutions greater than 0.03%. To date, this system has collected data on more than 3000 probe drops.

Figure 6

Expendable Probes Data Acquisition System (EPDAS)



Airborne Data Acquisition System

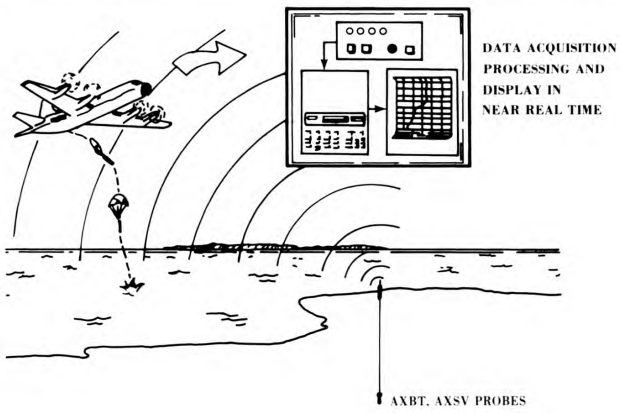
The Airborne Data Acquisition and Processing System (ADAPS) is an out-growth of the very successful EPDAS development. ADAPS has been designed for RP-3 aircraft installation (see Figure 7) with systems presently flying on the Naval Oceanographic Office's (NAVOCEANO) BIRDS-EYE and SEASCAN aircraft. ADAPS ties together data from expendable probe sensors, thermal radiation sensors, aircraft sensors, and navigation instruments to produce a highly automated field data collection and in-flight processing capability.

The data collected by ADAPS is displayed in near real-time for operator examination and selection of key parameter values. After operator designation, ADAPS formats the selected values into a standardized message and automatically prepares an error-free paper tape for worldwide message transmission via the military communications network.

ADAPS, the product of a new research tool for ocean science (EPDAS), is benefitting the operational Navy today by providing more accurate and timely ocean environmental data through increased productivity of NAVOCEANO airborne field surveys.

Figure 7

Airborne Data Acquisition and Processing System (ADAPS)



Cavitation Research System

The Cavitating Ocean Profile System (COPS) was developed recently to provide the David Taylor Naval Ship Research and Development Center with a unique tool for cavitation studies. The system (see Figure 8) can be used to determine the incipient cavitation point (that local pressure value where individual cavitation bubbles form and collapse in succession) as a function of ocean depth. In conjunction with other instruments that measure physical, chemical, and biological parameters of the water column, COPS can help the Navy's hydrodynamics experts understand the full nature and variability of cavitation conditions throughout the world's oceans. This improved knowledge will help our Navy operate more quietly while maintaining maximum speed and maneuverability.

COPS has been to sea on a number of recent occasions and is the only instrument of its kind known to exist in the free world that gives an accurate, reproducible measure of the actual at-sea cavitation conditions.

Figure 8

Cavitation Ocean Profiling System (COPS)

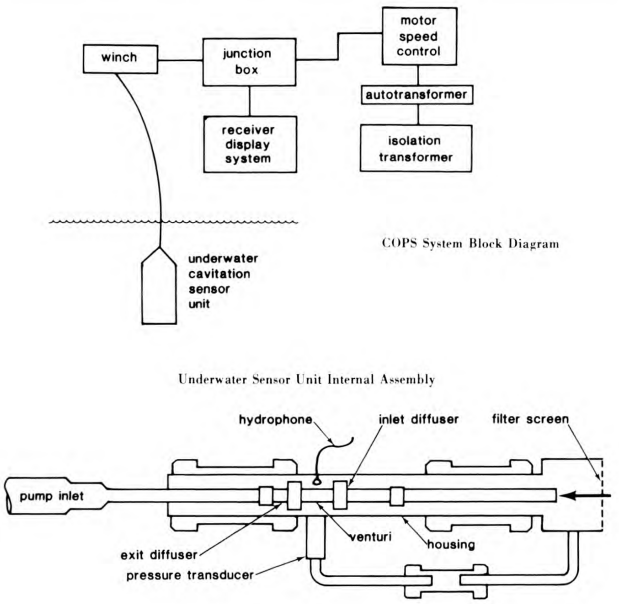
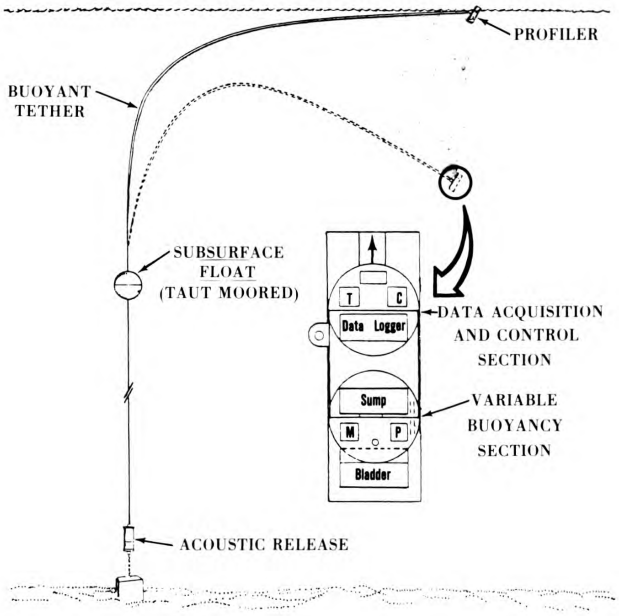


Figure 9

NORDA Vertical Profiler



Vertical Profiler

The NORDA Vertical Profiler (see Figure 9) is a variable buoyancy body that can be configured with a variety of oceanographic or acoustic sensors. With its internal timing controls, the profiler can be preprogrammed to descend and ascend at specified times. Its deepest diving depth is 1000 meters, and it is capable of over 50 dives using lithium battery packs to drive its internal ballasting pump.

While numerous other water column profilers have been developed over the years (mostly for continental shelf work), the NORDA Vertical Profiler is one of the very few that can profile up to and through the air-sea interface, which makes it nearly ideal for most measurements in this zone of high-energy exchange. It can additionally be outfitted with radio transmitter/receiver electronics for data transmission via satellite and receive remotely generated commands for operational mode change.

One major problem with surface buoyed oceanographic instrumentation is that it tends to attract local attention, which can result in its disappearance either by removal or sinking. The NORDA Vertical Profiler avoids this problem by being able to "hang" on its buoyant tether at depth, thereby leaving nothing on the ocean surface to attract attention. It cycles up and down (rather than down and up) as programmed, spending minimum time on the surface.

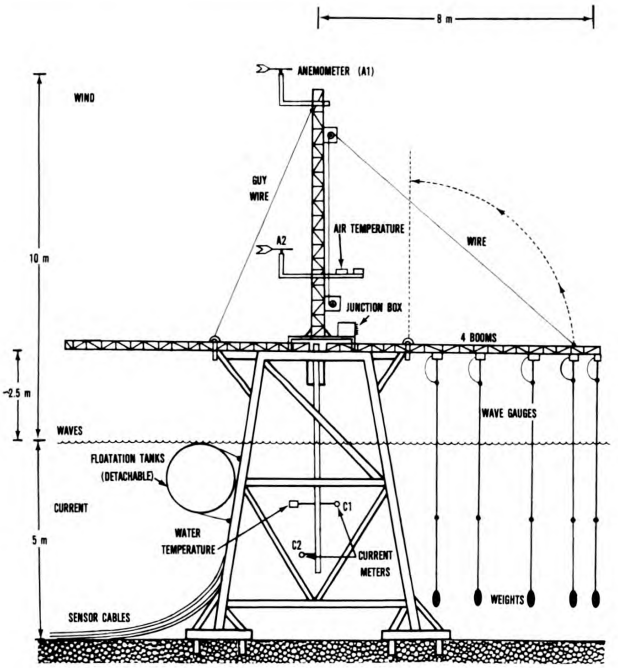
Wave Research System

The new tools of ocean research span the depths of the oceans from the deep seas to the shallow bays. The Air/Sea Interaction Measurement System (ASIMS) is an example of the shallow end of the spectrum (see Figure 10). This system is designed to measure winds, waves, water currents, and other environmental parameters that affect the energy exchange (interaction) between the winds and the resulting surface waves. ASIMS will permit NORDA wave researchers to accurately measure, under actual field conditions using modular wave gauge arrays, the wind/wave coupling processes during build-up, stabilization, and decay of surface wave fields. Variable spacing of the large number (24) of wave gauges accommodated permits concentration on wavelengths in certain frequency bands.

The data provided by ASIMS will enhance the Navy's understanding of wind-wave generation and, therefore, its modeling on computers. Improved models will permit more accurate simulations of the dynamic wave forces on ship hulls and marine structures, thereby providing a more cost-effective way of examining new designs and new materials being considered for construction.

Figure 10

ASIMS Instrument Towers (2) at Lake Pontchartrain



Seafloor Systems

Having considered new NORDA-developed tools for acoustic and oceanographic work, we will now briefly discuss some new developments in seafloor measurement systems.

Mapping and Charting

New tools for mapping and charting the topography of the seafloor are also being developed at NORDA. With support from the Defense Mapping Agency, major improvements are being added to the NAVOCEANO Hydrographic Survey Launches for increased accuracy and coverage of underwater coastal bottom features. The improvements are presently concentrated in two areas: addition of sector scan sonar capability for obstacle avoidance, delineation of shapes of navigation hazards, and quantitative depth measurements between sounding lines; and the integration of Global Positioning System (GPS) navigation capability.

The addition of sector scan sonar (see Figure 11) will permit azimuth-scan imaging of the coastal zone seafloor, hull-mounted sidescan sonar operation, and acquisition of data for between-track depth measurement. Interface equipment is being developed for integrating the sector scan sonar data with bathymetric and navigation data for later preparation of nautical charts. Adding the sector scan sonar (and its resultant data) will permit faster operation of the launches in shoal waters, wider track spacings without fear of missed features, and more efficient concentration of limited resources on detailed examination of underwater hazards.

The addition of GPS navigation capability (see Figure 12) to the survey launches will eliminate the need for advance geodetic surveys, for military support at shore navigation sites (as presently required), and for logistics support of those sites by helicopter; it will also result in better use of ship and launch time and produce sizable survey dollar savings to the Navy. Interface equipment will soon be developed for integrating the GPS data with sector scan sonar and bathymetric data collected by each launch, and will provide critical helmsman steering information for accurate bottom coverage.

Figure 11

Coastal Hydrographic Sonar (Sector Scan Sonar Improvement)

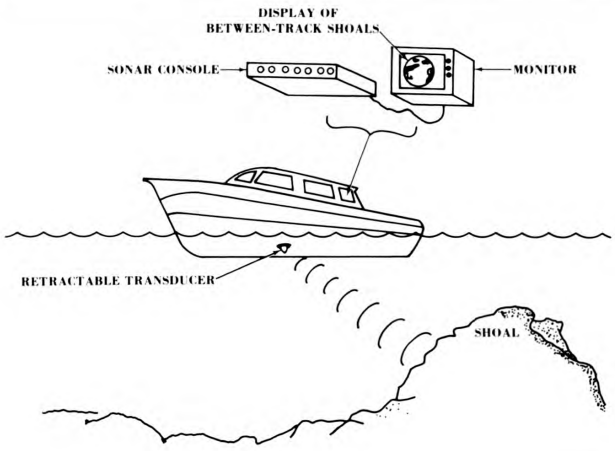
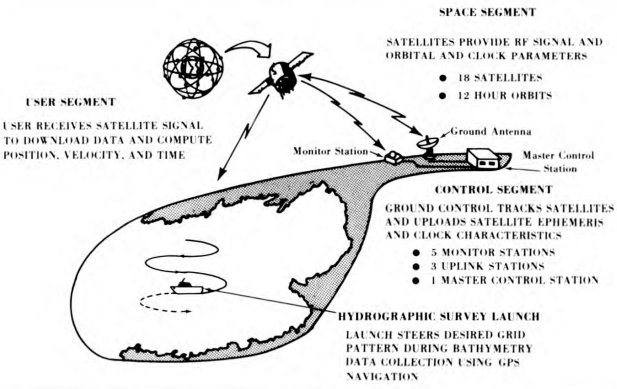


Figure 12

Coastal Hydrographic Sonar (Global Positioning System Improvement)



With these new tools, it is anticipated that the present survey launches of USNS CHAUVENET and USNS HARKNESS will increase nominal bottom coverage rate up to four times and deliver higher quality more complete data at the same time. The improvements are scheduled to be operational by 1988.

Deep Towed Seismic System

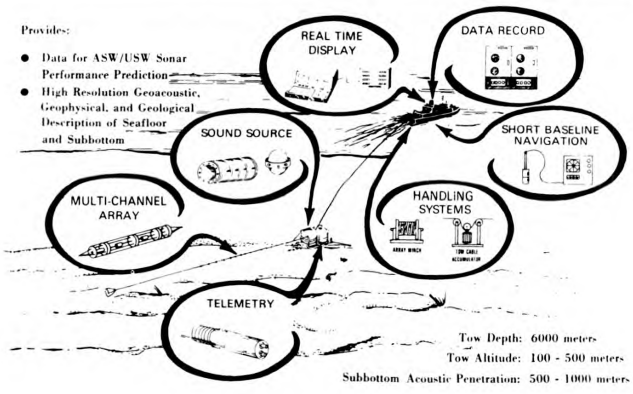
Within the past few months NORDA has completed development of the Deep-Towed Geophysical Array System (DTAGS), a major step forward in high-resolution measurement of the upper subbottom structure of seafloor sediments. The DTAGS system (see Figure 13) is towed at an altitude of 100 meters off the bottom in ocean depths of up to 6000 meters and yields a detailed acoustic "picture" of the first 500 meters of subbottom structure. DTAGS will increase measurement resolution by an order of magnitude over present surface-towed systems, and will substantially reduce the uncertainty in defining geoacoustic parameters.

The system hardware, which consists principally of a towed sound source and a long receiving array, is similar to present configurations used by the marine oil exploration community. The prime distinction is that the source and receivers are towed very near the bottom, thereby increasing the resolving power on the most critical sediment section for acoustic modeling (first 500 meters) and reducing the lateral footprint for improved feature horizontal definition.

DTAGS data will provide new foundations for improved quantitative geoacoustic models that can provide better estimates of acoustic propagation prediction in terms of compressional wave speed and attenuation. The DTAGS data will also provide better definition of the underlying geology and geophysical properties, which can be directly related to the variation in geoacoustic properties.

Figure 13

Deep-Towed Array Geophysical System Major Subsystems



Acknowledgments

The author would like to express his appreciation to the colleagues who participated in the technology developments and provided techical inputs for this article. In addition, we acknowledge the sponsor support from the Office of Naval Research, Office of Naval Technology, Naval Sea Systems and Naval Electronic System Commands, and the Oceanographer of the Navy.

About the Author

Clifford R. Holland worked as a civilian engineer at the Naval Coastal Systems Laboratory in Panama City, Florida for 12 years, before joining the staff of NORDA in 1977. He is presently Head of the Instrumentation Branch of NORDA's Ocean Technology Division, has authored more than 30 technical reports, journal articles and technical notes, and has received more than a dozen awards and commendations for his work during his career.

ADVANCES IN SHIP SCHEDULING

by Neal Glassman,
Office of Naval Research

Inflationary trends and rising energy costs encountered over the last decade have magnified the importance of problems in logistics management. Better logistics planning has become essential to compensate for the limited ability of technological innovation to hold down transportation costs.

New developments in mathematical optimization are greatly enhancing the scope and power of computer based approaches to logistics planning. Less than a decade ago, a far-sighted effort to apply the tools of computer analysis to logistics planning, in any but the most elementary way, was impractical because of the absence of data bases, effective solution methodology, and computer software for these types of planning problems. However, recent innovations in mathematical optimization and computer software design have brought about remarkable success in solving logistics problems of considerable complexity. The key element of many of these advances has been a series of technological breakthroughs in network and discrete optimization techniques that enable large and complex planning problems to be solved routinely and efficiently. The new procedures often require less than one-hundreth of the computer time and cost of methodologies previously applied. Simultaneously new advances in conceptualizing and formulating the fundamental decision models underlying logistics problems have greatly improved the usefulness of the solution results. These advances, used in concert, have shown that mathematical optimization is an extremely valuable tool for determining cost-saving insights.

In spite of these recent advances, a very small portion of this work has been devoted to routing and scheduling aspects of marine transportation problems. There are several reasons for this phenomenon including the degree of complexity, the difficulty in obtaining information that is considered proprietary or confidential, and the fact that most of the routing and scheduling experts in academia were either unaware of or uninterested in such problems.

The Military Sealift Command (MSC) is one of the principal naval activities that can benefit from an application of these techniques to a marine setting. In situations of emergency, MSC has the task of coordinating the movement of large numbers of cargoes by sea to provide contingency and mobilization sealift support to military forces in a given geographical area. The complexity of this task is such that no workable tools for solving the associated mathematical allocation problem satisfactorily have been developed.

A particular instance of the problem is faced by the Tanker Division of MSC. They have responsibility for a fleet of approximately 20 ships transporting bulk petroleum products worldwide. Scheduling this fleet is a demanding job that requires juggling a large number of variables in response to a dynamic environment. Moverover the collective economic impact of the many scheduling decisions that are required on a daily basis is enormous. A more detailed look is needed in order to appreciate the complexity of the problem.

The demand for movement of petroleum products arises at storage facilities in command areas submitting their petroleum products requirements to a Joint Petroleum Officer. The requirements are consolidated, prioritized, translated to tanker cargos and, eventually, submitted to the Military Sealift Command. The information provided to MSC includes product type, amount, when and where to load it and deliver it.

The planning horizon for this scheduling problem can cover a period of up to four months—the previous month, the current month, next month, and some preliminary data for one more month into the future. When the cargo information for a month is received, a scheduling effort is undertaken that extends the current schedule. The new schedule is adjusted on a day to day basis due to changes in cargo requests and contingencies such as bad weather.

Among the physical characteristics that must be considered when constructing a schedule are maximum transport weight, maximum speed, and minimum navigable water depth. If there are more cargoes to be lifted that can be assigned to Navy-controlled ships, some cargos will have to be assigned to spot charters. In order to make this assignment rationally, a number of costs must be considered: spot charter rate, port fees, cleaning costs, and marginal maintenance and repair costs resulting from using Navy controlled ships.

In order to construct a rigorously optimal schedule, one should consider all possible itineraries for each Navy ship simultanously. The enormous number of such joint itineraries makes this consideration impossible. Rather a simplification in the solution procedure is introduced here. A "schedule generator" is used to construct a menu of schedules for each ship. A schedule on

the menu defines a complete itinerary for a ship listing the ports entered during the time horizon, the time of entry at each port, and the quantities and types of fuels loaded and delivered at each port. The schedule generator excludes schedules which are impractical and are unlikely candidates for inclusion in a final optimal schedule, but includes a sufficient set of schedules so that potentially optimal schedules are not ignored.

Since the number of candiate schedules is limited by reasons of practicality and through physical constraints such as ship capacity and speed, port depth, and the necessity of meeting time-window constraints, the number of potential schedules from which an optimum routing plan are developed is small enough to be computationally tractable. The difficulty of this simplification is that the schedule generator must be subtle enough to eliminate impractical ship itineraries without eliminating those that are potentially optimal.

After generating a suitable menu of schedules an optimization algorithm must select one schedule for each ship so that the overall transportation plan has least cost. This cost not only includes the operating costs associated with the Navy's ships but the spot rate costs associated with loads which must be lifted by spot charters. This minimization is accomplished by selecting a set of ship schedules that maximize what might be called a profit function. A typical problem, involving twenty ships, 100 cargoes to be lifted and 5 cargoes per ship, will lead to an optimization problem with 120 constraint and 10,000 variables.

A more difficult problem also under study by the Military Sealift Command is the scheduling of cargo ships. In addition to the complexities discussed above, this more general problem is compounded by the possibility of multiple cargoes, many of which cannot go on the same ship, and complex ship-cargo compatibilities. With one ship able to carry over ten separate cargoes, able to pick up and deliver partial cargoes, and able to travel in convoys or separately, the computational complexity of this problem is an order of magnitude more difficult than that of tanker scheduling.

Preliminary tests indicate savings on the order of $1 million per month produced by optimal versus human scheduling in the peacetime environment just described. During wartime sealift, MSC will be responsible for over 200 ships and will not have enough experienced schedulers available to conduct the round-the-clock operations required. Efficient scheduling will be impossible without computer aid.

The Military Sealift Command faces only one aspect of deployment planning in a crisis environment. The Joint Deployment Agency, however, must plan for the effective use of all lift assets—planes, ships, trucks, trains, etc. The problem faced by JDA is one of mode selection. That is, they decide which cargoes will be lifted by sea, which by air, which by truck. As in many decisions, planning for logistics can be viewed as a hierarchy of decisions with each level requiring different techniques.

To understand the necessity for different techniques at each level of such hierarchical decision making situation, it is helpful to use the analogy of a zoom lens on a camera. As the field of view is increased, the level of discernable detail is decreased. As one zooms in on a particular area, the level of detail is increased, but only a part of the picture can be viewed at one time. Computer models can expand these limitations but cannot overcome them. In this case, the detail incorporated by the Military Sealift Command to plan tanker schedules would overwhelm the JDA perspective.

The dilemma facing the planner of mode selection is a circular one. The optimum application of lift capacity to the transportation network cannot take place until the routing and frequency of the movement requirements are known. On the other hand, the movement requirements cannot be optimally assigned to the transportation network until the capacity of the network is known. While in theory models can be developed to optimally address both sets of decisions at the same time, the complexity of such models would be prohibitive.

The solution, in this case, is an iterative scheme between these two complex models. First, movement requirements are assigned to the transportation network. Given these assignments, the movements are sequenced and time-phased so that network capacity is optimally used. Then, given the transportation schedule, movement requirements are optimally reassigned.This sequence continues until the system "closes" on a satisfactory combination of assignments and schedules.

The problem of deployment planning has been discussed at two levels: the topmost level, of mode selection, faced by the Joint Deployment Agency, and the more detailed level of route planning, faced by the Military Sealift Command. The Office of Naval Research is supporting the first attempts to apply the advances of the last decade in logistics planning to these areas. Although these two levels require different methods to obtain solutions, both require application of mathematical technology that was unavailable a few years ago.

About the Author

Dr. Neal Glassman is a scientific officer of the Mathematics Division of the Office of Naval Research. His publications have been primarily in the area of operations research. He is a member of the Operations Research Society of America and the Military Operations Research Society.

VISUAL PROGRAMMING

by Robert B. Grafton,
Office of Naval Research

Neither the term "visual programming" or the term "program visualization" really captures the spirit of a completely new way for programmers to interact with software and the programs they create. These terms do indicate that a new dimension can be added to software production, namely the ability to gain different insights and ways to deal with software through visual and graphical means. What is needed today to cut through the complexity of software are ways to clearly and concisely represent software in not only a static mode, but in a dynamic mode as well. Tools which give us the potential do just that are now in place. These are the powerful engineering workstations, small computers with high resolution, bit mapped screens. Input via mouse, touch pad, touch screen and keyboard as well as color make such tools easy to use for the non-programmer and programmer alike.

More and more people are convinced that visual programming offers new potential for positive changes in the way programmers create software, with resulting improvements in productivity of the software development community. This conviction comes from the realization that people tend to relate well to graphical representations. Indeed, some people work well with mathematical abstractions, but most people seem to generally develop some sort of graphical visualization of their software designs. The programming community has developed numerous techniques for graphically representing software. Some graphical techniques permit designers to describe specific data structures. Other graphical representations and abstractions are used to represent data flow in highly parallel architectures derived from the data flow and systolic array design methodologies. Perhaps graphical methods offer a more natural way to express algorithms, designs, data structures and control flows, than do specific language style statments.

Researchers are beginning to recognize three distinct, but related research areas that comprise visual programming. These are: (1) the use of graphics techniques to provide a new and useful view of software, (2) the development of graphics-based very high level programming languages, and (3) the animation of algorithms to deepen understanding of their behavior. Each of these will be described more fully through several programs funded by the Office of Naval Research.

Graphics Techniques

There are several different topics that could come under this heading. For example, it will be important to be able to isolate and store the essence of a program or software design. This would provide the basis for creating different views of the software tailored to the needs of different users. Certainly the views desired by a user, a manager, a novice maintainer, and a system analyst will be very different. The views will not be simple black and white pictures. Rather they will consist of a set of pictures and associated graphics carefully structured so that a person can navigate through them to gain a deeper understanding of the subject and desired information about the state of the software. The need will be to use color and dynamic representations to effectively present a complex mass of information to the viewer. An example of the work that will aid this effort is the graphics editing system developed by Professor Andy van Dam at Brown University. His system utilizes color, very high resolution graphics, and menu selection to give the user great flexibility in navigation through pages in a document. This kind of technique is being applied to the software development process. In another direction, one should be able to use graphics techniques to test, debug, and maintain software. Here animation can be particularly effective in guiding the user to bugs and logical inconsistencies in the software. The animation can be full or limited and ought to be coupled with as much automation as possible. A key idea here is that there needs to be an exact, formal correspondence between the icons depicting the software and the software itself. Then as the software is run, logical inconsistencies within the program can be shown up by highlighting or other techniques. An example of this approach is the automated debugging system, PEGASUS, which has been developed by Dr. Mark Moriconi at SRI International. Graphics techniques should have a very high payoff when used in a software environment which supports the whole software life cycle. In this paradigm, requirements, specifications, design decisions and the finished product would all be captured in graphical form and utilized by people who have to use or maintain the system or who have to find out about the system. Designs and design decisions would be contained in a kind of library, so that both maintainers and people doing designs for a similar subject could have an easy reference to past experience. There are certainly many more examples of the way computer graphical techniques can aid as us in getting new, comprehensive and easy to use views of software. Intriguing is the notion of software libraries kept in electronic form and presented to the browser in graphical form. It should be possible to keep whole programs, program templates, or program parameters in a library, show the information to the requestor in graphical form and permit the user to tailor software by filling in templates or parameters. Moreover, mechanisims based in appropriate logics and graphics should permit the user to create a system composed of software library pieces.

Graphical Programming

Within computer science research, there is a strong movement toward very high level programming languages. The potential of our current high level programming languages (Fortran, Algol, Ada, etc.) for increasing programmer productivity has nearly been exhausted. A new, more productive approach to the design and creation of software must involve languages and means of problem specification that dramatically increase our ability to express requirements to the computer. One approach is to create a language that is much closer to the technical language of the user. A different aspect is the creation of graphical programming languages, which will have icons and two dimensional objects as the symbols of the language. The goal here is to give a programmer or a user, the ability to perceive and manipulate an apparently real physical universe through the use of icons and symbols which can be naturally arranged on the screen. A graphical program is then an arrangement or sequence of arrangements of graphical symbols and icons in two (or possibly higher) dimensions. Since the arrangements thus created must be translated into instructions to the computer, there would have to be a precise mapping of the meanings of the symbols into a graph structure and then into efficient computer code. Alternatively, it may be possible to endow a compiler for such a language with inferential capabilities so that it can "reason" about the symbols and then map the result into machine code. There are many research questions which need to be addressed. One immediately comes up against the problem of developing an appropriate syntax and logic basis for a body of pictorial programming languages. In certain cases, it is possible to map directly into a high level language a very limited number of symbols (such as boxes with labels). Even though this approach may be very powerful, in that it may provide large increases in programmer productivity and program understandability, it does not exploit the power that is potentially available in a graphical language that is not tied to a conventional language. In a graphical programming language, it is necessary to provide clean but useful display abstractions for the programmer to use. There are deep questions about the kind of icons which are best to use for describing different situations. A small amount of work is being done on this subject. Dr. Robert Blazer at The Information Sciences Institute, University of Southern California, is doing research on an object oriented graphical programming system. Professor John Savage at Brown University has made graphical formalism for Milner's Calculus of Communicating Systems. The psychological aspect of visual programming is a research subject outside the experience of most computer science departments, but research groups now take this into account.

Algorithm Animation

The ability to see data flow and control structures of algorithms they execute will give software engineers and computer scientists a new ability to understand and "feel" the action of software. There have been several results in this area. Professor Tim Standish at the University of California at Irvine has used a color graphics system to highlight in red sections of code that have high activity. Thus important information about the program's operation is immediately available. At Brown University, Professor Robert Sedgewick has animated many different sorting and searching algorithms. An example from sorting illustrates his approach. The basic data representation for an unordered list is a cloud of dots in the Cartesian plane. Each dot represents an ordered pair (x,y) where the first coordinate is the place number of an item in a list, and the second is the position number in the sorted list. An element in its place has representation (x,x). Thus the ordered list is represented by dots on the 45 degree line. When a sorting algorithm is applied to the cloud of dots, a viewer can see how the algorithm sweeps through the cloud and obtain a radically different perspective on how the algorithm operates. Moreover, the computer can easily capture statistics on the performance and present these to the viewer as graphs and charts. Sedgewick has now found data representations for generic classes of algorithms. The challenge is to find representations for more complex data structures, such as those found in graph and statistics algorithms. These must convey a clear meaning to the viewer when the dynamics of the algorithm are shown within the data representation.

It appears that the software community is on the edge of a new paradigm for software production that will yield natural and easy to use methodologies for producing software. Moreover, the visual methods should significantly improve our ability to understand the actions and meaning of a given piece of software. However, deep research issues remain to be resolved before visual programming techniques are readily available to the software community. Amongst these issues are: how to manage the display of a large amount of information on a limited screen, finding software analysis techniques that can be used as automatic or semi-automatic tools by programers or others, and finding man-machine interface modes that are not only satisfying for many users, but also flexible and can be tuned to individuals user's needs.

About the Author

Dr. Robert Grafton is a scientific officer in the Computer Sciences Division of the Office of Naval Research, currently directing programs in software research and algorithms. His publications have been in the fields of computer sciences and mathematics.

PROLOG AND PARALLELISM:

The Inherently Sequential Nature of Unification

by David Mizell,
Office of Naval Research

Consider the problem of raising a value x to a large power, say, x^{2^k}, on a sequential computer that can perform a multiply in one execution cycle. This power of x can be computed on such a machine in k cycles by k squaring operations, one after the other. The interesting thing about this algorithm is that it cannot be sped up by using parallelism: n copies of the sequential machine cannot compute the same result any faster than the k steps it takes this single one. The proof goes as follows: no higher power of x than x^2 can be obtained in the first cycle, no higher power of x than x^4 can be obtained in the second cycle, etc. Such an algorithm is said to be *inherently sequential.*

The issue of the ability, or lack thereof, to solve computational problems significantly faster on parallel architectures than on sequential ones is currently of considerable interest among theoreticians who study the computational complexity of algorithms, because of its potential impact on the question of how generally applicable the highly parallel computer architectures now being proposed will turn out to be. Practical experience indicates that certain algorithms may be "unparallelizeable," since no way to speed them up by using parallel processors has ever been found. Ideally, future results from computational complexity theory would sharply define the boundaries, that is, mathematically characterize the spaces of inherently sequential and of feasibly parallelizeable problems. Note that these two classes of problems aren't necessarily all-inclusive; there are probably algorithms which can be sped up, but only at the cost of using an enormous number of processors, which is an exponential function of the size of the input.

Most existing results and ongoing research efforts in establishing the inherent sequentiality of computational problems rely on a relationship between the time and the space (i.e, the amount of memory) required by an algorithm, in terms of the size of its input. The logical reasoning based on this relationship can be informally described as follows: first, there is a class of problems whose solutions can be significantly sped up using parallelism. This class is referred to as NC (NC = "Nick's class," after its definer, Nicholas Pippenger). NC is a subset of the class P of problems that take polynomial time on a sequential machine ("polynomial time" means that the number of execution steps to perform the algorithm is a polynomial function of the size of the input). Second, it is almost universally believed that NC is a proper subset of P. Although no proof yet exists that NC ^{4} P, it would come as a great shock to complexity theorists to learn that the two classes coincide. Too many algorithms for problems in P have defied all attempts to parallelize them. Third, there is a class of problems in P such that if a problem in NC is also in this class, then NC = P. This is the class of *log-space complete* problems. Therefore, since everyone believes that NC ^{4} P even though it hasn't been formally proved, establishing that a problem is log-space complete amounts to declaring it to be unparallelizeable. This type of theoretical result has the practical effect of halting efforts to find a parallel implementation of the solution algorithm.

Log-space complete problems can be thought of as the "worst" consumers of memory of all problems in P, the polynomial time-complexity class. One of the simplest log-space complete problems is the "circuit value problem": given a Boolean circuit together with values for its inputs, find the value of the output. Problems are generally proved to be log-space complete by *reducibility* arguments; if problem B is complete and algorithms which solve A could easily be converted to solutions of B, then problem A is also complete.

Professor Paris C. Kanellakis and two of his students at Brown University (Prof. Kanellakis is supported by a contract jointly funded by DARPA and ONR Code 1133) reported a quite significant inherent sequentiality result in the June 1984 issue of the *Journal of Logic Programming.* They proved that the *unification* problem is log-space complete, by proving that the circuit value problem is reducible to unification. This is significant because unification is at the heart of the Prolog programming language. Prolog is currently the object of considerable interest because of its emphasis within Japan's Fifth Generation Computer System project.

Unification can be thought of as the search for a substitution of variables that will make two expressions identical. For example, the two expressions f(x,x) and f(g(y), g(g(z))) are unified by the substitution of g(g(z)) for x and g(z) for y. Prolog unifies logical expressions in order to establish that the truth of one implies the truth of the other. Unification is put to quite similar use in most automatic theorem provers.

At this time, computer scientists are divided on the subject of the implications of this result. One interpretation is that Prolog is the wrong programming language for parallel computers. According to current estimates, typical Prolog programs spend half of their execution time doing unification. Thus, even if the other half parallelized so well that its execution time dropped almost to zero, the best possible speedup of a Prolog system due to parallelism would be a factor of two. A second interpretation, more in favor with Prolog advocates, is that the inherent sequentiality of unification doesn't hurt because the parallelism will be found at higher levels in the Prolog system. Several different unifications could be run at once, each executed by a single processor of the parallel computer. Proponents of the first interpretation counter that dividing a Prolog program into many small unifications may not escape the inherent sequentiality result because executing a Prolog program may amount to one doing big unification even if it is divided up.

If the first interpretation turns out to be correct, the inevitable conclusion would be that the Japanese goal of massively parallel inference machines executing Prolog is inherently contradictory. They will either have to change the semantics of Prolog or choose another programming language. Most computer scientists would consider these two choices to be equivalent.

In any case, Kanellakis' result would not shatter all hopes for high-level, logic-oriented programming languages which parallelize well. There is an important subset of unification called *term matching,* for which efficient parallel implementations are known. Term matching can be thought of as "one-sided" unification: two expressions s and t match if a substitution of variables can be made in t that make the resulting expression identical to s. Term matching is used in several modern high-level languages, some of which are functional programming languages and some which are based on equational logic, but all of which have a semantics defined by *rewrite rules.* In these languages, the state of the executing program can be thought of as an expression E. A set of rewrite rules of the form L[R defines the set of possible "next states." If a term t of E matches some L, than E is rewritten with R replacing t. The computation terminates when E is reduced to a form in which no more rewrites of it are possible.

There has always been a tension between the wish to increase the expressive power of programming languages and the need to execute computer programs rapidly. It can be thought of as a conflict between efficiency at programming time and efficiency at execution time. The Kanellakis result illustrates that parallelism does not eliminate all problems of execution time efficiency. Rather, it increases by one the number of ways that a programming notation can be found to be execution-time inefficient. Applications, algorithms and languages will all have to be chosen with care, to insure that they exploit the potential execution speed of highly parallel computer architectures. I expect to see several such exciting research results in the rest of this decade which will shed light on just how to go about making these choices.

APPENDIX

WHAT PROLOG PROGRAMS LOOK LIKE:

Prolog statements are all of the form

$P :- C_1, C_2, C_3, \ldots, C_n$

which can be interpreted to read "If C_1 and C_2 and . . . and C_n are all true, then P is true."

EXAMPLE:

```
GRANDFATHER (X,Z) :-
FATHER(X,Y),PARENT(Y,Z)
```

Note: The above statement defines what a grandfather is: "if X is the father of Y and Y is a parent of Z, then X is the grandfather of Z."

```
PARENT(X,Y) :- FATHER(X,Y)
PARENT(X,Y) :- MOTHER(X,Y)
```

Note: There are two different conditions which can make one a parent. Separate Prolog statements with the same left-hand side can be thought of as having their right-hand sides connected by an "or."

```
SIBLING(Y,W) :- FATHER (X,Y),
                MOTHER(Z,Y),
                FATHER(X,W),
                MOTHER(Z,W),
                NOT-EQUAL(Y,W)
```

Notice a sort of expressive weakness of Prolong illustrated by the above statement. One would like to state the definition of SIBLING as an equivalence. That is, while the above statement says that two different people with the same parents are siblings, we know that the converse is also true: siblings are two different people with the same parents.

However, to express the converse in Prolog is awkward. It requires at least two more statements and additional control information to prevent the search for solutions becoming caught in an infinite loop.

FIRST-COUSIN(Y,Z) :- PARENT(X,Y),
SIBLING(X,W),PARENT(W,Z)
"Two people are first cousins if their parents are siblings."

FATHER(JOHN,JOE) :-
MOTHER(MARTHA,JOE) :-
FATHER(JOHN,JANE) :-
MOTHER(MARTHA,JANE) :-
FATHER(JOE,BILL) :-
FATHER(JOE,RALPH) :-
MOTHER(JANE,DAN) :-

Note: A Prolog statement with an empty right-hand side is interpreted as having a left-hand side that is always true. Such statements can be thought of as representing "facts." For example, the last statement above expresses "Jane is the mother of Dan."

A Prolog program can be thought of as the collection of facts and inference rules which make up a knowledge base, and the execution of Prolog programs consisting of the answering of queries of the knowledge base. For example, the query

GRANDFATHER(JOHN,BILL)?

would get the response

TRUE

from the Prolog system. The query

FIRST-COUSIN(DAN,X)?

would get the response

BILL
RALPH

—all of the correct solutions of the query. Note that unification would be used to find solutions to each query.

WHAT FUNCTIONAL PROGRAMMING LANGUAGES LOOK LIKE:

A simple example—a function which computes N factorial:

Fact (N)[*if* N = O *then* 1
else N * FACT (N-1)

Each statement in this language defines a rewrite rule. Statements are of the form x[y, which can be interpreted as "x can be rewritten as y." The successive rewrites of a call to this function with the parameter 5 would look as follows:

FACT (5)
5* FACT (4)
5*4* FACT (3)
5*4*3* FACT (2)
5*4*3*2* FACT (1)
5*4*3*2*1* FACT (0)
5*4*3*2*1*1
120

Note that the system would be expected to contain primitive-level rewrite rules for evaluating basic functions like * and +.

About the Author

Dr. David Mizell is a scientific officer at the Pasadena Detatchment of the Office of Naval Research where he oversees research in computer architecture, distributed processing, and a special program in parallel algorithms and software. His publications have been in the area of parallel computing. Mizell is a member of the Institute of Electrical and Electronic Engineer's Computer Society.

Research Notes

Polymer Microdevice Laboratory Established

With ONR and DARPA support, a new Polymer Microdevice Laboratory with "super-clean" rooms has been established at Case Western Reserve University in Cleveland, Ohio. The Director of the Laboratory is Scott E. Rickert, Professor of Macromolecular Science at the Case Institute of Technology. Primary emphasis in the new facility will be placed on the fabrication of submicron thickness polymer films by the Langmuir-Blodgett technique. The concept is well-known: it consists of spreading a monomolecular layer of some substance on a liquid, compressing it to orient the film and picking it up on a solid substrate by a dipping method. Repeated dips will produce multilayer films. With appropriate functional groups in the multilayer molecules, reactions can be initiated to produce "molecularly engineered" polymer films having novel electronic, optical, or dielectric properties. The short-term goal of the laboratory is to demonstrate that submicron film devices can be reliably produced with properties equal or surpassing those of conventional silicon-based semiconductors.

Thirty-First Power Sources Symposium

The 31st Power Sources Symposium, sponsored by the U.S. Army ERADCOM, was held in Cherry Hill, New Jersey last summer. Topics covered by the symposium included both batteries and fuel cells. The sessions on batteries were divided into groups covering rechargeable and nonrechargeable types with lithium batteries accounting for about 60% of the papers and attendance in each group. Included among the papers presented were discussions by Duracell of their rechargeable lithium battery based on a sulfur dioxide electrolyte (this system uses a lithium tetrachloroaluminate electrolyte salt and a cupric chloride cathode); a presentation by Dr. Alan Hooper, A.E.R.E. Harewell, on the lithium/poly-(ethylene oxide)/vanadium oxide solid state battery developed jointly in an Anglo-Danish program; and a report by Moli Energy on the safety aspects of their rechargeable lithium battery. General impressions derived from the symposium are: lithium batteries are beginning to dominate the thinking and efforts of the R&D community, safety issues are gradually being solved, lithium-thiony chloride technology appears to be replacing lithium-sulfur dioxide as the primary system of choice; and the activity in the rechargeable lithium battery field is increasing rapidly.

ONR Supported Research Featured in *Information Display*

The research of Dr. Margie M. Nicholson, Rockwell International Science Center, on electrochromism in rare earth diphthalocyanines is the subject of the feature article in the February issue of *Information Display*, the journal of the Society for Information Display. Dr. Nicholson's research has produced a multicolor electrochromic system which is being investigated in exploratory development this year for its potential in multicolor falt-panel displays for Navy use.

Meadow Brook Conference on Conducting Polymers

A workshop on the future role of conducting polymers in electrochemistry and related applications was held at Meadow Brook Hall on the campus of Oakland University, Rochester, Michigan during the summer 1984. This workshop was cosponsored by the Chemistry Division of the Office of Naval Research and the Department of Energy. The objective of the workshop was to convene those scientists presently involved in research on polymers and their potential applications in electrochemical, electronic and battery applications for the purpose of assessing the present state of the field, the potential applicability of polymers to these areas and the research issues which must be addressed before these applications can be developed. Approximately forty scientists were invited to participate. These participants represented groups from the U.S., U.K., France, Canada and Italy. The major topics for discussion were polymers as electrode materials, polymeric electrolytes and fundamental studies of conducting polymers. Informal, ad hoc discussion groups were formed on each of these topics. The groups discussed the respective topics, provided an overview of the findings at the final session of the workshop and will provide the results of the discussions for inclusion in the final report. This report is expected to be a valuable resource document for use in planning future research in electroactive polymers.

Growth of Metastable Metal Films

A new concept for growing non-equilibrium phase metal films has emerged from research on the formation of metal-semiconductor thin film structures by Dr. Gary Prinz and his collaborators at the Naval Research Laboratory (NRL). Earlier it was demonstrated that epitaxial iron (Fe) films could be grown on a GaAs substrate despite a 1.35 percent lattice mismatch, where the bcc phase of Fe was formed. The question came up could the substrate be used to stabilize a nonequilibrium structure for other metal films? In particular, could the bcc structure for Cobalt (Co) be formed as a metastable structure when its stable structure is the hexagonal close packed (hcp) phase. The concept has now been proven valid. For thin films up to 357 Angstroms thick, the metastable bcc phase of Co has been prepared by molecular beam epitaxy growth on a GaAs (110) surface. For greater thicknesses, the structure changes, and x-ray diffraction indicates the presence of both cubic and hexagonal phases. This thickness dependence on epi-layer properties is a feature common to many material systems.

Experimental measurements indicate that the magnetization of the bcc cobalt varies depending upon orientation of the crystal principal axes relative to the direction of the magnetic field, the [011] is the "hard" axis. For Fe the bcc alpha phase, it is the [111] axis which is "hard."

Several important aspects of thin films emerge from these experiments. As mentioned above there is the concept of using a semiconductor substrate to stabilize (force) metastable metal film phases to form. Since ferromagnetic properties are directly related to the phase of the crystal structure, this opportunity to prepare metastable phase, single crystal materials will open new studies on magnetism and other metal systems. In addition, artificially synthesized material phases can be conceived and prepared, for instance, multilayer systems with novel properties, magnetic or otherwise.

This last idea has recently been used to prepare a novel magnetic material which has *three* stable states in its magnetization curve, whereas normal magnetic materials have only two-i.e. two directions of the magnetization direction. The new material is formed by growing films in the following order: GaAs, Fe, Ag, Fe:Ag (Ag is silver). The magnetization curve indicates three states, two are the usual ones with two oppositely directed magnetization vectors, and third is a state of *zero* magnetization. This gives rise to ideas involving three level memory states which may find uses in data storage and logic operations of new types.

(Larry Cooper, ONR)

Breakthrough In Theory of Distributed Computing

Professor Jay Misra and his longtime collaborator Professor K.M. Chandy, Office of Naval Research contractors at the University of Texas at Austin, have come up with an abstract mathematical model of a set of distributed processes communicating with each other by passing messages. In this model, a distributed computation is represented by a sequence of events, where each event is an action that can be taken by a single process: sending a message, receiving a message, or making some internal change of its state. Parallelism is represented by the fact that distributed computations can be arbitrary interleavings of sequences of events from each of several processes. The innovation in their model is the introduction of a notion of isomorphism between computations: computations x and y are isomorphic with respect to process p (written x[p]y) if the substring of events from p that they contain are identical. Isomorphism generalizes to sets of processes, as well as to characterizing indirect relationships between computations by compositions of isomorphisms. The significance of the Chandy-Misra model is that it allows succinct, algebraic proofs of important properties of distributed systems, while previous models had either not yielded proofs at all or required long, complex ones. For example, Misra and Chandy give a five-line proof of the "impossibility of detection of process failure" theorem, whose original proof took several pages. Lower bounds on the number of messages necessary for mutual exclusion and termination detection are established with similarly brief proofs. With this powerful new formalism, proofs of various properties of distributed systems should be easier to obtain as well as more convincing.

(David W. Mizell, ONR)

Novel Approach to Design of Oral Vaccines Developed

Dr. John Clements at the Tulane University Medical Center with Office of Naval Research funding has demonstrated the feasibility of a novel method for targeting vaccines to the gastrointestinal tract. It has long been recognized that the immune system which protects mucosal surfaces such as the respiratory and gastrointestinal tracts is fairly independent of the immune system expressed via the blood; indeed, antibody molecules in the two systems are structurally quite different. The functional consequences of this dichotomy is that conventional immunization under the skin leads to good antibody responses in the blood but not at the mucosal surfaces. A commonly used vaccine aganinst cholera often fails to protect because of this phenomenon since the cholera bacterium can only be immunologically attacked within the intestinal lumen. Dr. Clements is a bacteriologist who has studied the molecular aspects of another diarrheal disease organism, toxigenic *E. coli*. One of the toxins of this organism, the heat-labile enterotoxin, bears a close resemblance to cholera toxin in that the protein consists of two sub-units, one that is responsible for its toxic activity, and one that binds it to cells in the intestinal wall via a ganglioside (glycolipid) on the surface of intestinal mucosal cells. Dr. Clements has cloned the gene for this ganglioside-binding peptide (called LT-B) and expressed it in a non-toxigenic *E. coli* commonly used for protein production. He then linked test antigens to the LT-B peptide and administered the complexes by mouth to mice. Such an immunization procedure resulted in vigorous intestinal antibody production to these antigens regardless of the size and intrinsic immunogenicity of the antigen, presumably because the antigens were "delivered" properly to intestinal immune system structures. Continuing work is examining the ability to use the LT-B peptide as a carrier for viral protein antigens and to determine if it will enhance immunity in the respiratory tree, where the same ganglioside is found. This method for immunization is reasonably economical and offers a solution to effective immunization against pathogens such as cholera and influenza which are highly significant in military and civilian populations.

(J. A. Majde, ONR)

Mysterious Bacterium Yields a Promising New Immunological Adjuvant

In the mid-seventies, a cell culture system was devised that permitted initiation of the immune response to certain antigens *in vitro;* it is termed the Mishell-Dutton system after its developers and is still actively used to investigate events occurring early in the immune response. It was observed early on that only certain lots of fetal calf serum could support the Mishell-Dutton assay, and Dr. Robert Mishell actively investigated the nature of the driving force. He subsequently found in 1983 that the active lots of fetal calf serum were contaminated with a gliding bacterial species (*Cytophaga sps.*) that passes most "sterilizing" filters and grows at refrigerator temperatures where sera are characteristically stored. Chemical analysis revealed that the polysaccharide slime from these bacteria is very active in stimulating the immune response, and Drs. Robert Mishell and William Usinger at the University of California, Berkely, undertook to determine if it could serve as an immunological adjuvant *in vivo,* that is, potentiate immune responses to vaccines. Purification and characterization of the polysaccharide have progressed rapidly, and preliminary tests in mice and primates suggest that it has great potential to drive antibody formation *in vivo*. While considerable work remains to be done before human trials are conducted, the project is an interesting example of making something good out of what most people would discard in disgust.

(J. A. Majde, ONR)

New Tunable Far Infrared Laser

The Office of Naval Research has been funding the University of California at Santa Barbara since 1980 to do basic research on Free Electron Lasers (FEL) using an electrostatic accelerator as the electron beam source. The objective of this effort is to demonstrate a two-step process. In the two-step process, intense radiation would be generated at far infrared wavelengths and this radiation would in turn be scattered from the electron beam to produce the short wavelength radiation.

UCSB succeeded in operating the first step of this process using an accelerator voltage of 2.94 MeV and beam current of 1.3 amperes with simultaneous recovery of the electron beam in August 1984. Output radiation was at a wave-length of 400-microns with a band witdth of one micron. Pulse width was up to 35-microseconds with a peak power of about 10 KW. The pulse length is limited by the efficiency of electron beam recovery. In these experiments a recovery efficiency of as much as 96 percent was obtained. The device is normally operated at a few pulses per second although it is capable of operating at considerably higher repetition rates. FEL startup time was observed to be about 4-microseconds. An untapered linearly polarized rare earth samarium-cobalt permanent magnet wiggler with 160 periods was used for these experiments.

The accelerator has now been upgraded to operate at up to 6 MeV. Experiments were done with an accelerator voltage of 5.5 MeV and beam current of 1.1 amperes yielding FEL emission at about 130 microns. Output energy has not yet been measured precisely, however, it is estimated that average power during the pulse was about 20 KW. Further experiments will be carried out to characterize laser performance under these operating conditions and then a new high current e-gun and electron beam line will be installed in preparation for the two-stage experiments which should get underway by the end of the calendar year.

Scientists at UCSB plan to use the far infrared output radiation to study fundamental problems in physics, chemistry, and biology. The UCSB device constitutes a breakthrough in the far infrared. No other device is capable of producing the power and tunable wavelength range of this device.

(R. E. Behringer, ONR)

Contractor's Research Featured in *The Economist*

Dr. Gary Lynch, University of California, Irvine, is the subject of a two-page article in The British international journal, *The Economist*. Dr. Lynch's work, supported in part by ONR, has led to a theory of memory which suggests that as an organism learns, the structure and number of its synapses change. When electrical impulses are passed rapidly through cells in a rat's hippocampus (part of the brain), those cells subsequently produce much stronger responses in the neurones to which they are connected. Like memory, this increase in the efficiency of communication lasts for weeks. Dr. Lynch finds that this change is associated with the appearance of more numerous links between the cells and with the appearance of synapses with an unusual, characteristically rounded shape. The Irvine scientists have become intrigued by the effect of a substance called leupeptin, which interferes with a rat's ability to navigate a maze. Leupeptin prevents a particular protein called fodrin from degrading. Fodrin forms a meshwork that is part of the scaffolding of nerve cells. But why should the degradation of fodrin help learning? The answer may be that fodrin also regulates post-synaptic receptors for a certain neurotransmitter called glutamate; fodrin can be degraded by an enzyme called calpain, which in turn is activated by calcium. What Dr. Lynch hypothesizes in learning is this: when a synapse is used, calcium enters the post-synaptic cell; if the synapse is used frequently, the calcium builds up to a level that switches on calpain. Calpain damages the fodrin meshwork, altering the shape of the cell and opening new glutamate receptors.

(J. L. Davis, ONR)

Forty Years of Excellence

1946
to
1986

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
ARLINGTON, VA. 22217

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

THIRD-CLASS MAIL
POSTAGE & FEES PAID
USN
PERMIT No. GS-9