

-the **SCIENCE RECORD**

Communications from the College of Science, Oregon State University



6-34A

fall
80



Charles L. Rosenfeld

St. Helens: A Natural Laboratory

The Science Record
College of Science
Oregon State University
97331

Volume 8, Number 1

THERAN D. PARSONS, Acting Dean
EVA M. MILLEMANN, Editor

CONTENTS

- 2 **Charles L. Rosenfeld**
Mount St. Helens: A Natural Laboratory
- 5 *Distinguished Professor Award*
- 5 *New Chairman in Computer Science*
- 6 **Edward H. Piepmeier**
Laser Microprobes and Chemical Analysis
- 8 *News and Notes*
- 9 *Carter Awards*
- 10 *Professor Goheen Retires*
- 12 *The Budget of the College of Science, 1979-80*

Cover

This photo, taken by Charles Rosenfeld on May 30, provides a view of Mount St. Helens' new crater as seen from the northwest shore of Spirit Lake. The Oregon National Guard helicopter in the foreground was used during a ground verification survey by Dr. Rosenfeld. The large blocks of dacite rock visible behind the helicopter were carried by a debris flow blasted 10 km north from the crater breach of Mount St. Helens. (Article photos by Charles L. Rosenfeld)

Charles Rosenfeld flips a switch, and a photographic negative suddenly flooded with light turns into a colorful map where blues, yellows, reds, and browns intermix. The film is a thermal infrared image taken with special equipment available on National Guard aerial surveillance planes.

Thermal imaging is an advanced technique for "seeing" objects through darkness, fog, or smoke by picking up the heat radiated and translating it into a picture. Dr. Rosenfeld points out that the map shows part of the Toutle River mudflow on the north side of Mount St. Helens and the drainage basin around it. The imagery gives an idea of how drainage patterns are being rechanneled through the mudflow—one of several things he is now investigating.

Rosenfeld, an OSU geographer specializing in landforms, has been busy since Mount St. Helens erupted last spring causing unexpected destruction. The eruption not only pulverized a cubic mile of earth over the landscape; it also catapulted Rosenfeld, and a few other Oregon and Washington scientists, into sudden notoriety.

As a reserve captain in the National Guard, Dr. Rosenfeld had already become familiar with Mount St. Helens and surrounding areas by flying many reconnaissance missions in the Cascades over the past five years. He happened to be on duty the weekend of May 18 and was thus in a position to reach the mountain within an hour of that first big eruption. His role in helping rescue missions after the explosion is well known, and much about it has already appeared in print. In recent months, he has been in demand as an author and a speaker. He has written several articles, including a keynote article for the September 1980 issue of *American Scientist*, and as of this writing (mid-September) he has given over fifty talks to various groups. In these roles, he has attempted to avoid media sensationalism and to inform the public objectively about what really happened and how it happened.

Less has been said, however, about Rosenfeld's primary scientific interest, his early involvement (since 1975) in monitoring studies of the Cascades volcanoes, and his continued efforts since the eruptions to observe and perhaps predict how the land will recover from such a catastrophic impact.

Dr. Rosenfeld is a geomorphologist who has been interested in the study of landforms since he was an undergraduate at the University of Pittsburgh. He has pursued his investigations in many remote areas—from the permanently frozen terrain of the Canadian Northwest Territory and Alaska to the arid desert areas of South America. He has had extensive training in the interpretation of remote sensing data, and his preparation as a scientist includes study at the geomorphology center of the University of Caen (Normandy) in France, where he completed work for his master's degree before returning to the University of Pittsburgh for a doctorate. He calls the Caen center "perhaps the finest geomorphology laboratory in the world, where scientists from many different countries work side by side." Dr. Rosenfeld joined the Department of Geography at OSU in 1974, after spending a brief period on the faculty of Brock University in Ontario, Canada.

Shortly after his arrival at OSU, Rosenfeld began flying National Guard reconnaissance missions in the Cascades as part of a monitoring study carried out in cooperation with the U.S. Geological Survey. The project was designed to observe heat output of the Cascades volcanoes.

"At that time, Mount Baker had begun to show signs of heating," says Rosenfeld. "The research entailed utilization of thermal infrared scanners to locate 'hot spots' in all the volcanoes—Mt. Baker, Mt. Rainier, Mt. St. Helens, Mt. Adams, Mt. Hood, Mt. Shasta, and Mt. Lassen." In monitoring changes in heat output since 1975, scientists were able to detect warming trends on Mt. Rainier, variable warming and cooling pulses on Mt. Hood, but very little activity on Mt. St. Helens until March 27 of this year.



Strangely, that was the first new "hot spot" observed on the mountain since 1975. It is difficult to say why.

"The thermal infrared studies at first were random samplings," explains Dr. Rosenfeld, "and could not produce very profound data. The project was more an alert system than anything else. It continued for five years without making headlines, but science seldom does. However, those early studies proved extremely valuable when St. Helens erupted because many of the techniques developed in those five years were used successfully by geologists to produce probably the best photographic and remote sensing coverage of a volcano in action."

A look around Rosenfeld's office is convincing enough. Boxes of photographs and reels of radar imagery are stacked everywhere waiting to be sorted and catalogued—that in itself a time-consuming project. "We acquired some of this imagery," he says, "by using radar to pierce through the erupting plume and to see where the eruption was coming from within the crater. Sometimes we came as close as half a kilometer from the crater's edge, under the mushroom cloud, using the infrared imagery and radar to see what was happening inside."

Dr. Rosenfeld stresses that continued monitoring efforts after the March activity permitted accurate prediction of an imminent eruption (the one on May 18) and its probable direction path. "We have learned a lot since then," he adds. "We know that a combination of things gives us advance warning. Increased seismic activity is followed by thermal changes. We learn much from aerial photography combined with radar, which allows us to analyze structural fractures and faults within the mountain. Also the constant inflation of the mountain dome on the north-east flank (at a rate of 1.5 m per day) was another indicative factor in that first eruption. We knew something big was going to happen, but we were not entirely prepared for the *magnitude* of the explosion."

Since the May 18 eruption, Rosenfeld has been busy monitoring St. Helens, summarizing and interpreting remote sensing data for other agencies like the U.S. Geological Survey and the U.S. Forest Service. This work involves several overhead flights per week to collect data and also ground verification trips. At this point, most of the flying is done by National Guard crews with Dr. Rosenfeld writing mission portfolios and giving occasional briefings. The agencies, however, are utilizing his interpreting expertise and not his primary areas of interest.



Charles Rosenfeld points to a color-coded thermal image enhanced on the display screen of the digital image processor in the OSU Geography Department. Equipment in the imagery analysis laboratory enables the quick production of maps, critical to the study of this rapidly changing landscape. (Photo by E. Obert)



North Toutle River debris flow, caused by the May 18 eruption, consists of 2-3 km³ of material blasted from the north flank of Mount St. Helens. The flow fills the valley to depths exceeding 100 m and extends 18 km to the west of the mountain.



Vertical view of the July 22 explosive eruption shows the circular vent at the bottom of the crater, nearly 1 km below the rim at right.



View of the August 7 eruption from the southwest includes mudflows in the foreground and devastated blast area behind the mountain.

Even though Dr. Rosenfeld has been awed like everyone else by what he has seen and watched very closely on St. Helens, he is intrigued by the chance of observing and possibly predicting how a new erosional equilibrium will come about. Even earlier, before the eruptions, he had sought to understand the indirect effects of volcanic activities on the Cascades. For instance, in 1975 he was monitoring the moisture in a large block of ash on the east side of the crater on Mount Baker to see if the melt-water could create a mudflow.

Observations of what happens in the impacted areas around St. Helens are especially important because they might help formulate a model of how erosional processes develop. Will an erosional

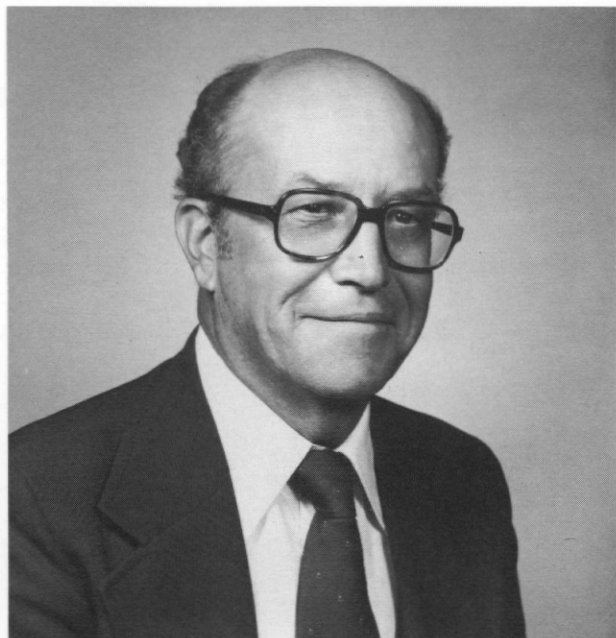
balance be reestablished by catastrophic landslides or by more gradual runoff from rainfall?

Presently, Rosenfeld is monitoring hydrologic changes in the area by observing the surface of the mudflows produced by the eruption to see how water collects in the low depressions and how it infiltrates into the mudflow itself. He is also examining how the surface drainage channels develop, as well as trying to infer some rate of subsurface movement of water. On the east side of the mountain, he is watching several representative drainage basins that have been impacted by ash. Observations are made by a combination of aerial photography taken at low-level

and ground verification trips, with photos compared at two-week intervals to determine how changes occur. During the winter, when cloud cover interferes, he must rely more on radar and thermal imagery.

As a student of landforms, Charles Rosenfeld has been given a golden opportunity—a “natural” laboratory less than 150 miles from his office. Hillslopes and drainage basins have been changed instantaneously by an act of nature. He can now observe how they recover and perhaps formulate helpful recommendations for those people who must decide about reestablishing roads, salvaging timber, managing forests and fish habitats.

Distinguished Professor Award



Robert R. Becker

Robert R. Becker, professor of biochemistry and chairman of the Biology Program, was especially honored on Faculty Day, September 22, by receiving one of two 1980 Elizabeth P. Ritchie Distinguished Professor Awards given this year.

The award, which was established to encourage excellence in undergraduate teaching and advising, is given each year to one or two faculty members selected from those nominated by a student-faculty committee.

Dr. Becker received a B.S. in chemistry from the University of North Dakota and an M.S. and Ph.D. in biochemistry from the University of Wisconsin. He came to OSU in 1962 after teaching at Columbia University for eight years and pursuing research at Oak Ridge National Laboratory, Tennessee, for two years. His primary scientific interest is the study of protein structures, and his research projects involve him in many collaborative efforts with other departments at OSU and with other institutions.

His outstanding qualities as a teacher were recognized as early as 1967 when he won the College of Science Carter Award. During his tenure at OSU he has been very active in university committees, organizations, and in the Faculty Senate, where he served as vice-chairman in 1973. He has also served on NSF panels for programs in Undergraduate Research Participation, Scientific Equipment, Student-Originated Studies, and Postdoctoral Fellowships. He was a member of the Pathobiological Chemistry Study Section of the NIH (1974-77) and is currently on their Biomedical Sciences Fellowship Review Group.

In 1978, Dr. Becker assumed the role of chairman and chief adviser of the Biology Program. With the support of faculty members from the biological sciences, he has been responsible for staffing, developing, updating, and modifying the courses offered in the program. More than 250 biology majors rely on his guidance for their academic progress.

In spite of his demanding schedule, Dr. Becker maintains a special relationship with his students, which is best summed up in the words of the award citation: "Bob Becker is noted for the challenging standards he sets for himself and his students, but the demanding rigor of his teaching is mixed with enthusiasm and humor."

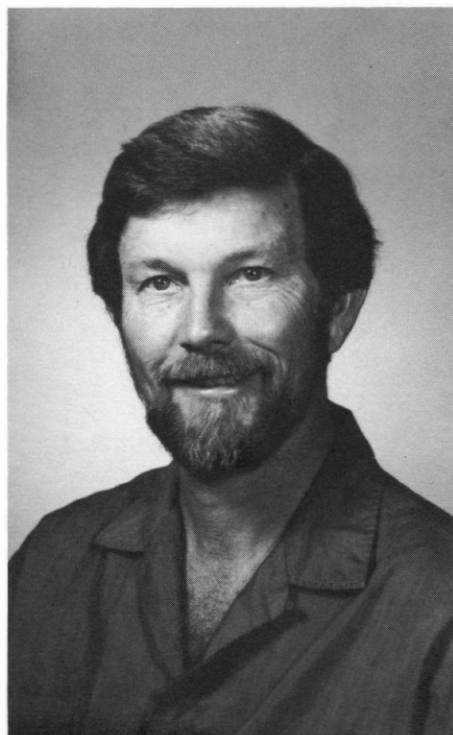
Fred M. Tonge

New Chairman in the Department of Computer Science

Fred M. Tonge is the new chairman of the Department of Computer Science. Dr. Tonge, who assumed his new position on September 1, comes to OSU from the University of California at Irvine, where he has been professor of Information and Computer Science since 1964. He held the position of chairman in that department from 1970 to 1971 and from 1974 to 1977. He was director of computer facilities at the same institution from 1964 to 1967 and was also a faculty member in the Graduate School of Administration.

Dr. Tonge has an undergraduate degree in industrial management and a doctorate in industrial administration

from the Carnegie Institute of Technology. He has had extensive experience in industry, having worked for or collaborated closely with Westinghouse Electric Corporation, National Cash Registers, the Rand Corporation, Burroughs Corporation, Crucible Steel, and others. He belongs to the Association for Computer Machinery and the Institute of Management Sciences. Recognitions and awards include the Ford Foundation Doctoral Dissertation Award, service as an ACM Lecturer, and the Department of Air Force Decoration for Exceptional Civilian Service received for his consulting services to the U.S. Air Force.



Edward H. Piepmeier

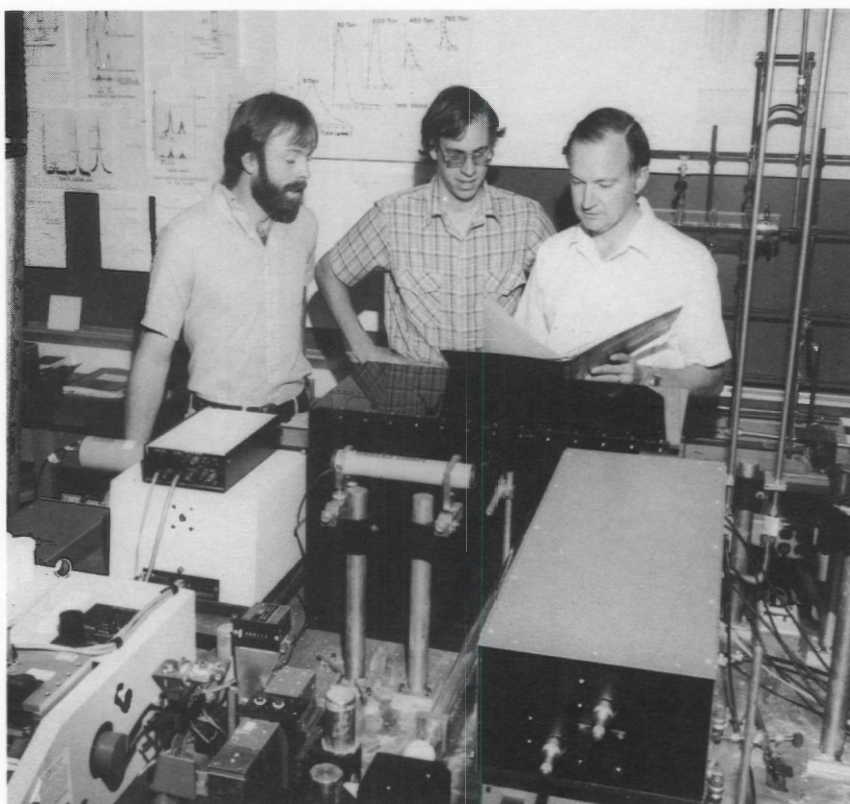
Laser Microprobes and Chemical Analysis

Since the first ruby laser was built in the early sixties, lasers and their potential uses have captured the public's imagination, partly through the prolific efforts of science fiction writers who have created countless versions of laser applications. In real life, although their vast potential is still being tapped, lasers have already created totally new and useful technologies in such varied fields as construction, medicine, cartography, industry, art, and even law.

For example, surgeons today can reach areas of the eye and the brain that were previously inaccessible by conventional methods. Special techniques have been developed that allow scientists to focus laser beams to spots only one tenth of a millimeter in diameter. These same techniques have been applied successfully in biology to analyze tissues and even to probe single cells. Artists began experimenting with laser engraving techniques almost as soon as the laser was built in the early sixties. Laser microprobes are ideal for such diverse uses as the analysis of precious archeological findings and old paintings of great value. For instance, successive layers of paint can be tested without damage to the artwork, either to help restore it to its original state or in some cases to prove fraud. Lasers have even been used to determine the validity of evidence in the courtroom. They have been very important in numerous industrial applications from welding to chemical analysis.

Edward Piepmeier, a professor of chemistry at OSU, has been interested in lasers and their possible applications in chemical analysis since the early sixties when he began graduate work at the University of Illinois. As an analytical chemist with a solid background in science engineering, Dr. Piepmeier uses laser beams to devise new ways of analyzing chemical samples to help solve problems encountered by people in many walks of life. He is especially interested in obtaining fundamental knowledge about methods of trace element analysis to improve the accuracy of these methods and to provide a solid foundation on which others may base their selection of a particular analytical method.

The laser microprobe technique used by Dr. Piepmeier has two distinct advantages that make it particularly desirable in specific applications. First, it is essentially non-destructive for samples of ordinary size since less than a



Dr. Piepmeier (right) discusses with students Arnold Lewis (left) and Gerhard Beenen the best parameters for their laser microprobe experiment. The two lasers appear in the foreground, while the microprobe chamber is in the background in a dust-free, black plexiglass enclosure.

microgram of the sample tested is vaporized; and secondly, it provides a very rapid method of analysis.

"Such rapid analysis," says Piepmeier, "is highly suited for refractory materials whose accurate analysis ordinarily requires a lengthy dissolution process. The composition of many materials used in energy conversion systems needs to be controlled within known tolerances if those materials are to withstand very high temperatures. In such industrial applications the laser microprobe can provide an invaluable tool for quality control and trouble shooting because of its rapidity. The microscopic nature of the laser microprobe can help in the identification of foreign inclusions in alloys, which must be eliminated if the alloys are to perform the task for which they were designed."

Chemical elements, their oxides and alloys, now being studied by Dr. Piepmeier and his research group include zirconium, hafnium, copper, aluminum, and iron. Zirconium and hafnium are important elements for this analytical method because they form two

of the most refractory oxides known. The other elements form less stable oxides whose chemical and physical characteristics are well known. "Rather than using the laser to analyze many different samples as might be done in an industrial situation," explains Piepmeier, "we have concentrated our efforts in designing experiments that help discover just what happens when a laser microprobe vaporizes a cloud of atoms. Studying well known chemical systems will help us understand how to proceed when we tackle new systems."

In Dr. Piepmeier's laboratory, lasers are currently being used for chemical analysis in two ways. A microprobe laser beam is used as a source of intense, coherent, radiant energy to vaporize instantaneously a small amount of a sample of matter to be analyzed; and a second laser is used as a source of tunable electromagnetic energy in the analysis of the resulting vapor plume.

In his experiments, Dr. Piepmeier focuses a pulsed dye laser beam on a very small area (0.3 mm in diameter) of a sample to be analyzed. On contact, the

beam creates a vapor plume that has a high concentration of atoms of the specific chemical elements present in the sample. These atoms absorb and emit light at specific electromagnetic frequencies. The atoms are then identified by their characteristic frequencies much like radio stations are identified on a radio dial by the specific electromagnetic frequencies at which they transmit. By measuring the amount of light absorbed or emitted by these atoms, it is possible to obtain their relative concentrations, which indicate the composition of the sample. A complete and accurate determination is achieved by comparing these measurements with those of standard reference samples whose composition is already known.

Detection of the elements, continues Piepmeier, can be improved in several ways. For example, the free atoms in the plume can be excited with a second laser beam to produce a strong fluorescence emission signal. Also, a chemically reactive atmosphere above the sample will tend to produce higher concentrations of atoms in the plume. These last studies will lead to a better understanding of the interaction of the atmosphere with the sample material, which in turn will indicate ways to improve further the analytical results.

One of the significant finds, early in his research, disclosed that some of the energy from the laser beam was also being absorbed by the plume of free atoms and molecules above the sample. He developed a mathematical theory, later proved correct, which showed that by shortening the wavelength of the laser and lengthening its pulse, more

laser energy would reach the sample analyzed.

Dr. Piepmeier suggests that possibly the most significant theoretical and experimental finding to come out of his research has been the discovery of a phenomenon known as "fluorescence saturation." While he was attempting to perfect a technique that used a second laser beam to probe the vapor plume (to determine its shape and the manner of its development on a microsecond time scale), he derived equations that showed how increasing the amount of light to which the atoms are exposed did not increase the fluorescence signal indefinitely—a find contrary to what was ordinarily expected at that time.

"Essentially," explains Piepmeier, "the results showed that the laser intensity could actually be increased to the point where as many atoms as possible were excited. When this region of saturation of the excited state was reached, the fluorescence signal leveled off. Realization that this level of excitation could be reached had a strong impact on research done by others in this and related fields. In fact, it led some researchers at Oak Ridge National Laboratory to detect even single atoms. Their technique involved laser ionization of saturated atoms, which were then individually counted using the same principle upon which the Geiger Counter operates."

More recently, Dr. Piepmeier's research group has developed a technique that makes it possible to choose an arbitrary wavelength within the tuning range of a laser and tune the laser beam to that wavelength one hundred times

more accurately than has ever been done before. He is now exploring the possibility of getting a patent for the procedure.

Such specialized equipment and advanced techniques are also used in familiarizing undergraduate and graduate students with what is new in analytical methods. In a field as rapidly changing as analytical chemistry, teaching new methods is a challenge. The only way to keep students abreast, observes Piepmeier, is to keep updating teaching equipment and to get interested students involved in special projects with the equipment used for research. He has developed a unique undergraduate course in analytical chemistry that emphasizes both instrumental measurement principles and chemical principles. Having become acquainted with self-paced, personalized instruction during a CAUT (College and University Teaching) workshop at OSU, he is now joining Prof. Stephen Hawkes (also of the Chemistry Department) in his development of undergraduate laboratory courses in analytical chemistry based on that type of instruction. In addition, Dr. Piepmeier teaches graduate classes in up-to-date methods of spectrochemical analysis.

To keep up with new techniques, Dr. Piepmeier spent a year in Holland in 1973 to study high resolution spectroscopy with Dr. Leo de Galan at the Technische Hogeschool Delft. During the summer of 1979, he spent ten weeks at the NASA Goddard Space Flight Center in Greenbelt, Maryland, collaborating in experiments in picosecond (10^{-12} s) spectroscopy. The NASA research team is expanding the frontiers of science by attempting to use short-time spectroscopy and lasers in a lidar (laser radar) experiment to map atomic oxygen concentrations in the stratosphere.

When asked about future directions for his work, Dr. Piepmeier replies that he plans to observe more closely how vaporized atoms in the laser microprobe react with the atmosphere. Under the sponsorship of the National Science Foundation, he and two of his graduate students, Gerhard Beenen and Arnold Lewis, are now investigating atmospheres of oxygen in argon. They later plan to use other gases in the hope of finding some chemical reactions that will help maintain a sample in the vapor state for a longer period of time so that the signal-to-noise ratio can be improved. He concludes by adding that this is an era in which high-temperature chemistry is of great importance both in and outside his field of specialization. He hopes to make a significant contribution in that area.

PLUME CROSS SECTIONAL SCAN

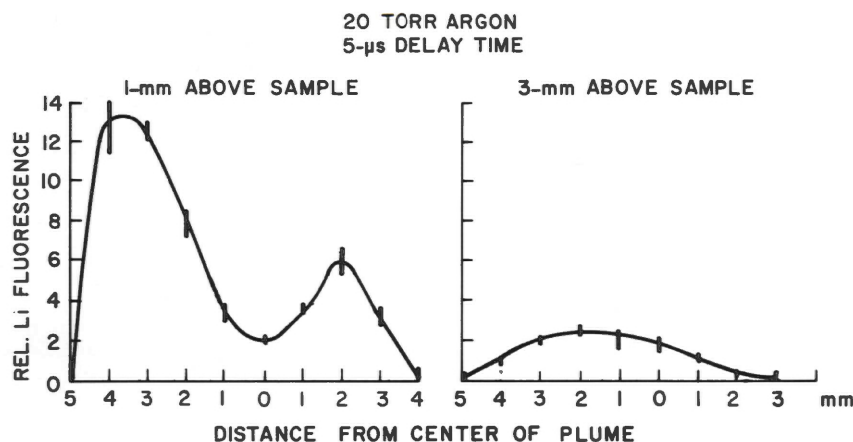


Figure 1. Spatially resolved fluorescence observations near the sample surface (left diagram) indicate a lower concentration of lithium (Li) atoms in the center of this laser plume than in the outer rim. Higher up in the plume (right diagram), the concentration is closer to the expected dome shape. These data indicate that the outer regions of the plume, rather than the center, may yield more accurate analytical measurements.

news & notes



ATMOSPHERIC SCIENCES

Stephen K. Esbensen was an invited participant at the Fifth Climate Diagnostic Workshop at the Univ. of Washington, Oct. 22-24. He coauthored (with Drs. **W. H. Quinn** and **D. B. Enfield**, OSU School of Oceanography) a paper presented at the workshop entitled "Interannual climatic anomalies: do they propagate?"

As director of the Climatic Research Institute, **W. Lawrence Gates** on Oct. 13-15 was host and also a participant in a meeting of the Working Group on Numerical Experimentation of the World Meteorological Organization (WMO). This group seeks to coordinate the work of the international meteorological modeling community as part of the recently established World Climate Research Program.

Richard W. Katz was a scientific visitor with the Environmental and Societal Impacts Group at the National Center for Atmospheric Research in Boulder, CO, during July and August.

Peter Maule gave an invited presentation at the Mid-America Solar Update Conference in St. Paul, MN, Sep. 10.

Allan H. Murphy was chairman of the International Programme Committee for the World Meteorological Organization Symposium on Probabilistic and Statistical Methods in Weather Forecasting, Nice, France, Sep. 8-12. **Dr. Murphy** and **Dr. Richard W. Katz** presented papers at that symposium. During October and November, Dr. Murphy visited the European Centre for Medium Range Weather Forecasts in Reading, England.

Hua-Lu Pan joined the department in September. He is responsible for courses in synoptic meteorology and weather prediction.

C. R. Nagaraja Rao reports that the construction of the Solar and Atmospheric Radiation Laboratory of the Department of Atmospheric Sciences has been recently completed. The 1600 ft² teaching and research laboratory is located in Withycombe Hall and is equipped with state-of-the-art solar radiation and data processing equipment. As a representative of OSU, **Dr. Rao** attended the annual meeting of the members of the University Corporation for Atmospheric Research (UCAR) at Boulder, CO, Oct. 14-15. He also participated on behalf of the department in the Workshop for Heads and Chairmen of University Departments of Atmospheric Sciences, held immediately after the UCAR members' meeting.

BIOCHEMISTRY AND BIOPHYSICS

Derek J. Baisted and **W. David Loomis** presented papers at the annual meeting of the American Society of Plant Physiologists, held at Washington State Univ., Pullman, Aug. 4-8. **Dr. Loomis** also gave a paper at the American Chemical Society meeting, Las Vegas, NV, Aug. 25-27.

Irving Isenberg has returned from a sabbatical leave spent at the University of Glasgow, Scotland, where he worked on gene expression in yeast and also on new methods and theories of data analysis.

W. Curtis Johnson presented a seminar on circular dichroism spectral analysis of protein structure at Case-Western Reserve Univ., OH.

Christopher K. Mathews is serving for the current year as chairman of the Microbial Physiology Study Section, National Institutes of Health. On Oct. 7, Dr. Mathews gave a seminar, "Enzyme interaction in DNA precursor synthesis," at New York Medical College.

Donald J. Reed attended an Environmental Health Sciences special review meeting and also the meeting of the American Society for Pharmacology and Experimental Therapeutics, Aug. 18-19. On Sep. 25-26, he gave an invited talk, "Metabolism of nitrosoureas," at a symposium on nitrosoureas in Dearborn, MI.

BOTANY and PLANT PATHOLOGY

Donald J. Armstrong presented a paper, "Genetic regulation of cytokinin metabolism in *Phaseolus* tissue cultures," at a colloquium on the metabolism and molecular activities of cytokinins, sponsored by the Centre National de la Recherche Scientifique at Gif-Sur-Yvette, France, Sep. 2-6.

Norman I. Bishop presented a paper, "Identification of a chloroplast membrane polypeptide as the photosystem II-dependent manganese-binding site in static and conditional mutants of *Scenedesmus obliquus*," (**J. G. Metz** and **J. Wong**, coauthors), at the Fifth International Congress on Photosynthesis in Halkidiki, Greece, Sep. 7-13. He also chaired a session on "Photosynthetic electron transport."

Richard O. Hampton attended the national meeting of the American Phytopathological Society in Minneapolis, MN, Aug. 23-28, where he presented two papers: "Soil-related greenhouse spread of bean mild mosaic virus" and "Evidence suggesting identity between alfalfa latent and pea streak viruses." Graduate research assistant **Robert F. Davis** gave a paper entitled "RNA recombinants as probes of cucumber mosaic virus seed transmission in *Phaseolus*."

Paul E. Hennon, **Paul F. Hessburg**, and **Keith M. Reynolds** attended the Regional Conference on Forest Pathology at the Western Disease Work Conference in Pengree Park, Ft. Collins, CO, Sep. 15-19.

Dalice I. Mills attended the 10th International Conference of Yeast Genetics and Molecular Biology at Louvain-La-Neuve, Belgium, Sep. 8-12, and presented a paper, "Quantitative and qualitative analysis of polyadenylated RNA sequences during meiosis of *Saccharomyces cerevisiae*."

Larry W. Moore presented an invited paper, "Biocontrol of *Agrobacterium tumefaciens*," at the Second International Symposium on Microbial Ecology, Univ. of Warwick, England, Sep. 7-12. **Kenneth F. Baker**, as a keynote speaker, contributed a paper entitled "Microbial antagonism—the potential for biological control." Following the meetings, **Drs. Moore** and **Baker** visited the Rothamstead Experiment Station, Harpenden, England and gave seminars at Wageningen and Baarn, the Netherlands. On August 24-27, **Dr. Moore** attended the meetings of the American Phytopathological Society at

Minneapolis, MN, where he presented two papers: "Interaction of *Rhizobium meliloti* agrobacterium radiobacter K84" and "Association of naturally occurring *Agrobacterium rhizogenes* with carrot root." He also participated in a "teach-in" on an "Identification manual for phytopathogenic bacteria." **Donald A. Cooksey** presented a paper, "Plasmid-determined Agrocin 84 sensitivity in *Rhizobium leguminosarum*," (**L. W. Moore**, coauthor).

Ralph S. Quatrano taught a course, "Developmental Biology," with Dr. David Epel at the Hopkins Marine Station, Stanford Univ., during July and August. He is invited to attend the Unilever Jubilee Symposium on Cellular Controls in Differentiation in Vlaardingen, the Netherlands, Dec. 14-17. Dr. Quatrano was elected to the Editorial Board of the journal *Plant Physiology* and appointed to the Editorial Committee of the *Annual Review of Plant Physiology*.

CHEMISTRY

Casey W. Bennett, as a member of an OSU team sponsored by the Swiss Government and Exxon Nuclear Co., spent Aug. 17-Sep. 4 at the Swiss Federal Institute for Reactor Research in Wuerenlingen, Switzerland, in conjunction with a research project designed to characterize the fuel-cladding mechanical interaction of two-size-sphere-pac reactor fuel. During this visit, he discussed current research at OSU, visited laboratories, and participated in technical meetings with various research groups.

Malcolm Daniels presented three papers at the International Photobiology Congress at Strasbourg, France, July 20-25: "Laser excitation of cytosin," (**C. E. Fairchild**, Dept. Physics, coauthor); "Laser excitation of oriented DNA, poly A and poly C," (**C. E. Fairchild**, OSU, **Graslund**, and **Rupprecht**, Univ. Stockholm, coauthors); and "Lifetimes of DNA luminescence by synchrotron excitation," (**Ballini** and **Vigny**, Université P. et M. Curie, Paris, coauthors). Following the meeting, he participated in synchrotron research at LURE (Orsay).

James D. Ingle, Jr., attended the 2nd Chemical Congress of the North American Continent in Las Vegas, NV, Aug. 24-29, where he presented two papers: "Improvements in analytical chemiluminescence measurements" and "Instrumentation and methodology for fluorescence measurements."

Edward H. Piepmeier presented a paper entitled "What causes those shifty spectral line profiles in laser-induced ionization saturation spectrometry?" at the 2nd Chemical Congress of the North American Continent in Las Vegas, NV, Aug. 24-29. His graduate students **Arnold Lewis** and **Gerhard Beenen** also contributed papers.

James D. White has been appointed to the Editorial Board of the *Journal of Organic Chemistry* for a five-year term beginning in January 1981. He served as chairman of an NSF Workshop on Synthetic Organic and Natural Products Chemistry, held at Dartmouth College, July 9-13. In September and October, he gave invited lectures at Duke Univ., Univ. of Wisconsin, and Abbott Laboratories (Chicago).

Carter Awards

Kensal E. Van Holde, professor of biophysics, and Albert E. Frank, instructor of atmospheric sciences, were selected to receive respectively the 1980 graduate and undergraduate Carter Award for "outstanding and inspirational teaching" in the College of Science.

Dr. Van Holde, who is presently on sabbatical leave at the Marine Biological Laboratory, Woods Hole, MA, and the Weizman Institute in Israel, has been a faculty member of the College of Science since 1967. He had previously taught for ten years at the University of Illinois, after earning a Ph.D. in physical chemistry from the University of Wisconsin.

For several years, Dr. Van Holde has studied the structure of DNA. More recently, his efforts have focused with singular success on investigations of the structure of eukaryotic chromatin, which is essential to the expression of cell function and reproduction. He and other scientists in his laboratory played a key role in determining the "beaded-string" structure of chromatin. The significance of his work was recognized in 1977 when he was awarded an American Cancer Society Research Professorship and the OSU Alumni Association Distinguished Professor Award. The authority and clarity of his presentations to graduate seminars have been known at OSU and other institutions. He served for five years as instructor and for four years as instructor-in-chief in the physiology course at the Marine Biological Laboratory, Woods Hole, Massachusetts.

During his tenure at OSU, he has regularly taught both graduate and undergraduate courses in biochemistry and biophysics, ranging from introductory courses to "special topics" courses for advanced students.



Kensal E. Van Holde



Albert E. Frank

In Dr. Van Holde's opinion, teaching and research are equally indispensable facets of the educational process, each of benefit to both the teacher and student. He adds, "I would never choose to work in a situation where I could not teach."

Albert E. Frank, a faculty member in the Department of Atmospheric Sciences since 1977, began his teaching career at OSU as a teaching assistant while completing an M.S. program in that department. Al Frank, who received a B.S. from Pennsylvania State University, is primarily interested in synoptic meteorology—the analysis of weather systems from data obtained through satellite, land observations, and other sources.

As an instructor in the Department of Atmospheric Sciences, Frank has shown that he has the ability to communicate to students his excitement about the atmosphere. He has been responsible for a demanding program of undergraduate instruction, which includes introductory courses on the atmosphere to departmental majors and also to a large number of non-majors.

"The two groups have different needs," he notes, "but both majors and non-majors bring to the classroom a natural curiosity about the air that surrounds us. I capitalize on this curiosity and try to make students aware of the great variety, complexity, and beauty of the processes occurring in the atmospheric environment."

"It was especially gratifying for me," he adds, "to see the first group of majors that I had taught as sophomores in 1977 graduate this past June." As is often the case with many good teachers, Al Frank derives great personal satisfaction from watching his students grow and mature, not only academically but also as individuals.

John T. Yoke attended the 21st International Coordination Chemistry Conference last July at the Université Paul Sabatier in Toulouse, France, where he presented a lecture on "Cobalt catalysis of the autoxidation of ethyl phosphinite, phosphonite, and phosphite esters." The conference was sponsored by the International Union of Pure and Applied Chemistry and the Centre National de la Recherche Scientifique, France.

William S. Bregar, **Michael J. Freiling**, and computer science student, **Brian Lantz**, attended the First Annual Conference of the American Association for Artificial Intelligence, at Stanford, CA, Aug. 19-21. **Dr. Bregar** and **Dr. Freiling** attended the annual meeting of the Association for Computational Linguistics, Philadelphia, June 19-21.

Curtis R. Cook is on sabbatical leave at Colorado State Univ., where he is conducting research in the areas of graph theoretical measures of computer program complexity and graph grammars and language.

Paul Cull attended an NSF-sponsored short course on "Strategies for Increasing Participation of Women in Mathematics-Related Fields," Oregon Graduate Center, Oct. 23-24.

Michael J. Freiling attended a conference on Computer Graphics, SIGGRAPH '80, in Seattle in July and one on the programming language LISP, held at Stanford in August. Dr. Freiling also attended the Sixth Very Large Data Base Conference, Montreal, in October. He has been elected vice-president of the Willamette Valley chapter of the Association for Computing Machinery.

Graduate student **Dan Kogan** gave a seminar, "A semantic level model of information," at the System Development Corporation, Santa Monica, CA, Oct. 2.

Ted G. Lewis was an invited speaker at the Euromicro Workshop on Microprogramming in Austria last summer. On the same trip, he addressed the Danet consortium in Munich and presented a seminar on distributed system kernels at the Univ. of Stuttgart. He also attended the MIT Data Flow Workshop in Cambridge, MA, June 16-20, and presented an invited lecture, "Testing concurrent programs: the interleave principle," at the Honeywell Corporate Computer Sciences Research Center in Bloomington, MN, June 26. Dr. Lewis was a panelist at the ACM SIGSMALL meeting in Palo Alto, CA, Sep. 18. He spoke on "Staffing the third wave."

Barry A. Levine presented a paper on "The inference of tree systems using tree derivatives and a sample strength parameter" at the Fifth International Conference on Pattern Recognition of the IEEE Computer Society, Miami Beach, Dec. 1-4.

COMPUTER SCIENCE

Bella Bose and Prof. T. R. N. Rao (Southern Methodist Univ.) are coauthors of a paper on "Unidirectional error codes for shift register memories," presented at the International Symposium on Fault Tolerant Computing in Kyoto, Japan, Oct. 2-5.

William S. Bregar has been named to the Review Board of *The Journal of Computer-Based Instruction*. Dr. Bregar presented a paper, "Production systems, an artificial intelligence tool applied to computer-assisted instruction," at the Third Canadian Symposium on Computers and Education, Vancouver, B.C., May 1980.

Professor Goheen Retires



Harry E. Goheen, professor of mathematics and computer science, will retire at the end of fall term 1980 after a long career and twenty-five years of service to Oregon State University.

Professor Goheen received his undergraduate and advanced training at Stanford University. He taught at Syracuse University, the University of Pennsylvania, and Iowa State College before joining OSU in 1955. His early studies were primarily concerned with efforts to determine the restrictions on structures used in abstract algebra. His Ph.D. thesis, which enumerated all permutation groups of a particular class, set the tone of his interest in mathematics and its relationship to the world.

Early in his career, he became interested in large-scale calculating machinery and the development of computers, but particularly in the theory of computation. He was a founding member of both the Association for Computing Machinery (1947) and the Society for Industrial and Applied Mathematics (1954). Professor Goheen taught the first course in computer science offered at OSU. He became a member of the Department of Computer Science when it was first established in 1973 and has since guided six doctoral students to their advanced degrees in the theory of computation and about forty master's candidates in mathematics and computer science. Prior to 1973, he directed doctoral dissertations in the Department of Mathematics.

Harry Goheen summarizes his scientific career briefly by saying: "Everything I have

ever done was directed to one end—understanding how people arrive at their views of reality. How to they see the world? What schemes do they devise to understand their surroundings and to control other people and events?" He believes that computers can make people aware of their own influence in the course of events, and he is firmly convinced that this understanding will increase in the future.

When asked about how he will occupy the time previously dedicated to teaching, he explains that he will continue to explore the philosophical question of how people formulate their concepts of reality. Through travel and study, Professor Goheen has acquired some understanding of Western cultures. He now would like to expand his knowledge of the non-Western worlds—Asia, Africa, and the Middle East.

To Professor Goheen travel is something more than just getting from one place to another by air. First of all, he enjoys going by ship. As a naval officer during wartime, he developed a life-long yearning for the open ocean and those feelings experienced when contemplating expanses of ocean and space. Secondly, he likes to study in depth the people and places he visits. For him searching and learning have been a way of life that will pick up momentum when he retires.

ENTOMOLOGY

Victor J. Brookes was an invited participant to the 3rd International Vitellogenin Workshop, held in Kandersteg, Switzerland, Sep. 7-10, and sponsored by the Swiss National Academy of Sciences, Swiss National Science Foundation, the International Society of Developmental Biologists, and Interpharma.

Bruce F. Eldridge has been elected to the Governing Board of the Entomological Society of America. On Oct. 13-17, he was chairman of a committee that reviewed the mosquito control research program at the University of California.

GENERAL SCIENCE

Paul L. Farber's paper, "The transformation of natural history in the Nineteenth Century," was read at the annual meeting of the History of Science Society held in Toronto, Oct. 16-19.

John H. Lytford, Jr., spent five weeks in Kenya during the latter part of August and early September observing and photographing alpine zonation (up to 16,300 feet on Mt. Kenya) and ecological aspects of the savanna, grassland, and coastal sand dune communities.

Michael C. Mix was an invited participant to the 11th International Symposium of the Princess Takamatsu Cancer Research Fund, on "Phyletic Approaches to Cancer," held in Tokyo, Nov. 11-13. He presented a paper on "Polynuclear aromatic hydrocarbons and cellular proliferative disorders in *Mytilus edulis*." At the end of the symposium, participants were invited guests at a reception held by H. I. M. Princess Takamatsu at her residence. Dr. Mix spent an

additional week visiting various laboratories throughout Japan.

Henry Van Dyke was the delegate of the OSU Chapter to the national meeting of the Society of Sigma Xi in San Diego, Oct. 10-13.

Robert C. Worrest presented a paper, "Impact of simulated solar ultraviolet radiation upon estuarine microcosms," at the Eighth International Congress on Photobiology, Strasbourg, France, July 20-25. Dr. Worrest was also on the organizing committee of a NATO Advanced Research Institute on "The role of solar ultraviolet radiation in marine ecosystems," held in Copenhagen, Denmark, July 28-31. He was the panel leader for the sessions covering the biological effects of solar ultraviolet radiation and presented papers entitled "Effects of UV-B radiation on marine photosynthesis" and "Models relating to world-wide marine productivity and economic consequences of stratospheric ozone depletion." In August, Dr. Worrest accepted a mobility assignment with the U.S. Environmental Protection Agency, Corvallis, to act as project leader for the Photobiology Program for a two-year period. **Bruce E. Thomson** has accepted a similar assignment to act as a research assistant in the Photobiology Program.

GEOGRAPHY

Robert E. Frenkel has returned from a one-year sabbatical leave. He spent eight months at the Division of Geobotany, University of Nijmegen, the Netherlands, where he studied numerical methods for vegetation classification. During the year, he was invited to lecture on Pacific Northwest salt marshes at the University of Amsterdam, Nijmegen, Groningen, and Utrecht. In Feb-

ruary 1980, Dr. Frenkel was presented by the Oregon State Land Board with a certificate for outstanding contribution to the state's Natural Areas program. On Oct. 24, he gave a paper on defining the upper limit of coastal wetlands at the meetings of Pacific Estuarine Research Society in Arcata, CA.

Marvin E. Gloege coordinated a state-wide Land Use Planning Institute held at the University of Oregon, Sep. 10-12. **Philip L. Jackson** presented a paper on performance zoning and one on natural hazards planning. **Thomas J. Maresh** gave a paper on regional economic planning.

J. Granville Jensen, professor emeritus, revisited Amazonia, Brazil, for three weeks during September, and specifically the Jary Company forestry project and colonization along the Transamazon road. In October, he presented the Honors Forum lecture at Northern Arizona University and spoke on Amazon development.

Gordon E. Matzke gave an invited paper, "The development consequences of Tsetse control," at the 23rd annual meeting of the African Studies Association in Philadelphia, Oct. 15-18.

Keith W. Muckleston received a National Academy of Sciences travel grant that permitted him to participate in the International Geographical Union meetings in Japan in August-September. At the pre-congress meetings of the International Hydrological Programme, held at Ibaraki, he chaired a session and presented a paper entitled "Selected human aspects of water development in the Columbia River basin." At the Section on Hydrology in Tokyo, he also chaired a session and gave an invited paper, "Impacts of water uses on the Columbia River hydrologic environments."

Charles L. Rosenfeld has given numerous lectures on the Mount St. Helens eruption

both on campus and to professional societies such as the American Society of Photogrammetry, the Irrigation Association, the Geological Society of Nevada, the University of Nevada, the American Society of Chemical Engineers, the Houston Geophysical Society, and the University of Texas, El Paso.

GEOLOGY

Alan R. Niem and **Edward M. Taylor** presented two papers, "Paleogeology of north-western Oregon Coast Range" and "Geology and development of the Cascade Range," at the Cascadia Conference held at Salishan Lodge, Salishan, OR, May 5-8, 1980. **Dr. Niem** also participated in October on a one-week cruise off Oregon and Washington with the U.S. Geological Survey, on-board the ship *RV Samuel P. Lee*.

Robert S. Yeats and **Charles L. Rosenfeld**, Geography, presented a paper on fracture systems on Mt. St. Helens at a symposium on the Mt. St. Helens eruption, held at the American Geophysical Union meetings in B.C., Sep. 25.

MATHEMATICS

Philip M. Anselone visited the Dept. of Mathematics at Texas Tech Univ., Sep. 15-19. Prof. Anselone's visit was sponsored by the Visiting Mathematician's Program, which is being funded by the Ex-Students Association of Texas Tech Univ. Prof. Anselone gave several talks and participated in faculty and student discussions on research problems.

Kennan T. Smith visited the Univ. of Manitoba, Canada, during August and September.

Returning from sabbatical leave are **Arnold Kas**, who spent a year at the Univ. of California, Berkeley; **M. N. L. Narasimhan**, who spent the past year in Warsaw, Poland; and **Dennis C. Jespersen**, who was at Claremont College, CA. **Stuart M. Newberger** is on leave at UCLA for the academic year 1980-81.

MICROBIOLOGY

Lyle R. Brown presented a paper, "Synthesis of RNA polymerase during growth transition," in a workshop on RNA polymerase at the Eighth International Spore Conference at the Marine Biological Laboratory, Woods Hole, MA, Oct. 9-12.

John L. Fryer attended the North Pacific Aquaculture Symposium in Newport, OR, Aug. 25-27, where he gave a paper on "Viral diseases of salmonid fish in Oregon, U.S.A." Scientists from Canada, Japan, U.S.S.R., and U.S.A. attended the symposium. **James R. Winton** presented a paper, "Isolation and characterization of a new reovirus from chum salmon," (**C. N. Lannan**, **J. L. Fryer**, and **T. Kimura**, coauthors). **R. P. Hedrick** and **A. Amandi** presented poster sessions on their research carried out in Dr. Fryer's laboratory.

Richard Y. Morita was elected Honorary Member of the Deep-Sea Biological Society. He contributed papers to the 2nd International Symposium on Microbial Ecology, Warwick, England, Sep. 7-12, and the 15th European Symposium on Marine Biology, Kiel, West Germany, Sep. 30-Oct. 3. The titles are: "Microscopical and microcultural studies of marine bacterioplankton: distinction of two types of bacterial heterotrophs in terms of size and growth rate," (**F. Tor-**

rella, coauthor); and "Thioploca: possible methylotroph and significance in the food chain," (**R. Itirriaga** and **V. A. Gallardo**, coauthors).

Thomas J. Rogers attended the North Pacific Aquaculture Symposium, Newport, OR, Aug. 25-27, where he presented a poster session, "Partial characterization of a high and lower molecular weight immunoglobulin in rainbow trout (*Salmo gairdneri*)," (**P. J. O'Leary** and **J. L. Fryer**, coauthors).

John S. Rohovec also attended the Symposium in Newport and presented a poster session—"Effects of copper on the resistance of salmonid fish to selected pathogens," (**R. P. Hedrick** and **M. D. Knittel**, coauthors).

Ramon J. Seidler hosted a research meeting on "Vibriosis in the Environment" in Corvallis, Oct. 1-2. Public health officials and scientists from institutions in Louisiana and Maryland were present.

James R. Winton, a graduate student of **Dr. Fryer**, was the winner of the Sea Grant Association's 1980 Student Research Abstract Competition for his work in isolating a new chum salmon virus. Winton isolated the virus in cells taken from chinook salmon during inspection of salmon eggs before they were imported to the U.S. from Japan.

PHYSICS

John A. Gardner has returned from a sabbatical year spent at the Univ. of Warwick, Coventry, England, and at the Max Planck Institute in Stuttgart, Germany. He presented a paper, "N.M.R. in liquid bismuth metal," at a symposium in Grenoble, France.

Carl A. Kocher is now serving as President of the Oregon Section of the American Association of Physics Teachers.

Victor Madsen spent two months during the summer 1980 at the K.F.A. Jülich Laboratory, Jülich, Germany, and one and one-half months at the Lawrence Livermore National Laboratory. He attended the International Nuclear Physics Conference in Berkeley and coauthored a paper for that meeting entitled "The nuclear structure approach to the imaginary nucleon-nucleus optical potential." He also attended the fall meeting of the Division of Nuclear Physics of the American Physical Society in Minneapolis.

Kwang-Bock Yoo attended the International Conference on Nuclear Physics in Berkeley, CA, Aug. 24-30. He presented a seminar on "Pion absorption in the Mandelstam model" at the Univ. of Massachusetts, Sep. 2.

STATISTICS

Jeffrey L. Arthur spent the summer as a visiting faculty member in the School of Industrial Engineering at Purdue Univ. On Aug. 25-27, he attended the summer Computer Simulation Conference in Seattle, where he presented a paper, "Determination of the significant production factors in timber harvesting through computer simulation."

H. Daniel Brunk gave a presentation entitled "A probability space is a tree" at the IVth International Congress on Mathematical Education in Berkeley, CA, Aug. 10-16.

Lyle D. Calvin participated in a site visit for the National Cancer Institute in Memphis, TN, Oct. 16-17.

G. David Faulkenberry met with members of the U.S. Department of Agriculture and faculty at Kansas State Univ. to discuss research on non-sampling errors, Oct. 30-Nov. 1.

Paula Kanarek received the 1980 OSSSO (Oregon State Statistics Students Organization) award for significant contribution to the education experience of statistics students.

Kenneth E. Rowe attended a meeting of the regional committee of the Society of Sigma Xi in New Haven, CT, July 20, and the Gordon Research Conference, July 27-Aug. 1. As regional director, he also attended the Sigma Xi National Assembly of Delegates in San Diego, Oct. 9-14.

Justus F. Seely has been elected District 6 representative to the Board of Directors for the American Statistical Association.

ZOOLOGY

Andrew Blaustein has received a Released Time Award for winter term 1981 and will conduct research at the Univ. of California at Berkeley and UC at Santa Barbara.

Charles E. King presented a paper, "The evolution of life span," at a symposium organized to examine the genetics of life histories, Univ. of Iowa, Oct. 13-14.

Jane Lubchenko presented invited seminars, Oct. 21-Nov. 2, to the biology faculties at the Univ. of California at Santa Cruz, UC Davis, and the Univ. of Nevada at Reno on "Comparative effects of herbivores in three rocky intertidal communities" and "Effects of herbivores on life histories of some marine algae."

Frank L. Moore and **Philip Brownell** were invited participants at the VIII International Symposium on Neurosecretion, Friday Harbor, WA, Sep. 4-10. **Dr. Moore** presented a seminar, "A new approach to behavioral endocrinology," to the Department of Zoology, Univ. of Washington, Seattle, Oct. 22.

John E. Morris attended the International Congress on Cell Biology in West Berlin, Aug. 31-Sep. 5. While in Europe, he also visited laboratories in Upsala, Sweden.

Alfred Owczarzak has returned from a 1979-80 sabbatical leave, part of which was spent at the Department of Biology, Vanderbilt Univ., TN. **Dr. Owczarzak** worked in the laboratory of **Dr. B. J. Bogitsh** on the electron microscopic histochemistry of the *Bge* snail cell line. The research continued on his return to Corvallis.

NEW FACULTY APPOINTMENTS

The following scientists have joined the faculty of the College of Science for the 1980-81 academic year: **Hua-lu Pan**, Visiting Assistant Professor, in the Department of Atmospheric Sciences; **Jerry Harpst**, **Channa Shalitin**, **Yechiel Shalitin**, Visiting Associate Professors (courtesy); **James R. Davie**, **Dean A. Malencik**, **Michael Meredith**, **Kay D. Pauling**, **Brinda Ramanathan**, **Elizabeth Rocha**, **Charles S. Schasteen**, and **Helena Vadi**, Research Associates, in the Department of Biochemistry and Biophysics; **Mitchell A. Avery** and **Kolbjørn Hagen**, Research Associates; **Michael Schuyler**, Visiting Professor; **Ramanujan Srinivasa**, Research Associate; **Peter Weightman**, Visiting Associate Professor; **John C. Westfall**, Assistant Professor, in the Department of Chemistry; **Bella Bose**, **Barry A. Levine**, **Douglas B. Moran**, Assistant Professors; and **Fred M. Tonge**, Professor/Department Chairman, in the Department of Computer Science; **John S. Locker**, Visiting Assistant Professor; **Raphael Loewy**, Visiting Associate Professor; **Lea F. Murphy**, Assistant Professor; **Stuart P. Thomas**, Instructor/Director MSLC, in the Department of Mathematics.

The Budget of the College of Science, 1979-80

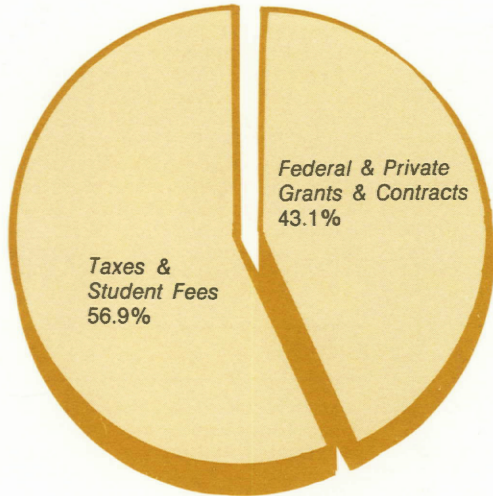


Figure 1: Major Sources of Funds for the College of Science, OSU, 1979-80 (Total \$16,210,036).

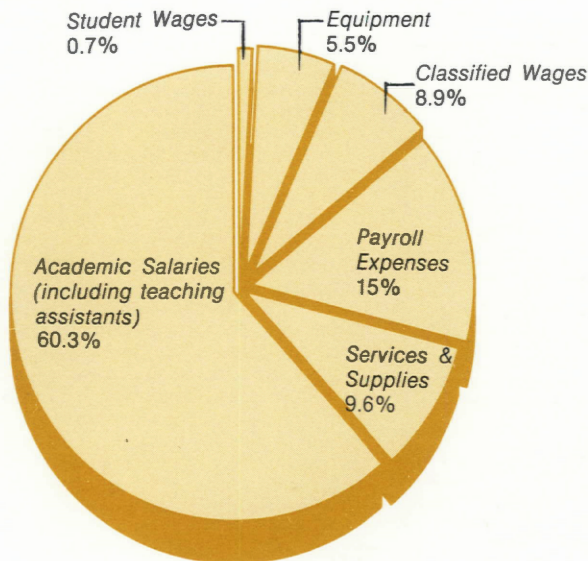


Figure 2: Expenditure of Taxes & Student Fees for the College of Science, OSU, 1979-80 (Total \$9,221,294).

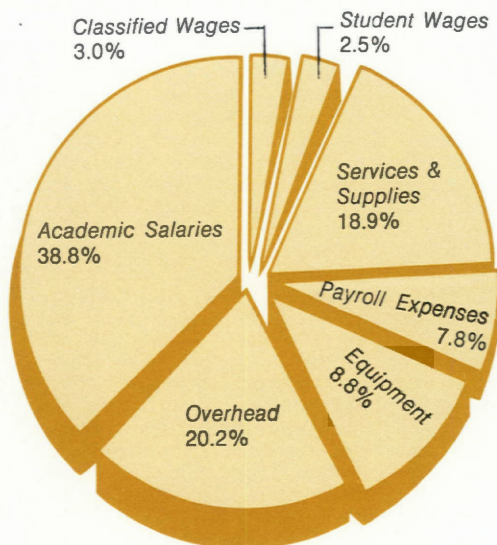


Figure 3: Expenditure of Federal & Private Grants & Contracts for the College of Science, OSU, 1979-80 (Total \$6,988,742).

The 1979-80 expenditures from the College of Science accounts are portrayed in the accompanying diagrams. Figures 1, 2, and 3 are similar to diagrams representing the College budget that were published in the fall issue of *The Science Record* in previous years.

From a review of expenditures for a four-year period, several trends that are important to the future of the College become apparent. The over-all increase in budget for this four-year period has been \$4,472,475 (38.1%). This consists of a \$1,691,850 (22.5%) increase in tax and student fee dollars and a \$2,780,625 (66.1%) increase in grant and contract funds. In this time span, the percentage of the total budget derived from grants and contracts (Figure 1) has increased from 35.9 to 43.1. The one-year increase in grant and contract funds from 1978-79 to 1979-80 was \$1,260,812 or 24.2 percent. The comparatively greater increase in grant and contract activity reflects the improved posture of our faculty in research and education for research, and their ability to obtain funding in the face of strong competition for research dollars.

Expenditures from the instructional budget (Figure 2) have maintained about the same percentage distribution for four years. Personnel costs consume about 85 percent of the budget as they did four years ago. Payroll expenses as a portion of personnel costs have increased significantly with improvements in fringe benefits and the accelerating cost of the Social Security program.

The distribution of expenditures from grant and contract funds (Figure 3) has remained remarkably constant for four years. Personnel costs are a much smaller fraction of this budget than in the instructional budget with proportionately larger amounts being spent for equipment, services, and supplies.

It is again apparent that the College of Science is utterly dependent upon outside grants and contracts to fulfill its research mission. Only \$1,391,268 was expended from the instructional budget for equipment, services, and supplies. This amount must pay for office operations, telephone, printing, maintenance, paper, and other supplies, as well as provide supplies for formal laboratory instruction. Obviously there is very little left for support of research. Actually, even the figure \$1,391,268 is misleading. Less than half of this amount was originally budgeted. The remainder came from transfer of funds during the course of the year, including a special equipment allocation, returned overhead, and funds provided by the Dean of Research, the Vice-President for Administration, and the Chancellor for various purposes. Whatever their administrative source, most of these transferred funds came originally from grant and contract overhead rather than from student fees or taxes. It would be a difficult accounting task to demonstrate that research is entirely self-supporting, but it appears to be. In fact, it could be said that grant and contract activity subsidizes undergraduate instruction.