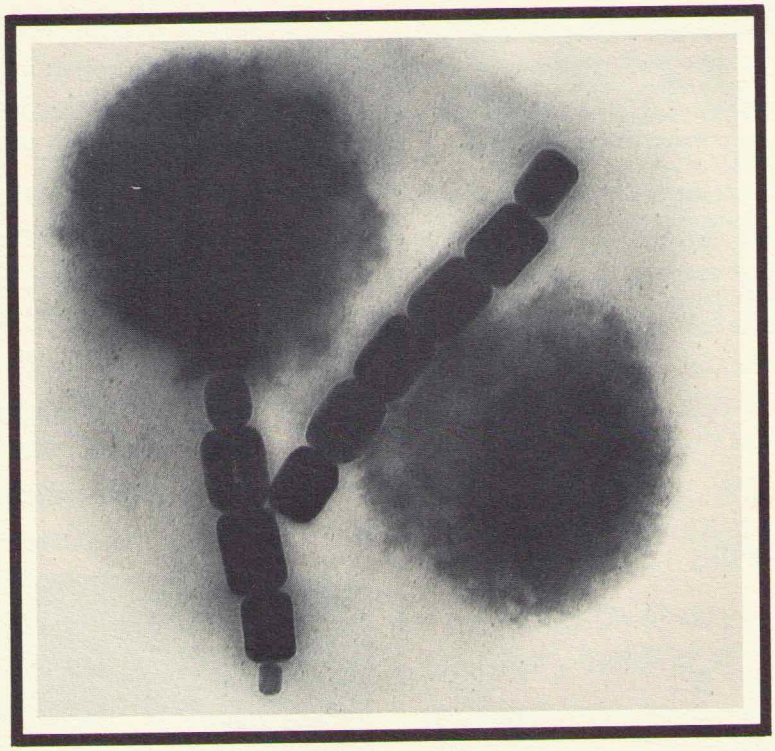
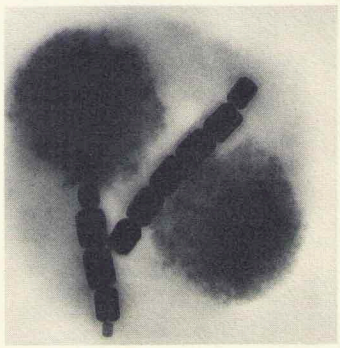
GRADUATE PROGRAMS IN CHEMISTRY
UNIVERSITY OF NEW HAMPSHIRE



Cover Photograph



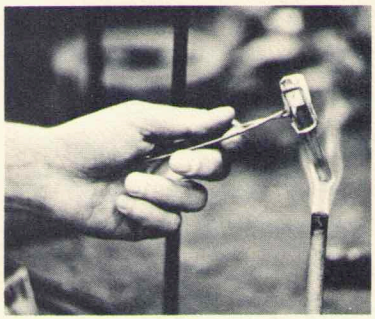
Transmission electron micrograph of the interior of a magnetotactic bacterium found in marine sediments. These bacteria can sense the earth's magnetic field, which may serve as a cue to their orientation. The novel chains of particles, rich in iron, are probably ferromagnetic, thus imparting a magnetic moment to the organism. Photographs courtesy of Dr. Richard Blakemore of the Department of Microbiology, UNH, who discovered this phenomenon.

Contents

The University

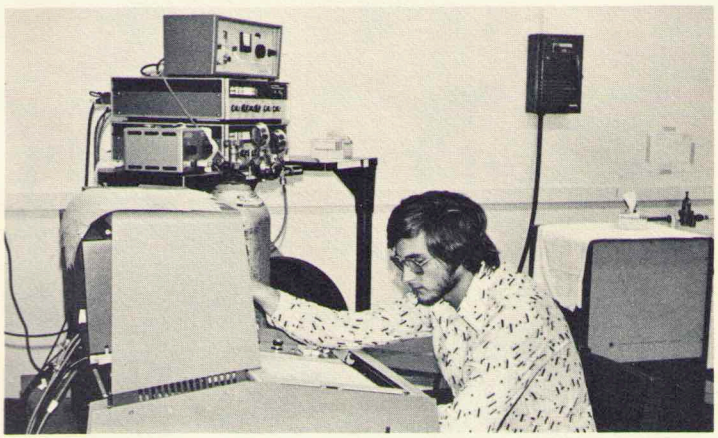
The University of New Hampshire was founded in 1866 as a land-grant college. It has 58 buildings devoted to instruction, research, and administration. Total University land exceeds 3,500 acres. The University of New Hampshire has experienced a rapid but controlled growth in the past decade. The full-time enrollment is slightly above 10,300, including about 900 graduate students. Durham was one of the first settlements in New England and is rich in cultural Americana. The University occupies a beautiful 188-acre campus near the heart of the town.

The Department and Facilities

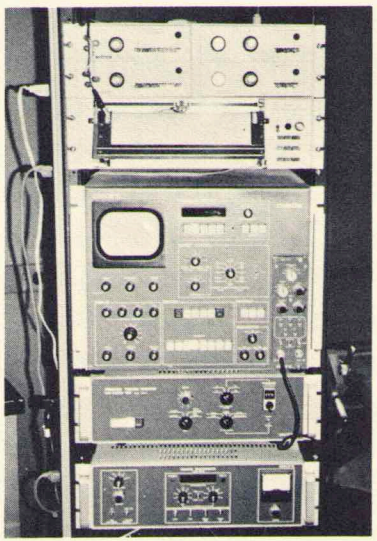


The Department of Chemistry has 17 faculty members and 45 graduate students, an optimum size for those who want close, personal student-faculty relationships, yet large enough for vigorous scientific activity.

The department is situated in Parsons Hall, a modern $5.5-million research and classroom facility completed in 1970. Among the specialized equipment available to students and faculty are a mass spectrometer, ESR spectrometers, high-resolution infrared and far-infrared spectrometers, X-ray diffractometers, NMR spectrometers, a Cary recording spectrophotopolarimeter, Mössbauer spectrometer, a Durrum stopped-flow rapid-reaction spectrophotometer, a cobalt-60 irradiator, emission spectrographs, differential scanning calorimeter, and a wide range of smaller instruments. In addition, other major instruments such as a scanning electron microscope and an electron microprobe are available through the University Instrumentation Center and the Center for Industrial and Institutional Development (CIID) in Parsons Hall. The University has a high-speed DEC-10 computer system in Kingsbury Hall next to the chemistry building, with terminal clusters situated throughout the campus.



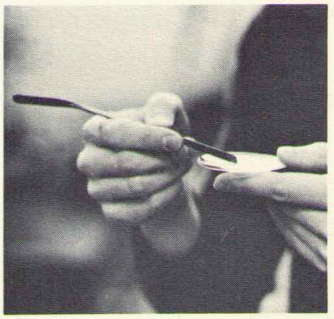
The chemistry library is housed in the chemistry building and subscribes to over 200 chemical and related journals, with complete back issues in virtually all of them.



Supporting Staff

The department has a number of supporting personnel who aid in the teaching and research efforts of the faculty and students. This staff consists of an administrative assistant, an accounting clerk, secretaries, technicians, stockroom attendants, and an analyst for service on C,H, and N determinations and routine NMR spectra. The department also has the services of machinists, a glassblower, an electronics technician, a purchasing agent, draftsperson, and a photographer.

Traditional Programs

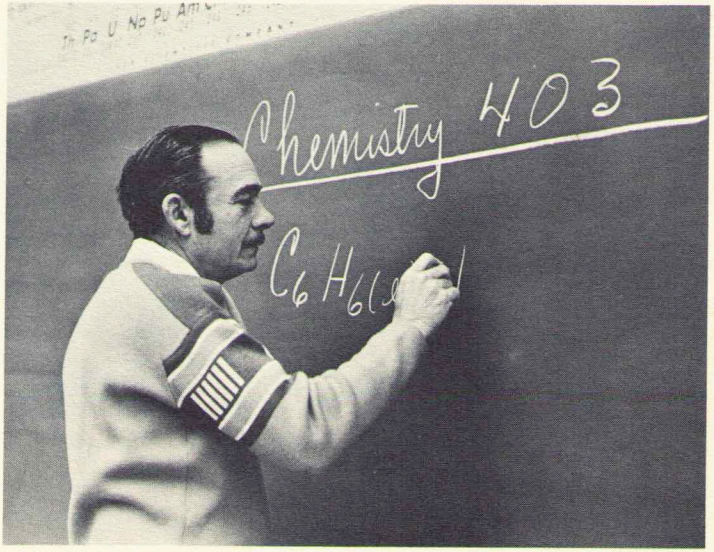


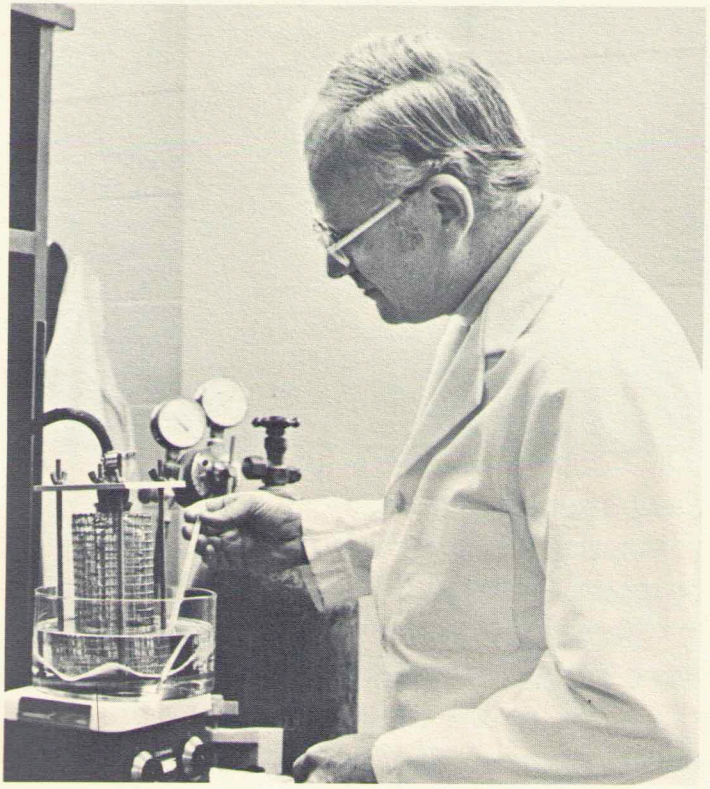
The department offers programs of study leading to the M.S. degree and the Ph.D. degree, with specialties in the fields of analytical, inorganic, organic, and physical chemistry. The M.S.T. (Master of Science for Teachers) degree is also offered.

The M.S. in Chemistry degree is designed to provide students an opportunity to participate

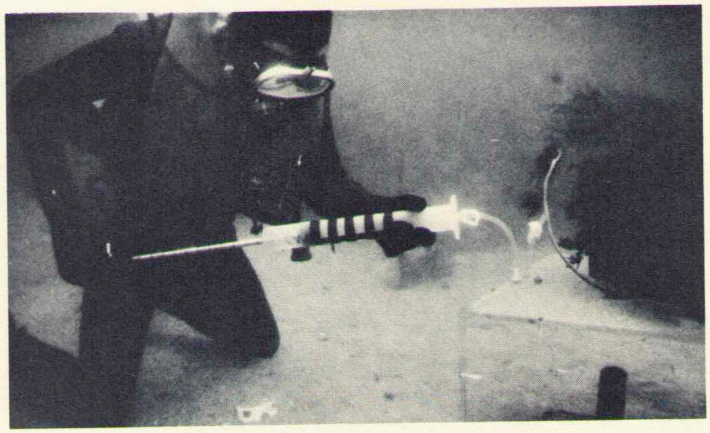
in graduate education without the longer academic or research commitment of a doctoral program. It is also useful to students who wish to extend their training prior to entering a doctoral program. The M.S. degree program allows students to participate in advanced course work and at the same time develop a research program that will make a significant contribution to chemistry.

The Ph.D. program in chemistry is designed to train students as mature scientists capable of independent activity, *i.e.*, capable of conceiving a research problem, planning and carrying out the necessary experimental work, properly interpreting the results, and conducting independent study to advance their knowledge. Traditionally, the Ph.D. degree is the mark of scholarly attainment and connotes a high degree of proficiency in a specialized field in addition to a breadth of knowledge of other fields. The program is intended to assist the student in attaining the required scientific maturity, mastery of a chosen area of chemistry, and an adequate proficiency in all other areas. The doctoral program in chemistry is designed to permit the well-prepared and capable student to complete his or her degree in three to four calendar years.



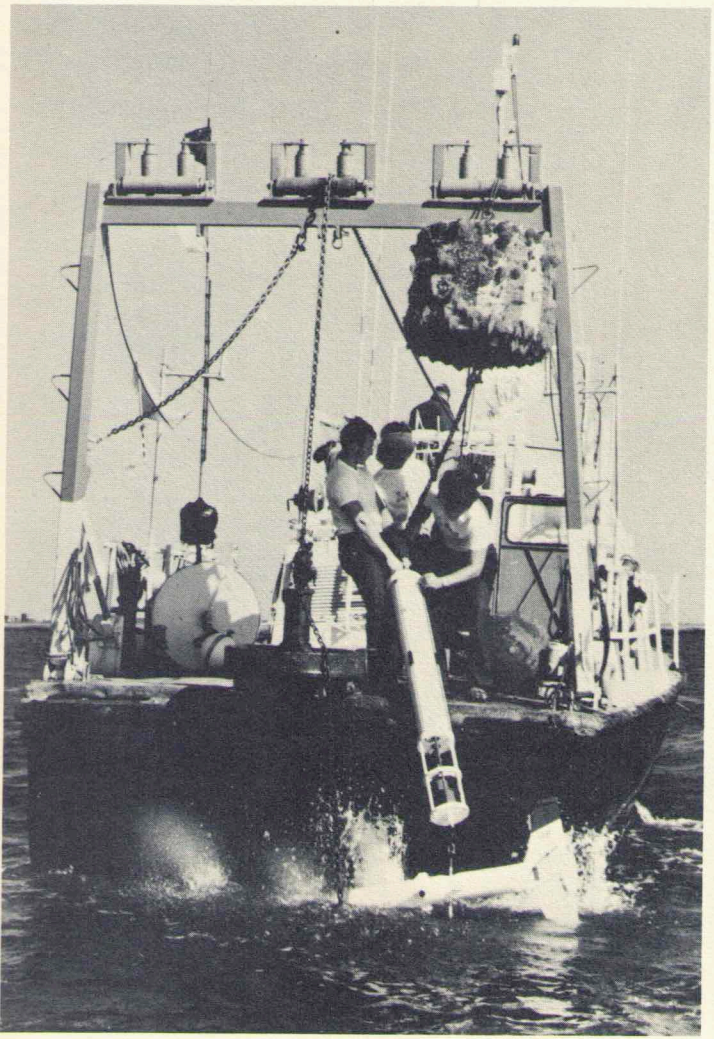


Interdisciplinary Programs



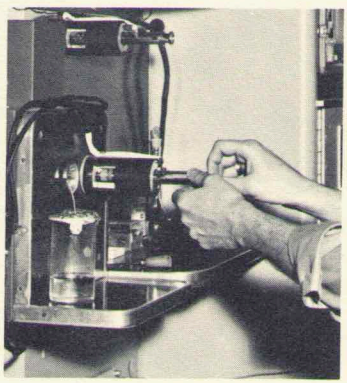
Chemistry continually infuses neighboring disciplines with its theories and practical applications. The Department of Chemistry has ties with the Departments of Biochemistry, Chemical Engineering, Civil Engineering, Earth Sciences, Microbiology, Physics, Zoology, Mechanical Engineering, and Botany, and the UNH Center for Industrial and Institutional Development (CIID). A Soil and Water Chemistry Option is offered jointly with UNH's Institute of Natural and Environmental Resources. With the modern oceanographic research facilities of the University, graduate and undergraduate students alike have the opportunity to conduct research in the traditional fields of chemistry as applied to the marine environment.

A student who is interested in the application of chemistry to another discipline may enter one of the approved Interdisciplinary Options in Chemistry. In these programs the student chooses a research problem to be supervised by a participating faculty member who may or may not be a member of the chemistry department. A five-member faculty committee and the student plan his or her program. Since the degree granted is a Ph.D. in Chemistry, the committee consists of at least three faculty members from the Department of Chemistry. The thesis supervisor is the chair-person of the student's doctoral committee.



The doctoral committee advises the student, supervises his or her educational program, and evaluates progress. The student, in conjunction with the doctoral committee, may design a formal interdisciplinary program in course work and research, or may elect to take only chemistry courses but choose a thesis topic which centers on an interdisciplinary problem of a chemical nature.

These options offer the student the unusual opportunity to gain a broad knowledge of chemical principles and techniques normally used in "pure" research and to gain experience in their application to other scientific disciplines.

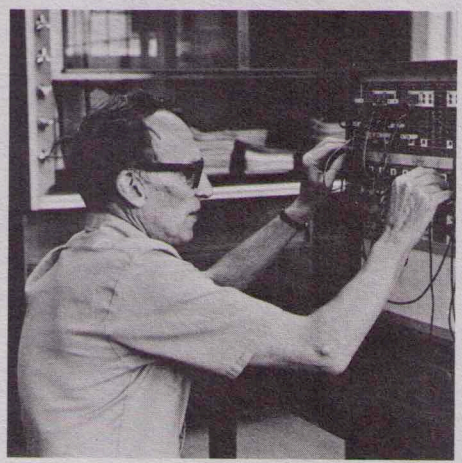


Recently students have elected interdisciplinary options in Soil and Water Chemistry, Marine Chemistry, and Chemistry—Earth Sciences.

Research opportunities are available in multidisciplinary areas, such as oceanography, chemical physics, and the life sciences, as well as in the traditional disciplines of analytical, inorganic, organic, and physical chemistry. Because of the wide research interests of the faculty, the dissertation may be done in most areas of chemistry. The following pages describe the faculty and their research. A list of current publications is included separately with this booklet.

ALEXANDER RENTON AMELL
Professor

Ph.D., 1950,
University of Wisconsin.
Physical chemistry: radiation chemistry; kinetics, tracer studies; isotopic exchange.

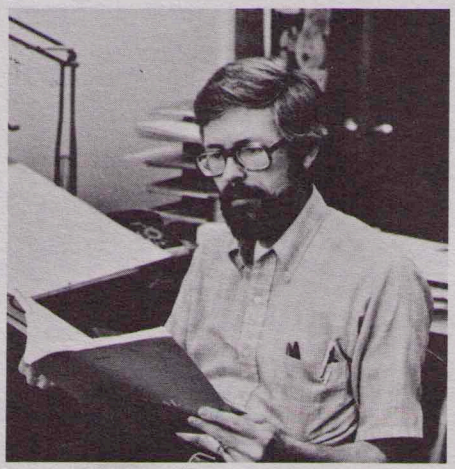


We are studying the effects of high energy radiation upon chemical systems. Our work is concentrated upon solutions, both aqueous and nonaqueous. Currently under investigation is the radiation of solutions of azo dyes, determination of the products of the irradiation, and the proposal of mechanisms which would lead to these products.

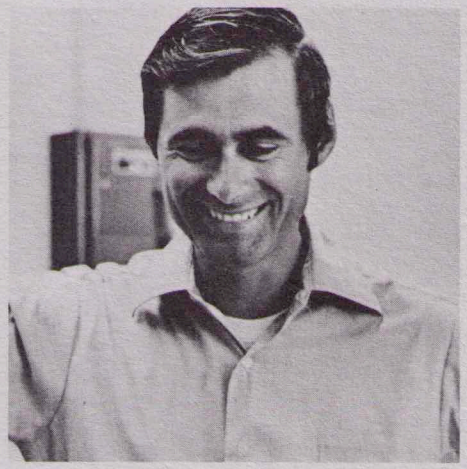
KENNETH KAAE ANDERSEN
Professor

Ph.D., 1959,
University of Minnesota.
Organic chemistry: stereochemistry of organosulfur compounds; chemical ecology.

We work in two areas of organic chemistry. One involves substitution reactions at sulfur and emphasizes stereochemistry and stereospecific reactions of substances such as sulfoxides and sulfonium salts. Our aim is to devise syntheses of chiral organosulfur compounds which have potential use in asymmetric synthesis and whose reactions lead to a better understanding of substitution mechanisms.



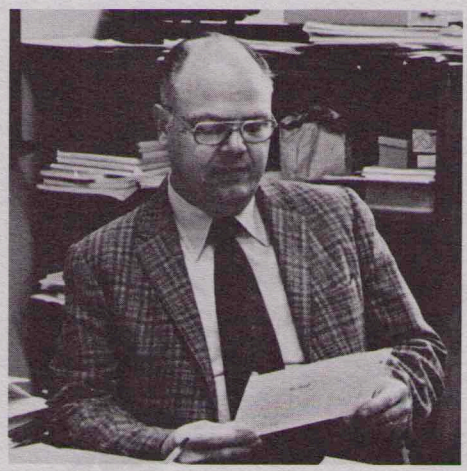
The second area is in the province of natural products. We are investigating compounds in seaweeds native to the New England coast. We are isolating biologically active substances which may be the chemical defense used by algae against predators. This project involves the collection of seaweed, sometimes by SCUBA diving; the extraction and isolation of the organic compounds; and, finally, their structural elucidation by spectroscopic and chemical means.



N. DENNIS CHASTEEN
Associate Professor

Ph.D., 1969,
University of Illinois.
Biophysical and bioinorganic chemistry: application of EPR spectroscopy and other physical methods to the structure and function of metalloproteins, marine chemistry.

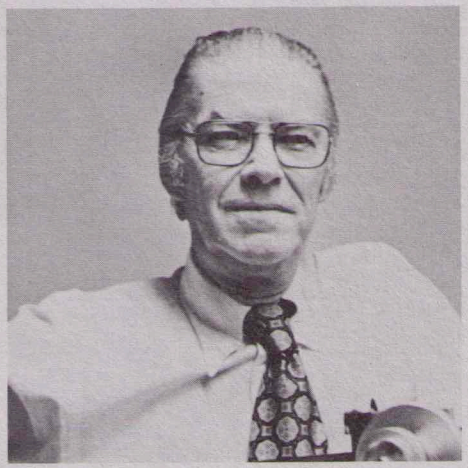
We are interested in the role of transition metals in various biological processes. Areas currently under investigation include isolation and characterization of metalloproteins involved in the biomineralization process of marine shell deposition and metal site studies of the iron transport protein serum transferrin. These studies rely heavily on EPR spectroscopy and other physical methods to probe the metal binding sites of biopolymers. In addition, we are involved in the application of EPR spectroscopy to the study of transition metals in marine environments. This is a collaborative effort with Professor Henri Gaudette of the Department of Earth Sciences.



CLARENCE L. GRANT
Professor and Chairperson

P.h.D., 1960, Rutgers University. Analytical chemistry: spectroscopic techniques applied to geological and biological problems, water and sediment relationships; sampling statistics.

Our research regarding metal complexation in water consists of studies of metal complexes in both freshwater and seawater systems. Studies with inorganic and organic ligands are in progress. The effect of varying environmental factors such as pH, salinity, organic content, and particulate concentration on metal speciation is being investigated. We use ion selective electrodes and atomic absorption—flame emission methods in conjunction with separation techniques to acquire experimental data on the concentrations of various species. Such data is essential if we are to make intelligent predictions of toxicological potential for various organisms. Comparisons with thermodynamic models are made where such models are available.



HELMUT MAX HAENDLER
Professor Emeritus

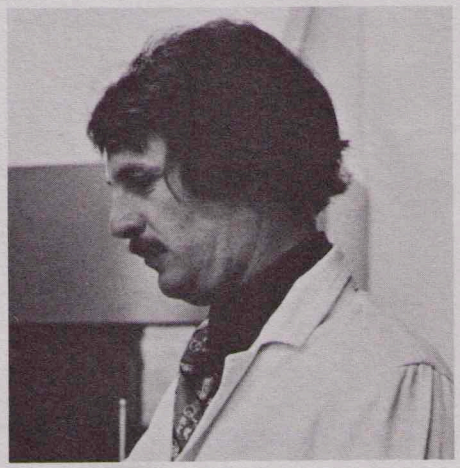
Ph.D., 1940,
University of Washington.
Inorganic chemistry: reactions in nonaqueous solvents; X-ray crystallography and its application to inorganic chemistry, solid state reactions.

Our current studies in the fluorine research deal with thermal characteristics of fluoride hydrates and complex fluorides. Nonaqueous media are used to carry out inorganic reactions involving metal salts. New chalcogenide compounds are being synthesized by vapor transport techniques, and structural studies are made of these and of a series of metal complexes of chelating organic acids.

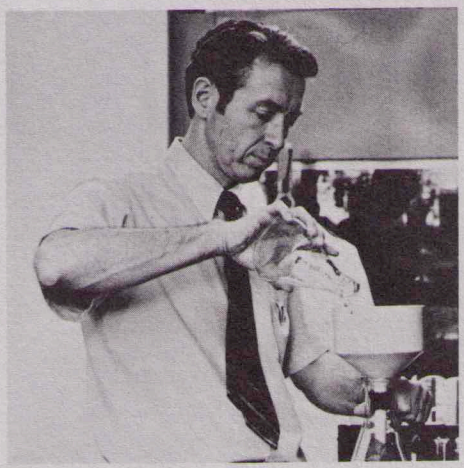
COLIN DAVID HUBBARD
Associate Professor

Ph.D., 1964,
University of Sheffield.
Physical chemistry and physical biochemistry: kinetics and mechanism of transition metal complex substitution reactions; mechanisms of enzyme-catalyzed reactions; proton transfer reactions; rapid reaction methods.

Our interests are centered upon the detection and characterization of elementary steps in labile chemical and biochemical systems thereby allowing an understanding of the detail of the reaction mechanisms. Studies are also being done in the enzyme systems,



aspects of whose mechanisms of catalysis currently under investigation are chymotrypsin, cholinesterase, and chymopapain. In the field of transition metal complex substitution reactions, the effects of ligand charge, ligand donor atom nature, ligand substituents, and ligand stereochemistry upon the kinetic reactivity are studied in an investigation of the detailed substitution mechanisms. The application of these results to metal ion involvement in biological systems is also considered. Proton-transfer reactions having anomalously large isotopic effects are under investigation. Criteria for quantum-mechanical tunneling are sought.

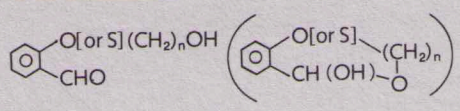


PAUL RAYMOND JONES
Professor

Ph.D., 1956,
University of Illinois.
Organic chemistry: novel macrocyclic lactones; ring-chain tautomerism; reactions of organocadmium compounds.

In our research on the chemistry of organocadmium compounds, the less recognized reactions of organocadmium reagents (R_2Cd, RCdX) are being investigated: for example, displacement of X at a saturated carbon in allylic and benzylic halides and in α-halo esters, and rearrangements of the organic moiety in the organocadmium structure.

We are also researching benzomacrocycles as models for ring tautomers. Series of novel compounds of the following types (I, II) are being prepared and examined. The structures shown in parentheses are the unprecedented macrocyclic ring tautomers, which, it is proposed,



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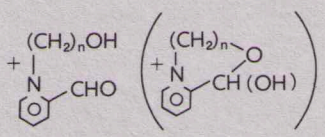


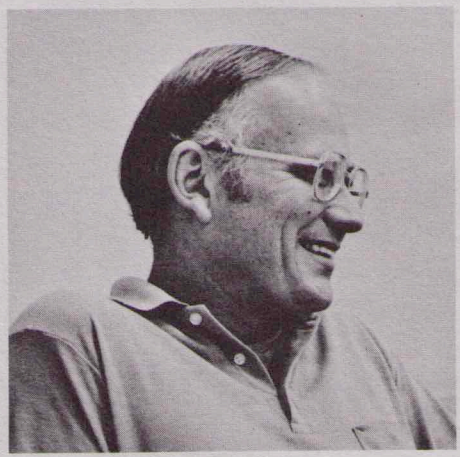
II

can be detected by NMR techniques and chemical trapping experiments. Some of the compounds already studied exhibit mild antibacterial activity.

JAMES D. MORRISON
Professor

Ph.D., 1963,
Northwestern University.
Organic chemistry: stereo-chemistry; asymmetric reactions; homogeneous catalysis; peptide synthesis.

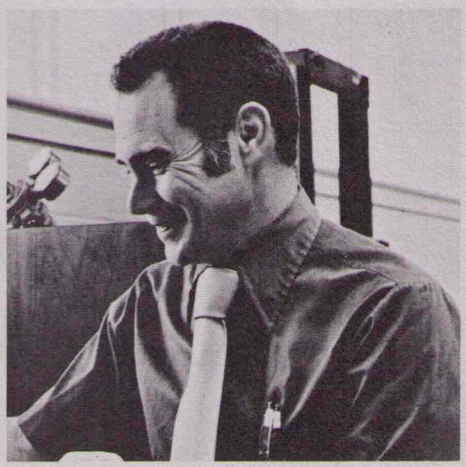
We are studying various kinds of asymmetric organic reactions, particularly catalytic reactions involving organometallic reagents and transition metal systems. Some of our research is therefore a blend of organic and inorganic chemistry. A particular interest at the present time is the design of new homogeneous hydrogenation reactions involving complexes of metals such as rhodium. Projects concerned with studies of chiral reactions using isotopic labeling, the synthesis of chiral ligands, the synthesis and reactions of chiral epoxides, and chiral photo alkylations are also in progress. We are also interested in peptides, particularly the synthesis of cyclodepsipeptides and bicyclic peptides with anticoagulant and antibiotic properties.



CHARLES WESLEY OWENS
Associate Professor

Ph.D., 1963,
University of Kansas.
Physical chemistry.

Our first program of research is in the solid-state chemical reactions initiated by nuclear particles and radiation, photolysis, and heat; *in-situ* identification of intermediates. We also engage in Mössbauer spectroscopy dealing with monitoring solid-state chemical reactions in environmental and laboratory media.



FRANK LOUIS PILAR
Professor

Ph.D., 1957,
University of Cincinnati.
Physical chemistry:
quantum chemistry.

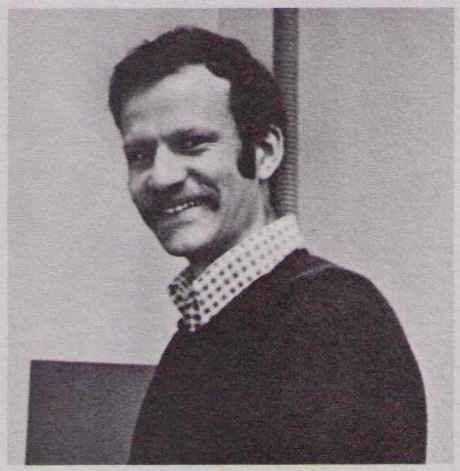
Our current work concerns theoretical calculations on biologically active molecules by means of approximate molecular orbital methods. Some recent

work is attempting to relate calculations on the zwitterion form of amino acids to the mechanism of protein synthesis, and correlating the electron populations of 5-fluorouracil with its anticancer activity.

ALBERT KENDALL SAWYER
Professor

M.S. 1947,
University of Maine.
Organic chemistry: preparation and reactions of organotin hydrides.

Several areas of interest include the preparation and reactions of organotin hydrides and compounds containing tin-tin bonds with and without functional substituents. We are also interested in redistribution reactions involving organotin compounds. Of particular current interest are syntheses of new branched chain organopolytins with and without functional substituents on tin and of unusual organotin compounds of the type $(RSn)_n$.



W. RUDOLF SEITZ
Assistant Professor

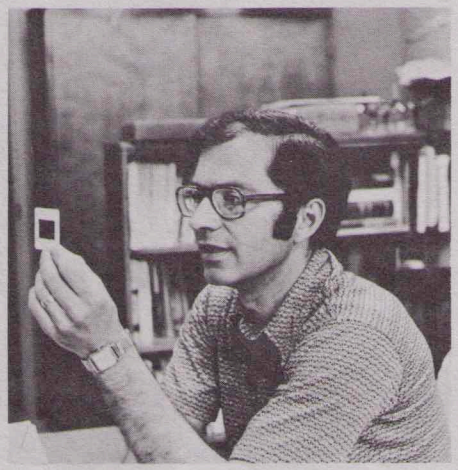
Ph.D., 1970,
Massachusetts Institute of Technology.
Analytical chemistry.

Our major research interests include developing and evaluating new approaches to biochemical analysis and immunoassay based on chemiluminescence (CL) and bioluminescence (BL). We are particularly interested in developing analytical systems using immobilized enzymes to catalyze CL and BL. Another research area involves developing sensitive interference-free analytical methods for phosphorus, sulfur, and other nonmetals in a variety of matrices by coupling flame photometry and furnace vaporization. A third research interest is to evaluate fluorescence and phosphorescence as a means of characterizing natural humic material and its interaction with metals.

J. JOHN UEBEL
Professor

Ph.D., 1964,
University of Illinois.
Organic chemistry: solvolysis reactions; conformational analysis; NMR shift reagent studies; marine natural products.

We are engaged in organic research on three fronts: (1) reactions of allylic compounds — studies of the Sn2′ reaction, (2) the use of NMR shift reagents as structural tools, (3) chemical defenses of seaweeds. In



the first area, we are particularly interested in understanding the factors that determine the direction of nucleophilic attack on an allylic system. In the second, we are seeking to understand and develop the use of lanthanide shift reagents as structural tools. The third area represents a joint research project along with Dr. K.K. Andersen and Dr. M. Ikawa (biochemistry). We are isolating and identifying compounds from New England coastal seaweed and sponges with an eye toward finding out more about the chemical defenses of these plants.

JAMES H. WEBER
Professor

Ph.D., 1963,
Ohio State University.
Inorganic chemistry: organometallic chemistry; metal complexes of natural water organic matter.

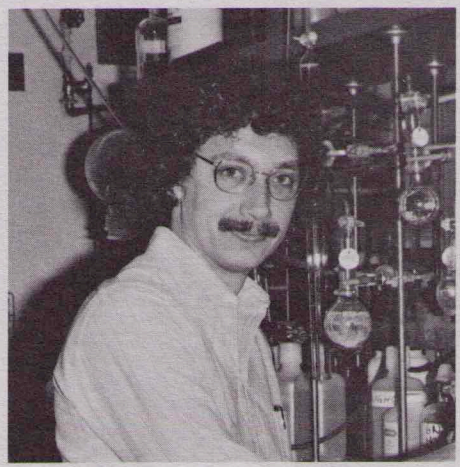
Our research in organometallic chemistry emphasizes the formation and reactivity of mono- and dialkylcobalt complexes. We effect cobalt-carbon bond cleavage and study the mechanisms and products by kinetics, GC, NMR, etc.

In another area we are studying metal complexes of natural water organic matter. This environmental research emphasizes the study of heavy metal ion-organic matter complexes in rivers, lakes, and oceans. Present studies include (1) stability constants between the organic matter and metal ions, (2) the chelating capacity of natural water, and (3) the nature of the bonding in the metal complexes.

GARY RAYMOND WEISMAN
Assistant Professor

Ph.D., 1976,
University of Wisconsin.
Organic chemistry: conformational analysis; structure of free radicals in solution; electron transfer in organic systems; synthetic and physical aspects of host-guest chemistry.

Our interests lie in three areas of physical organic chemistry. One area emphasizes investigation of oxidation-reduction reactions of nitrogen-containing compounds. Specifically, electron spin resonance and electrochemical techniques are used to study structure and stability of radical ions and other intermediates.



In host-guest chemistry, the applicability of hosts (such as crown ethers) for complexation of organic cationic intermediates is being examined.

Finally, dynamic nuclear magnetic resonance is being utilized in conformational analysis and the study of dynamics of complexation phenomena.

CHARLES MERVYN WHEELER, JR.
Professor

Ph.D., 1951,
West Virginia University.
Physical chemistry: polarography of organometallic compounds; electrochemistry of indium complexes.

We are principally interested in using electrochemical methods to study complex ion formation and the mechanisms of reactions at the dropping mercury electrode.

Our studies of polarographic and electrochemical cell measurements provide data with which to determine the formula and stability constant of a complex metal ion. Thermodynamics data can also be obtained from these data. It is of interest to study the effect of different substituent groups on the magnitude of the stability constants. The mechanisms and, indeed, the products of many reactions vary when compounds are oxidized or reduced at the dropping mercury electrode. We have found the investigation of the effect of pH and electrode potential on such a variation of interest in this instance.

EDWARD H. WONG
Assistant Professor

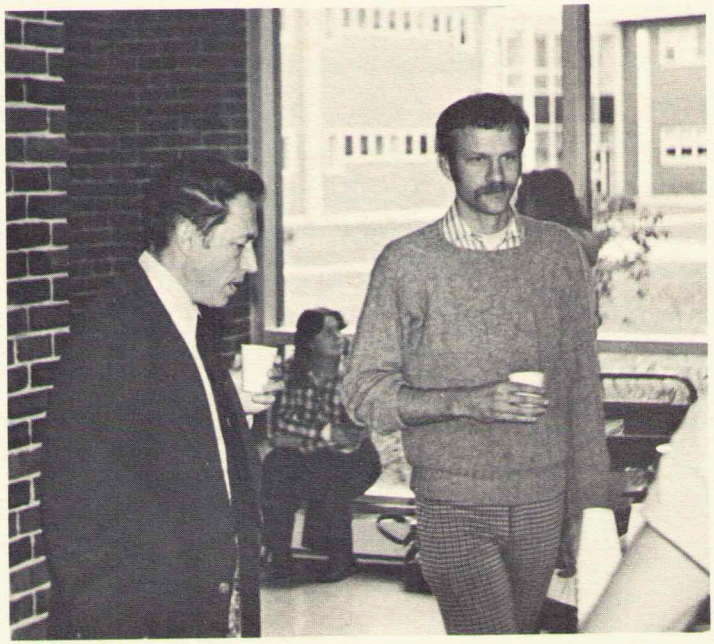
Ph.D., 1975,
Harvard University.
Inorganic and organometallic chemistry: synthesis and studies of polyhedral boranes and boron analogues of biological compounds; transition metal centers in homogeneous catalysis.

We are investigating the influence of the redox process upon polyhedral geometries of boron clusters, and we seek evidence for electron delocalization in these superaromatic compounds through the isolation and study of stabilized radical boranes.

Research into boron analogues of amino acids and dipeptides will be pursued to evaluate their biological activities. Our second area of interest concerns the preparation of ligand systems capable of constraining two or more metal centers to allow

for multi-center activation of substrates; the goal is to demonstrate synergistic effects of interacting metal centers in both homogeneous catalysis and in metalloenzymes containing several metal sites.

Each week there are two seminars, one held jointly by the analytical, physical, and inorganic divisions and the other by the organic division. Speakers include prominent scientists from academia, industry, and government, as well as students. In addition the H.A. Iddles Lecture Series in honor of the late Harold A. Iddles, who was head of the department for 30 years, brings outstanding researchers to the campus. Some past H.A. Iddles lecturers include the late Arthur C. Cope, Massachusetts Institute of Technology; Professor Vincent du Vigneaud, Nobel Laureate, Cornell University Medical School; Professor Louis Fieser, Harvard University; the



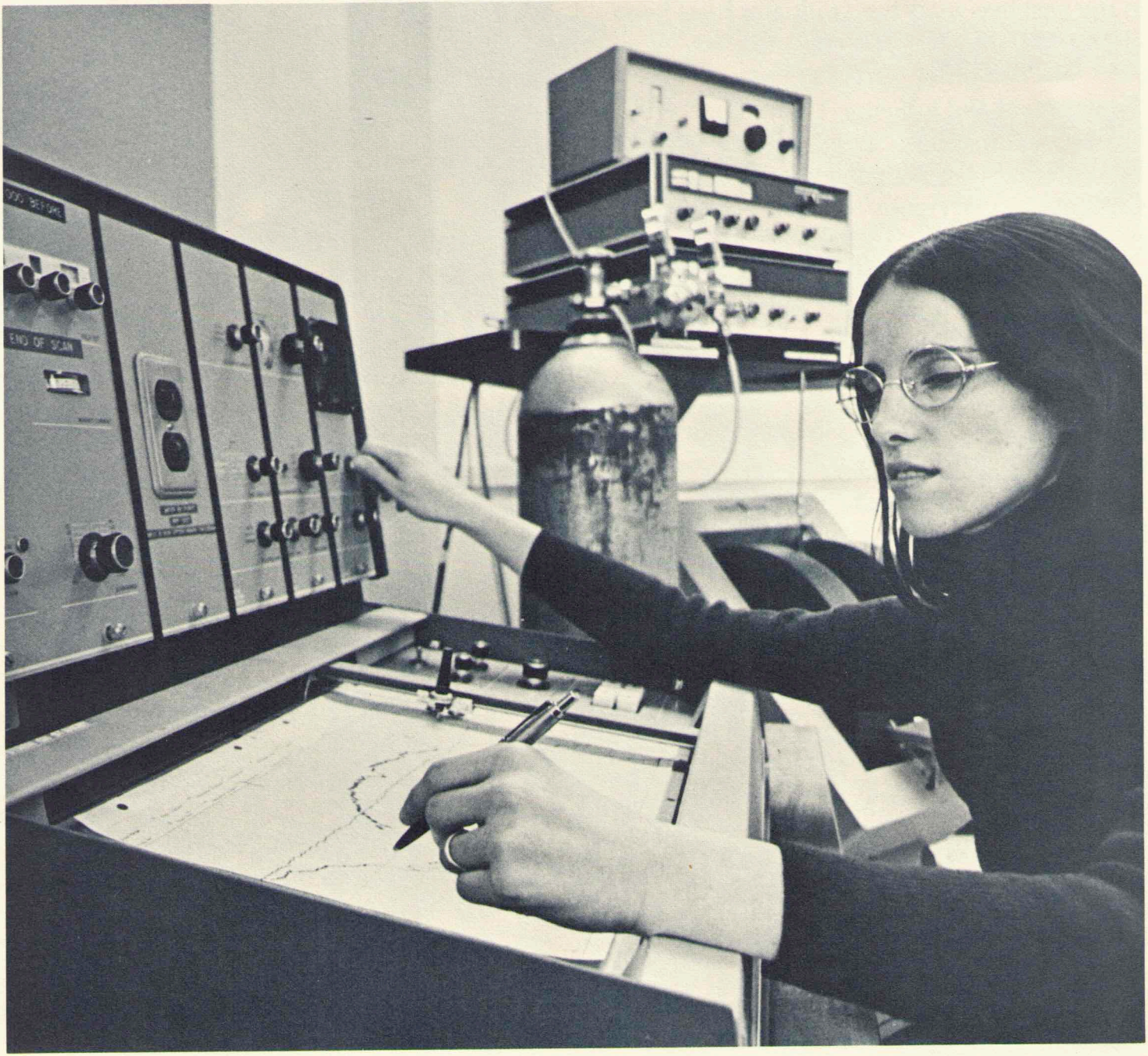
late Farrington Daniels, University of Wisconsin; Louis Hammett, Columbia University; Manfred Eigen, Nobel Laureate, Max-Planck-Institut für Physikalische Chemie; Kenneth B. Wiberg, Yale University; George Pimentel, University of California at Berkeley; Kurt Mislow, Princeton; George S. Hammond, University of California, Santa Cruz; and Daryle Busch, Ohio State University. In 1977 the Strem Chemical Company began sponsoring an annual lectureship similar to the H.A. Iddles Series. The Sigma Xi lecture series also had a number of speakers of interest to chemists.

Degree Requirements

M.S. The student must complete a total of 30 credits of graduate work of which not more than 10 credits are thesis research. The remaining 20 credits are made up of seminar (1 credit), in which the student presents a topic from the current chemical literature, and course work 700 level or above. Typically, M.S. students take six or seven courses. Two of these courses must be selected from the three core courses: inorganic (Chem. 803), organic (Chem. 801), and physical chemistry (Chem. 805). In addition, the student is required to write and successfully defend a thesis based on original research. The M.S. degree normally takes two years to complete.

Ph.D. The student typically takes from seven to nine graduate courses of which four to six are in his or her major field. The exact number of courses depends on the area: analytical, inorganic, organic, physical, or interdisciplinary. Ph.D. students are required to take the three core courses, Chemistry 801, 803, and 805. At the end of the first year, the student is examined in his or her major area. Successful completion of the exam permits the student to take cumulative exams in the second year. Two technical seminars must be presented in addition to the formulation and successful defense of an original research proposal before his or her doctoral committee.

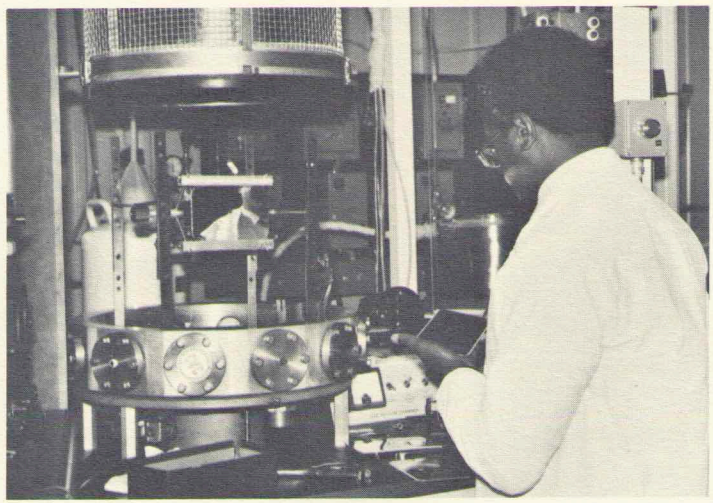
A reading knowledge of German or Russian is required by the analytical, inorganic, and physical divisions. A reading knowledge of German and either French or Russian is required by the organic division. Research work begins during the first two years but it is normally not a full-time activity until the student's third year, when most of the other requirements have been completed. The average student takes four years to complete a Ph.D.


END OF SCAN

Employment Opportunities

In the past five years our graduates have been placed with the following concerns.

Government and Industry: Dupont de Nemours; GAF Corporation; B.F. Goodrich Laboratories; Health Sciences Laboratory, Gulf Oil Corporation; Handy Harmon Company; Information Systems; IBM; Interex Research Corporation; Miles Laboratories; Monsanto; Process Division Section, Norwich Pharmacological; Occupational Safety and Health Administration; Argonne National Laboratory; Naval Weapons Laboratory, Polychrome Corporation; Experimental Agricultural Chemicals, Rohm-Haas Company; Department of Medicinal Chemistry, The Schering Corporation; SISA Associates; Smith, Kline and French; 3M Company; Ventron Corporation; Westinghouse.



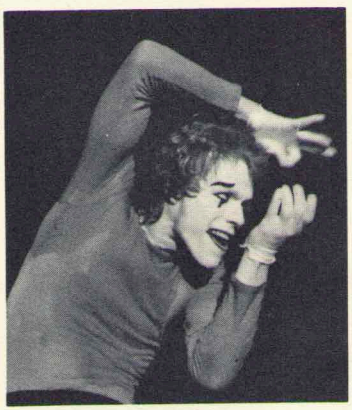
Academic: Chemistry Department, University of Alberta; Framingham State Teachers College; Chemistry Department, Montana State University; Center for Industrial & Institutional Development, University of New Hampshire; Department of Mechanical Engineering, University of New Hampshire; Chemistry Department, Universidad Nacional Autonoma de Nicaragua; Chemistry Department, Phillips Exeter Academy; Southern Foundation for Research and Education; Chemistry Department, SUNY at Fredonia; Natural Science Department, Southampton College; Chemistry Department, Towson State College; Centro de Petroleo Y Quimica – Instituto Venzolano de Investigairones Cientificas; Chemistry Department, Wilmington College; Worcester Foundation for Experimental Biology.

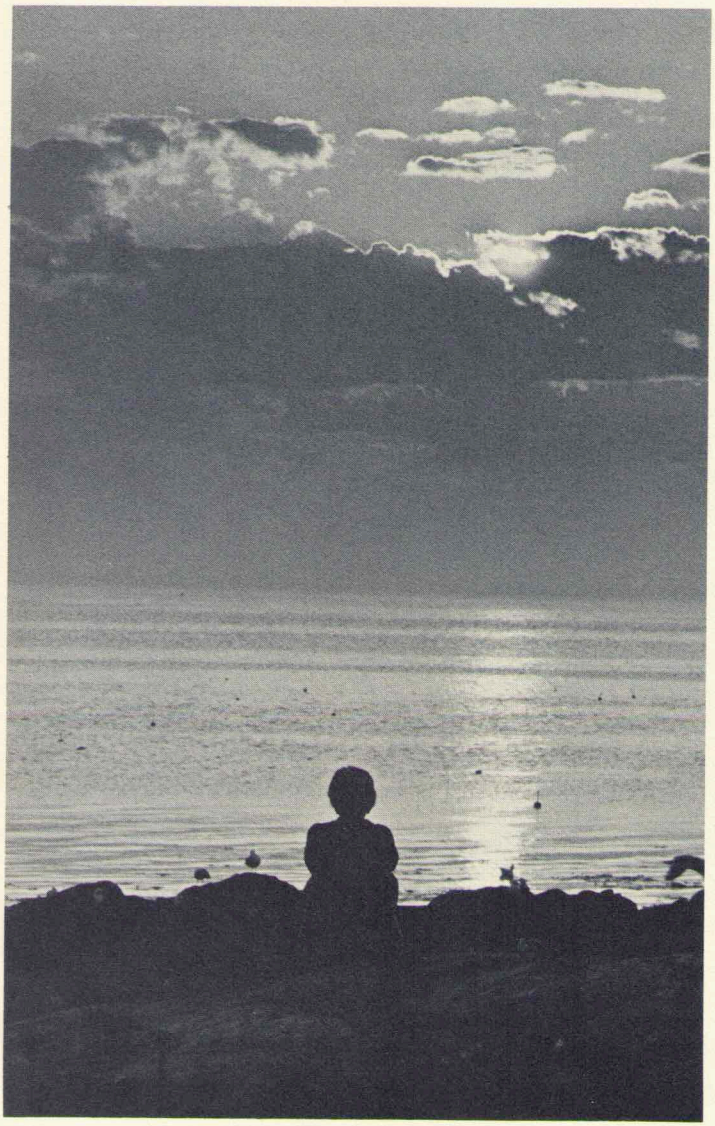
The Area

The University is ideally situated – 15 miles to the Atlantic coast where beaches, fishing, boating, and SCUBA diving are available; 65 miles to Boston, cultural center of the Northeast; and 60 miles to the wilderness attractions of the White Mountains. The campus is surrounded by more than 3,000 acres of woods and fields. University recreation areas have facilities for hiking, swimming, sailing, canoeing, and camping.

Cultural Attractions

The University offers many inexpensive opportunities to explore culture and art forms. With two theaters, two art galleries, and several auditoriums seating up to 5,000 persons, UNH is a major cultural resource for New Hampshire. A change in pace is available through the University galleries, lectures, concerts, theater productions, or films. The Celebrity Series presents a sampling of the country's top professional artists. The University Theater annually produces four major plays; a dance concert; several children's theater programs; and the Undergraduate Prize Production, a collection of original one-acts written by students.





Two major lecture series offered on campus are the Saul O Sidore Lecture Series, which presents critical and controversial issues; and the Davidson Lecture Series, which frames business topics in terms of international concerns. Many academic departments also offer lectures in their disciplines.

The University Art Galleries feature exhibitions of paintings, sculpture, crafts, as well as works by graduating Bachelor of Fine Arts students.

Financial Aid

For qualified individuals, support is in the form of teaching assistantships, research assistantships, UNH fellowships, and dissertation year fellowships. These all carry a waiver of tuition. In addition, several types of appointments are available with the Center for Industrial and Institutional Development (CIID) in which the student works on chemical problems of importance to industry and government in the New England region. In the summer, students are generally supported by summer fellowships and teaching or project assistantships. Since the stipends are subject to change, they are given on the separate information sheet included with this booklet. The lack of a sales tax or state income tax contributes to the low cost of living in New Hampshire relative to many other parts of the country.

Housing

Babcock House, the graduate residence hall, is a major center of graduate student activities. It is situated next to Parsons Hall. A limited number of University apartments are available for married couples in Forest Park. In addition, off-campus housing is available in Durham and neighboring towns. For further information and application forms, write to the Housing Office, Stoke Hall.

For further information about our programs, please write to:

Coordinator of Graduate Studies
Department of Chemistry
University of New Hampshire
Durham, New Hampshire 03824

Credits

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