

UNIVERSITY OF

DOUGLAS M. RUTHVEN, ANDREW CHASE*

University of Maine • Orono, ME 04469-5737

The University of Maine was established in 1868 as a Land Grant College (The Maine State College of Agriculture and Mechanic Arts), but in its early years enrollments were very small. The first graduating class (1872) numbered only 6, although by 1876 it had reached 33 and by 1911 it numbered 140 (including 15 students who were awarded Master's degrees). Today, with about 10,000 students, the University of Maine is still not large by state-university standards, but it is the only multidisciplinary university in Maine as well as the only one to offer a full engineering program. The College of Engineering has about 1200 students in all, including 138 graduate students and about 300 students enrolled in Engineering Technology. Somewhat unusually, chemical engineering (with 180 undergraduates and 30 graduate students) is the largest of the engineering departments.

CHE DEPARTMENT HISTORY

Some important milestones in the history of chemical engineering at U Maine are listed in Table 1. The first program in chemical engineering appeared in the catalog in 1908, the year in which AIChE was

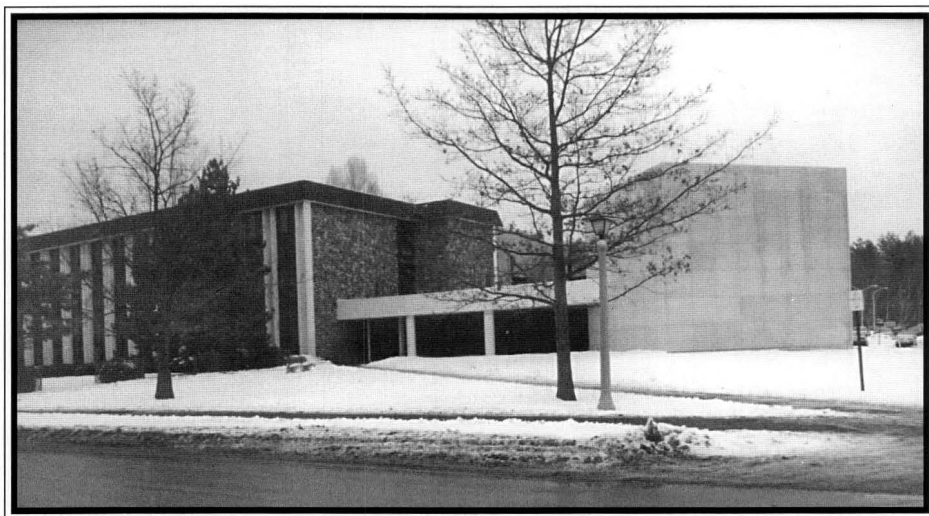


Figure 1. *Jenness Hall and the Soderberg Center (right).*

founded, and the first ChE degrees were awarded in 1911. At that time, chemical engineering was part of the Chemistry Department and, in common with most ChE programs of that era, the course content was essentially what we would now call "applied chemistry." In the early 1920s, an MS program was introduced, and (following the lead of MIT) courses titled "Unit Operations" appeared in the undergraduate curriculum.

The founder of the modern department, Lyle C. Jenness (in whose honor the chemical engineering building is named), was appointed to the faculty in 1926 (see Table 2). He served as a faculty member for forty years, the last twenty of them (1947-1966) as Department Head.

Chemical engineering became a separate Department in 1946, but for the next twenty-five years it continued to be housed, with the Chemistry Department, in Aubert Hall. A separate ChE building, Jenness Hall, was completed in 1972, but some of the laboratories remained in Aubert Hall until 1986 when, with a substantial extension to Jenness Hall, the Department was finally accommodated at a single location. A second exten-

* Andrew Chase is Professor Emeritus of Chemical Engineering, having served on the U Maine faculty from 1949 to 1982.

... through the shrewdness and foresight of its founders . . . and with the generous help and support of the Foundation, U Maine has become an important niche player, providing a supply of well-trained and capable graduates with a special focus on the needs of the pulp, paper, and associated industries and acting as a center for fundamental research on problems of practical concern to that industry.

MAINE

sion to Jenness Hall, to provide a state-of-the-art lecture room and conference room with distance education facilities, as well as an extension to the Pilot Plant, is due to open in April, 1997.

Throughout most of its history, the Department has been closely linked with the paper industry and its present success is due in no small measure to the generosity of donors from that industry. The first course in pulp and paper technology appeared in 1913, but it was Lyle Jenness who first fully appreciated the importance of focusing on the needs of this industry. He seems to have been among the first to recognize that the paper industry involves a wide range of standard chemical engineering operations, and that to meet its staffing requirements, the industry needed broadly trained chemical engineers rather than narrowly trained paper technologists. The U Maine Pulp and Paper Foundation was established in 1950 and incorporated in 1953 through the efforts and generosity of twelve alumni, all of whom had risen to important positions in the industry (see Table 3). Of particular note are J. Larcom Ober, whose generous bequest in 1990 financed the Ober Professorship, and Frederic Soderberg, who bequeathed \$4.3 million to the Foundation in 1993 (of which about half has been used to finance the final phase of the Jenness Hall expansion and the Soderberg Center).

Since 1970, the Foundation has been managed by Mr. Stanley Marshall, Jr., as its Executive Director. The annual income is now about \$800,000, of which about half is devoted to merit-based student scholarships. Many, but by no means all, of these scholarships go to chemical engineering students—a significant number of students in other engineering disciplines are also supported. The Department also receives direct financial support of about \$200,000/year from Foundation sources.

In addition to financial support, the Department is the beneficiary of a finely tuned recruiting program mounted by the Foundation to attract top high school graduates to engineering in general and to chemical engineering in particular. In addition to an extensive series of high school visits, a short residential course is organized during the summer for

Spring 1997

TABLE 1
ChE Department Milestones

1908	First courses in ChE listed in UM catalog
1911	First ChE degrees awarded
1923	MS program introduced
1926	Lyle C. Jenness appointed to faculty
1946	ChE formally separates from chemistry; Roy Whitney appointed head of ChE
1947	Roy Whitney resigns; Lyle C. Jenness appointed Head (retired in 1966)
1948	AIChE Student Chapter formed; first female ChE graduate
1950	UM Pulp and Paper Foundation established by 12 UM alumni (incorporated formally in 1953)
1951	ChE program accredited by AIChE
1958	Major extension to laboratory facilities at Aubert Hall
1960	Gottesman Computer Center established in ChE (first computer center on campus)
1962	PhD program introduced
1972	Department moves to its own building—Jenness Hall
1973	Cooperative work experience program introduced
1986	Jenness Hall extension to accommodate ChE laboratories and Pilot Plant
1997	Soderberg Center and Pilot Plant extension to Jenness Hall

TABLE 2
Profile of Lyle C. Jenness

Born	November 1, 1900; South Danbury, NH
Education	BS, Chemical Engineering; UNH, 1922 MS, Chemical Engineering; UM, 1925 D.Phil. (Honorary); UNH, 1966
Teaching Career	Depts of Math and Chemistry; UM, 1923-26 Chemical Engineering; UM, 1926-66 Head of Chemical Engineering; UM, 1947-66
Deceased	May 4, 1986, in Orono, ME

TABLE 3
Founding Members of UM Pulp and Paper Foundation
Articles of Incorporation signed on 27th of July, 1953, at Orono, ME

President	J. Larcom Ober:	V. President, Scott Paper Co..
Vice Presidents	Frederic A. Soderberg Walace B. Parsons	V. President, Huyck Felt Co. Keyes Fibre Co.
Secretary	Henry W. Fales	St. Croix Paper Co.
Treasurer	Ralph A. Wilkins	Bird and Son, Inc.
Directors	George D. Bearce Philip S. Bolton John S. Calkin Thomas G. Mangan Harold Holden M.C. McDonald Raymond W. Davis	St. Regis Paper Co. Robert Gale Company University of Maine International Paper Eastern Fine Paper Great Northern Paper Co. Robert Fibre Co.

top-ranked high school juniors. The students spend a week on campus taking part in a series of activities, including selected experiments, to introduce them to chemical engineering (see Figure 2).

The State of Maine ranks 46/50 in per capita funding of higher education and 50/50 in research funding. Without the support of the Foundation, it would not have been possible to develop and support a high-caliber, nationally competitive chemical engineering program.

BS PROGRAM

The BS program, which last received full ABET and AIChE accreditation in 1995, is summarized in Table 4. One hundred and thirty credit hours are required for graduation, and the course structure and content, including general education requirements, are similar to most US university programs. Communication skills and teamwork are emphasized.

A special feature of the program is the emphasis on cooperative work experience that takes place in the junior year. Between completion of the sophomore year in May and the start of the senior year the following September, students spend two four-month periods in industry, separated by one regular term (either fall or spring) on campus in Orono and three months of summer school to pick up key courses missed during the internship period. The benefits of this program are mutual since it provides employers access to a pool of capable, trained manpower on what amounts to a trial basis, and it provides students with valuable practical experience and an insight into the opportunities and challenges faced by a junior engineer. More than 85% of the students select the co-op option, even though it involves significantly more work. The benefits are clearly apparent from the hiring statistics, which show that the co-op graduates almost invariably receive the earliest and usually the best offers of permanent employment.

In addition to the usual unit operations laboratory, the Department has a fully equipped pulp and paper laboratory, which is used as a teaching laboratory (for pulp and paper courses), as a testing service in conjunction with the Pilot Plant, and for research. The Department has always made it clear that we offer a general chemical engineering program rather than a program in pulp and paper. Nevertheless, the

curriculum does allow for a modest degree of specialization through the choice of technical electives. Furthermore, most of our industrial partners (who provide the places for co-op students) are associated with this industry, defined in its broadest sense to include the equipment and materials suppliers as well as the companies actually involved in pulp and paper production. The industrial base of the state is heavily dependent on the pulp and paper industry, so it is hardly surprising that the majority of U Maine chemical engineering graduates eventually find employment in this industry.

Student numbers have shown steady growth over the years and, with a freshman class of about 50 and graduating classes of about 35, we are now approaching full capacity. The first female to complete the program graduated in 1948, but until the late 1970s, the number of female graduates remained relatively small. The proportion of female graduates has increased rapidly in recent years and now amounts to about 35%. Our program has gained a reputation as one of the more challenging on campus, and the apparently high attrition rate is accounted for mainly by transfers to less demanding programs.

RESEARCH AND GRADUATE STUDIES

The MS degree in chemical engineering was introduced in 1923 and the PhD in 1962, but a significant emphasis on graduate studies and research developed only in the 1970s. Today, the Department has approximately 30 graduate students divided almost equally between the PhD and MS programs. The Foundation provides financial support for up to five first-year graduate students and this goes a long way toward solving the problem of how to fund first-year students before they select a research project. About two-thirds of the graduate students are citizens or permanent residents of the US. This is a much higher proportion than in most chemical engineering departments, in part as a result of a policy restricting the use of Foundation funds to the support of American students.

Perhaps the defining feature of the research program is its close collaborative relationship with industry. The Department has well-equipped research laboratories that include major items, such as an NMR spectrometer and an environmental scanning electron microscope, that are not commonly found in chemical engineering departments. In addition to the usual small-scale laboratory equipment, there is a fully

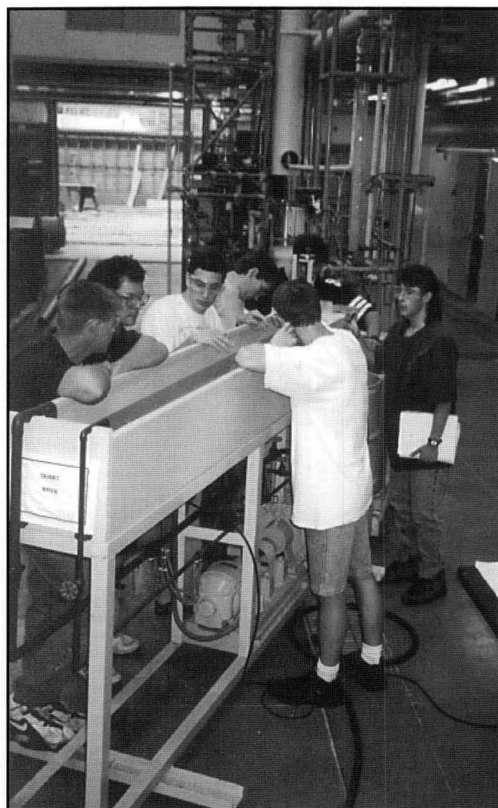


Figure 2. Robert Bilodeau (second from left), a PhD student, assists a group of high school juniors with a hydraulics experiment.

equipped paper-making Pilot Plant, valued at approximately \$5 million. The research program is funded at a level of about \$1.2 million/year, of which about two-thirds comes directly from industry and the remaining one-third from government sources. In addition, the Pilot Plant generates about \$600,000/year from industrial contracts.

Two of the major research groups (Paper Surface Science and Recycle Fiber Technology) are structured as industrial research partnerships in which the member companies (27 companies between the two consortia) pay an annual fee to support research in the designated area. This provides a steady base of financial support at about \$400,000/year for the two programs. Research results are distributed to the members prior to publication and are reviewed at meetings of the consortium, held two or three times a year. These

meetings provide a forum for comments and feedback from the industrial partners as well as an opportunity to suggest additional critical experiments and to propose future research directions. They also provide a useful forum for graduate students to meet and talk with their industrial sponsors, who frequently have a somewhat different perspective. In several instances, the relationships established in this way have led directly to offers of employment. Further details of these and other research activities follow.

Paper Surface Science Program

(Profs. LePoutre and Bousfield; ten students)

The emphasis of this program, supported by a consortium of fifteen companies, is on developing a fundamental understanding of surface treatment processes such as paper sizing,

coating, printing, and gluing. This requires detailed studies of both the physics and chemistry of the surface interactions and the fluid mechanics of fluid-paper contacting. Since the fluids involved are generally non-Newtonian suspensions, the rheological and fluid mechanical problems are complex. Recent studies have focused on several different issues. For example, print gloss is a critical indicator of the quality of the final printed page. A laser-beam system has been developed to monitor the ink-gloss dynamics starting at 0.1 sec after the printing nip. Analysis of the surface-tension driven leveling of the ink filaments reveals that the filament diameter has a critical impact on the final gloss level. The structure of a paper coating depends on the pigment type, the proportion of latex or water-soluble binders, and the mode of application and drying. Systematic studies of the effects of key variables have been carried out using light scattering techniques to monitor the porosity and roughness of the surface.

Cooperative Recycled Fiber Studies

(Prof. Thompson; five students)

The overall aim of this program, supported by a consortium of twelve companies, is to provide fundamental research to support and supplement the paper industry's own research and development efforts in relation to the problems associated with the recycling of fiber. Research has been focused mainly in three areas: flotation, repulping; and high-consistency dispersion. Experimental flotation stud-

TABLE 4
The BS Chemical Engineering Program at UM

YEAR 1			
<i>First Semester</i>		<i>Second Semester</i>	
Analytic Geometry and Calculus	4	Analytic Geometry and Calculus	4
Chemical Principles I / Lab	4	Chemical Principles II / Lab	4
Physics for Engineers and Physical Scientists I	4	Physics for Engineers and Physical Scientists II	4
Introduction to Chemical Engineering I	2	Introduction to Chemical Engineering II	2
Humanities/Social Sciences Elective	3	Humanities/Social Sciences Elective	3
Total Hours	17	Total Hours	17
YEAR 2			
<i>First Semester</i>		<i>Second Semester</i>	
Analytic Geometry and Calculus	4	Intro. to Diff. Equations and Linear Algebra	4
Organic Chemistry Lecture I	3	Organic Chemistry Lecture II	3
Organic Chemistry Laboratory I	2	Electric Circuit Fundamentals	3
Fundamentals of Chemical Engineering	4	Chemical Engineering Thermodynamics I	3
Humanities/Social Sciences Elective	3	Statistics for Engineers	3
		Humanities/Social Sciences Elective	3
Total Hours	16	Total Hours	19
YEAR 3			
<i>First Semester*</i>		<i>Second Semester*</i>	
Physical Chemistry I	4	Physical Chemistry II	4
Elements of Chemical Engineering I	4	Elements of Chemical Engineering II	4
Process Control	3	Chemical Engineering Laboratory I	2
Chemical Engineering Thermodynamics	3	Chemical Engineering Kinetics	3
Statics and Strength of Materials	3	Technical Elective I**	3
Total Hours	17	Total Hours	16
YEAR 4			
<i>First Semester</i>		<i>Second Semester</i>	
Computer-Aided Process Design	3	Process Design Projects	4
Elements of Chemical Process Design	3	Chemical Engineering Seminar	1
Chemical Engineering Seminar	0	Technical Elective III**	3
Chemical Engineering Laboratory II	2	Humanities/Social Sciences Elective	3
Technical Elective II**	3	Humanities/Social Sciences Elective	3
Humanities/Social Sciences Elective	3		
Total Hours	14	Total Hours	14

*Co-op students are absent for either the Fall or Spring semester of the junior year. The necessary courses are picked up during two summer school sessions to allow graduation in four years.

** Technical electives include the polymer sciences sequence, the control sequence, the pulp and paper sequence, or any of the 500-level graduate courses.

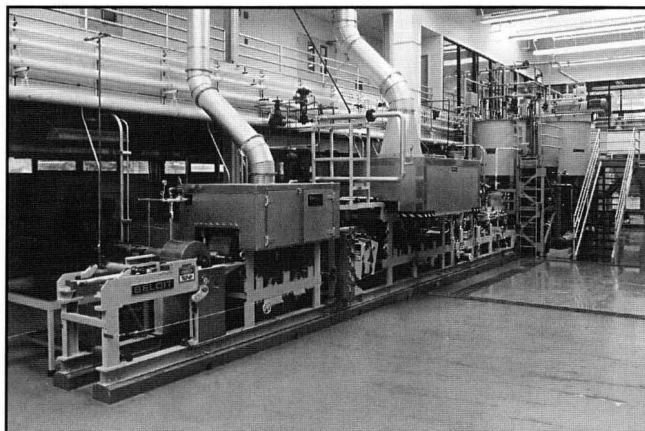


Figure 3. General view of the U Maine Pilot Plant showing the paper machine.

ies have addressed a wide range of important issues related to deinking. Theoretical studies have focused on developing a fundamental hydrodynamic model to calculate bubble and particle trajectories and predict the conditions for particle capture in a flotation cell. Repulping studies have been concerned mainly with toner/fiber and stickies/fiber detachment and the consequences of incomplete detachment on the performance of subsequent operations. The breakdown of toner particles and the fate of "hairy" particles in a modified 12-inch disk refiner have also been investigated.

Pulp and Paper Pilot Plant

(Prof. Genco; professional staff; four students)

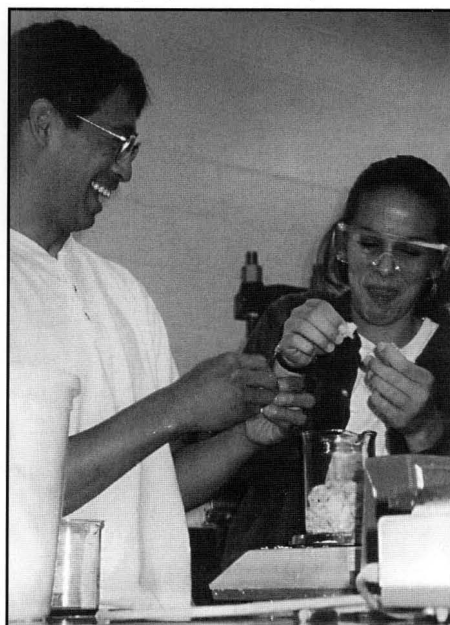
The Pilot plant is a fully equipped and instrumented facility that includes stock preparation and pulping, hydrocyclone cleaners, and a small-scale (12-inch) continuous paper machine (see Figure 3) as well as blade and roll coaters. One can thus start with wood, straw, recycled paper, or any other fibrous material and study the full paper-making process through to coating and final finishing of the sheet. The facility is run partly for research and partly as a routine testing facility for which the client company pays a service fee. Recent research has been focused on the development of new environmentally friendly bleaching and pulping processes based on the use of oxygen rather than chlorine as the primary oxidant as well as on advanced refining and drainage studies.

Supercritical Fluids

(Prof. Kiran; two post-doctorals; four students)

Professor Kiran has established a well-equipped high-pressure (up to 1000 bar) laboratory for studying the thermodynamic, transport, and kinetic aspects of supercritical fluids and polymer solutions. A series of integrated studies focusing on both the fundamentals and applications of near and supercritical fluids has been carried out over a period of more than ten years. Among the fundamental topics recently studied are the *Kinetics of Pressure-Induced Phase Separation*

Figure 4. Students share a laugh in the paper laboratory.



tion (PIPS) by Time-Resolved Light Scattering and Density Modulated Supercritical Polymerization, in which the density/pressure/temperature of the solvent medium is adjusted to achieve controlled phase separation and the precipitation thresholds are adjusted to control the molecular weight and morphology of the resulting polymers. More practically oriented studies have focused on the formation of micro-structured polymeric materials, delignification, and pulping under supercritical conditions, and on the possibility of using supercritical impregnation of other polymeric species to modify cellulose fibers and/or wood in order to improve the physical properties.

Sensors and Neural Networks

(Prof. Pendse; three students)

Hemant Pendse's main research focus has been on the development of advanced sensors—notably the application of ultrasound to the characterization of slurries. This has led to the development of a commercial instrument, the *Acoustrophoretic Particle Analyzer*, which can provide information, without dilution, on the particle size distribution of quite concentrated slurries. Present research is focused on generalizing these techniques to obtain information on particle shape and to study the characterization of suspensions, polymer melts, and porous media. The possibility of applying virtual sensors using a neural network to improve the control system at a local pulp mill is being investigated, in collaboration with Prof. M.T. Musavi of the Electrical Engineering Department.

ChE DEPARTMENT—UNIVERSITY OF MAINE

ChE FACULTY

Douglas W. Bousfield (*Associate Professor*)

BS, Montana State, 1981 • MS, Oregon State, 1983 • PhD, California-Berkeley, 1986
Non-Newtonian fluid mechanics, fluid suspensions, particle hydrodynamics, and flow in thin films; Director of Graduate Studies

Albert Co (*Associate Professor*)

BS, University of Philippines, 1972 • PhD, Wisconsin, 1979
Polymer rheology, slip casting, transport phenomena; responsibility for computing facilities and LAN

Joseph M. Genco (*Calder Professor and Director of Pilot Plant*)

BS, Case Institute, 1960 • MS, Ohio State, 1962 • PhD, Ohio State, 1965
Pulp and paper technology, delignification of wood, novel pulping methods

John C. Hassler (*Professor*)

BS, Kansas State, 1960 • PhD, Kansas State, 1966
Process control, instrumentation and computer interfacing, mathematical modeling

John J. Hwalek (*Associate Professor*)

BS, Clarkson College, 1977 • MS, Illinois, 1980 • PhD, Illinois, 1982
Process analysis, neural networks

Erdogan Kiran (*Gottesman Research Professor*)

BS, MIT, 1969 • MS, Cornell, 1971 • PhD, Princeton, 1974
Supercritical fluids, physics and chemistry of polymers

Pierre LePoutre (*J. Larcom Ober Professor*)

BSc, Ecole des Hautes Etudes Industrielles, Lille, France, 1957 • MS, N.C. State, 1960 • PhD, N.C. State, 1969
Physics and chemistry of surfaces, adhesion, paper surface science

Kenneth I. Mummé (*Professor*)

BS, Lawrence College, 1954 • MS, U. Maine, 1966 • PhD, U. Maine, 1970
Process control; Director of undergraduate studies and co-op program

Hemant P. Pendse (*Professor*)

BTech, IIT, Bombay, 1975 • MS, Syracuse, 1977 • PhD, Syracuse, 1980
Development of sensors, colloid and surface chemistry, neural networks applied to process control

Douglas M. Ruthven (*Professor and Chair*)

BA, Cambridge, 1960 • MA, Cambridge, 1963 • PhD, Cambridge, 1966 • ScD, Cambridge, 1988
Adsorption and adsorption separation processes

Edward V. Thompson (*Pulp and Paper Foundation Research Professor*)

BS, Cornell, 1956 • PhD, Brooklyn Polytechnic, 1962
Recycle fiber technology, flotation and interfacial phenomena

ADJUNCT PROFESSOR

Nick G. Triantafillopoulos

PhD, IPST, Atlanta, 1991
Principal Technologist, GenCorp Specialty Polymers, Inc.

FACULTY ASSOCIATE

Stanley N. Marshall, Jr.

BS, U. Maine, 1961 • MS, U. Maine, 1964
Executive Director of UM Pulp and Paper Foundation

COOPERATING PROFESSORS

Barbara J.W. Cole

PhD, Washington, 1986 • Associate Professor of Chemistry, U. Maine

Barry S. Goodell

PhD, Oregon State, 1983 • Professor/Chair, Dept of Wood Science, U. Maine

Marquita K. Hill

PhD., California-Davis, 1966

Stephen M. Shaler

PhD, Penn State, 1986 • Associate Professor of Wood Science

Charles E. Tarr

PhD, North Carolina, 1966 • Associate Vice President for Academic Affairs, Dean of Graduate Studies, Professor of Physics

OTHER RESEARCH AREAS

With the appointment of Barry Goodell, a biochemist by training, as a cooperating professor, the Department has made a cautious entry into the field of biochemical engineering. Two ChE graduate students are now working on projects involving the application of enzymes and chelating agents to pulping and bleaching. Albert Co is a former student of Byron Bird, and he has inherited his mentor's penchant for complex fluid mechanical problems. He is currently studying the effects of polymer rheology and operating conditions on draw resonance in multilayer film casting, a problem that is closely related to some of the problems encountered in the production of polymer coated paper. Douglas Ruthven joined the Department as Chair in 1995. When not fighting with the University Administration to preserve the chemical engineering budget, he continues his research on adsorption and adsorption processes and his editorial duties for *Chemical Engineering Science*.

THE FUTURE

There are many excellent chemical engineering departments in the U.S., and most are larger and far better funded than U. Maine. Through the shrewdness and foresight of its founders (notably Lyle Jenness), however, and with the generous help and support of the Foundation, U. Maine has become an important niche player, providing a supply of well-trained and capable graduates with a special focus on the needs of the pulp, paper, and associated industries and acting as a center for fundamental research on problems of practical concern to that industry. With increasingly stringent environmental regulations and decreasing availability of traditional sources of fiber, there is no shortage of challenging problems to address.

Our first priority for the future must be to maintain and strengthen our links with industry through the Foundation, the co-op program, and the collaborative research programs in order to ensure that our students, in both undergraduate and graduate programs, receive a first-class, practically oriented engineering education. Half the faculty are within seven years of the "normal" retirement age, so the need to hire some younger members to continue the tradition is obvious. The current hiring freeze at U. Maine thus presents a significant obstacle that will have to be overcome. □