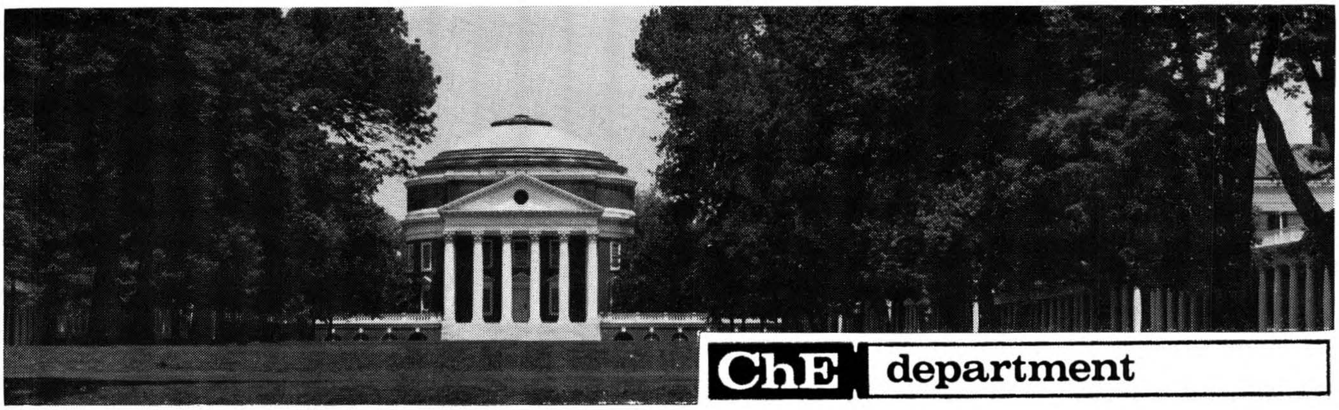

"Mr. Jefferson's Academical Village"

Professor Vincent W. Uhl discusses chemical engineering at the University of Virginia.

"This institution will be based on the illimitable freedom of the human mind. For here we are not afraid to follow truth wherever it may lead, nor to tolerate any error so long as reason is left free to combat it."—T. Jefferson

We are reminded by quotations such as this, and also by the buildings and grounds at the core of the University of Virginia that Thomas Jefferson had a great deal to do with our institution. His "academical village" was founded in 1819; it was his major preoccupation when he retired from public life. Mr. Jefferson designed its first curriculum, recruited faculty, laid out the grounds and served as architect for its buildings. They were designed in a classical, peculiarly American Style, which set the pattern for the buildings to follow. In fact, his neo-classic mode had a profound effect on architecture in the United States in the nineteenth century.

The growth and influence of the University was seriously interrupted by the Civil War; in the twentieth century it regained its leadership and gradually increased its enrollment. At present the student body, including Law and Medicine total about 11,000, a number which might be considered modest particularly for a state university. Many feel that this size is ideal, but the growth is now accelerating toward an estimated size of 18,000 a decade hence.

Many rich, live customs and traditions contribute to provide a unique character. Outstanding is the effective Honor System, which has been student controlled and administered since its inception in 1842. Our legendary "coat and tie" has almost vanished, but most students are still neat in appearance. And there have been drastic changes; beginning this year, we have become, like most state schools, totally co-educational. Needless to say the immediate effect has been pleasant and the engineering students applaud it.

Visitors are impressed by the overall aspect of the university and its location. The buildings and grounds, both the central "academical village" and their considerable extensions, present a fine environment. This is the result of inspired original planning and conscientious efforts to retain the original beauty. Many of the buildings were designed to present vistas of the beautiful, rolling countryside. In addition, the university is located on the edge of a city of 36,000, cosmopolitan in character yet somewhat isolated. Charlottesville is 115 miles southwest of Washington, and 70 miles west of Richmond in central Virginia; the Blue Ridge mountains are a few miles west. We find that the general resulting atmosphere not only makes for good living, but is also conducive to scholarly discussion and study.

SCHOOL OF ENGINEERING AND APPLIED SCIENCE

Engineering has been offered since 1836. At present about 1350 students are enrolled in the School of Engineering and Applied Science, 350 of whom are doing graduate work. We have the usual major engineering departments, plus Materials Science for only graduate work, and Nuclear Engineering. Biochemical Engineering also deserves mention. Representing a cooperative effort by the Engineering and Medical Schools, it currently has a staff of 13, 23 graduate students, and two postdoctorates; it offers only a doctoral program. Over the years, the School has also set up divisions to offer undergraduate courses of the quality and emphasis needed in Graphics, Applied Mathematics and Humanities; the latter, formed almost 40 years ago under Dr. Joseph Vaughan, is unusual and will be mentioned again. Applied Mathematics now includes Computer Science, and within the last five years has become a degree-granting department offering first a graduate and now also an undergraduate program.

The Engineering School has been conspicuously successful in promoting cooperation between departments, in teaching courses and in interdisciplinary research. This appears to be due somewhat to our moderate size, but it probably results also from the close relationship and good technical awareness that exists between many of our staff and among most departments. Inter-school cooperation, with Medicine, Architecture, and the College of Arts and Sciences has also been good.

CHEMICAL ENGINEERING

Bachelor degrees have been awarded in chemical engineering since 1913. In the early years Joseph C. Elgin and Lauren B. Hitchcock taught in the department. J. Henry Rushton became chairman in 1937; first Virgil C. Williams and then Darrell E. Mack was his associate. Dr. Rushton was followed by Robert M. Hubbard in 1946. Early during Bob's chairmanship funds for a new building were secured and an exceptionally functional facility with a floor area of 20,000 square feet was completed in 1950. Although it was then commodious, we are now making full use of this building; the remarkable thing is that most of the space is being used for the purpose for which it was originally intended! Also under Dr. Hubbard's leadership the Chemical Engineering Department pioneered in graduate study in the Engineering School introducing a master's program in 1949 and doctoral work in 1956. When Bob Hubbard arrived he *was* the department. Beginning with Otis L. Updike, who also joined the department in 1946, Bob gradually built a fine teaching staff. This has included John W. Eldridge, who left in 1962 to become Chairman of the Department of Chemical Engineering at the University of Massachusetts, and James H. Gary, now Chairman of Chemical and Petroleum Refinery Engineering at the Colorado School of Mines. In 1963, Bob Hubbard stepped down and Vincent W. Uhl came from Drexel Institute of Technology to assume the chairmanship.

The teaching interests of our present staff of seven embrace the basic subject areas of chemical engineering. Each member teaches graduate and undergraduate courses, in addition to involvement in graduate research. Newcomers to the department are encouraged and aided in developing their own niche and specialty. Some interaction has developed in departmental research; this is evidenced in joint direction of dissertation research, both within and across departmental lines. The staff all have contact with the industrial scene, some from former employment, others from consulting, or both.

UNDERGRADUATE PROGRAM

Our aspiration for our undergraduate students has been stated as **"to develop competence in attacking new engineering problems and in securing optimum solutions to existing problems in chemical and allied fields.** This competence is based on a sound understanding of fundamentals, on familiarity with experimental methods, on general engineering background, and on the developed power to marshal these elements with proficiency to handle problems, many of which are quite complex". We feel that these goals are largely realized by a bachelor's program within the span of four or five years.* The ingredients supporting this accomplishment are our faculty, the quality and attitude of our students, and the resources—several of which are unique—of the School of Engineering and Applied Science.

Our undergraduate curriculum happens to correspond closely in subject weighting to the current survey average in Barker's report**, with the exception of our greater emphasis on humanities (Table I).

TABLE I. **Distribution of Subject Areas for CHE Curricula**

	ChE Curricula			
	Barker's Avg.		*Univ. of Va.*	
Communicative skills	5.0		6	
Humanities	18.3		21	
Subtotal		23.3		27
Mathematics	16.7		16	
Chemistry	23.8		26	
Physics	9.7		10	
Subtotal		50.2		52
Mechanics	5.2		3	
Electrical Engineering	3.7		3	
Materials	1.4		3	
Subtotal		10.3		9
Chemical Eng. (required)	33.8		33	
Chemical Eng. (elective)	2.3		6	
Subtotal		36.1		39
Graphics	1.4		4	
Economics	0.8		0	
Technical Electives	6.4		3	
Computer	1.2		4	
Subtotal		11.8		11
Total semester credit hrs.		131.7		138

One of the unique aspects of our curriculum is a program of four courses, two in the first and two in the last year, taught by our Division of the Humanities. This program is based upon an *interaction of many disciplines, and is intended* to challenge the student to face the modern world from a broad perspective. It is roughly equivalent to two years of college English, but is faster-paced and includes many areas beyond rhetoric and literature. Articulation skills are cultivated effectively in this program. In addition, five elective humanities courses are chosen to develop or enhance knowledge in fields such as economics, psychology, sociology, philosophy, history, religion, and literature. This elective program, planned by the student with his advisor, generally has two areas of emphasis.

*A five-year program is optional. The student may be enrolled for a minimum of 15 credit hours each semester; more humanities and technical electives are taken.

**Barker, D. H., "Reduction in Hours and Introduction of Common Years into the Chemical Enineering Curricula", Department of Chemical Engineering, Brigham Young University, Provo, Utah. Report received July, 1970.

. . . our students enjoy a high degree of individual attention . . .

Since 1965 the Engineering School has had a core program, extended in 1970 to the first two years. These have been some of the salient guidelines: a maximum of 17 or 18 credit hours per semester; a maximum of six or if possible five required courses per semester; the elimination of *needless* duplication of course material. First year students are introduced to computer programming in the BASIC language, which is then applied to the solution of simple engineering problems followed by a series of short engineering projects. Because of the chemistry requirements of chemical engineering, some exceptions are necessary in the second year from this core curriculum. As part of this core program all students take a minimum four of seven elective courses in the engineering science: mechanics (3 courses), electrical science (2 courses), thermodynamics, and science of materials. All competent departments participate in the planning and teaching of these core courses. Our department participates in teaching the materials science, thermodynamics, computer programming, and engineering problems courses. We have in fact taken a leadership role in the formulation and direction of the core thermodynamics course, and are proud of its thoroughness.

The physical operations are taught from the transport viewpoint; in addition a weekly lecture, which is part of the two-semester chemical engineering laboratory course, emphasizes the relation of the transport theory to experiment and practice. These lectures also introduce new topics for which there are special laboratory exercises. Some aspects of mass transfer operations will now also be considered in a two-semester, third-year course in Equilibrium Processes. This course will bring together stoichiometry, thermodynamics, phase equilibria and stagewise operations. Our conviction is that these topics should be related for effective instruction. Background in industrial chemistry and plant practice is provided by plant inspection trips and a seminar course in the senior year. Here the students learn on their own about some processes and each presents certain ones to the class. The student gets practice in oral reporting and learns how to become the *expert* on a topic. In preparing for these talks the students are guided to and required to use established library searching techniques.

Some (but admittedly limited) flexibility is provided by three technical electives, two of which are taken in a given field such as biomedical engineering, chemistry, materials science, mathematics, or other areas of chemical engineering. Such areas include equipment design for which there is a course, based on extensive notes by Dr. Hubbard plus selections from Perry. Another popular departmental elective is applied surface chemistry, taught by Dr. John Gainer. It, along with the required kinetics course, reflects the strong inclination of some of the staff to emphasize applied chemistry to our students. All seniors take reaction kinetics, process control, and plant design. The process control course has a balance of hardware emphasis with theory, and makes use of six elaborate teaching aids, modules which demonstrate the modes of control and the characteristics of different devices used to sense and control temperature, flow, and pressure. In the plant design course the elements of technical economics are emphasized, using material developed by Dr. Uhl for his AIChE TODAY SERIES short course. A process design is completed by students working in teams of three on one of the problems first developed by Washington University in cooperation with Monsanto. Generally the seniors also attack the AIChE Student Contest Problem on an individual basis.

We are particularly proud of our two undergraduate laboratory courses, which have been a prime and continuing interest of Dr. Hubbard. Much of the apparatus and equipment is specially designed or modified to facilitate instruction. Many pieces are transparent so that the action can be visually observed. Some experiments are on pilot scale units, relatively heavily instrumented, some with quite sophisticated controls. Recently a pilot plant was completed for the catalytic reaction of methanol and steam to produce hydrogen and carbon monoxide. The unit reaches steady state quickly, the reactants are cheap and available, and the products are disposable. This unit is already proving useful in providing a process experience and in generating raw kinetic data for analysis. Perhaps the outstanding feature of the laboratory is that the equipment *works* smoothly and predictably.

Our students enjoy a high degree of individual attention. This is feasible because our classes are small and possible because our staff are generally on hand and interested. Only staff members are used for lecture courses; graduate students such as NDEA trainees, however, direct problem sessions and occasionally run a section of the laboratories. We are very conscious of, and stress, good teaching. Classrooms in our building are equipped with (or for) the usual teaching aids and we use them, particularly the overhead projector.

Between ten and twenty receive bachelor's degrees in most years. A high proportion go directly to industry. We are pleased with reports which we receive about our recent graduates: "immediately useful", "not bewildered by industry", "know what is expected of them". About a quarter of our students continue their education in chemical or other branches of engineering. Generally a couple of students from each class continue in other fields such as graduate business, law, or medicine.

Because of the varied teaching and research interests of our faculty we consider we have achieved a good balance, one in which our graduate program effectively complements undergraduate work.

FACULTY INTERESTS

The areas of interest and special research fields of our staff members range broadly over almost the full breadth of process engineering.

Dr. Charles Barron works primarily on problems which involve the integration of chemical reaction theory into the analysis of complex process systems.

Dr. Gainer's original research interest in liquid diffusion, diffusion in polymer solutions and transport through membranes has now been extended to mass transfer in biological systems.

Dr. Robert Hubbard's research interests have been in the fields of continuous ion exchange, extended surface heat transfer, process dynamics and the measurement and control of process variables.

Dr. Donald Kirwan, who recently joined the faculty, has research interests in the general field of unusual separation techniques.

Dr. Lembit Lilleleht's interest lies primarily with the fluid mechanics of multiphase systems.

Dr. Vincent Uhl has long had interests in mixing, heat transfer and technical economics; his current research is concerned with mechanically aided heat transfer.

Dr. Otis Updike has long been interested in computers and their application to chemical engineering problems—initially analog machines, later digital and hybrid.

Despite the breadth of research interest exhibited by our faculty, the areas are effectively complementary, as with process dynamics, fluid mechanics and mass transfer. Some research has involved collaborators from other departments: nuclear engineering, mechanical engineering, materials science, biomedical engineering. We anticipate that this cooperation will grow, in particular in the area of materials science with work on blood clotting. About one-third of the present research is concerned with life processes: the development of blood-mimic fluids, blood flow modeling, diffusion studies in biological fluids, reactions related to the absorption of oxygen in the lungs, enzyme kinetics and protein separation methods.

GRADUATE PROGRAM

In recent years we have built an active community of graduate students which numbers more than twenty, over half of whom are engaged in doctoral work. We very seldom keep our own undergraduates; because we are convinced that students benefit greatly from a change of scene, we insist that they go elsewhere to continue their studies. While we welcome students from other countries, we strive for diversity and balance. Foreign student enrollment is now about 30 percent of the total. We currently graduate about

Our aspiration for our undergraduate students: to develop competence in attacking new engineering problems and in securing optimum solutions to existing problems in chemical and allied fields.

eight masters and four doctoral students each year.

Almost all graduate students are supported financially by fellowships which allow them to devote full time to study and research, or on assistantships for research only. In addition to the usual sources of support such as NSF Fellowships, NDEA Traineeships, industrial fellowships and research grants, we receive a substantial sum each year from the bequest of Christopher Memminger which supports several students each year and departmental research. Mr. Christopher Memminger, the donor, was a graduate of the University of Virginia and founder of the Coronet Phosphate Company.

Our entering masters students normally take courses in fluid mechanics, thermodynamics, reaction kinetics, three elective courses and two courses in mathematics, one of which may be the applied mathematics course taught in the department. Heat transfer courses are taught by members of the Mechanical Engineering, Nuclear Engineering or Chemical Engineering Departments. Although a non-thesis master's program is on the books for engineering, we usually require a thesis for chemical engineering students. We encourage students to complete work for the masters within twelve months and this has been possible in most cases.

Our doctoral program has a traditional emphasis, except for the interdisciplinary atmosphere. A requirement of special interest is selection and development of a proposition in an area different from that of the dissertation to demonstrate ability to do original work. This must be completed in a month, and students are then orally examined on their reported solutions as well as on their general knowledge; this constitutes their comprehensive examination as doctoral candidates. Reading proficiency is required in one foreign language.

We also work with our graduate students to cultivate the ability to organize and present technical matter effectively. Each student speaks several times at our graduate seminars and we encourage them to speak at local and national meetings when practical. We want our graduates to be articulate.

CONTINUING EDUCATION

The department has been continuously aware of the educational needs of the chemical engineers in the many chemical and process industries in Virginia. For several years we have offered a part-time graduate program; by now this has served the needs of a number of chemical engineers working in nearby plants. To be of broader service, beginning in 1968, we have offered about three short courses each year; each staff member has developed a course in one of his specialties. These have had the extra advantage of increasing our awareness of the problems of industry and improving our contacts with working engineers. It is a program which we hope to continue.

THE FUTURE

For the future, we expect to continue offering a four-year undergraduate program based on a strong background in chemistry (as well as physics and mathematics) in which the student will gain adequate proficiency with analysis, synthesis (from process design), and computation, and cultivate one or more humanistic areas. Research will probably become still more interdisciplinary in character and will grow in its emphasis of living processes. To balance the theory, the graduate program, at least for some students, will continue to emphasize practical engineering.

A SUMMATION

What are some of the marks of our department? Diversity of research interests. Collaboration in research. Research concerned with life processes. Balance between undergraduate and graduate programs. Concern about good teaching. For the undergraduate: stress on fundamentals; sound chemistry background; development of computational prowess; excellent laboratory experiences; promotion of some feel for the practice of engineering. For graduate students: programs with traditional research emphasis; development of creativity, analytical ability, and articulation; conversancy with fundamentals; the power to apply knowledge to practice. In this we feel we are fulfilling this dictum of our founder:

"A University on a plan so broad and liberal and modern as to be worth patronizing with the public support, and to be a temptation to the youth of other states to come and drink of the cup of knowledge and fraternize with us."— T. Jefferson