ChE educator

Art Humphrey

and Biochemical Engineering at the University of Pennsylvania

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THE PAST ACADEMIC year served as a milestone for the field of biochemical engineering and the University of Pennsylvania. Not only did the year mark the 25th anniversary of the biochemical engineering program at the University, it was also the 25th anniversary of the leadership of the program by its founder at Penn, Arthur E. Humphrey.

There are older and larger biochemical engineering programs in existence, but none can rival the record of Penn's program in terms of its dynamic growth and production of graduates who have gone on to become leaders in the field. To mark these achievements, the University hosted a special 25th anniversary symposium to which all the graduates of the program were invited. The "alumni" who attended participated in panel discussions on the future of biochemical engineering in the areas of food production (discussion led by Stanley Barnett), energy production (led by Charles Cooney), production of chemicals (led by Daniel Wang), and preservation of the environment (led by Larry Erickson), with a roundtable discussion on the future of biochemical engineering education led by Richard Mateles.

ORIGINS OF THE PROGRAM

IN 1953 ART ARRIVED at Penn, fresh from his PhD studies in chemical engineering at Columbia University. While working on his doctorate, he developed an interest in fermentation technology and subsequently took additional training in food technology at M.I.T. At Columbia, Art, along with Ernest Henley (now at the University of Houston), was the first doctoral student of Professor Elmer Gaden who was later to be cited as the "father of biochemical engineering" (in a cover story in the May 31, 1971 issue of *Chemical Engineering News*). It was through Elmer Gaden's influence that Art's interest in fermentation systems matured. Elmer had written his own thesis on "Mass Transfer in Fermentation Systems under the supervision of Arthur W. ("Pop") Hixson at Columbia, working in conjunction with a biochemical engineering team (Karow, Bartholomew, and Sfat) at the Merck Company. (It is of some interest to note that reporting of the 1945 McGraw-Hill Process Development Award, presented to Merck for its "Biochemical Engineering Development of the Penicillin Process," is apparently the first mention of "biochemical engineering" in the chemical engineering literature.)

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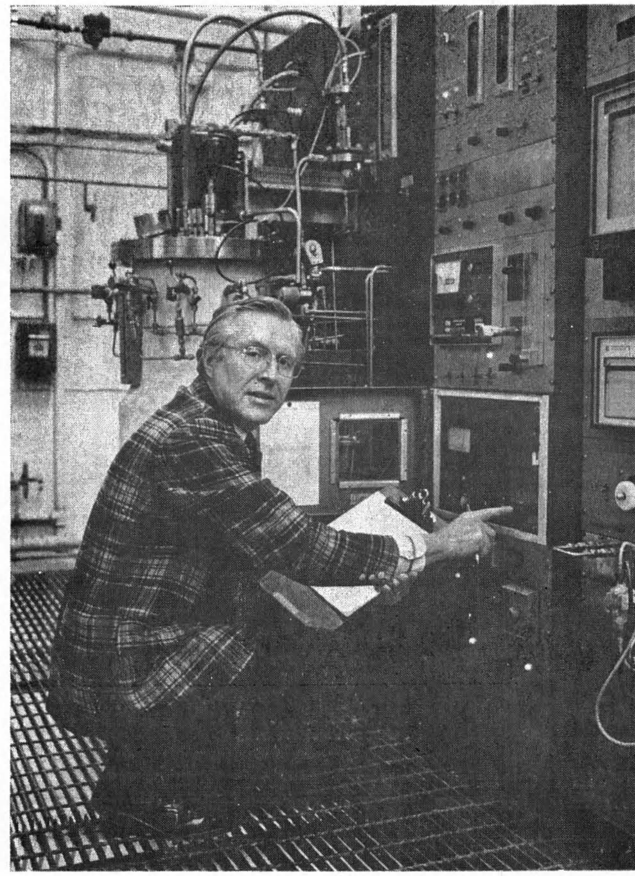


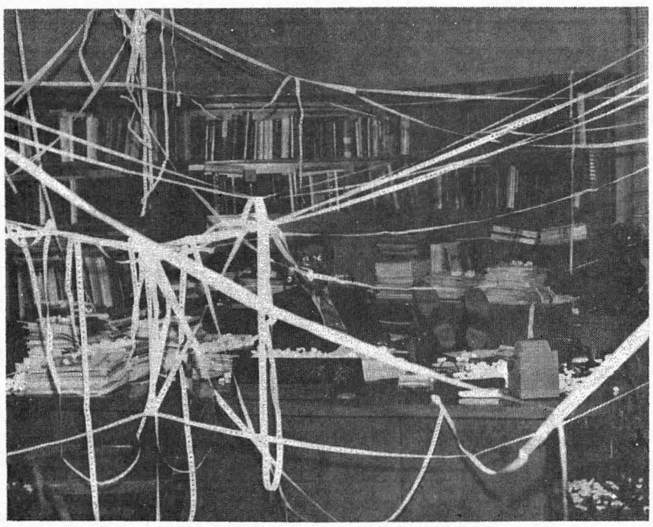
Art inspects the fermenter laboratory.

Art joined Penn's chemical engineering faculty as an assistant professor and in the fall term of 1953 offered a new course in biochemical engineering. Since 1953 the biochemical engineering program has grown steadily, and in 1972 it was officially recognized when the Department of Chemical Engineering formally changed its name to the Department of Chemical and Biochemical Engineering.

THE MAN BEHIND THE PROGRAM

AS OVERWORKED AS THE WORD "dynamic" is in today's usage, it is nevertheless the appropriate term to characterize the founder of Penn's biochemical engineering program—Art Humphrey. Whether at work in his laboratory, or leading a faculty debate, or scaling a mountain in Guatemala, Art is possessed of energy that leaves others much younger in a race to catch up, and he inspires his contemporaries to set equally challenging goals for themselves.

In his 25 years at Pennsylvania, Art has established professional credentials that are indisputable. As a scholar of biochemical engineering in general, and fermentation technology in particular, he has published over 150 technical papers and co-authored two textbooks which are regarded as the bible in their fields, *Biochemical Engineering* (Academic Press, 2nd ed., 1976) and *Fermentation & Enzyme Technology* (John Wiley, 1979). He holds three U.S. patents and has actively consulted for more than 20 chemical companies during his career. He has served on and chaired numerous AIChE committees including the FBP



Art seems to approve of his students' efforts at office "redecoration."

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Division, and between 1975 and 1978 was a director of the organization. He has also been a past chairman of the MC&T Division of ACS and of the Working Group on the Production of Substances by Microbial Means of the US/USSR Committee on Cooperation in Science and Technology. In addition, he served from 1971-1973 as a member of the NSF Advisory Committee for Engineering. In 1973 he was elected to the National Academy of Engineering.

Such a summary of professional activities, however, doesn't begin to capture Art Humphrey, the man, who by virtue of his enthusiasm and exuberant love for life succeeds in making people want to work together toward a common goal. Art always has a full complement of five doctoral students to work with him as advisees or, more appropriate to the man, associates. Over the years he has formed a special bond with his students based on mutual respect, willingness to devote intense effort to a project, and in no small measure on the ability to dish out and take a practical joke. For pranks he's played on his students, Art was rewarded on one occasion with the careful "redecoration" of his office (as shown in the accompanying photograph) and on another with the clamping of a ball and chain on his leg only minutes before he was to make a presentation to the University Trustees. In Houdini-like fashion he arrived before the Trustees on time sans ball and chain.

Art is an avid outdoorsman who cheerfully ignores middle age (and some say common sense) as he pursues his interests. Having hiked the trails of much of this country, he frequently substitutes an opportunity to climb a mountain in a foreign country in place of the honorarium he would receive for lecturing there. Such negotiations have enabled him to climb Mount Fuji in Japan, Popocatepetl in Mexico, and Augua in Guatemala, among others. Last year when taking up skiing for the first time, Art found himself by mistake in an advanced intermediate class and, not having the good sense to get out of the class, "mostly fell

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down the hill" and received a National Standard Medal for downhill racing as a result. Each year Art leads a departmental canoe trip down the Delaware River, an activity he organized 16 years ago (when Bob Bird was a member of that group). The annual event now involves between 60 and 70 people, including faculty members, students, alumni, and participants from other schools. This year an eight-mile run was included as part of the trip, and he typically outpaced the younger generation—without having trained for the run.

The honesty and openness with which Art approaches every aspect of his life generates an unswerving loyalty among his associates. Never afraid to admit when he's wrong or simply doesn't know an answer, he leads people to trust that they'll "hear it straight," good or bad, in dealing with him. Add to these qualities Art's rare talent of being a good listener, and the result is an individual who is extremely effective in accomplishing the work he sets out to do. His spirit has inspired and guided the development of Penn's biochemical engineering program over 25 years, and it has set the tone with which the biochemical engineering faculty now approaches the next 25 years.

BIOCHEMICAL ENGINEERING AT PENN TODAY

ART HUMPHREY STILL heads the biochemical engineering program within the University's Department of Chemical and Biochemical Engineering, despite his heavy administrative load as Dean of the School of Engineering and Applied Science. (From 1962 until he was named Dean in 1972, he served as Chairman of the Department of Chemical Engineering.) Art and three others of the Department's 12-member faculty have the focus of their teaching and research activities in the area of biochemical engineering. At least three others conduct a significant portion of their research within the field. Collectively, this group conducts a research program amounting to $500,000 a year, and this past year they published the program's 150th paper on biochemical engineering problems (out of a total of more than 350 scientific articles published by these individuals). Six national AIChE, ACS, and ASEE awards have been won by members of the group, and two members have been elected to the National Academy of Engineering.

Those members of the faculty of the Department of Chemical and Biochemical Engineering who participate in the biochemical engineering program are:

David J. Graves:	**enzyme kinetics**
Arthur E. Humphrey:	**fermentation technology**
Douglas A. Lauffenburger:	**cell population dynamics**
Mitchell D. Litt:	**biorheology**
Daniel D. Perlmutter:	**enzyme reactor dynamics**
E. Kendall Pye:	**enzyme behavior and purification**
John A. Quinn:	**bound membrane systems**

The facilities which are used in both the research and teaching functions of the biochemical engineering program consist of four primary laboratories: the fermenter laboratory, a wet chemistry laboratory for enzyme analysis, a membrane laboratory, and a reactor laboratory.

The fermenter laboratory (pictured in an accompanying photograph) centers about a 70-liter highly instrumented fermenter that is coupled to a PDP 11/34 computer with a 96K core capacity and three discs (two fixed), a Calcomp plotter and a video screen for data acquisition and control. The facility is supported by a Nuclide Mass Spectrometer and other appropriate analysis equipment. In addition, the laboratory has a number of smaller fermenter units, including a 20-1, 14-1, two 1-1, and five 500-ml systems—most having temperature, pH, foam, and dissolved oxygen control.

ACADEMIC PROGRAMS

UNDER THE LEADERSHIP of Art Humphrey, the biochemical engineering faculty has always insisted that the academic program remain a part of the basic program in chemical engineering, allowing the "biochemical" aspects of the program to emerge from an emphasis on biological processes. Because of the emerging significance of bioconversion processes in the production of energy, food, and chemical feedstocks and as a means for controlling the environment, students are eager to investigate these problems. The faculty believes the students' eventual careers are better served by having them pursue these interests from a solid foundation in chemical engineering, rather than by focussing exclusively on a subspecialty.

Thus, the undergraduate *bio*chemical engineering student takes the standard chemical engineering curriculum, but biochemistry is substituted for one of the courses in organic chemistry, as is a biology course for the course in nuclear physics. In addition, the student will take two or three courses in microbiology, biological processes, utilization of wastes, biochemical engineering, or food engineering as his senior technical electives; and his senior research project will focus on a biological process.

Out of a senior chemical engineering class of 45 students, about 7 of them will be taking courses with a focus in biochemical engineering. Most of these students will either continue their biochemical engineering studies at the graduate level or will enter medical school.

At the graduate level the student planning a focus in biochemical engineering is also expected to take the core courses in chemical engineering—in applied mathematics, transport processes, reactor design, and thermodynamics. The student is then expected to take courses in advanced biochemistry, molecular biology, and genetics, in addition to the four basic graduate courses in biochemical engineering.

The basic graduate level biochemical engineering courses include:

Biochemical Engineering:	**fermenter kinetics, design and operation**
Biological Processes:	**physics and chemistry of biological processes**
Enzyme Technology:	**behavior and utilization of enzymes**
Utilization of Wastes:	**waste utilization and treatment**

These courses are taught by the faculty on a rotating basis, i.e., once every other year. They are frequently team-taught with the help of visiting professors and members of the University's Department of Biochemistry and Biophysics.

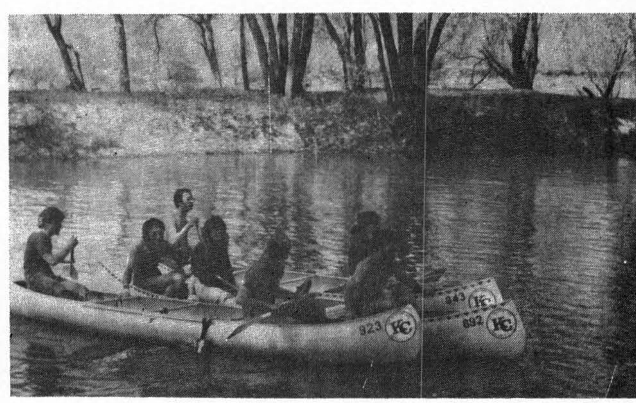
Students in the graduate program can develop and shape their programs to serve their own particular career emphases by selecting additional courses in areas ranging from nutrition to microbiology. They are free to select these courses from throughout the University's graduate and professional programs, including its Medical School and School of Veterinary Medicine.

At any given time, about 15 students in the chemical and biochemical engineering graduate program (which numbers approximately 50 full-time students) will be focussing their studies in the direction of biochemical engineering. Upon receiving their doctoral degrees, these individuals generally seek employment in the food production, pharmaceutical, waste treatment, and chemical process industries, or in academia.

When questioned, most of the alumni of Penn's biochemical engineering program say they consider themselves chemical engineers who have an interest in biological processes, for such is the slant of their curriculum. This may in part explain why Penn graduates have never encountered problems on seeking employment. Indeed, a recent graduate of the program looking for a position in the biochemical field received more than ten offers from firms, with several offers in excess of $31,000 a year.

FUTURE OF BIOCHEMICAL ENGINEERING: ART HUMPHREY'S VIEW

THE FACULTY OF THE biochemical engineering program at Pennsylvania looks forward to continued growth of the program. The field is now



Over 60 faculty members and students now participate in Art's annual canoe trip down the Delaware River.

coming into its own and the opportunities are unlimited. Perhaps the enthusiasm of those active in Penn's biochemical engineering program comes across best in the words of the man responsible for its flourishing here—Art Humphrey.

"Never has the future for biochemical engineering looked so bright. This is due largely to the energy crisis and the attendant emphasis on the use of renewable resources, meaning materials of biological origin. It seems fairly evident that many of these materials will be processed by biological means, with the use of enzymes, in order to achieve low temperature, energy saving processes. The environmental crisis and the increasingly strict limits placed on the use of nitrates, phosphates, and other surface water contaminants mean that more efficient and more complicated waste treatment systems will have to be evolved. Also, wastes will be viewed in the future as valuable resources which can be treated to yield useful materials.

"Perhaps the most significant development affecting the future of biochemical engineering is the explosion of knowledge concerning genetic engineering techniques. Not only do we now possess the ability to cultivate both animal and plant tissue cells in large-scale reactor systems, but we can transfer their genetic information for making various biologically active molecules such as insulin into more easily cultivated bacterial cells by gene splicing techniques. Soon the scientist will be able to create cells with virtually any desired metabolic activity. When this comes to pass, the biochemical engineer will become active in efficiently simulating and optimizing many of nature's special reactions in stainless steel fermenters. In many ways biomass can be regarded as the crude oil of the future. Just as crude oil now serves as the feedstock of the petrochemical industry, from 'barrels of biomass' will come a number of the chemical feedstocks of the future. It would not surprise me to see biomass refineries emerging within the next decade.

"I for one will welcome the change. I believe the chemical engineering textbooks of the future will reflect this change and will include examples of biomass problems along with those from the petroleum industry. Chemical engineering is a truly broad-based discipline, and I believe it is already demonstrating its concern not just with physical and chemical changes, but with biological changes as well." □

ChE book reviews

CONTACT CATALYSIS, VOLS. 1 and 2

Edited by Z. G. Szabo, Elsevier Scientific, 1976
Reviewed by John B. Butt, Northwestern U.

This monumental two volume set is an essay of the Catalysis Club of the Hungarian Academy of Sciences with individual chapters contributed by thirteen different authors. In many ways the work is reminiscent of the series "Catalysis" edited by Prof. P. H. Emmett in the 1950's, and it promises to be as useful. True to the title, the entire field of contact catalysis is treated, starting with the fundamentals of solid state science, chemisorption and kinetics in the first volume, with applications concerning preparation, characterization, and catalytic reaction engineering in the second volume. The topics included are treated in quite some detail and in many instances represent current state of the art in both catalysis research and applications.

With so many different aspects of the field treated in such detail, it is difficult in a review of reasonable length to do other than cite certain parts that are of particular use to the reviewer. In this respect, there are particularly fine treatments of adsorption on solid surfaces and physical characterization methods which eclipse much existing literature. For example, the characterization methods discussed include x-ray diffraction, electron-optical methods, magnetic properties, electrical properties, adsorption, infrared and EPR spectroscopy.

Another very useful chapter deals with the preparation of catalysts. This is particularly timely now, since we have attained sufficient abilities in characterization that the long-time

Continued on page 44.