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THE COLLEGE LOOKS AHEAD
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This new section of Engineering: Cornell Quarterly will feature periodic “commentary” by prominent educators and practicing engineers on various aspects of engineering education. Dr. James A. Perkins, retired president of Cornell University, expresses his concern for the future of the professional schools. His remarks are taken from an address he gave at the 1969 annual meeting of the American Society for Engineering Education.

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Shown on the cover are four of the ten modern buildings on the Engineering Quadrangle at Cornell. They are Upson Hall, top left; Bard Hall, top right; Olin Hall, bottom left; and the Ward Laboratory for Nuclear Engineering, bottom right.
GUIDELINES FOR THE FUTURE

by Edmund T. Cranch

That the research of today becomes the practice of tomorrow has great significance for engineering education. Any institution that wishes to lead in the education of future student generations and to forge new areas of engineering activity must possess vital research programs. The knowledge gained through such programs and the approaches developed soon become the substance of graduate education, and in a surprisingly short time research topics get integrated into undergraduate courses. It is sometimes difficult for undergraduate students, who are working their way through the curriculum maze, to perceive the impact of university research activities on their education. At times, in fact, they might question research activity and suggest that it is irrelevant to them because it diverts attention from their concerns. What the student of one graduating class rarely grasps is the process by which the knowledge and insight of advanced studies have directly influenced his academic program. Because there is a close connection between research and education, it is important that new re-
search directions are chosen and not left solely to chance. Although it would be self-defeating in an academic environment to make rigid plans leaving little room to seize new opportunities for research or develop promising areas, there are strong indications that some measure of long-range planning is indeed necessary.

When viewed with the perspective of their evolutionary development, educational programs are not strongly characterized by evidence of advanced planning. Indeed, many persons believe that the absence of such planning has provided the flexibility required for the creation of new programs and their rapid appendage to existing specialties. As new problems and far-reaching developments cascade upon us, we begin to have a different perspective on time and our economic resources. Both the easy evolution of bygone years and the more recent rapid expansion of research and graduate-level education can result in uncoordinated programs that fall short of their potential. It is increasingly apparent that quality educational programs will evolve only as the result of well-conceived objectives combined with effective leadership and planning.

In order to review the array of questions associated with planning in Cornell engineering, Dean Andrew Schultz, Jr., appointed the Long-Range Planning Committee. It consists of Herbert J. Carlin, J. Preston Levis Professor of Electrical Engineering; Walter S. Owen, Thomas R. Briggs Professor of Materials Science and Engineering; William R. Sears, John L. Given Professor of Aerospace Engineering; and the author. Some of its considerations are included here with some of the educational consequences.

NEW OPPORTUNITIES

If we are to educate engineers who can reach out to the real world and contribute to areas having the greatest need of attention, we must be able to recognize and, in some cases, anticipate new fields. It is not enough to merely recognize that an area will grow and conclude that it contributes a viable, useful, and stimulating field appropriate for Cornell. It must also have a solid intellectual content, a scientific or engineering base, and challenging prospects for application to the real needs of society. From a practical point of view, it must also have possibilities of attracting interested students, high-quality faculty, and research funds. Ideally, to make a unique contribution, Cornell should have special responsibilities, interests, or competence in a field by virtue of its history, geographical location, and personnel. And we should have supporting fields in a variety of disciplines. The above criteria are met by several of the areas which follow, and the College of Engineering must be alert to special opportunities in these fields.

Bioengineering
Ocean Engineering
Geophysical Problems
Technology and Urban Quality

BIOENGINEERING

What educational specialization is appropriate for a subject which touches almost every engineering discipline?
"Any institution that wishes to lead in the education of future student generations...must possess vital research programs."

This field is destined to play a pervasive role in engineering, for it ranges from the fundamental biological processes to the health care of millions of people. It includes such topics as bionics, life support systems, biophysics, artificial organs, medical instrumentation, biomaterials, clinical health care, and food production. Although the full dimensions of engineering participation are not clearly outlined yet, it is certain that engineering and applied science will make major contributions to this area of fundamental importance to mankind. It is not a wild postulate that engineering will one day interact with the biological sciences in as fruitful a way as it has in the past with physics and mathematics.

The wide scope of bioengineering confronts the academic community with both opportunities and dilemmas. How does one select areas of research concentration? Which topics will be most important in ten or twenty years? The winter 1968 issue of this publication (volume 2, number 4) was devoted to "Some Engineering-Biological Interfaces" already underway at Cornell. Work in bionics and chemical food production and instrumentation—the beginnings of an engineering-biology relationship—was described. In spite of the obvious handicap of not being close to a medical research hospital, Cornell has the potential for expanded interaction with other academic groups in Ithaca; the Division of Biological Sciences, the Chemistry Department, the Veterinary College, and the Centers of Materials Science and Applied Mathematics have already begun interaction with Engineering in this effort.

Discussions have been initiated to explore the possibility of a concentrated effort in the area of artificial organs. The heart transplant operation has dramatically drawn attention to the possibility of developing an artificial heart. Failure of the cardiovascular system is the number one cause of death in the United States, with approximately 700,000 people dying from heart disease each year—a number exceeding that from all other causes put together.

Many of the problems associated with an artificial heart are ones familiar to engineering: energy sources, mate-
The subject of an artificial heart is replete with scientific and engineering problems of a most challenging sort—ones with the complexity characteristic of engineering systems and ones in which economic and ethical questions are matters of life and death and are intimately related to the public welfare. Certainly, the criteria of a solid intellectual content, a scientific and engineering base, and challenging prospects for application to the real needs of society are met in full measure by this area in the field of bioengineering.

Choices of faculty research emphasis will have far ranging effects, for they will govern the type and variety of topics available to graduate students and the kinds of courses offered by the College of Engineering. In a relatively short time new undergraduate bioengineering courses will appear, as faculty arouse undergraduates’ interest. The flexibility of the College’s new Core Curriculum, to be effective in September 1970, provides students with the appropriate environment for an education which combines engineering and the life sciences.
The project-centered research activities represented here show the applicability of fundamental engineering knowledge to a wide variety of problems. In 1 a student prepares to add a soil storing and testing device to the wheel of a lunar roving vehicle for which Master of Engineering candidates in electrical and mechanical engineering designed a guidance control system. In 2 Professor Donald L. Turcotte of the Graduate School of Aerospace Engineering supervises research on the sonic boom. His group built a device capable of simulating sonic booms in order to study their properties. In 3 and 4 a Master of Engineering design project sponsored by the New York State Department of Conservation is shown. It involved developing an electronic system to monitor wild deer in an effort to reestablish the balance of nature upset by the disappearance of predator animals.
OCEAN ENGINEERING

In this area infused with technology, what is the role of engineering education to be?

The need to increase his mineral, energy, and food resources has drawn man's attention to the oceans—the last great unexplored region on Earth. During the past fifteen years, we have seen the first deep submergence vehicles. The oil industry has led in the exploration and development of off-shore oil and gas deposits. Man has become conscious that he is no longer restricted to a two-dimensional surface. He has begun to explore and exploit the ocean he must come to regard as a three-dimensional region. In fact, the ocean floor and what lies beneath it could be the most significant part of the ocean environment. Dr. F. N. Spiess of Scripps Institution of Oceanography predicts that "within 50 years man will move onto and into the sea—occupying it and exploiting it as an integral part of his use of this planet for recreation, minerals, food, waste disposal, military and transport operations, and, as populations grow, for actual living space."

Supported by the recommendations of the President's Council on Marine Resources and Engineering Development, there is now widespread recognition that the exploration and exploitation of the ocean environment will become a national goal. Deep submersible structures, undersea manipulators and machinery, energy conversion, underwater sound and acoustical oceanography, geophysical instrumentation, oceanographic buoys, current circulation, thermal effects, mineral resources, food production, and transportation are all constituents of deep ocean technology. As with many of the challenges and problems facing man today, knowledge alone is not synonymous with constructive exploitation. Progress is directly dependent upon the tools of technology and their degree of perfection. It is now generally accepted that the chief components of ocean engineering know-how either exist already or are within reach. What is lacking is the combination of components to form complex systems that can function economically and safely in a hostile environment.

How can Cornell's College of Engineering participate in the forthcoming developments in ocean engineering? What educational and research roles should we take? It is an interesting historical fact that, until very recently, education in marine engineering in the United States had declined to a point where very few schools had programs and most of those were not characterized by the vigorous, modern research activities of other engineering disciplines. Marine engineering education was on the verge of extinction.

The present recognition of the ocean frontier, however, has caused a rebirth of the field at some institutions with special facilities or unique locations. Cornell has neither a special facility nor an ocean location. We do have strong programs in the major engineering disciplines, however, and curricula which provide the opportunity for design emphasis.

It is clear that the vast majority of engineering positions in this field will be filled by persons trained outside the
formal marine engineering programs. Hence, an important educational role will be that of interesting students in and familiarizing them with the activities, scope, and potential of careers related to the marine environment. In the past few years, several design projects in mechanical and in electrical engineering at Cornell have been carried out on ocean engineering topics. It would be appropriate to expand these design projects and coordinate them in such a way that student and faculty attention would be focused on this field.

In response to the National Sea Grant College and Program Act of Congress, the National Science Foundation established a program to support and encourage the nation’s institutions of higher education, other institutes, laboratories, and public and private agencies to play a major role in marine resource development. Although Cornell has a favorable location for the study of deep inland lakes and is reasonably close to the Great Lakes, access to the ocean is essential. In conjunction with the Water Resources and Marine Sciences Center and a group of professors, mainly from the Division of Biological Sciences, the College of Engineering has been exploring the possibility of joining with other universities more favorably located on or near the ocean to form a cooperative program. As one part of this program, the College envisions participation in an Ocean Engineering Summer Institute which would emphasize design aspects of engineering education. The design projects undertaken would involve solutions to practical problems arising in the marine environment. Such projects could be integrated with the design courses during the academic year and hence be related to the regular educational program. By keeping the focus on activities directly related to marine applications, the dual goals of relevance and interest in ocean engineering could be achieved. Thus, a direct contribution would be made to the education and training of engineers for marine resource development. The vigorous development of such cooperative ventures awaits adequate funding by government agencies responsible for a greatly expanded ocean engineering effort.

GEOPHYSICAL PROBLEMS

What are the engineering consequences of large scale geophysical effects?

As population centers expand and man attempts large scale control and manipulation of his environment, there will be an increasing need for a better understanding of geophysical effects and their interaction. Ambitious engineering projects have already created the need for a much more complete understanding of seismic disturbances and of the atmospheric and ocean environments. These geophysical problems are no longer solely the province of those studying the Earth’s crustal history; they are now part of a wide range of problems important to the welfare of man. The National Academy of Engineering and the National Academy of Sciences have called for an increased national effort to learn more about these natural phenomena, characterized by their large scope and unpredictable nature, and to bring the techniques of modern applied science to bear on them.
The Great Alaska Earthquake of 1964 took 115 lives in a sparsely populated area and caused over $300 million in public and private property losses. As high density population centers extend over ever increasing regions, there is a great risk that by the year 2000 such earthquakes could take thousands of lives and cause billions of dollars in property damage. Environmental catastrophes include not only such seismic-related effects as tsunamis and landslides but also the atmospheric-related hazards of hurricanes, tornadoes, and floods.

Research projects on geophysical problems currently underway in the College extend from fundamental studies of the physical behavior of the Earth's crust and the influence of seismic waves on underground structures to studies of the geophysical processes associated with the growth of large river deltas. A theory known as the "new global tectonics" is now generally accepted as the comprehensive description of the physical behavior of the Earth. With thermal convection within

The broad range of activities of a modern engineering department—teaching, research, service to the profession—is illustrated in these photographs.

1. Professor David J. Henkel, chairman of the Department of Geotechnical Engineering, explains the operation of a soil testing apparatus in the soil mechanics laboratory of the College.

2. Members of the Center for Aerial Photographic Studies are shown working on an inventory study of land use and natural resources for the New York State Department of Commerce.

3. Professor Donald J. Belcher, director of the Center, discusses techniques of interpreting landforms to optimize their usefulness.

4. A one-week course offered in the summer of 1969 dealt with the mechanism of landslides in various geological environments. Here, Professor Henkel discusses the qualities of stratified clay found on a field trip to examine local landslide phenomena.
Above right: One of the by-products of affluence is effluence. To preserve the beauty and delicate balance of nature, man must increasingly turn his attention to ways of preserving the earth's natural resources. He must find ways of disposing of his wastes as well as means to maintain the high quality of life advanced technology has made possible—and, in doing so, plan for the long range as well as for the short range.

Far right: A series of discussions on thermal pollution of large bodies of water grew out of concern at Cornell and in the Ithaca community for plans to construct a nuclear power plant on Cayuga Lake. Professor K. Bingham Cady of applied physics discusses with local townspeople and concerned faculty and staff at Cornell the dissipation of plumes of heat in large bodies of water.

the mantle as the driving mechanism, surface heat flux distribution, temperature-depth dependence, volcanism, oceanic crust structure, including the spreading of continents at major faults (mid-Atlantic ridge), and other features can be predicted from the theory. Another investigation involves the study of the interaction of seismic waves with underground structures and cavities. Applications include transportation and hydraulic tunnels, underground habitats and storage facilities, and seismic wave characterization for warning systems and earthquake-resistant surface structures.

The Department of Geotechnical Engineering is engaged in research which includes studies of landforms, groundwater conditions, landslides, soil and rock deformations, and the growth of large river deltas such as the Mississippi, the Niger, and the Ganges. These areas are geologically young and active and involve complex problems of soft sediments, stability of underwater formations, and the influence of waves and currents.
The problems are diverse in nature and include atmospheric and oceanic fluid flow, transport phenomena, seismic and fluid wave propagation, landforms, changes taking place in the overall physical environment, and the engineering consequences of these phenomena. Existing disciplines such as fluid and solid mechanics, thermal science, and geotechnical studies are involved. The field is characterized by a wide diversity of engineering and scientific knowledge and is intimately associated with man's accommodation to his environment.

Because many of the new developments in geophysics will be based on advanced techniques, it is most appropriate that the main educational effort at Cornell be at the graduate level. The College is now exploring ways to bring its resources to bear in a more unified effort to enable a graduate program to gain the necessary supportive base.

TECHNOLOGY AND URBAN QUALITY

What relationship does engineering have to the complex technical and social problems of urban society?

In condemnation of the living and working environment created by man, Shelley wrote, "Hell is a city much like London, a populous and smoky city." Today, we are confronted not only with the vast physical and biological desolation of our urban areas but also with the accompanying social conditions, which threaten the very existence of society. The pervasive, creeping degradation of our urban environment has been well documented—air and water pollution, ecological destruction, inadequate waste disposal and housing, choked transportation—with its human consequences to the quality of life. The degradation has reached such proportions that we can now see the possibility of a new Bill of Rights, one which would extend far beyond the original legal concepts of freedom from governmental coercion and assure equal opportunity to all to live in unpolluted, uncongested communities having adequate health care, housing, education, recreation, and transportation facilities.

Some of the questions confronting us
In the Department of Agricultural Engineering at Cornell, several research investigations are directed at relating environment to biological mechanisms. At the right Professor Norman R. Scott adjusts a thermoelectric gradient layer calorimeter for small animal environmental investigations. At the far right a student secures the entrance to a controlled atmosphere chamber for selection of plant phenotypes.
are: What is engineering's relationship to the complex technical and social problems of urban society? Is engineering socially neutral? Does the process of rational education have a role to play? What are the social responsibilities of engineers and what are the educational consequences? The attitudes and answers to such questions will require new modes of thought in the engineering community and research of a different nature from that previously described.

Prior to World War II, the goals of engineering education were quite closely linked with the professional needs and activities of industry. The extensive professional courses offered in engineering schools pointed the student toward almost immediate utilization of specialized skills upon graduation.

The period since 1945 has been characterized by a different emphasis. The achievement of breadth has penetrated beyond the basic sciences to an array of engineering sciences. These are now presented at a much higher level of sophistication than previously, and the engineering curriculum has widened to include more courses in the humanities and the social sciences.

It is now becoming evident that a substantial portion of our technological effort must be directed at greatly improving the urban environment. In fact, engineers must come to recognize that they will have to spend at least as much time correcting and preventing the urban-environmental consequences of human activity as they do pressing on with the further exploitation of nature. To this end, the College recently created such groups as the Departments of Environmental Systems Engineering and Water Resources Engineering and the Center for Environmental Quality Management.

Education has not yet really come to grips with the social and human conditions of modern man in his technological society. It is increasingly discernible at Cornell, for instance, that students and faculty feel that all is not well in undergraduate engineering education if it deals almost exclusively with the tools and processes of technology and ignores the accompanying human conditions. With the assignment of 20
"What is engineering's relationship to the complex technical and social problems of urban society? Is engineering socially neutral?"

to 25 percent of the curriculum to the humanistic-social stem, engineering education has slipped into a mode of operation which, though convenient, should be regarded with suspicion. The engineering student is "sent out" or "turned over" to another discipline to take his humanistic-social courses. But a basic assumption here is that the student will choose a coordinated set of electives that will constructively influence his mode of thought, perhaps altering his value structure and personal priorities. It is further assumed that he will integrate the technical and humanistic-social aspects of his education and that his career choices will be influenced by this integration. Yet as educators we know that few students are successful in bridging the gaps left by the dichotomy between engineering education and education in the humanities and social sciences on most campuses. Furthermore, a recent national committee, of which Dean Schultz was a member, has reported to the American Society for Engineering Education that the humanistic-social stem in engineering curricula is often purposeless.
We must look at engineering education to see what changes should be made to better educate our students so they will be alert to the problems of contemporary society and to the roles that they might play in the resolution of these problems.

The College of Engineering at Cornell is presently reviewing what might be done in its undergraduate program to enhance the concepts of social responsibility and social involvement. There are no successful models in this area of engineering education. It is an area that will require great imagination, dedication, and understanding on the part of the faculty, as well as some experimentation. A possible approach might include the initiation of project seminars at an early stage in the curriculum, perhaps beginning in the freshman year. Initial topics could include case studies in technology for rural, underdeveloped areas. Volunteers for International Technical Assistance (VITA) is a ready source for such cases, combining specific technological needs with the human and economic conditions of less fortunate people.

As the student advances in his curriculum the problems could take on a wider significance and include a more comprehensive systems approach to the urban-environmental problems facing our society. Perhaps professors from the humanities and social sciences could work with engineering faculty to plan and teach project seminars. It might even be possible and indeed appropriate for nonengineering students to be included in these seminars. This dimension of the program might be a very effective way to include some of the concepts and content of engineering education in the experience of nonengineering university students. A successful approach to urban problem solving in our socioeconomic, technical environment requires, in any case, that some measure of engineering education be included. Such courses would expose all students to the social responsibilities and consequences of technical decisions and the need to reconcile these factors with the economic facts of life.

The above represents but one approach to defining the problem con-
of theoretical and applied mechanics at Cornell. Among his administrative responsibilities is the long-range planning for research activities of the College. He assists in the formulation and coordination of all research projects, currently numbering over one hundred.

Dean Cranch earned the Bachelor of Mechanical Engineering degree with distinction from Cornell University in 1945 and the Doctor of Philosophy degree, also from Cornell, in 1951. He joined the Cornell faculty in 1950. He has consulted for the Lincoln Laboratory at the Massachusetts Institute of Technology, the Cornell Aeronautical Laboratory, Ramo-Wooldridge Corporation, General Electric Company, Aerojet General Corporation, Bausch and Lomb Corporation, Corning Glass Works, and the Owego Laboratory of the International Business Machines Corporation. He is currently active as a consultant for the Electro-mechanical Corporation.

During his most recent sabbatical years, 1958–59 and 1964–65, Dean Cranch held National Science Foundation fellowships, the first in the Engineering Mechanics Division at Stanford University, and the second at the Federal Institute of Technology in Zurich, Switzerland.

Dean Cranch maintains an active teaching interest in the College’s sophomore mathematics program and is senior author of the text Engineering Mathematics, which is used in the program. His wide-ranging educational interests at Cornell are reflected by his membership on the faculty of the School of Engineering Physics, the Graduate Field of Applied Physics, the Center of Applied Mathematics, and the Materials Science Center.

He is a member of the American Society of Mechanical Engineers, the American Society for Testing Materials, the Society for Experimental Stress Analysis, the American Society for Engineering Education, Sigma Xi, and Tau Beta Pi. His research interests include dynamics of shells and wave propagation in solids, both areas in which he has published extensively.
Freshmen entering the College of Engineering at Cornell University in 1970 will find several innovative departures from the traditional program of study usually offered to underclassmen. Gone will be the monolithic two-term required sequences of courses in chemistry and physics, replaced by one-term courses in each subject. Each student will have an opportunity to choose any two natural science or social science courses from astronomy to zoology, from anthropology to sociology. The introductory freshman engineering courses, one each term, will also be changed considerably.

The sophomore year, too, will be transformed. Instead of completing two full-year courses in engineering science (electrical science and mechanics, for instance), a student will elect four one-term courses, only one of which will be required as a prerequisite for entrance to a particular engineering field, such as civil engineering, in the junior year.

The requirement that every student take a precisely prescribed core program that will specifically prepare him for upperclass work in the engineering discipline of his choice has been rejected and replaced by the philosophy that all students should have a breadth of underclass educational experience.

For those who are not familiar with engineering education, such changes hardly sound revolutionary—and, indeed, change has been a way of life to the profession. But these modifications do show a major departure from the usual course of study in engineering. It has long been argued that all engineering students need a common base of experience in mathematics, physics, chemistry, engineering science, and graphics. But this base of experience has proved to be too limiting in preparing students to move into new directions in engineering. What was needed was a fresh look at the freshman and sophomore years to devise a program which would promote individual diversity without impairing later progress in an engineering field. Any shift in requirements had to take into account the need for adequate preparation for traditional upperclass programs and the need for a logical basis for the development of suitable hybrid programs.
Figure 1. NEW AND CURRENT FRESHMAN AND SOPHOMORE PROGRAMS
College of Engineering at Cornell University

CURRENT FRESHMAN PROGRAM

**FALL**
- MATH I
- INTRO. TO ENGINEERING I
- CHEMISTRY I
- PHYSICS I
- FRESHMAN HUMANITIES SEMINAR

**SPRING**
- MATH II
- INTRO. TO ENGINEERING II
- CHEMISTRY II
- PHYSICS II
- FRESHMAN HUMANITIES SEMINAR

NEW FRESHMAN PROGRAM

**FALL**
- MATH I
- INTRO. TO ENGINEERING I*
- CHEMISTRY I*
- NATURAL OR SOCIAL SCIENCE
- HUMANITIES OR SOCIAL SCIENCE

**SPRING**
- MATH II
- INTRO. TO ENGINEERING II*
- NATURAL OR SOCIAL SCIENCE
- PHYSICS I*
- HUMANITIES OR SOCIAL SCIENCE

CURRENT SOPHOMORE PROGRAM

**FALL**
- MATH III
- ENGINEERING SCIENCE A
- ENGINEERING SCIENCE B
- PHYSICS III
- HUMANITIES OR SOCIAL SCIENCE

**SPRING**
- MATH IV
- CONTINUATION OF A
- CONTINUATION OF B
- PHYSICS IV
- HUMANITIES OR SOCIAL SCIENCE

NEW SOPHOMORE PROGRAM

**FALL**
- MATH III
- ENGINEERING SCIENCE W*
- ENGINEERING SCIENCE Y*
- PHYSICS II*
- HUMANITIES OR SOCIAL SCIENCE

**SPRING**
- MATH IV
- ENGINEERING SCIENCE X*
- ENGINEERING SCIENCE Z*
- PHYSICS III*
- HUMANITIES OR SOCIAL SCIENCE

**KEY**
- *New or Substantially Revised Courses
- Elective Courses (One of the four new Sophomore Engineering Sciences is a Required Prerequisite for Admission to a Junior Year "Major"
Aided by student opinions, faculty committees spent nearly a full calendar year planning such a program.

The Curriculum Study Committee, chaired by Professor Dennis Shepherd, worked during the summer of 1968 and reported to the Policy Committee in September 1968. Following many hours of Policy Committee deliberations, reports from two ad hoc subcommittees, numerous meetings with groups of interested students, and two college-wide faculty seminars, a modified proposal and suggested changes in College legislation were prepared and submitted to the faculty. A somewhat amended version of this proposal was approved in May 1969.

CHALLENGE TO FACULTY

Approval of the new program by a large majority of the engineering faculty is indicative of their progressive approach to engineering education. Revised programs, to be effective, require major changes of faculty viewpoint, considerable revision of objectives, and drastic revision of many courses. By setting up clearly defined objectives, the faculty has provided a vital baseline for curricular development and reevaluation of courses and course content in the future. This reevaluation is conducted almost continuously by effective teachers, and it is certainly helpful to have the objectives precisely defined. In addition, periodic examination of the curricula by the faculty assures that the courses are acceptable to a changing faculty and a changing society.

CHALLENGE TO STUDENTS

Students will be the true test of the effectiveness of the new engineering core curriculum. But in what manner? Clearly, flexibility implies personal initiative and responsibility—to make the best use of classroom time and the additional hours spent educating oneself. But to do this requires personal "research" of a kind not often undertaken by undergraduates. That is the research of obtaining sound advice and substantive and valid information about possible courses of study. Uninformed freedom of choice is illusory, and flexibility without responsibility is purposeless.

Unwise course selections may produce excessive specialization and provincialism or a course program having little true significance for the needs of a student. Thus, more effective communication between students and faculty will be required, particularly in the area of advising. Realistic and critical self-appraisal by the student of his objectives and motives will be necessary, and advisors must understand student aims and desires in order to recommend appropriate courses. In short, students must come to the realization that enduring education must be self-sustained.

By becoming directly involved with his own personal intellectual and professional development, a student will be forced not only to plan his own program but to take responsibility for it. For the engineering student who prefers the passive approach to education, our new curriculum will indeed be frustrating. But for those interested in having a wide latitude of choice and a broad educational experience, their years at Cornell should be rewarding.
Engineering graduates from Cornell in the 1970s . . . will be more interdisciplinary in their background and in their thinking.”

STUDENT COMMITMENT

Some students approaching the underclass program seek a clear direction to specific engineering disciplines with minimum impedance, while others desire to understand the full scope of the human condition in which engineers must work. Our new program can accommodate both extremes, and hopefully both student types can profit from each other’s experience as well as from that of their classmates enrolled in other colleges at Cornell. Matriculants may enter engineering because of their interest in the profession or as a preferred background for medicine, business, law, or some other profession.

Motivation is the major criterion which will distinguish the successful from the unsuccessful student. As the motivation for a personally developed program of studies should be greater than that for a more externally conceived program, so should the degree of commitment to such a program be greater.

Secondary school students are becoming increasingly aware of growing opportunities in oceanography, bioengineering, computer science, and large-scale urban problems such as transportation and land utilization. These and many more represent areas in which both the “traditional” and the “new breed” engineers will play major roles. But it has been the promise of the new, the unknown, that has captured the attention, the imagination, and the ambitions of the best of our youth. Today, too, the promise of a better life for everyone in society is an almost implicit element in their thinking.

NEW EDUCATIONAL ATTITUDES

Neither the College of Engineering nor the University is a monastery where self-serving professors merely contemplate their disciplines and seek truths within the confines of an enclave. The University and the College are products of society and must be responsive to society. Responsiveness necessitates understanding and evaluating social needs and then reflecting these in educational programs. Obviously, elements of “programming” are common to all engineering disciplines, but there are elements which must be individualized if a concerned graduate is to think constructively about human as well as technical considerations in his professional practice.

In any curriculum it is much easier to teach facts and procedures and to discuss problems having specific answers than to develop concepts and methods of approaching problems and to work with open-ended problems for which there is no single solution. Concepts, methods, and general problems are most important in the development of self-educating abilities.

Demands by students for education relevant to the needs of society have accelerated the rate of change of curricula and are considered valid and desirable by most educators. It is clear that students object to sterility in their programs. While training in an art or a craft is through an apprenticeship to learn the master’s techniques, education in engineering should prepare men and women to solve the unknown, the novel, the unique. This requires an approach
rather than a procedure; ingenuity rather than memory; and self-confidence rather than prior experience with a similar problem.

A CLOSER LOOK AT THE CHANGES

The exposure to more natural science and social science elective courses in the first two years should make students more conscious of other areas of the University. It is expected to be particularly welcomed by students planning a hybrid program, such as bio-engineering. However, it is also available for students who have a genuine concern for the ethics or the social responsibilities of the engineering profession.

While this article is in preparation, a faculty-student committee is determining what directions will be taken in the one required introductory engineering course for each semester of the freshman year. Although their conclusions are not yet known, it is clear that there will be opportunity for a multi-

Top: Professor Burton conducts a meeting of the Policy Committee, which submitted its recommendations for changes in the Core Curriculum of the College to a faculty vote in spring 1969. The changes adopted by the faculty will give students greater flexibility in their curricular choices.

Bottom: Members of the Engineering Student Council met informally with Professor Burton and Professor Howard G. Smith, Director of the Division of Basic Studies in the College, to give their views on the proposal for a new Core Curriculum.
1. A sophomore engineering student at Cornell may choose to enter a Field Program in his junior year or a College Program. The College Program provides an opportunity for students interested in an interdisciplinary study of subjects to pursue their interests in the undergraduate years. Combinations of such subjects as environmental systems and city planning are possible; these cut across departmental, school, and even college lines, as is illustrated by this engineering student who is taking courses in city planning in the College of Architecture, Art, and Planning.

2 and 3: During the summer of 1969 an ad hoc committee, appointed by Dean Schultz and consisting of both students and faculty members, met to study ways of improving the two required freshman engineering courses. Presently, those courses are concerned with graphics and design and digital computing—and in general with an orientation to the engineering profession. In 2 a student is shown in a graphics laboratory; in 3, a meeting of the ad hoc committee chaired by Professor Christopher Pottle.

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FUTURE HOMEWORK

What about the humanities? For some time now about one-fifth to one-
fourth of most undergraduate engineering programs at engineering institutions have consisted of electives in the humanities and social sciences. Yet clearly there are still far too many young engineering graduates who are immune or indifferent to the context in which they will practice their profession. Often they become so engaged in the immediacy of their own work that the social significance of it escapes their notice. Fortunately, there is evidence to suggest encouraging changes in student attitudes.

One challenge that the humanist must face is that of meeting engineering students on their own ground. Engineering faculty too must work to devise courses that can be directed at liberal arts students who are interested in developing an insight into the workings of technology.

During this summer, a faculty committee has been at work developing a seminar-type program that would focus on the social responsibilities of the engineer. Another committee of professors from both the College of Arts and Sciences and the College of Engineering has considered new approaches to education in the humanities and social sciences to enhance their relevance and significance for engineering undergraduates. Hopefully, the vitality of this important element in the education of engineers will be strengthened by the efforts of both committees.

The need for enhancement of the scientific and humanistic basis of engineering education should be evident, and comparison of the revised program with that of a few years ago shows that
Table 1. PROPOSED ENGINEERING SCIENCES (SOPHOMORE YEAR)
(All courses listed are of one term duration.)

<table>
<thead>
<tr>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Area</td>
<td>Physics and Electricity Area</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>Electric Circuits</td>
</tr>
<tr>
<td>Systems Analysis</td>
<td>Electromagnetic Fields</td>
</tr>
<tr>
<td>Computer Science</td>
<td>Contemporary Applied Physics</td>
</tr>
<tr>
<td>Probability</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Group III</th>
<th>Group IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics and Materials Area</td>
<td>Chemistry Area</td>
</tr>
<tr>
<td>Mechanics</td>
<td>Organic Chemistry</td>
</tr>
<tr>
<td>Strength of Materials</td>
<td>Physical Chemistry</td>
</tr>
<tr>
<td>Materials Science</td>
<td>Thermodynamics</td>
</tr>
</tbody>
</table>

NOTE: An undergraduate engineering student takes four engineering science courses during his sophomore year. Three of these he elects from three of the four subject areas shown above. The fourth course is prescribed by the Field or College Program he chooses as his “major” for upperclass study.

marked progress has been made. Similar improvements in the professional aspects of our programs (the subject matter that distinguishes one field from another) must also be continued.

Teaching basic skills is relatively easy; preparing students to conceptualize is somewhat more difficult; and requiring them to face the unknown is especially difficult. Both faculty and students have their work cut out for them.

AIMS OF THE COLLEGE

It is clear that most students who seek admission to Cornell's College of Engineering are doing so with the promise of a wider and richer educational experience beyond the immediate confines of technical subject areas. The flexibility of our program, effective in September 1970, accommodates both the generalist (relative to engineering) and the specialist. The new program neither prevents students from electing courses of marginal importance to their needs nor prevents their concentration in narrow fields.

The intellectually gifted student can now move more rapidly into challenging and more satisfying courses. The revised core curriculum puts the College in a much better position to accommodate the junior and community college graduates, building upon their educational experiences rather than requiring them to match Cornell subject matter levels upon transfer. While there may still be a bias operating against young women interested in engineering (from their families and friends), we hope that many will take a serious look at the new program at Cornell.

In summary, the program allows, but does not require, greater breadth of study in the underclass years. Engineering graduates from Cornell in the 1970s will be less categorizable in terms of particular engineering disciplines and certainly will be more interdisciplinary in their background and in their thinking. No longer will every engineering graduate from a particular school or department have had nearly the same technical courses. Recruiters and employers will surely find broader interests and broader competence in graduates of the revised program at Cornell, and, we trust, greater self-confidence.

“...education in engineering should prepare men and women to solve the unknown, the novel, the unique.”
A late spring class meets on one corner of the arts quad. During this past summer another ad hoc committee in the College of Engineering considered ways to enrich each engineering student's education in the humanities and social sciences. Its membership included faculty from the areas of English, Electrical Engineering, Government, Materials Science and Engineering, Psychology, Sociology, and Thermal Engineering, as well as students enrolled in the College of Engineering.

During the academic year 1968–1969, Malcolm S. Burton was chairman of the College's Policy Committee. It was during this period that the core curriculum of the College was reviewed, and proposals for changes were prepared, discussed with faculty members and students, and modified into the final form accepted by the faculty in May 1969.

The author is professor of materials science and engineering and assistant director of the Department of Materials Science and Engineering at Cornell. From January 1965 to January 1966 he was acting director of the Department. Professor Burton joined the Cornell faculty in 1946, after beginning his teaching career as an instructor in mechanical engineering and then assistant professor of metallurgy at the Massachusetts Institute of Technology. He earned a Bachelor of Science degree in mechanical engineering from Worcester Polytechnic Institute in 1940 and a Master of Science degree in metallurgy from the Massachusetts Institute of Technology in 1943.

During sabbatical years, Professor Burton has served as a research metallurgist for the Cornell Aeronautical Laboratory in Buffalo, New York, and for E. I. Du Pont de Nemours in Aiken, South Carolina. He is author of the textbook Applied Metallurgy for Engineers and numerous technical papers on materials engineering. His interests have centered on relating materials science developments to applications in engineering.

Professor Burton is a member of the American Society for Metals, the American Society for Engineering Education, the American Institute of Mining, Metallurgical and Petroleum Engineers, and Sigma Xi.
The Future of the Professional Schools

The following is excerpted from the Fourth Distinguished Lecture of the American Society for Engineering Education, given by James A. Perkins, retiring president of Cornell University, at the annual meeting of the Society on June 25, 1969 at the Pennsylvania State University.

It may be useful to give you a few observations on professional education from one who has looked at the subject from a variety of vantage points—as a professor in the liberal arts, as a government employer of professional talent, as a foundation officer, and as a university president. At each of these stops in my life I have learned something about the difficulties of educating young men and women for professional careers, and at each stop I came to have increasing respect for the efforts of professional educators to improve and reform their schools.

Many of these efforts have been extraordinarily successful—so successful, indeed, that professional schools in America have become both a mecca and a model for professional education throughout the world. And yet I think none of us... is completely satisfied with professional education as it exists in the United States today...

For the fact is that professional schools, and therefore professional education, today confront two extremely complex problems. The first is the unbelievable expansion of the knowledge that is the basis of each professional field. The second is the widening responsibilities that society places on the professional and that feed back into the professional schools more and more demands for a still broader education. Both of these pressures on the professional schools must somehow be contained within the requirement for a four-year program of broad undergraduate preparation and the commitment to specialization as the basis of truly professional performance.

These pressures will have a profound effect on the educational philosophy and direction of the professional schools, and perhaps the nature of the university itself. It is no wonder that they are forcing professional schools inevitably toward changes in curriculum, admissions practices, and accountability.

Before taking up these changes—and at the risk of belaboring one or two obvious points—I would like to [comment] briefly [on] the pressures of knowledge and the increased responsibilities of the professional...

... To become an engineer today... means virtually to become a scientist, and there is hardly time in the four years of an undergraduate engineer's life to accumulate all the intensive knowledge he must have in his increasingly specialized and sophisticated field. Each year he must know more math, more physics, more chemistry. Each year he is forced into a narrower orientation toward his specialty.

At the same time, knowledge tugs at the professions extensively. In order for the medical student to know all he should about human health, his study of biology must be married to physics, engineering, and psychology. Law now involves the behavioral sciences and the humanities as much as it does the history of law and public process. The modern engineering student must now
squeeze into his crowded schedule additional courses in biology and computer science—and still maintain between twenty and twenty-five per cent of his program in the liberal arts.

It is not enough, however, for the professional to accumulate a wide base of knowledge that bears on his specialty. Now, because he knows more about his work he is also expected to know more about the effects of his work. He is asked to be both specialist and generalist, to understand all the ramifications of what he does, and so to fit his efforts and his research together with what others are doing that some grand and beneficial human design will emerge.

... It has become painfully apparent in the recent past that doing your own thing in the sciences and professions does not necessarily produce the greatest good for the greatest number. The natural and human ecological effects of narrow specialization begin to border on disaster.

This rude awakening to the practical effects of specialization has coincided with the delivery of another coup de grace—the end of the happy myth that “God's in His heaven and all's right with the world.” We may not have fully appreciated the influence upon us over the years of the assumption that we were each a part of an integrated and divine machine functioning for a beneficent, if mysterious, purpose. Under such an assumption, the professional could afford to operate as a narrow specialist because the great design somehow guaranteed that individual and diverse interests would add up to a general interest.

But now the myth has been largely destroyed by the decline of religious faith, by skepticism about the idea of inevitable progress, and by the reality we are forced—by increased knowledge, communication, and experience—to see all around us. We are now faced with the necessity of building a new order to replace the one we have discarded. And this rebuilding, we know, must be the work of generalists working with specialists who take the broad view.

For either the grand design and the redefinition of our priorities will be left to authoritarian solution... or the professionals, who are very deeply and increasingly involved in the highest policy decisions throughout our society, will have to assume the responsibility of operating with a well developed moral judgment of how their special work affects the whole.

This demand from society for very broad-gauged, responsible professionals is reinforced... by today's students. More and more of them want to answer as well as articulate social needs. One of the chief causes of campus unrest, it seems to me, is the great antipathy of students to the amoral, uncritical judgment-making of much of scholarship. Students require of the professional that he be a citizen of the world as well as a specialist in his work. And they demand of their education that it help them become citizen-professionals, too. The students of architecture don't want to learn just how to design houses; they want to help design a better kind of living. The students of law want to be trained for useful work in achieving equal rights for everyone, not simply for an appreciation of the fine points of corporate contracts.

The professional and the professional school are thus operating in a new kind of world.
of world. Although they are expected to be better at their jobs than ever before—to know more, to teach more, to perform under what may at times seem impossibly high standards—they are at the same time expected to be more accessible and intelligible and more practical in terms of the public good. The professional must now be a true man of affairs, and it is, according to society, the obligation of the professional school to make him so.

These pressures are forcing the professional schools to make changes in areas that are already apparent and in others that will only begin to be visible in the next decade. . . .

. . . [With respect to curriculum content] I am persuaded that many professional schools are becoming more relevant and contemporary in their course offerings, and that the disciplinary base for undergraduates continues to widen. Where the professional roadblocks still exist, the pressures of society and student demand will act as powerful levers to force change.

But two quite serious problems of curriculum content remain. These problems grow from the fact that there is going to be a rising demand for the generalist—for the man who is able to see across a variety of specialties, who has some grasp of social purpose, who understands something of the nature and destiny of man.

To train such a person, the professional school will have to solve, first, the old difficulty of providing a liberal arts foundation for its students. There is no doubt that the liberal arts schools, in large part because they have developed their own specializations to such a professional degree, have failed to make the humane studies fully useful to the professional student. Some liberal arts schools would even deny that it is their responsibility to do so. The result is that everyone is unhappy—the student who is driven to look for gut courses in the humanities, the liberal arts professor who wants to teach only liberal arts professionals, and even the few professional schools that have tried to capture arts programs within their own colleges.

I think that one answer to this problem, if there is any at all, will be closely
related to the solution of the second curricular difficulty facing professional schools—the necessity for working out new and well integrated relationships with each other. Inter-professional fluidity is becoming the order of the day, and so there are more and closer connections between, for example, medicine and engineering. ... Architecture and government, nursing and nutrition, agriculture and international affairs, journalism and public health—there is hardly a professional school on any university campus whose subject of study is not deeply implicated in a variety of other professional fields. There will come a time, and I hope it is soon, when several combinations of graduate degrees will be possible....

I think it is likely that such inter-professional work may produce the kind of educators in the humanities that the professional schools have been looking for. That the professional student has in the past received so little nourishment from the arts college may be due in large part to the fact that no common language or body of interest has been developed between them. Such commonality must be developed. Without it the strain on relations within the university, which grows from this disjunction, may well become intolerable. It is quite clear to me, furthermore, that the arts college needs the professional as much as he needs it. For if the professional student withdraws into his professional shell, he will take with him his hardheaded concern for the practical effects of his work—and both the arts college and the professional school will be the losers.

The key here, as is often the case, lies with the faculty. We clearly need humanists who are really interested in the needs of pre-professional students and in their future. We need humanists who are as concerned about the individual in their classrooms as they are about the subject matter they teach. We need humanists who are as general in their interest and attitude as they would wish the professional educator to be. There are both humanists and social scientists who meet this description, but we need many, many more.

We also need faculty in our professional schools who have absorbed the traditional concerns of the humanist for the instinctive and spiritual side of man. The humane style must not be the exclusive prerogative of the humanist.

I hope that the universities will see as their immediate and urgent next task the healing of the division between the professional schools and the arts colleges. The nation's necessary preoccupation with the restructuring of its system of values will involve all of us. Those who are sensitive to this great task... must find ways to forge an effective partnership.

The second large area of change for the professional schools will be in admissions policies and practices. The sheer pressure of numbers will be decisive here. Society needs more doctors, lawyers, nurses, architects, urban planners, public health experts—indeed, professionals in almost every field—than the universities are now turning out. And more and more students are demanding entry.

In the past the allocation of places in professional schools has been determined by a variety of factors—the restrictions of the guild, as in the case
of medicine; the tradition, or the budget, or the availability of housing, laboratories, and library facilities of any particular university; the political footwork of a dean; or simply the temper of the time. The university has tried to balance all these factors as best it could.

But now such internal considerations are not enough. The professions are no longer anyone’s private property. The country must have more well trained professionals. It must make better use of its black people and of its women. If the universities do not train them, some other institution will. The university must, therefore, allot its professional school admissions on a far more enlightened and responsible basis than its frequently disjointed policies have allowed in the past. If the university does not take determined steps of its own to match its output of graduates in the vital professions with an informed estimate of society’s need, to bring more black students into graduate schools, to make it possible for women to do the same professional work as men—then it is inevitable that society will by one means or another make these decisions for the university. Some kind of procedure for making such projections has been discussed for years. It is now time for the universities to work together to accomplish the job.

The third area of change is the public accountability of the professional school. The cost of professional education is fast reaching the point where the state-supported professional school, in particular, will go broke without substantial infusions of public funds. But the public authority always wants to know where the money is going.... This public accountability will increase, too, as more and more students push for entry into professional schools. The exclusivity of the guild and the relatively esoteric standards with which the professions have traditionally barricaded themselves against the unwashed laity will be increasingly vulnerable to student attack. We are discovering this now in medicine, but it has long been true in teacher education, as it will be in other professions where the public need outpaces the professional schools’ capacity to meet it—or, even more dangerous, where the content of instruction is patently out of touch with contemporary reality.

What, then, is the future of the professional schools? Obviously they cannot, nor do most of them try to, pretend that changes are not now required. What they may not be prepared for is the magnitude of the changes ahead.... The professional school is the troubled link between the university and society. If it cannot turn out useful men and women who are both broadly and specifically knowledgeable about their business and if it does not respond to public need and help to lead society toward enlightened goals, then society’s estimate of the value of the university will be reduced—and the university’s role in preparing people for responsible leadership will be seriously compromised.

At the moment, precisely because he does the work that is put before him and because he minds his own business, the professional in today’s world is viewed with skepticism if not with alarm. His role is at a public discount, and yet his power for good and evil is without precedent. While politicians and philosophers debate the ends, the scientists, doctors, teachers, [and] technologists are going ahead with the means—and in effect often determining the ends.

How crucial it is to our common future, then, that what the professional is taught and the context in which he learns it... are given the most intelligent attention we can supply.

Before coming to Cornell in 1963, Mr. Perkins was vice president of the Carnegie Corporation of New York and of the Carnegie Foundation for the Advancement of Teaching; from 1945 to 1950 he was vice president of Swarthmore College; from 1937, when he received the Ph.D. degree from Princeton University, until 1941 he was a faculty member and assistant director of the School of Public and International Affairs at Princeton.
Joseph O. Jeffrey has been named professor emeritus by the Cornell University Board of Trustees, effective July 1, 1969. His biography and brief biographies of new and visiting faculty follow.

Joseph O. Jeffrey was recently appointed professor of materials science and engineering, emeritus, at Cornell University. Since 1925, when he began his teaching career at Cornell as an instructor in the Sibley School of Mechanical Engineering, Professor Jeffrey has contributed forty-four years of service to the University. He was made professor of engineering materials in 1944.

Professor Jeffrey was graduated from Cornell in 1925 with the degree of Mechanical Engineer and earned the Master of Mechanical Engineering degree from Cornell in 1933. He is the author of technical papers on heat transfer and the mechanical properties of nodular cast iron and graphite.

He has been a consultant for Utica Radiator Company, Gould’s Pumps, Kennedy Valve Company, Ithaca Gun Company, Temco, Incorporated, and most recently, the Morse Chain Company, a division of Borg-Warner Corporation in Ithaca. Early in his career, Professor Jeffrey was employed by Curtiss-Wright Corporation and International Motors (Mack Trucks), and by the Research Laboratories of General Electric Company. After World War II, he spent a sabbatical leave as a technical adviser for La Consolidada, S.A., in Mexico City, D.F., where the company was starting one of the largest steel mills in Mexico.

In connection with his work on power transmission drives for Morse, Professor Jeffrey has been issued two patents and has one pending on chain design. He has aided the company in the development of new materials and processing methods for producing power transmission drives and components as well as in improvements in the mechanics and kinetics associated with power transmissions.

Professor Jeffrey is a member of the American Society for Metals, Sigma Xi, Tau Beta Pi, and Phi Kappa Phi.

During the academic year 1969–70 he is teaching on a part-time basis in the Department of Materials Science and Engineering at Cornell. He will also serve as executive secretary of the Cornell Society of Engineers, a group of approximately 2,500 Cornell engineering alumni, and will continue his consulting practice.
Merrill L. Andrews is assistant professor of applied physics. He received the B.A. degree from Cornell University in 1960 and the Ph.D. degree from the Massachusetts Institute of Technology in 1967. Mr. Andrews was a research associate in the Cornell Laboratory for Plasma Studies before joining the faculty at Cornell.

Dieter G. Ast, assistant professor of materials science and engineering, is a native of Germany. He received the Diplomarbeit in 1965 from Max Planck Institut fur Metallforschung in Stuttgart, and the Dipl. Phys. in 1966 from Technische Hochschule in Stuttgart also. He hopes to receive his Ph.D. degree from Cornell in 1969. Mr. Ast's current research is in field ion microscopy.

Donald L. Bartel, assistant professor of mechanical systems and design, was awarded the B.S. and M.S. degrees from the University of Illinois in 1961 and 1963, respectively. He received the Ph.D. degree in 1969 from the University of Iowa. From 1963 to 1965, Mr. Bartel was assistant professor of engineering at Black Hawk College. His special interest is the application of optimization techniques to diverse design problems.

Joseph A. Burns, assistant professor of theoretical and applied mechanics, received the B.S. degree from Webb Institute of Naval Architecture in 1962 and the Ph.D. degree from Cornell University in 1966. During 1967–68 he was a National Academy of Sciences Resident Research Associate at the Goddard Space Flight Center in Greenbelt, Maryland. His special interest is the field of space physics.

Robert R. Capranica, associate professor of electrical engineering, was awarded the B.S. degree in 1958 from the University of California at Berkeley, the M.S. degree in 1960 from New York University, and the Sc.D. degree in 1964 from the Massachusetts Institute of Technology. From 1958 until he joined the faculty at Cornell, he was a member of the technical staff of Bell Telephone Laboratories, Inc., Murray Hill, New Jersey. He is a member of the Acoustical Society of America, the American Association for the Advancement of Science, the American Society of Zoologists, the American Society of Ichthyologists and Herpetologists, Sigma Xi, and Tau Beta Pi. The area of his specialization is communications biophysics.

John E. Dennis, Jr., assistant professor of computer science, was awarded the B.S. and M.S. degrees from the University of Miami in 1962 and 1964, respectively. He received the Ph.D. degree from the University of Utah in 1966. Mr. Dennis was assistant professor of mathematics at the University of Utah from 1966 to 1968 and during the academic year 1968–69 was a lecturer in computer science at the University of Essex, England. He has published several articles on Newton's Method.

Joseph C. Dunn is assistant professor of theoretical and applied mechanics. He received the B.Aero.E. and M.S. degrees from the Polytechnic Institute of Brooklyn in 1959 and 1963, respec-
Adelphi University awarded him the Ph.D. degree in 1967. During 1965 and 1967, Mr. Dunn was an instructor in the Engineering Extension Program at the University of California at Los Angeles, and since 1959 he has worked for the Grumman Aircraft Engineering Corporation, Bethpage, New York. His current research is in differential game theory.

Mark J. Eisner, assistant professor of operations research, was awarded the B.A. degree by Harvard University in 1960. He received the Ph.D. degree from Cornell in September of this year. An instructor in the Department of Operations Research in 1968, Mr. Eisner has also taught short courses in digital computing as part of the Continuing Education offerings of the College. His special interest is mathematical programming.

David J. Gries is associate professor of computer science. From 1966 until joining the faculty at Cornell, he was assistant professor of computer science at Stanford University. He earned the B.S. degree at Queens College in 1950, the M.S. degree at the University of Illinois in 1963, and the Dr. rer. nat. from Munchen Technische Hochschule in Munich, Germany, in 1966. In 1962, Professor Gries received two awards from the United States government for outstanding initiative, quality, and quantity of work. At the time he was a mathematician-programmer for the United States Naval Weapons Laboratory, Dahlgren, Virginia. He is a member of the Association for Computing Machinery.

William F. Lucas, associate professor of operations research, was awarded three degrees from the University of Detroit: the B.S. in 1954, the M.A. in 1956, and the M.S. in 1958. In 1963 he received the Ph.D. degree from the University of Michigan. Professor Lucas was a visiting associate professor of mathematics at the University of Wisconsin during 1966–67 and a visiting assistant professor of economics and statistics at the Middle East Technical University in Ankara, Turkey. He has lectured at Bowdoin College and Princeton University and was employed from 1967 through 1969 at The Rand Corporation in Santa Monica, California. Professor Lucas is a member of the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics. He is especially interested in game theory.

Ross A. McFarlane, associate professor of electrical engineering, is a native of Ontario, Canada. He received the B.Sc. degree from McMaster University in 1953, and the M.Sc. and Ph.D. degrees from McGill University in 1955 and 1959, respectively. From 1961 until coming to Cornell, Professor McFarlane was a member of the technical staff of Bell Telephone Laboratories, Whippany, New Jersey, where he worked in the areas of quantum electronics and molecular spectroscopy. He is a member of the Canadian Association of Physicists and Sigma Xi and is on the editorial advisory board of the Journal of Molecular Spectroscopy.

Arnim H. Meyburg is a citizen of the Federal Republic of Germany. He earned the B.A. degree at the Free University of Berlin in 1964 and the M.S. and Ph.D. degrees at Northwestern University in 1969. As assistant professor of environmental systems engineering, Mr. Meyburg is interested in urban transportation and planning. He has studied settlement patterns and transportation services in Belgium, West Germany, England, Scotland, Wales, Mexico, and Arizona.

George L. Nemhauser is professor of operations research. Before joining the Cornell faculty he was associate professor of operations research at Johns Hopkins University, where he was named one of the eight best teachers in the School of Arts and Sciences in the student Course Guide (spring 1968). He earned the B.Che.E. degree at City College of New York in 1958 and the M.S. and Ph.D. degrees at Northwestern University in 1959 and 1966, respectively. During 1963–64 Professor Nemhauser was visiting lecturer at the University of Leeds, United Kingdom. He is a member of the Operations Research Society of America, the Institute of Management Science, the Society for 34
Industrial and Applied Mathematics, the American Institute of Industrial Engineers, and the American Association of University Professors. The author of Introduction to Dynamic Programming (1966), Professor Nemhauser has special interests in quantitative methods in operations research, with emphasis on the theory and application of mathematical programming.

- Guillermo Prada, assistant professor of electrical engineering, is interested in systems theory. He received the B.S.E.E. degree in 1964 from the Massachusetts Institute of Technology and three other degrees from Syracuse University: in 1966, the M.S.E.E. degree; in 1969, the M.S. and the Ph.D. degrees.

- Roland L. Ruhl is assistant professor of engineering. He earned two degrees at Cornell University: the B.M.E. in 1965 and the M.B.A. in 1966. He expects to receive his Ph.D. degree from Cornell this fall. Mr. Ruhl has been a teaching assistant and instructor in the Division of Basic Studies, College of Engineering, Cornell University, since 1965.

The following are visiting faculty at Cornell for the academic year 1969–70.

- Donald L. Day, visiting professor of agricultural engineering, is associate professor of agricultural engineering at the University of Illinois. His specialty is agricultural waste management.

- James N. Goodier is the AVCO-Victor Emanuel Visiting Professor of Engineering for the fall term in the Department of Theoretical and Applied Mechanics. He is associate professor of engineering mechanics at Stanford University.

- Ryszard B. Hetnarski is visiting associate professor of theoretical and applied mechanics. He is a research scientist at the Institute of Basic Technical Problems, Polish Academy of Sciences, Warsaw.

- Walter H. Ku, visiting associate professor of electrical engineering, is a senior engineering specialist in the field of circuit control at the Applied Research Laboratory of Sylvania Electric Products, Inc., Waltham, Massachusetts.

- John A. Meyer, visiting associate professor of applied physics, is associate professor of nuclear chemistry at the State University College of Forestry at Syracuse University.

- George H. Miley, visiting professor of applied physics, is professor of nuclear and electrical engineering at the University of Illinois.

- Rudi S. B. Ong, visiting professor of aerospace engineering (spring term), is professor of aerospace engineering at the University of Michigan.

- Robert A. Peart is visiting professor of agricultural engineering. His specialty is operations research, and he is professor of agricultural engineering at Purdue University.

- Itiro Tani, emeritus professor of aeronautics at the University of Tokyo, will be the AVCO-Victor Emanuel Visiting Professor of Engineering (spring term) in the Graduate School of Aerospace Engineering.
The following publications and conference papers by faculty members and graduate students of the Cornell College of Engineering were published or presented during February, March, and April 1969. The names of Cornell personnel are in italics.

■ AEROSPACE ENGINEERING


■ AGRICULTURAL ENGINEERING


■ APPLIED PHYSICS


■ CHEMICAL ENGINEERING


Edwards, V. H., and Finn, R. K., “Chemical Effluents as Fermentation 36


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**CIVIL ENGINEERING**


COMPUTER SCIENCE


ELECTRICAL ENGINEERING


The College
Looks Ahead

The year was 1868 and the place a young Cornell University. Candidates for entrance to the University were ordered to "report at the cellar door of the Cornell library building for examinations. The examinations in spelling and grammar were held in one corner of the cellar room, arithmetic in another, geography in between, wherever there was sufficient light to read by."

Since this modest beginning over a century ago, much has affected the character of engineering education at Cornell, as engineering practice itself has changed. In 1868 only one field of engineering—civil engineering—was available for study, and there was more "art" than "science" involved in both the instruction offered and the practice of that day's civil engineers.

During the past century, American technological advances have been impressive. They have greatly influenced the character and growth of engineering education in this country. Yet, although the scientific content of engineering becomes greater every day, the fundamental role of technology has not changed over the past one hundred years. That role is to employ knowledge, insight, and experience in an effort to produce useful products and services for people. Besides being an agent for progress and change, the modern engineer is being asked by society to help determine its directions, directions that will be seriously affected by new technologies.

In this issue, Edmund T. Cranch, associate dean of engineering at Cornell, explores some of the areas he considers vital for research and study in the next decade. Malcolm S. Burton, professor of materials science and engineering and 1968-69 chairman of the College's Policy Committee, outlines the new underclass "core" curriculum of the College, to be effective in September 1970. This significantly revised curriculum places the burden of choice for the breadth and depth of his education more squarely on the student's shoulders.

And in a new section, "Commentary," retired president of Cornell James A. Perkins probes some of the critical issues facing the professional schools today. He deals especially with changes in curriculum, admissions practices, and public accountability of the professional schools.

It is a truism that the one constant factor in engineering education is change. Nevertheless, it is worth reiterating that today's professionals must be responsive to the changes that new technology will effect. This issue examines the most recent changes in the engineering curriculum at Cornell and some of the research areas projected for future study by the College of Engineering.