

ENGINEERING EDUCATION AND RESEARCH AT YALE

- I. Recent History
- II. The Review Process
- III. Sections or Departments
- IV. Sections to Departments
- V. Council of Engineering
- VI. The Divisional Committee
- VII. The Future

## Engineering Education and Research at Yale

### I. Recent History

In 1962, on the premise that the integration of applied physics and chemistry with the more traditional engineering disciplines would enhance the excellence of Yale's teaching and research, the School of Engineering was replaced by a new Department of Engineering and Applied Science within the Faculty of Arts and Sciences. The Department has proved to constitute a major improvement, but experience has shown that an organization so broad and unstructured is not the ideal means to bring engineering teaching and research within the general intellectual life of the University. Admittedly the concept of a vital engineering program within an Arts and Sciences environment is radical, but the vision is so promising that it merits great effort to make it a reality. Given Yale's particular complexion, traditions, and size, there is no better place to continue this unique experiment. Given the needs of the nation today, there is no better time for Yale to re-affirm its commitment to excellence in engineering and applied science.

Since 1962, the Department of Engineering and Applied Science has achieved a number of notable successes: new faculty appointments have revitalized chemical engineering; an excellent research activity in applied physics has been established; fruitful

cross-disciplinary research collaborations have been nurtured; a healthy relationship with the applied mechanics activity in the Department of Geology and Geophysics has grown; modern undergraduate programs fusing science with technology have been developed; the breadth of the Ph.D. programs has been emphasized; and sophisticated interdisciplinary courses developed by the Department offer significant technical and scientific insight into societal problems, and are widely appreciated by Yale students who are not majoring in science. However, while the interdisciplinary aspects have flourished, our unconventional organization has not met with broad approval in the engineering profession. Further, diminished support available to the University in the early 1970's resulted in a reduction in the size of the faculty and the elimination of desirable areas of development in engineering. As a consequence of this unfortunate combination of circumstances, the national visibility of Yale Engineering has faded. It must also be admitted that the merging of disciplines with distinctly different traditions and priorities into a single department has made it quite difficult for the faculty to harmonize its appointments strategy.

In the last four years the University's financial condition has improved considerably. Though it is too early to claim that financial equilibrium has been achieved, it is possible to foresee reasonable stability in the overall size of the Faculty of Arts and Sciences. Despite the financial stringencies that intervened, the years since 1962 have witnessed progress towards the University's

goal for engineering. In the following paragraphs, a specific plan for a new stage of the continuing development is outlined. It is the result of two years of intensive effort by the faculty of the Department of Engineering and Applied Science, the Physical Sciences Advisory Committee, and the Faculty of Arts and Sciences Executive Committee. External reviewers gave generously of their time and effort in Yale's behalf; the University is deeply indebted to them.

## II. The Review Process

For the last two years the Department and the administration have jointly engaged in a thorough appraisal of Yale's record in engineering education and research. They have identified strengths and weaknesses, and have considered a variety of suggestions for improvement. To ensure the quality and impartiality of the appraisal, a two-stage external review was implemented. Twelve nationally recognized leaders were assembled in four committees representing chemical engineering, electrical engineering, applied mechanics, and applied physics. Each group was asked to visit the campus and to assess separately its aspect of the Department. Written evaluations and recommendations were distributed to the faculty for comment. In the second stage, the four committee chairmen reassembled in New Haven, studied the separate reports and commentaries, and developed overall recommendations. These recommendations also generated

intense discussion in the faculty. All reports and faculty comments were forwarded to the University administration for study, and the administration in turn sought the advice of other science faculty through the Advisory Committee on the Physical Sciences. Final recommendations were developed by the President, the Provost, the Dean of the Graduate School and the Dean of Yale College, who, as the Executive Committee of the Faculty of Arts and Sciences, must recommend any reorganization plan to the Yale Corporation.

All parties agreed that the four groups within the present Department merit greater autonomy than they now have in proposing faculty appointments and promotions. Yet the intellectual content of each area is intimately interrelated to that of the others. If the desired autonomy is to be attained without sacrificing the Department's interdisciplinary strengths, new governance is required, comprising distinct units operating under an umbrella organization. Nearly all parties agreed that the overall academic program should remain within the Faculty of Arts and Sciences. The crucial questions concern the nature of the relationships between the units, the umbrella organization, and the Faculty of Arts and Sciences. The plan which has emerged is detailed below.

### III. Sections or Departments

The University intends to replace the Department of Engineering and Applied Science with new departments organized along traditional lines, but coordinated by a new Council of Engineering. Most modern engineering departments in other institutions of quality are comprehensive and include significant areas of interest which do not now exist at Yale. Unfortunately, the resources necessary to establish all these areas are not now available, and it will take time to develop them. But there is now both desire and need for prompt action. Rather than wait, the University intends to act immediately, using resources in hand to indicate decisively the direction of the near future.

As an intermediate and clearly transitory first step, the present Department of Engineering and Applied Science will be dissolved, and its faculty will re-group into a Department of Chemical Engineering, and Sections of Electrical Engineering, Applied Mechanics, and Applied Physics, each autonomous as regards its power to recommend faculty appointments and promotions directly, following the normal procedures for departments in the Faculty of Arts and Sciences. To establish the Department and the Sections, all faculty members of the present Department will be asked to choose the unit with which they wish to affiliate. Consistent with normal procedures in the Faculty of Arts and Sciences, secondary

(joint) appointments can be arranged later by mutual consent, but the one-person-one-vote rule will apply unless specific exception is approved by the Provost. After appropriate consultation, the President will appoint a chairman for each unit. Through its chairman, each unit will be responsible to the Provost for its own faculty budget, and for a minimum administrative budget. (As described below, most purely administrative functions will be handled by the Council, an organization in which all units will participate.)

The Sections will differ from most departments in the Faculty of Arts and Sciences insofar as they do not at this time claim comprehensive coverage of their fields. Nevertheless, each Section will be charged to develop its own educational and research programs, and, if desirable and feasible, to grow into full-fledged comprehensive departments. The process of transition from status as a Section to status as a Department is described below.

#### IV. Sections to Departments

The external review committees and a majority of the engineering faculty are convinced that the full potential of engineering and applied science at Yale will not be realized until

full-fledged engineering departments are established. It is also generally agreed that additional resources are essential to achieve that goal. It is obvious that the additional support is not likely to be achieved by redirection of other FAS resources, for such action would require elimination or severe reductions of other less desirable programs; and the Academic Review Committee has not identified such programs.

It follows that external resources must be tapped to finance the desired expansion. Sources for such expansion are most likely to exist in industry, in the pool of alumni of the former School of Engineering, and in programs of the Federal Government. Particularly for the first two, fund-raising efforts have, in the past, been severely hindered by a wide-spread perception that engineering has been badly treated at Yale. Announcement of the establishment of a Department of Chemical Engineering should help; but the negative perception will not be completely removed until full-fledged Departments of Electrical Engineering and Mechanical Engineering emerge, carrying traditional labels and prerogatives. Yet no matter how excellent its members may be, to bestow the title of Department on a faculty group that lacks the breadth of most of the established departments in its field would be unwise. It would invite misunderstanding, and generate comparisons unfair to the group and to the University. Instead, the University will clearly and firmly state its two-step strategy. Simultaneously with the establishment of the Sections, the President



will declare that the Sections, for persuasive academic reasons, are intended to grow into PAS Departments of Electrical Engineering and Mechanical Engineering (and possibly Applied Physics).

To move from a Section to a Department will demand considerable academic and entrepreneurial energy so as to meet certain specific requirements. When should a Section be deemed ready for designation as a Department? When resources are in hand or firmly pledged to permit the Section

- 1) to mount at least one ABET-accredited undergraduate major (Applied Physics excepted), a terminal master's degree program, and a Ph.D. program, all without lessening the Section's contribution to the Council's interdisciplinary programs;
- 2) to carry out an active research program involving its Ph.D. students, and to maintain and modernize as necessary its research laboratories;
- and 3) to attract undergraduate and graduate students and faculty of the highest caliber.

Each Section aspiring to become a Department should prepare a detailed plan to achieve these goals, and submit it for consideration

by the Council, the Physical Sciences Advisory Committee,  
and the Faculty of Arts and Sciences Executive Committee.

The Physical Sciences Advisory Committee believes that one, and only one, of the new units now possesses sufficient breadth, and commands sufficient resources, to presently qualify as a Department. Assuming that all the faculty members associated with the current Chemical Engineering activity wish to join the new unit, and that no others so elect, the new unit would have only seven faculty positions. However, departments in this field of engineering are not usually large, in part because other sectors of engineering furnish important segments of the educational program in chemical engineering. Undergraduate accreditation in this field has been particularly difficult at Yale because of a conflict between the distributional requirements imposed by the Accreditation Board for Engineering and Technology and those stipulated by Yale. There is a new plan which may lead to a resolution; it will be tested in the accreditation review this year. (This conflict is specific to Chemical Engineering, and is not a problem in other fields of engineering.) A terminal master's degree program should be developed. The Advisory Committee attests to the quality of the research program and to the attractiveness of Chemical Engineering to students and potential faculty. It does, however, strongly recommend that the two tenure positions to become vacant in the near future be filled, if and when

they are reconfirmed, by persons widely respected as bona-fide chemical engineers; term positions should also be so used, for the Advisory Committee does not anticipate that faculty positions additional to those now authorized will be available in the near future.

The Executive Committee of the Faculty of Arts and Sciences has accepted this evaluation, and will recommend to the Corporation the establishment of a Department of Chemical Engineering.

For Electrical Engineering, the Physical Sciences Advisory Committee sees a need to build new strength in the areas of energy, devices, and computer hardware. It recommends that the four faculty positions now held in reserve (one with tenure and three on term) be allocated to the Section of Electrical Engineering, with first emphasis being given to recruitment of a senior individual in computer engineering. These resources, plus impending retirements, if and when they are reconfirmed, should provide sufficient means for building a truly first-rate activity in electrical engineering, and merit in due time the unit's conversion from a Section to a Department.

The Faculty of Arts and Sciences Executive Committee accepts this view, and will recommend to the Corporation the establishment of a Section of Electrical Engineering.

In order to recruit a senior person in computer engineering, a balanced search committee will be established immediately by the President. It will be composed of three members from the Section of Electrical Engineering, one member from the Section of Applied Physics, one member from the Department of Computer Science, and one member who is a distinguished electrical engineer on the faculty of another institution. The remaining faculty positions available may be used to construct an attractive package to aid this recruitment. It is intended that the senior person will provide the experience and statesmanship to assist in the rapid evolution of the Section into a Department.

Both the external Review Committee and the Advisory Committee believe that the development of a comprehensive Department of Mechanical Engineering requires the addition of a substantial number of faculty in areas such as thermal science, robotics, materials, etc. The Advisory Committee therefore recommends, as a temporary measure, establishment of a Section of Applied Mechanics until new resources have been raised sufficient to permit its proper evolution into the Department of Mechanical Engineering that must ultimately develop if Yale is to have a strong and balanced engineering program. Advantage must be taken of impending retirements and expiring term appointments to advance towards this goal, for the Advisory Committee does not anticipate that faculty positions additional to those

presently authorized are likely to become available in the near future.

The Faculty of Arts and Sciences Executive Committee accepts this recommendation, recognizing that it places a heavy responsibility on the current faculty in Applied Mechanics. It will recommend to the Corporation the establishment of a Section of Applied Mechanics.

For Applied Physics, the situation is more complex. The Advisory Committee applauds the variety and the excellence of the research programs in Applied Physics. An undergraduate major has been developed jointly with the Physics Department, but it is too early to judge its merit or its attractiveness to students. However, there can be no doubt of the present value to Yale of a Section of Applied Physics. What the optimum course of its development may be is less clear. On the one hand, many of the activities of the applied physicists are to be found in modern departments of electrical engineering. If their activities could be congenially joined with those of the electrical engineers, the evolution of the Section of Electrical Engineering into a Department would be accelerated. On the other hand, the applied physicists have strong disciplinary ties to the faculty of the Department of Physics. Whether there should ultimately be two Physics Departments is debatable. The

Executive Committee of the Faculty of Arts and Sciences believes it would be premature to attempt a final disposition at present; further, whatever that disposition may be, it requires the enthusiastic support of the faculty involved. The Executive Committee of the Faculty of Arts and Sciences will therefore propose to the Corporation the establishment of a Section of Applied Physics with the expectation that in the next several years this unit will develop appropriate relations with both the Section of Electrical Engineering and the Department of Physics so as to evolve a long-term solution which is optimum both as regards professional compatibility and the use of limited resources.

The creation of autonomous Sections of Electrical Engineering, Applied Mechanics, and Applied Physics, and a Department of Chemical Engineering will enable and encourage these units to seek excellence within their respective disciplines. However, to insure that autonomy does not result in parochialism, a new Council of Engineering will be established to preserve and promote interdisciplinary research and teaching in engineering and applied science.

#### V. Council of Engineering

The Council of Engineering will be composed of the four Section/Department Chairmen and chaired by a fifth person appointed by the President. In broad terms the Council will be responsible for preserving and promoting excellence in engineering and applied science, particularly as reflected in interdisciplinary research and teaching. It will also insure that the entire Yale community benefits from that excellence.

Specifically, the Council is expected to:

- . augment rather than supplant the normal prerogatives of the Sections and Departments
- . provide the coordination necessary to insure the availability of the common core of basic engineering courses (e.g. thermodynamics, fluid mechanics)
- . support interdepartmental educational programs (e.g. Applied Mathematics, Engineering Science, the current Ph.D. program)
- . support interdepartmental courses for non-science majors
- . support collaborative research
- . coordinate, with the Development Office, major fund-raising efforts

To provide the necessary support, the Council will manage a budgeted faculty salary pool corresponding to the faculty resources presently allocated to the interdisciplinary programs which will become its responsibility. However, the Council will not propose specific faculty appointments or promotions to the Appointments Committees; the budgeted pool is over and above that reserved to the autonomous units, and is intended solely to compensate them for faculty participation in Council programs. The Council will also manage the existing funds restricted to engineering and applied science, but not designated to a specific discipline, using these funds to support programs, Sections, or Departments as it deems most helpful.

The Council will also assume a significant administrative function. In order to prevent waste, duplication, and excessive administrative overhead, the administrative functions and facilities furnished by the present Department (e.g. business management, secretarial pool, student shop, space) will be retained as assets in common, supervised by the Council.

The Council will also be responsible, through a single Director of Graduate Studies, for the recruitment and selection of graduate students for all Sections and Departments that comprise the Council, and will negotiate with the Dean of the Graduate School concerning their admission and support.



The Council Chairman will negotiate directly with the Provost concerning the resources necessary to carry out the Council's functions.

VI. The Divisional Committee

As in other Divisions of the Faculty of Arts and Sciences, the Physical Sciences Advisory Committee is composed of senior faculty members; it, in turn, constitutes a majority of the Senior Appointments Committee for the Physical Sciences. It is assumed that this committee is qualified to understand the full intellectual range within its Division, for the Executive Committee of the Faculty of Arts and Sciences depends heavily for its decisions on the wisdom of the divisional advisory committees.

Rightly or wrongly, some engineering faculty members are convinced that the Physical Sciences Advisory Committee has not always in the past fully understood their problems or appreciated their virtues. The traditions and motivations of engineers differ from those of scientists, and it is essential that the divisional committee be so structured as to always include an engineering point of view. The present Advisory Committee has recommended that a representative from each of the new Sections

or Departments be included in the Committee to ensure its breadth. Further, it recommends that recognition be given to the new thrust by a new title: the Division of Physical Sciences and Engineering.

The Faculty of Arts and Sciences Executive Committee accepts these recommendations, and will implement them for the next academic year. It recognizes however that the enlargement of the Advisory Committee from eight to eleven members may create problems of unwieldiness, and it will, therefore, review the composition of the Committee with the Director of the Division after a trial period of three years.

#### VII. The Future

Engineering is at the threshold of a new era at Yale. Bright though its future is, we chart new paths and do not, cannot, foresee all the pitfalls. Eighteen years passed between the last two serious appraisals of our engineering programs - far too long. These appraisals were guided by experts sympathetic with Yale's goal; and we should avail ourselves of such help more frequently. To that end the President intends to convene in New Haven at least every two years visiting committees for each Section or Department, and to ask them to scrutinize Yale's efforts with impartial expertise. These visits should

culminate in a comprehensive review five years from now. If we err, early warning can initiate correction; if we succeed, our virtues will be more widely noted.

As we phase out the Department of Engineering and Applied Science, it is appropriate to note again its accomplishments. The faculty and staff of the Department have enriched the art of engineering education. Many of their innovations have survived the test of time, and will continue to grow. With its emphasis on applied science, the Department has been notably successful in developing research programs of the highest quality in areas which its predecessor School had ignored. If the Sections, Departments, and the Council which succeed Engineering and Applied Science can summon the same level of creative energy, the University will gain in stature and in its ability to serve. Reorganization per se is meaningless; a new organization can only provide an environment. It is, after all, the willingness, the enthusiasm, and the quality of the students, the staff, and the faculty that will gain the day.