17. A. A. Abrikosov, *J. Exptl. Theoret. Phys. (USSR)* **32,** 1442 (1957); *Soviet Phys. JETP (Engl. Transl.)* **5,** 1174 (1957); *J. Phys. Chem. Solids* **2,** 199 (1957).
18. G. B. Yntema, *Phys. Rev.* **98,** 1197 (1955).
19. S. H. Autler, *Rev. Sci. Instr.* **31,** 369 (1960).
20. B. T. Matthias, T. H. Geballe, S. Geller, E. Corenzwit, *Phys. Rev.* **95,** 1435 (1954).
21. J. K. Hulm, *Phys. Rev.* **98,** 1539 (1955).
22. J. E. Kunzler, E. Buehler, F. S. L. Hsu, B. T. Matthias, C. Wahl, *J. Appl. Phys.* **32,** 325 (1961).
23. R. M. Bozorth, H. J. Williams, D. D. Davis, *Phys. Rev. Letters* **5,** 148 (1960).
24. C. P. Bean, *ibid.* **8,** 250 (1962).
25. V. D. Arp, R. H. Kropschot, J. H. Wilson, W. F. Love, R. Phelan, *Phys. Rev. Letters* **6,** 452 (1961); J. O. Betterton, Jr., R. W. Broom, G. D. Kneip, R. E. Worsham, C. E. Roos, *ibid.* **6,** 532 (1961).
26. H. R. Hart, Jr., I. S. Jacobs, C. L. Kolbe, P. E. Lawrence, in *High Magnetic Fields,* H. Kohn, B. Lax, F. Bitter, R. Mills, Eds. (Wiley, New York, 1961), p. 584.
27. J. E. Kunzler, *Rev. Mod. Phys.* **33,** 501 (1961); J. H. Wernick, F. J. Morin, F. S. L. Hsu, D. Dossi, J. P. Maita, J. E. Kunzler, in *High Magnetic Fields,* H. Kohn, B. Lax, F. Bitter, R. Mills, Eds. (Wiley, New York, 1961), p. 609.
28. B. T. Matthias, *Phys. Rev.* **92,** 874 (1953).
29. J. E. Kunzler, *Bull. Am. Phys. Soc.* **6,** 298 (1961).
30. ———, *J. Appl. Phys.* **33,** 1042 (1962).
31. T. G. Berlincourt, R. R. Hake, D. H. Leslie, *Phys. Rev. Letters* **6,** 671 (1961).
32. M. J. Fraser, J. K. Hulm, H. Riemersa, A. J. Venturino, R. E. Wein, *Cryogenics* **2,** 116 (1961).
33. R. R. Hake, T. G. Berlincourt, D. H. Leslie, in *High Magnetic Fields,* H. Kohn, B. Lax, F. Bitter, R. Mills, Eds. (Wiley, New York, 1961), p. 341.
34. S. H. Autler, *ibid.,* p. 324.
35. H. Riemersa, J. K. Hulm, A. J. Venturino, B. S. Chandrasekhar, *J. Appl. Phys.* **33,** 3499 (1962).
36. W. Meissner and R. Ochsenfeld, *Naturwissenschaften* **21,** 787 (1933).
37. F. London and H. London, *Proc. Roy Soc. London* **A149,** 71 (1935); *Physica* **2,** 341 (1935).
38. See F. London, *Superfluids* (Wiley, New York, 1950), vol. 1.
39. E. A. Lynton, *Superconductivity* (Wiley, New York, 1962).
40. D. Shoenberg, *Superconductivity* (Cambridge Univ. Press, New York, 1952), p. 140.
41. See N. F. Mott and H. Jones, *The Theory of the Properties of Metals and Alloys* (Dover, New York. 1958), p. 179.
42. J. Bardeen, L. N. Cooper, J. R. Schrieffer, *Phys. Rev.* **108,** 1175 (1957).
43. J. Bardeen, *Rev. Mod. Phys.* **34,** 667 (1962).
44. A. M. Clogston, A. C. Gossard, V. Jaccarino, Y. Yafet, *Phys. Rev. Letters* **9,** 262 (1962); A. M. Clogston, *ibid.,* p. 266.
45. B. S. Chandrasekhar, *Appl. Phys. Letters* **1,** 7 (1962).
46. F. Reif, *Phys. Rev.* **106,** 208 (1957); G. M. Androes and W. D. Knight, *ibid.* **121,** 779 (1961).
47. The materials we call "mixed-state superconductors" are also called "type-II superconductors" and "negative surface energy superconductors" in the literature.
48. C. P. Bean, M. V. Doyle, A. G. Pincus, *Phys. Rev. Letters* **9,** 93 (1962).
49. N. V. Shubnikow, V. I. Khotkevich, Y. D. Shepelev, Y. N. Rjabinin, *J. Exptl. Phys. (USSR)* **7,** 221 (1937).
50. J. D. Livingston, *Phys. Rev.,* in press.
51. C. P. Bean, unpublished. It appears from R. Kamper, *Phys. Rev. Letters* **2,** 290 (1962), that H. London has developed the same theory.
52. Y. B. Kim, C. F. Hempstead, A. R. Strnad, *Phys. Rev. Letters* **9,** 306 (1962).
53. R. W. Shaw and D. E. Mapother, *Phys. Rev.* **118,** 1474 (1960); J. J. Hauser and E. Buehler, *ibid.* **125,** 142 (1962).
54. F. J. Morin, J. P. Maita, H. J. Williams, R. C. Sherwood, J. H. Wernick, J. E. Kunzler, *Phys. Rev. Letters* **8,** 275 (1962).
55. A. B. Pippard, *Proc. Cambridge Phil. Soc.* **47,** 617 (1951).
56. ———, *Proc. Roy. Soc. London* **A216,** 547 (1953).
57. B. B. Goodman, *IBM J. Res. Develop.* **6,** 63 (1962).
58. L. P. Gor'kov, *J. Exptl. Theoret. Phys. (USSR)* **36,** 1918 (1959); *ibid.* **37,** 1407 (1959); *Soviet Phys. JETP (Engl. Transl.)* **9,** 1364 (1959); *ibid.* **10,** 998 (1960).
59. B. B. Goodman, *Phys. Rev. Letters* **6,** 597 (1961).
60. See also T. G. Berlincourt and R. R. Hake, *ibid.* **9,** 293 (1962).
61. P. S. Swartz, *ibid.,* p. 448.
62. J. Hauser, *ibid.,* p. 423.
63. B. B. Goodman, *Phys. Letters* **1,** 215 (1962).
64. P. W. Anderson, *Phys. Rev. Letters* **9,** 309 (1962).

News and Comment

Graduate Aid: Poll of Educators Suggests That Needs Vary Widely in Scientific Disciplines

In the debate over how this country can produce more scientists and engineers, two conflicting articles of faith endure side by side: graduate support is now so abundant that even a mindless warm body finds the government ready to foot the bill for an advanced degree; and lack of financial assistance prevents many qualified students from continuing their studies.

The latter point of view is held by the President's Science Advisory Committee (PSAC), which last December recommended a financial aid program aimed at achieving an "abrupt increase" in the percentage of undergraduate science and engineering majors going on to graduate study. The committee said the increase could be achieved without a decline in quality, principally by removing financial barriers to graduate training (*Science*, 21 Dec. 1962). The proposal was attacked by a number of scientists and educators on the grounds that just about anyone capable of absorbing graduate training can now find fairly generous support, and that an abrupt increase was to be had only by accepting students of questionable ability.

Since the debate, unfortunately, is accompanied by a remarkable dearth of reliable statistics, *Science* thought it might be useful to ask the chairmen of undergraduate science and engineering departments (i) how their students were faring in obtaining assistance for advanced studies, and (ii) what governmental steps they would propose to expand the nation's supply of scientists and engineers. Accordingly, questionnaires were sent to 750 undergraduate chairmen in the so-called EMP (engineering, mathematics, and physical sciences) fields, covering every such department that turned out more than ten majors in these fields in the 1959–60 academic year. Within a month, 347 usable replies came back, providing a fund of information that suggests that a great deal of the debate simply has not been dealing with reality. After paying due homage to the perils of polling, it appears that the adequacy of support varies widely among the disciplines, and that a shotgun approach to graduate aid would justify the fears of the critics.

The key question in the poll ran as follows: "In recent years, the number of graduate fellowships from various sources has increased. Based on your own experience with recent students at your institution, has the increase been sufficient to insure that all of your qualified and interested graduates desiring assistance for graduate study have been able to obtain it?"

The 347 replies can be tabulated as follows:

	Yes	No	Uncertain
Mathematics	46	38	7
Engineering	28	61	5
Chemistry	87	7	
Physics	43	25	
Total	204	131	12

A breakdown of these replies also indicated that PSAC was on the mark when it concluded that an increase in graduate support would expand enrollments in engineering and mathematics, but the returns suggest that in chemistry and physics the potential is now fairly close to being realized. This conclusion arises from replies to a series of questions on how many of last year's graduates the chairmen considered qualified for graduate training, and how many of these—regardless of the reason—chose not to go on to graduate school.

The physics chairmen reported that about half their students were qualified for graduate training, and that of these qualified students about 80 percent actually went to graduate school. Though the questionnaire did not go into the matter, it is probably a safe assumption that a fair proportion of the remaining 20 percent went on to graduate training in other fields of science. It thus appears to be unlikely that many more graduate physics enrollments can be obtained from the existing undergraduate student body, no matter what inducements or benefits are made available.

The chemistry chairmen, who overwhelmingly reported that graduate assistance is adequate, stated that slightly less than half their students are qualified for graduate training, and that of these, a little over a third actually continue their training. Student motives in these matters are extremely difficult to divine, but it does not appear unreasonable to assume that if almost all who seek aid are able to find it, an increase in assistance would not be likely to encourage more students to go to graduate school.

However, a different situation appears to exist in engineering and in mathematics. The engineering chairmen, who stated the greatest lack of graduate support, reported that a little over one-third of their students were qualified for graduate training, and that of these, only about half continued their training. This leaves the inference that if greater assistance were available, more qualified students could be expected to pursue graduate study. This conclusion is substantiated by results of a recent survey conducted by the Engineering Manpower Commission. In a poll that brought responses from 136, or 90 percent, of the nation's graduate-engineering deans, it was reported that of 3160 fellowships now available, only 33 are not being used, largely because of special restrictions that make them difficult to fill. The deans stated that they could use another 6420 fellowships spread across the whole engineering curriculum.

The situation in mathematics does not appear to be critical, but an examination of the returns suggests that a substantial increase could probably be expected if additional support were available. When the replies that were placed in the "uncertain" category are excluded, the proportion of mathematics deans who reported the existing number of fellowships to be adequate for the needs of their qualified students was a little over half. The overall return indicated that about one-third of the undergraduates were qualified for graduate training and that, of these, about 50 percent actually went on to graduate school. These figures would seem to indicate that an increase in the number of fellowships would probably induce a fairly substantial number of additional students to undertake graduate study.

Recommendations

The least measurable, but perhaps most illuminating, responses to the questionnaire were the recommendations for steps the federal government might take to increase the number of advanced degree holders in the EMP fields. A breakdown of these replies is difficult to achieve, since the responses were in essay form, but the most frequent recommendations dealt with, (i) improving secondary education; (ii) enlarging stipends to encourage married students to pursue graduate training, and (iii) improving undergraduate instruction, especially at the smaller institutions.

For example, George N. Garrison, chairman of the mathematics department at the City College of New York, wrote: "Any steps which would decrease the number of bright high school students who do not get to college with reasonably good mathematics and science programs would, I think, increase the number of good graduates in four years' time. One problem connected with the production of scientists, engineers and mathematicians is the lack of secondary teachers in these areas."

A similar view was expressed by Hulen B. Williams, head of the chemistry department at Louisiana State University: "Give more emphasis to quality and level of science and math education in junior and senior high schools." And by Harold Walba, chairman of the chemistry department at San Diego State College, who said, "Start with the first grade and work up."

Emphasis on the high school level was also recommended by Robert I. Walter, chairman of the chemistry department of Haverford College: "Most students have already decided upon their area of study by the time they arrive in college. Nearly all qualified college graduates go on to graduate school. The loss occurs at the high school level. It seems to me," he continued, "that the problem of reducing loss of good people is not a purely academic one. It involves disinterest, cultural alienation, and lack of motivation in the high schools, and particularly in the big city high schools. Most graduates of the suburban 'quality' high schools now go on to college, and from there to graduate school. Our losses occur at the lower levels, where bright students never acquire an interest in intellectual problems."

Although federally financed graduate fellowships vary in amount, the most generous tend to be around half the $6000 or $7000 a year starting salaries that many undergraduate degree holders in engineering and the sciences find waiting for them fresh out of school. Directing their attention to this, a number of the respondents stated that the *size* of stipends is probably as important as the number if qualified married students are to be encouraged to continue their studies. This view was especially prevalent in engineering, which, among the EMP disciplines, has the least tradition of graduate training and the best vocational opportunities for the undergraduate degree holder.

A. H. Zerban, dean of engineering at the University of Hartford, commented that "many of our best graduates are married and cannot go on to graduate study for financial reasons." Family allowances, he suggested, might be one way to induce them to continue their studies. Concern about the financial plight of the married student was also expressed by F. M. Filler, dean of engineering at the University of Houston, who said that financial pressures on married students create "our largest loss."

The financial and status problems of the smaller institutions appear to be very much on the minds of people at

such places, and in fairly large numbers they expressed the view that federal policies guarantee that the rich get richer. H. B. Blodgett, dean of engineering at the University of Nevada, stated, "Good or bad, graduate students are being bought today and the better prospects are going to the highest bidders. If the government is to provide more assistantships, more attention should be given to the smaller schools desiring to improve their graduate capabilities. The 'name' places seem 'fat' enough."

A similar view was expressed by a Midwest mathematics department chairman who chose not to be quoted by name: "Most or many of the NSF fellows go to the 'big' name schools, so schools such as ——— never see such students."

Many who offered complaints along these lines recommended that fellowships be awarded directly by the universities, rather than by the federal agencies where they originate. The trend, incidentally, is actually in this direction, since federal agencies are now responding to the smaller schools' complaints that fellowship recipients who can choose their school are flocking to the prestige institutions and ignoring worthy but less known places. The space agency, for example, is distributing 880 fellowships this year, all of which will be tied to particular institutions, many of them on the small and less-well-known side.

Other representative statements were as follows.

H. C. Thomas, chairman of the physics department, Texas Technological College: "about the only ones we have who should go on [to graduate training] and do not . . . [are those] . . . who want to make some money or have financial obligations they cannot meet if they go to graduate school. I think it is unlikely that a graduate fellowship can or should provide a stipend comparable to what the B.S. could make if he went to work. I, therefore, am forced to believe that the place at which financial help would produce the greatest results would be at the undergraduate level. This would entail the provision for more and better teachers and for more financial assistance to the undergraduates."

G. M. Almy, associate head, department of physics, University of Illinois: "it is my impression . . . that when the cream of the entering group [at Illinois] has been awarded fellowships, the group accepting teaching assistantships is of somewhat lower quality in undergraduate academic performance and in their graduate work than the teaching assistants of six or eight years ago. . . . I think it is safe to say that we are not getting graduate students of the Ph.D. caliber in proportion to the greatly increased number of applicants."

J. B. Hart, chairman of the physics department at Xavier University: "The fellowship program should be extended to universities which offer only a master's program. More assistance should be given to those *undergraduate* departments which wish to improve the quality of their product. Why increase production at the graduate level when the raw material is not what it should be?"

Lamar Field, chairman of the chemistry department, Vanderbilt University: "Permit more teaching by NDEA, NSF, NASA, etc. fellows. These are now *discouraged* [from teaching] and represent those most able to reach and inspire undergraduates. Moreover, many of these present fellowships make it difficult for the smaller schools to compete for excellent graduate assistants."

P. Kusch, chairman of the physics department, Columbia University: "The current emphasis on encouraging students to undertake careers in science, of which the increased availability of fellowships is a symptom, has brought to graduate school an increased number of students neither temperamentally nor intellectually equipped for graduate study in science.

"It is my opinion that the college graduates with the greatest promise of productive careers in science had highly superior secondary school training. Corollary: Select high schools for boys and girls of exceptional promise. Offer strong inducements to people of ability to make a career of teaching in such institutions. Attempt to improve science teaching in liberal arts colleges. I think that potential talent is not discovered, encouraged and adequately trained in large numbers of independent liberal arts colleges."

Finally there was one questionnaire that went astray and ended up in the physical education department of a large southwestern university. The chairman replied that fellowships in his field were "definitely not" in adequate supply, and offered the view that "physical education should be included in the federal scholarship program."—D. S. GREENBERG

R&D: Ill-Starred Nuclear Plane Project Is Subject of Hard Look by General Accounting Office

A post mortem on the nuclear-powered aircraft program, which was canceled by Presidential order in 1961 after 15 years and $1 billion had gone into the work, has opportunely appeared at a time when the TFX affair has centered public attention on federal procurement policies and management of research.

The review of the so-called ANP (Aircraft Nuclear Propulsion) project was carried out by the General Accounting Office, the auditing arm of the legislative branch, which was created by Congress to keep tabs on how the money the legislators appropriate is spent. Although much of the material in the GAO's review of the Joint Atomic Energy Commission–Department of Defense project has appeared before in Congressional hearings and committee reports, the new study, with its detailed chronology and allocation of blame in unemotional auditor's terms, makes a useful primer of how not to conduct an R&D project. (A copy of the report, *Review of the Manned Aircraft Nuclear Propulsion Program*, can be obtained for $1 from the Accounting and Auditing Library, General Accounting Office, 441 G St., N.W., Washington 25.)

The GAO review says that the ANP project suffered severely over the years from changes in emphasis and direction in the program. Sternest criticism, perhaps, is directed at the Department of Defense and the Air Force for failing to furnish "sufficient and timely guidance to those responsible for carrying out the ANP program." The record shows, for example, that an AEC request in 1948 to DOD for its views on the military worth of a nuclear-powered plane did not receive a reply until 1951, and then only under pressure.

The report goes on to relate how facilities costing more than $17 million were built but not used, or little used, and how expensive design and related work was wasted. The GAO says also that cost data obtained from prime contractors was unsatisfactory and that unallowable costs were charged to contracts.

The veering course which the project took and its failure to pay off in a prototype plane or engine brought it under constant scrutiny from Congress and the Executive, and it was sub-