as an introduction to the professional study of biology. It is perfectly possible to teach a respectable introductory course so that no future engineer who takes it will thereafter be blind to the broad biological consequences of his professional work. But until such a reform in emphasis and arrangement comes from our side of the fence we are in a poor position to urge that the fence be let down.

At a higher level of instruction, it will be a great contribution if we can overhaul our courses in ecology, building them squarely into the structure of the other natural sciences. The possibility of this was suggested long ago by Henderson in his *Fitness of the environment*. It has been carried beyond the point of suggestion by both Jenny and Nikiforoff in their studies of soil energetics and has been considered by Transeau in relation to vegetation. Unquestionably, much more research is needed on such problems as the energy patterns of plant communities and drainage systems. But the basic means exist for organizing what we know so that it will carry its influence down to the elementary level in biology. Once this is done, that influence may extend across boundaries of knowledge to command the professional respect and serve the needs of that magnificently disciplined group of our colleagues, the engineers.

Meanwhile there is the possibility that those who train engineers may take some initiative in the matter. It is encouraging to note that The Ohio State University, along with several other institutions, is inaugurating an optional five-year engineering course in the hope that it will result in broader training. I do not envy the dean who attempts seriously to liberalize the present tight curricula. It will take courage to follow the course of reform in medical schools; it will take even more to avoid the pitfalls which have at times defeated the intent of premedical liberal education. I predict, however, that the first good engineering school to grapple boldly with the problem will acquire such prestige that other institutions will hasten to follow its example. It is generally true that the schools with the highest standards have the longest and best waiting list.

Shift of Employment Among Younger Scientists

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SCIENTIFIC PERSONNEL HAS PROBABLY never experienced the situation now existing with respect to demand. The unprecedented enrollment in institutions of higher education and the great expansion in scientific work generally have resulted in extraordinary recruitment efforts by employers. Evidence of unusual shifting of employment by scientists has been apparent. In particular, the less fortunately situated higher educational institutions have complained of the difficulty of recruiting and maintaining faculties in the sciences. The implications of rapid shifting are clear enough to require no elaboration. The smaller institutions do train a very large proportion of the higher-education population. Should much shifting occur, it would seem likely that properly qualified instructors would become unavailable for a significantly large part of the students in colleges and universities.

To secure some measure of this trend, the Office of Scientific Personnel of the National Research Council has polled a sample of those receiving doctoral degrees in the sciences in the years 1936–45, inclusive. The survey was confined to 13 disciplines in which the maximum competition for personnel among educational institutions was expected. About 10 per cent of the total number was selected as a sample, with slightly higher numbers in some disciplines. The survey was confined to the years stated, since the future of the sciences lies largely in the hands of the younger men. This does not mean that older scientists are not shifting. But especial importance seems to attach to the distribution of those who must be the leaders of science in the near future. Although replies are arriving daily, the present study includes only approximately the first two-thirds to reply. A rough check of perhaps 200 later replies does not alter the results significantly.

One interesting fact is that almost 10 per cent of the questionnaires were returned without forwarding addresses. Since the original addresses were in practically all cases relatively recent, the implication is that most of these individuals had shifted employment. Thus, figures on shifts in employment given below must be corrected upwards by a figure of 9 per cent or less, depending on the interpretation of the lack of proper address.

Table 1 shows the shifting occurring within the past 12 months among the first 975 scientists replying to the questionnaire. It will be seen that 248, or 25.4 per cent, have actually changed employment. The greatest shifting is within education. Here, 92, or about 10 per cent, of the younger scientists have changed jobs. Most of these have found more favorable employment in some other educational institution, although 26 have left the field of education. The Government has lost about 80 scientists, most of these going, presumably, to the universities and colleges. Much of this probably occurred

early in the year, when wartime researches were terminating.

The survey also elicited information on firm commitments to shift employment. Although Table 1 shows that 248 younger scientists have changed employment, there are, in addition, 135 younger scientists who have positive commitments to change, either by accepting new positions or by signing contracts. There are significant differences in the nature of these expected shifts. The shifts from the Federal Government are proportionately much less, accounting for only 20 per cent of the shifts, whereas the shifts from the Federal Government in Table 1 account for 36 per cent. In education, however, the shifting is heavy. Almost 60 per cent of the expected shifts occur either from educational institution to educational institution or out of education to industry and the Government. Shifts from one educational institution to another account for 66 out of 92 of these shifts.

Thus, 383 shifts in employment among 975 younger scientists have occurred recently or will take place shortly. (A scientist shifting twice in this period is counted but once.) This is over 39 per cent. Adding to this a conservative 5 per cent from those whose addresses are unknown, it is safe to say that nearly 45 per cent of the scientists in this age group have changed or will change employment in an 18-month period beginning about a year ago, if our sample is a valid indication. There seems little reason to doubt its fairness.

The question was asked as to whether the respondent was now contemplating or seeking a change. About 20 per cent of those not covered above replied in the affirmative, and the proposed nature of the change was indicated in a few cases. If these changes eventuate, the total changes will approach the two-thirds mark. However, the likelihood of changes in all these cases is not determinable.

The total picture, however, is certainly indicative of an abnormal condition which has serious implications. This information has been furnished to the President's Scientific Research Board, which will discuss the phenomenon together with other information in the report on scientific personnel.

Table 2 is a tabulation of the returns to give an indication of the employment of these younger scientists. It should be noted in particular that industry and the Federal Government employ almost half of this group. The decreasing incidence of scientists in the military services is interesting.

Table 3 shows the activity of the younger scientists. Particularly noteworthy is the fact that while Table 2 shows that education employs more than the Federal Government and industry together, Table 3 indicates

TABLE 1

PRESENT-DAY SHIFTING OF SCIENTISTS AWARDED PH.D. DEGREES DURING THE DECADE 1936–45, INCLUSIVE

Changed within the last year:	Agriculture	Bacteriology & microbiology	Biochemistry	Botany	Chemistry	Engineering	Entomology	Geology	Mathematics	Physics	Physiology	Psychology	Zoology	Totals	Per cent
From Federal Gov't to Education	3	2	2	4	8	3	2	4	5	5	6	7	1	52	5.3
" " " " Industry	2	2	2	1	2	1	1	0	3	1	1	0	1	17	1.7
" " " " State Gov't	0	0	1	0	0	0	1	0	0	1	0	1	1	5	.5
" " " " Federal Gov't	0	1	2	1	0	0	0	0	0	2	0	4	1	11	1.1
" " " " School or Military	0	1	0	0	0	0	1	0	0	0	0	0	2	4	.4
From State Gov't to Education	0	0	0	1	0	0	1	0	0	0	0	0	0	2	.2
" " " " Industry	0	0	0	0	0	0	0	0	0	0	0	1	0	1	.1
" " " " State Gov't	0	0	0	0	0	0	0	0	0	0	0	1	0	1	.1
" " " " Federal Gov't	1	0	0	0	0	0	0	0	0	0	0	0	1	2	.2
" " " " School	0	0	0	0	0	0	0	0	1	0	0	0	0	1	.1
From Industry to Education	0	0	2	1	2	2	0	3	3	5	1	3	0	22	2.2
" " " Industry	1	2	2	1	7	4	1	4	0	4	1	2	0	29	2.9
" " " State Gov't	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
" " " Federal Gov't	0	1	2	0	1	0	0	0	1	3	0	0	0	8	.8
" " " School or Military	0	0	0	0	0	0	0	0	0	1	0	0	0	1	.1
From Education to Education	3	2	8	6	4	2	5	2	9	6	5	6	8	66	6.8
" " " Industry	0	2	2	0	2	3	1	0	0	0	2	1	1	14	1.4
" " " State Gov't	0	0	0	0	0	0	1	0	0	0	0	0	0	1	.1
" " " Federal Gov't	1	2	1	0	1	1	0	0	1	0	0	3	0	10	1.0
" " " School	0	0	1	0	0	0	0	0	0	0	0	0	0	1	.1
Totals	11	15	25	15	27	16	14	13	23	28	16	29	16	248	25.4

Total number of questionnaires sent: 1,600; total number of replies received: 975; questionnaires returned—forwarding addresses unknown: 91; unemployed: 17; per cent known to have changed within last year: 25.4.

that many more scientists list research, rather than teaching, as their activity. The totals in this column are not exclusive, but there seems reason to believe that a significant number listed as employed by educational institutions are actually spending full time on subsidized research. It seems probable that some of the recent shifting is toward contract research.

TABLE 2

DISTRIBUTION OF EMPLOYMENT OF SCIENTISTS EARNING PH.D. DEGREES DURING THE DECADE 1936–45, INCLUSIVE

Employment	Full and part-time employment*					
	Federal Gov't	State Gov't	Industry	Education	Military†	Unemployed‡
May 1, 1946	137	52	305	472	36	13
%	13.5	5.1	30.0	46.5	3.6	1.3
May 1, 1947	114	52	309	520	3	17
%	11.2	5.1	30.4	51.2	.3	1.6
Near future§	105	43	326	526	4	17
%	10.3	4.2	32.0	51.5	.4	1.7
Future‖	104	43	323	532	4	17
%	10.2	4.1	31.6	52.0	.4	1.7

* About 40 individuals are working in more than one category.

† Military men not counted in Federal Government column.

‡ Returned to school: 13; women who have married: 4.

§ Assuming present commitments are fulfilled and "definite offers likely to result in change of employment" are accepted.

‖ Assuming changes are made for which desire is expressed.

In a report to the President, "A Program for National Security," by the Advisory Commission on Universal Military Training, figures are given for expenditures in 1947 for research as differentiated from development (p. 179). The figure in the Government, in universities, and in industry is about $335,000,000. This is probably about five times the rate of expenditure in 1937, since this is the ratio of expenditure for research and development in 1947 and in 1932. The resulting personnel demand accounts for the present unprecedented situation in employment. It seems obvious that careful thought is needed to insure that the stresses resulting from this situation do not militate against the soundness of scientific development.

TABLE 3

TYPES OF WORK BEING DONE BY PH.D. SCIENTISTS

	Agriculture	Bacteriology & microbiology	Biochemistry	Botany	Chemistry	Engineering	Entomology	Geology	Mathematics	Physics	Physiology	Psychology	Zoology	Totals	Per cent
Part or full-time teaching	27	17	26	35	36	39	26	21	53	45	32	42	60	459	38.0
Part or full-time research	46	40	52	25	109	48	38	26	18	81	29	31	31	574	45.7
Part or full-time administration	14	14	12	4	30	30	9	20	8	13	9	14	7	184	14.6
Unemployed*	1	1	2	0	2	0	3	1	2	1	1	1	2	17	1.4
Military	0	1	0	0	0	0	0	0	0	1	1	0	0	3	0.3

* Returned to school: 13; women who have married: 4.