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The Little Researcher

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IT HAS BEEN RIGHTLY SAID that war does not favor the discovery of new principles in science, although, superficially, we seem to make progress through the exigencies of war at greatly accelerated speed. But science in wartime is largely technology. Gadgets are refined to almost unbelievable delicacy.

Many people do not seem to understand this basic fact. The Bush Committee's slogan, "Back to Basic Research," was emphasized for physics and chemistry, but did not extend to biology; for the report did not recognize that medicine and agriculture are applied or "technological" sciences. The men who wrote the report failed to grasp the fact that medicine and agriculture would languish if basic biology dried up, just as engineering applications would cease to prosper if pure research in physics and chemistry were stifled. In the compromise Kilgore-Magnuson Bill (S. 1850), we as biologists are glad to note that the biological sciences are recognized—at least on paper—on a par with the physical sciences.

When we view our national pre-eminence in the fields of applied science, *i.e.* in technology and "Yankee inventiveness," we should not forget that until recently we have been borrowers from Europe, and particularly from Germany, of the basic principles upon which our most cherished gadgets, the automobile, the airplane, and the radio, depend. With a large part of Europe suffering a severe setback in research, we must take over; otherwise, applied research, which provides better and more useful things—and also jobs—will gradually dry up.

Our Government is wise, therefore, in taking steps to stimulate both pure and applied research. America must organize its scientific talent into as effective a machine as possible. Congress is struggling with this problem. Many are concerned, however, lest the "control" of research be centered in an irresponsible governing board which will administer the law in a spirit of authoritarianism. Without freedom of thought, initiative and originality will be stifled. No group of men is endowed with omniscience, or the clairvoyant gift of knowing in which direction science will sometime advance; indeed, while scientists may plan an attack on a problem through a series of experiments and observations, the results may lead them into unexpected and unforeseen highways. Even the wise manager of industrial research will give a maximum of freedom consistent with the objectives of a given laboratory, which are necessarily more of a short-range order. But there should be no difference in the basic training for either pure or applied research; for if one accepts a place on a team, it is his duty to help carry the ball to the common goal.

The chief function of the Federal Research Board—the "National Science Foundation" of the new Kilgore-Magnuson Bill—will be the placing of financial support where the prospect of returns seems most certain. This is a great responsibility; How it will be met is the concern of all the people. I have a very modest suggestion involving only 1 or 2 per cent of the hundred million dollars recommended for the annual budget of the Foundation. It is my recommendation that 1 or, at most, 2 per cent be apportioned to the Little Researchers, of whom there are thousands, chiefly instructors of science in the small colleges. Just as it is agreed that the Little Business Man is a powerful factor in our economic life, I hold that the Little Researcher constitutes a not inconsiderable factor in the development of scientific research in the United States, as elsewhere. I speak chiefly from the viewpoint of the biologist, but am of the opinion that what I say is also true of the physical sciences and the social sciences.

Colleges and universities are the training schools of researchers and are the source of the available research personnel. They are the home of research and, although much research has been transplanted to industry and to endowed research institutes, these must always look to the universities for their trained investigators and their research directors.

It is hard to realize how recent these developments

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are! As Dr. Harlow Shapley said in his testimony at the U. S. Senate hearings on the Kilgore Bill: "It's been only a few years that we were in a position to say to our scientists, 'At least half of your time and responsibility are to be devoted to original investigation in your field of science.'" The Johns Hopkins University, founded in the 1880's, was the first university in the United States to be organized on the German plan, which provided for teaching and research as dual functions of all of the members of the faculties.

The transfer of research to large industrial corporations is a still more recent development, for at the beginning of this century there were exactly three "industrial" scientists; this clan now numbers 70,000.

The universities which took the lead in providing opportunities for research and teaching were at first the richest and strongest. Today the number of colleges and universities runs into the thousands. Dr. R. Walters, in *School and Society,* 6 December 1939, lists about 100 "large" and 400 small universities and colleges. These are the "upper 500" in the college field. In the first group of Walters' classification 700,000 students are taught by 50,000 teachers. In the 400 smaller four-year Colleges of Liberal Arts and Sciences listed by Walters, 240,000 students are taught by 22,000 teachers. These professors, together with 8,500 teachers in technological schools and 5,000 in teachers' colleges, constitute quite an array—over 75,000—of potentially qualified researchers.

In addition to the schools mentioned, there are a thousand weaker institutions of "higher learning" which serve as best they can in the neighborhood of another 25,000 young people.

What is the status of research in these colleges? Certainly the larger universities—Walters' first 100, let us say—possessing the pick of the personnel and almost limitless equipment, will, except for isolated cases, lead in research output. An examination of abstracts of papers published in the *Proceedings of the American Society of Zoologists* shows that teachers in the larger universities write most of these. The same holds for the American Botanical Society. This may be due in part to the fact that the small-college teacher does not attend national meetings.

In proceedings of state and local academies of science the small-college teacher makes a somewhat better showing. About one-third of the articles come from the many small colleges and high schools of the state, while the three large universities, Chicago, Illinois, and Northwestern, contribute 42.7 per cent, and professional schools, 10 per cent.

If research has been an essential and axiomatic function of large universities for less than a century and of industry for half that period, why not interpret this movement as a trend that will presently extend to the smaller colleges, which we are now prone to think of merely as teaching institutions?

A prime hindrance to research is the heavy teaching schedule usually imposed upon the teacher in the small college. In some instances only a superman could carry the load and, in addition, even think of research problems. Paradoxically, it is these selfsame institutions that pride themselves on their pedagogics, claiming superiority over big universities because of "personal attention" to the student. Personally I would rather send my son or daughter to a university where a class of 500 is divided for laboratory and quiz purposes into sections of 20 to 24 students conducted by enthusiastic instructors who know their subject thoroughly—a condition which a live department seeks to maintain—than to a small institution where the overworked instructor has to hop with superficial preparation from one subject to another all day long and sometimes at night. Such a condition is, of course, an extreme but all too common one.

SOURCES OF ILLINOIS STATE ACADEMY CONTRIBUTIONS* 1935–1944

Year	Small colleges and high schools	Large universities	State surveys, museums, and gov't bureaus	Professional or nonacademic	Total
1944	4	11	3	4	22
1943	16	17	11	6	50
1942	33	43	9	4	89
1941	27	52	5	9	93
1940	28	41	11	4	84
1939	23	42	15	11	91
1938	21	30	12	8	71
1937	48	29	11	7	95
1936	25	25	18	12	80
1935	29	40	19	9	97
	254	330	114	74	772

* Acknowledgment is made to Miss Dorothy Rose, editor for the Illinois State Academy of Science, for this tabulation.

Often the inability of the biology professor to distinguish genuine learning from superficiality is shown in the way the teacher stuffs his catalogue with courses. I have before me the catalogue of a college of 200 students whose Biology Department is manned by one man who presides over 33 courses, 6 of which are given at night! I know of a teacher who had a vacant period which he used to work with his small rat colony. When the president found this out, he assigned him a class at his "vacant" period, while the teachers who loafed or rested in their vacant periods continued to loaf or rest.

Such conditions are usually the fault of the college

president. "Let the big centers of learning attend to the research," he is apt to say; "we have the world's teaching on our shoulders."

That this attitude is inimical to the best interests of his college I shall attempt to prove by showing that research makes for (1) perpetual youthful enthusiasm on the part of the college teacher for his subject and its dissemination, which enthusiasm is (2) "catching" to the student and (3) worth while in itself.

The first two arguments for research on the part of the college teacher are closely related, for the saying, "As teacher, so pupil," is as true today as it was yesterday. The argument that a person is a good teacher because he takes no interest in research is most inane, although it is likewise foolish to claim that a successful researcher is always a good teacher. An astoundingly large proportion of graduate students come from certain small colleges through the personal influence of certain professors. Such professors may not always publish extensively, but they, with their students, are continuously reconnoitering along the frontiers of learning.

The extent to which the small college contributes students to the graduate schools of the larger universities is indicated in these figures: Among the 12,000 college graduates who took the Graduate Record Examination the first five years (these were given in the years 1937–1942) 500 colleges were represented. It would be interesting to analyze these data. It is high time that the contribution of the small college in awakening our future science personnel be more fully recognized.

In his clever but, through overstatement, misleading book, *Teachers in America,* Jacques Barzun contends (p. 202) that, where there is emphasis on research, "parents and students must be reconciled to indifferent teaching as the rule, and men choosing the academic career must either give up hope of advancement or be master-jugglers in their early years, at the cost of other good things of life—health, friendship, and contemplation."

But let us be reasonable. Everything may be abused, and in places there may be undue emphasis on research. Cases of neglect of students by the Big Researcher are well known to all of us. Nevertheless, I do hold, and have seen it happen, that "the man who ceases studying at 25 is a dried-out and dull teacher 10 years later." It is unfortunate that just such driftwood all too often gravitates to elementary instruction, to the great detriment of the student as well as the subject. On the other hand, one of my friends, a very productive researcher, who recently left a research institute to join a small college, writes me that he is happy to be back at teaching and especially happy that at the end of his first year a half dozen students upset tradition by doing research with him. The new idea is the talk of the campus.

Research may also be used in elementary courses, as, for example, in the project method described in the October 1926 *Anatomical Record* by Dr. Madeleine Grant, of Sarah Lawrence College, or the "optional experiment" which my colleagues, Steggerda and Gray, described in the February 1940 *Journal of Higher Education* and which they have used with considerable success in an elementary, five-semester-hour course in mammalian physiology.

The intellectual awakening which the college student experiences in the favorable environment has great social value. It devolves on the small colleges, partly because of their number and strategic position of nearness to the people, to help recruit scientists. Because of the war there is a deficit of 150,000 students of science and technology who would have received the Bachelor's degree. It has been estimated by the Bush committee that by 1955 the deficit of those holding advanced degrees will be about 17,000. One of the objectives President Roosevelt had in mind in instructing the Bush committee to study the science situation in America concerned the discovery of scientific talent. He used the following language: "Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?" With one accord we all say: "Of course it can."

When I was in Russia in 1935, attending the International Physiological Congress, I found the enthusiasm among the young scientists perfectly electric. We can do the same, for we have a good start.

I fully realize that research has some of the attributes of the creative and requires what has been called the scientific imagination. The urge must come from within. Perhaps there are industrious teachers of science wholly lacking in this who yet can hardly be said to have missed their calling. I cannot help believing, however, that anyone reading "critically and voluminously" (presumably as a substitute for research?), as Barzun suggests, wil sooner or later become aware of the fragmentary nature of his knowledge and experience a curiosity about methods of finding out things he does not know.

We do not expect to find geniuses everywhere in science departments of either the large universities or the small colleges. Very rarely architects of the framework of science, like Faraday or Pasteur or Darwin, appear either in a large or a small university. But there would be no architects if the day laborers of sci-

ence were not adding stone on stone and sand-grain on sand-grain to the building. For no generalization was ever grasped out of thin air, but was based on the multitude of facts laboriously collected and recorded in print by the "hod carriers" of science.

Even a small study may have, to the researcher, broader implications than appear on the surface. I recall my first publication. My chief, the late Dr. T. H. Montgomery, was writing a monograph on a genus of spiders and had to find out if the number of teeth on the claws of spiders was a reliable specific character. The result was my paper on "Variability of the number of teeth on the claws of adult spiders"—on the surface, about as unimaginative a piece of work as possible. Yet it put me in touch with the universal principle of variation, the raw material of evolution; I learned something of taxonomy; and I got interested in spiders—all this by working concretely on a small problem. Certainly nobody reading the paper would derive any inspiration therefrom; but it did settle one small point for Dr. Montgomery, and that infinitesimal part of the world's work was done. We should not criticize any piece of research because it is small but only because it is not well done, if that is the case.

I hope I have made out a case for the Little Researchers—the science teachers in the small colleges constitute an army of actual and potential researchers. In this I seem to have the support of the Bush committee, which says, speaking of the small-college, "non-research institutions":

> In developing a program of postwar federal aid to scientific research, attention should be given to the potentialities of these schools. To the extent that one sample is representative, at least 40 per cent of the small liberal arts colleges in this country are desirous of conducting research, and are prevented from doing so by lack of funds.

I therefore ask for the Little Researcher a small part of the sum about to be appropriated by Congress for the stimulation of research. I would ask for only 1 per cent of the annual appropriation contemplated in the Bush report. One per cent sounds like a modest proportion, but it is in fact a huge sum compared with past and present sums available. In this connection I am reminded of the fund which the Illinois Academy of Science has had to dispense for research, a sum which by common consent went annually to men in the smaller colleges. In 1943, when I served as chairman of the committee, we had the munificent sum of $213.37 to dispense! This was divided among three men and was much appreciated far beyond the amount of money involved.

By way of contrast, research now runs into big money. The troublesome 200-inch reflector for the Mt. Palomar Observatory will cost considerably over $1,000,000; Dr. Lawrence's cyclotron at the University of California has cost about the same; the Illinois legislature has appropriated out of state funds the sum of $1,700,000 for the University's "betatron," the electron accelerator; the expenditures of the Yerkes Laboratories of Primate Biology, devoted to researches on the chimpanzee, are approaching the $750,000 mark. It is apparent to anyone who looks into the matter that the bulk of moneys must be concentrated for big things in the big laboratories. Broadly conceived, long-time programs are no longer one-man jobs, but require teams and cooperation, in attacks even upon single problems, of scientists possessing information in a variety of fields. Basic biological researches require more and more the collaboration of the physicist and the chemist with the biologist. Many researches now require expensive equipment beyond the imagination of scientists of 50 years ago.

I therefore agree heartily that the bulk of public funds for research must go to the large centers. At the same time I do contend that a small part of the new financial aid should trickle down to the Little Researchers scattered widely over the country. I predict that the results of aid to these one-man organizations will amply justify the outlay.

Scanning Science—

The professor of mineralogy in Harvard University one day observed two young women examining his mineral cabinet, one of whom was evidently searching for some particular species. Offering his help, he found that the object of her quest was feldspar. When shown the mineral she seemed very much interested in the specimens, expressing herself as gratified at having the chance to see and touch them. The professor asked her why she so desired to see the particular mineral. The answer was that for some years she had been obliged to teach in a neighboring high school, among other things, mineralogy and geology, and that the word feldspar occurred so often in the text-book that her curiosity had become aroused as to its appearance.

—24 April 1896