

PRESIDENTIAL ADDRESS

SCIENTISTS—MORE OR LESS?

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The year 1952 will be known as the year of the big wind. That was the prophecy of a radio wit last January first. He referred, of course, to the political campaign that is already engulfing us. Therefore, it may be appropriate to borrow the quadrennial theme, "to view with alarm but point with pride," to consider a problem that we have as members of this Academy of Science in this year 1952.

A year ago, at the morning session of the Academy in Bloomington, Dr. Bevan presented an interesting survey of the history and programs of

state academies of science. He listed ten types of objectives guiding the various academies, and this Academy conforms very well with the others. One of our three major objectives is "the diffusion of scientific knowledge and scientific spirit," and as one of the activities to attain that objective, the sponsorship and guidance of the Junior Academy of Science. After a number of years of work in this Academy, I have come to the conclusion that this sponsorship in itself justifies the existence of our Senior Academy.

The members of our Junior Academy, and such as they, are the future hope of this Academy and of this country and even, possibly, of the world. They are the ones with the most apparent vigor and enthusiasm for science. They, and their leaders, are the ones who really put an enormous amount of effort into this 45th annual meeting. Right now several hundred potential scientists are raising a hubbub of scurrying effort and shrill voices in final exertions to present their year's project to the best advantage.

This year for the first time, there were seven regional Junior Academy contests, and only "First Prize" winners were eligible to come to this state meet. Long hours of effort and thought have gone into their projects, and we hope that many of them will retain their enthusiasm and thrill of attainment for years to come. This year, also for the first time, our Council has decided to reduce the time allotted to this morning session to provide in the program a definite period for the Senior Academy to see some of the results of our Junior Academy work. So I "point with pride" to one of our State Academy's greatest achievements—the promotion of a vigorous Junior Academy that has touched thousands of high school students this year. We salute them and particularly their leaders. The director of our Junior Academy, Mr. Robert Smith who worked in Herrin last year and in DeKalb now, has done a magnificent job of organization and activation. Our Council has devoted nearly one-third of its time to the problems and program of the Junior Academy, but I believe it is worth it.

But having pointed with pride, I must now "view with alarm" a seemingly anomalous condition. I refer to the decreasing number of students who are choosing science majors in college and the resulting scarcity of graduating scientists, engineers, research workers, and those entering related professional fields.

A cursory survey of the condition might lead to the conclusion that since college and university enrollments are decreasing there is a corresponding decrease in science students. But the decrease is much more than that; proportionally as well, there is a sharp decrease. If we could omit the abnormally low college enrollments during the war and the two or three years of high enrollments after the war, I believe evidence would show an alarming trend through the past fifteen years in our source of supply of science personnel.

National survey groups recently noted this problem. Industrial leaders are becoming concerned, particularly with the shortage of engineers. Several large corporations have spent thousands of dollars in advertising and in radio time to publicize this problem. Last September's *Fortune Magazine* reviewed the critical needs in this area and the same month's issue of the *Scientific American* was "solely devoted to an assessment of our human resources." Their data show that the students enrolled at present in engineering schools have so decreased in numbers that it is now predicted that in 1954 only 15,000 will be graduated, to meet an anticipated demand for 30,000. On the same

basis, present enrollments indicate 29,000 science graduates in 1954, compared to 75,000 in 1950. This is the most serious man-power shortage that America faces today. For out of the science graduates must come our future teachers and researchers who alone can produce the backlog of basic scientific knowledge upon which our future progress, and possibly even survival, will depend. The cause of these conditions, and particularly of the indicated trend, needs examination. I should like to attempt that and also indicate some remedies.

Scientists, like all other groups, are the product of heredity and environment. Since nothing can be done about the heredity contribution, environment seems to be the field to study, particularly if we consider education as a segment of environment.

Three periods in the life of the current younger generation seem worthy of examination—pre-college, college, and post-college—as contributing to the declining supply of scientists.

Free public education (not counting taxes, of course) is a laudable feature of our democracy. The percentage of our people who have completed high school is constantly increasing and the illiteracy ratio is decreasing. Compared with 25 years ago, our citizens on the average are much better educated—at least to the level where they can now understand movies, and radio and television programs. That is desirable; at least it creates a market.

But the constantly increasing population in the public schools has resulted in large classes, inadequate

equipment, and not enough actual space. These conditions are coupled with an overworked teaching staff that is underpaid by any standard of qualification, compared to even semi-skilled labor.

Unfortunately, in attaining the aim of universal education, the philosophy of primary and secondary education has undergone a marked change. To achieve a higher general level of literacy, teachers often must be satisfied with a lower level of achievement. That is a serious indictment. Nevertheless, public education today is geared to the masses. The major attention is on quantity rather than quality.

A short conversation with the better teacher will soon show that this change in standards in the last quarter of a century has not been a "grass-roots" change; rather it has been imposed from above. The responsibility rests at a higher level. It comes back to the college campus to education departments, and most specifically to certain leading professional educationists. By persistent publication of their ideas and by persistent pressure on state legislatures, state departments of education, and county and city school administrators, extensive changes have been made in recent years in methods, in objectives, in curricula, and in legal requirements for our public schools. To this fraternity of educationists, change, *ipso facto*, is improvement. They feel compelled to revise their professional vocabulary every five years. An old expression is as abhorrent as milady's last year's hat. In most of these revisions they merely reverse the biblical exhortation by putting old

wine in new bottles—with a new label of course.

While these educationists have been promoting their views, college and university leaders in the old-line subject matter fields have been too engrossed in their particular areas to bother with the lower levels of education. They have neglected to insist on adequate presentation of their lines of subject matter in the lower school curricula. They assumed recognition of the need for adequate training in grammar, spelling, arithmetic, literature, and the sciences. Consequently, in the face of constant one-way pressure without counter pressures, there has been a shift in emphasis. Naturally the educationist with little training in the sciences has promoted his greatest interest. Without counterbalancing pressure, the educationist's strong points and interests will be reflected in the curricula he advises, and his weaker interests will be slighted. Thus the rise of professional Education, and the lack of interest by the supporters of the sciences and humanities, has brought about profound changes. The public school teacher has found it best to concur with the demands of the higher-ups.

Accompanying this basic change in the philosophy of public education, conditions are such that in many high schools today all students must be passed. No stigma of failure must be attached to any academic inadequacy. In many modern schools final examinations are taboo. Discipline is used only in extreme cases to protect life, if not always property. Nothing must be done to warp an adolescent personality.

Students must be inspired to study, but not too much. No distasteful tasks should be assigned. Homework is frowned upon; so the student will have more time for social experiences. Students should be motivated to choose their own projects, which must be integrated into all fields of knowledge. The fact that three times as much time is necessary to accomplish some projects by this indirection must be disregarded. The primary objective is social adjustment for living in a democracy. The final product, if a student were in contact only with this system of preparation, would be a person unprepared for a practical world where one is judged by results and not effort alone, is held responsible for actions, and who would probably be fired from his first job for ignorance, indolence, and insubordination.

Dr. Fuller, who is coordinator of the Academy's Collegiate Section, has done a masterful job of pointing out the foibles and failures of the educationists in the January 1951, issue of *Scientific Monthly*.¹ If a chemical judgment could be applied to the response to this article, I should say that it produced a high heat of reaction.

At least two rebuttals of his article have been offered by educationists. One by Williams and Laurits² criticized his approach as unscientific. They suggested he should have used carefully collected data such as through a system of questionnaires, so beloved and revered by education leaders. Such a questionnaire, concerning the inadequacies of high

¹ Fuller, *Scientific Monthly*, vol. 72, pp. 32-41, 1951.

² Williams and Laurits, *Scientific Monthly*, vol. 72, pp. 282-288, 1951.

school graduates, sent to college teachers today would be about as necessary as one to support the opinion that there are fewer horse drawn vehicles now than thirty years ago. The other answer by Reeder³ attempted to analyze the cleavage between the educationist and the academician. He stated that "the former is primarily interested in the individual, the latter in subject matter," that the liberal arts teacher does not understand the teaching-learning process leading to "the neglect on his part of any real interest in developing in his students the power to think." If Dr. Reeder implies that the product of public schools today is trained to think under the new "teaching-learning process," he has a standing invitation to disillusionment by trying to get a college freshman chemistry class to understand and use simple principles of chemistry even with "societal" applications.

Both rebuttalists dwelt extensively on the new social objectives of public school education and pleaded for the recognition of the modern system as an experiment in learning, based on research in the learning process. They may have succeeded in disparaging Dr. Fuller's appreciation of modern educational philosophy, but they failed to explain the *necessity* of the conditions he deplures. If it be granted that the old school objectives did not include enough training for citizenship and that former teaching processes were wrong, correction of those wrongs does not necessitate the abandonment of training in the fundamental tools of

learning, such as a knowledge of simple mathematical processes and an ability to use the English language correctly and with some degree of efficiency. Also, many high schools in some way produce an atmosphere of mental slovenliness in which intelligence and thinking are frowned upon by the students.

One of the most serious indictments of American public education today is that, with so much attention to training for social adjustment by mass production methods, students are cut to the same pattern and level. Secondary education now tends to produce followers, not leaders. But democracy must also have leaders. It must encourage individuals with originality, independence and even eccentricities. Elementary and secondary schools are urged to use all kinds of tests and techniques to help the backward child, which is as it should be; but a corresponding program for the development of the brilliant student is usually lacking.

It seems reasonable that as much special attention should be given to those in the upper quartile as to the lowest 25 per cent in intelligence. In the larger schools at least, the better students could be recognized early in high school and given special courses in addition to the regular work, or as a substitute for some of the less challenging courses or activities. Such work in the basic academic fields would help future leaders to get much more out of college. Our school administrators recognize different levels of ability in physical activities and have special programs to develop the best for winning athletic teams. It is certainly just as important to recognize and give special

³ Reeder, Am. Assoc. Univ. Prof. Bull. 37, pp. 506-521.

attention to those with mental superiority. At least they should occasionally be challenged to the limit of their mentality, rather than confined to activities that produce mental laziness.

Last year a bulletin was produced in this state by the Illinois Secondary School Curriculum Program entitled "The Schools and National Security" and labeled further "Recommendations for Elementary and Secondary Schools." In many respects it is a very complete manual for the schools. But although its 296 pages contain numerous references to training for "followership," there are only two references to leadership, one a fleeting mention in the introduction and the other in the section on Science Education. All the current brand of "pedagogy" is there, such as "undergirding," "psychological climate," "societal strength," and "group interaction," but the superior student is ignored.

The point is this—science subjects are the most difficult in the curriculum; they attract the superior students. But if superiority is neglected and mediocrity is encouraged, from whence will come our future scientists? "If the salt have lost its savour, wherewith shall it be salted?" Science subjects in many high schools are going by default. One high school in southern Illinois had five sections of high school chemistry twelve years ago, last year it had one. The reason or excuse: chemistry is too hard, the students won't take it. In this era of encouraging students to make their own choice, even through the omniscient ages of six to sixteen, the easy road is chosen, the challenging and diffi-

cult one is by-passed.

One more observation—one of the latest developments in education (I hope it is not another fad) is *guidance*, and through it, the future of science might be saved. However, the guidance program in too many schools is in the hands of those who have little understanding of the methods, the demands, and even the contributions of science. Our schools need guidance personnel with an interest in science and its future—persons who will early find young students with the proper qualifications and will urge them to prepare for that field. As it now is, in most cases, the over-all approach and interpretation is social. The result is that potential scientists may be guided away from a field for which the guider has little sympathy. It is possible that some of these so-called guidance experts, along with social-minded directors, are accomplishing an objective that is held by some—that the progress of science should be stopped for a while to give the social forces a chance to catch up. If this be true, the future security of our country is at stake and guidance to the guidance program is indicated.

So again I point with pride to this year's program of the Junior Academy. It is active in spite of competing forces and its leaders should be commended. The young participants may be the valiant vestige of a vanishing race.

Let us now follow the progress of a young, potential scientist on a college or university campus. The average entering freshman, particularly in state-supported schools, has but little facility with simple mathe-

matical tools and a restricted comprehension of the uses for rhetoric and a vocabulary. His scholastic record has been compiled through memory and mimicry, rather than ability to think. Awaiting him in most undergraduate circles is an atmosphere of mental indolence where the primary goal is only the accumulation of the required credits for graduation with the minimum of mental exertion. How else can one explain the emphasis on choosing easy courses with the easiest instructors and an abstinence from activities that are not entertaining.

Part of this atmosphere is created by the student body. Many of the collegiate populace, as elsewhere, have succumbed to the easy way of the dole, of grabbing much but giving little, of following rather than leading. More and more often students are encountered, when a class subject involves new ventures of complex thought, who blithely tune out their mental receiving set and sit out the period in a blissful vacuum. This mental lethargy has always been the bane of teachers, but seldom has it been as broad and deep as it is today.

But not all of this pervading atmosphere is of student origin; college administrative practices also contribute to it. Qualitative standards of admission beyond possession of a high school diploma are constantly being attacked and often relaxed. In the competition for larger student bodies, quality is sacrificed for quantity. Standards of retention and readmission are lowered. Popularity contests by departments and teachers are condoned. Courses involving only crafts-

manship or memory supplant those that require thought and reasoning. Curricula that produce trained technicians rather than educated individuals are accepted. And finally, many professional student counselors encourage procedures in which failures are rationalized and plain evidence of sheer laziness and mental incapacity is disregarded.

It is related that shortly after Thoreau was graduated from Harvard in 1837 he spent an evening with Emerson discussing, among other things, higher education. Emerson congratulated Thoreau on his attaining the baccalaureate from such a great university and said, "You should be proud to be an alumnus of Harvard. Just think, it teaches every branch of knowledge." Thoreau's reply was: "Yes, every branch of knowledge and none of its roots."

Possibly it was ever thus, but certainly now even more. In such an academic atmosphere as we now too often have, it is remarkable that as many students as do, choose to be science majors. With subject matter that requires thought and understanding, intensive study and long laboratory hours, it is surprising that many more do not take the easier road to academic degrees. It is encouraging to examine scholastic honor rolls and find them dominated by science majors in the more difficult curricula. So our more rigorous demands attract the more virile students; for that we can be thankful. We do get the cream of the crop, but there is danger that the cream will not continue in supply with the trend toward homogenization in secondary education. And

the constant efforts to dilute that cream in higher educational environments make it increasingly difficult to whip it into its necessary useful form.

But students themselves and college administrators do not create all the obstacles to the production of scientists. The college teacher is also a party to discouragement. Frankly, some are just not good teachers. Some are lazy. Others seemingly exhaust themselves getting higher degrees and coast forever after. Some look upon teaching chiefly as a means of livelihood and it becomes that only. Others become bored with the fundamental, elementary subject matter that must be presented over and over. They forget that, although it is old stuff to them, it may be new and challenging to an ever-recurring audience that is hearing it for the first time. To them also, laboratory experiments become only necessary routine, rather than a means for illustrating interesting phenomena and for developing powers of observation, reasoning, deduction and scientific conclusions. All too often experience in teaching becomes synonymous with impatience with student difficulties, intolerance of new ideas and methods, uninspiring presentation of subject matter, and deadening, turn-the-crank automatism.

To some, teaching is frankly secondary, following other personal and professional interests. It becomes an unimportant but necessary obligation. This attitude is often aided and abetted by higher officials, particularly in universities where advancement is based primarily on research and administrative duties.

All of these attitudes of students, administrators and teachers are basic contributors to the easier way. A continuing flow of scientists and leaders can not arise from such an atmosphere of *laissez faire* and languid methods. It is up to science teachers in particular to promote attitudes and actualities of high scholarship, research, and thought, so that our colleges may continue to promote learning and education rather than becoming institutes of mere training and propaganda. Such a program should yield educated leaders, not just trained robots.

One other point. Although science is completely impersonal, it is subject to applications thought up by human minds. Thus many people consider science more a menace than a support, due to applications supplied by evil or desperate minds. This presents another challenge—to transmit to the nonscience student an appreciation, and if possible an understanding of the methods, the objectives, and the contributions of science in this modern age. One cannot afford to disregard a group that in later years may sit in judgment. That also necessitates a coordinate obligation—that science students must understand better and be able to assume their responsibility to society. As the recent Harvard Report states, they should acquire abilities “to think effectively, to communicate thought, to make relevant judgments, to discriminate among values.” Particularly since the last war have those objectives become significant and curricular changes to meet them have followed in the field of general education. As one observer said, “M. I. T. is humanizing

the sciences and Harvard is simonizing the humanities." Incidentally, as you might suspect, that remark came from a Princeton man.

Toynbee, the English historian, propounds that the Christian Church was the bridge between the Hellenic civilization and our modern Western civilization. So too the colleges, and particularly the college science teachers, are the major link between the raw material of the younger generation and the future advance of science. That is a profound obligation.

And finally, the circumstances that await a bachelor scientist also need some examination. Conditions in our present economic and political muddle contribute little to the attractiveness of a scientific career. The freshman who now chooses science does so in the certainty that at the end of four years of special training he will have two immediate prospects—at least two years of military service, or employment at a salary less than that of a skilled workman. Neither prospect lends much inducement to embarking on a course of study that requires brainpower, perseverance, and long hours in study of difficult subject matter when much easier ways are open. Until such conditions are changed, there will be little change in the downward trend of supply.

The law of supply and demand eventually should remove the economic difficulty, even without benefit of union organization and tactics. But our economy and industry can not wait for that. A campaign of action and recruitment down to the lowest levels of training is needed to reverse present trends.

The other condition is in the hands of the military and political leaders. They have been told, and they themselves say, that modern warfare, and therefore probable survival, depends upon superiority in technology and scientific developments. Nevertheless, their concept of available manpower seems to be concerned only with supplying operators of massive quantities of guns, planes, tanks, supply trucks and ships. Admiral Moreell said last September that "if we are to have this power, we must have available the scientists and engineers who can devise, design and build the instruments of modern war."

Young men need encouragement to complete their scientific training. Many of them with true patriotic feeling do not seek the possible onus of deferment. But if scientists are even more necessary than soldiers and sailors, then students in scientific courses should be as honored, and deferred, as are students at West Point and Annapolis. Further, to prevent diversion of available graduating scientists to the armed forces, provision should be made for immediate use of their scientific training upon graduation. It would not seem unreasonable to organize a Science Corps, with a distinctive uniform, that would be just as honored in national service as one of the military units. A two-year period of enlistment could be required. The personnel of such a Science Corps could be assembled in the summer following graduation and given a three-months basic training course, if the military mind must be satisfied. In the fall, on the basis of predetermined qualifications, the members

of this Science Corps could be dispersed to graduate schools, atomic energy projects, proving grounds, or vital industries, as the need demands. At the end of their enlistment period, the individuals would revert to citizen or reserve status or could continue in the Corps, as do the military school or ROTC enlistees.

Perhaps the deferral of successful college students and the appointment of the Scientific Manpower Advisory Commission indicate a realization of the errors made in the last war. If so, it is a step in the right direction. But until a definite policy is implemented that will permit science students to complete their college training and that will make specific use of that training after graduation, curricula in science will not be on the preferred basis that they deserve for the future survival of democracy.

In conclusion, a critical analysis such as this should include suggestions for remedy. If all the persons involved in the available supply of scientists can agree that more scientists are needed to promote better living and to protect our way of life, then a program should be produced that will work to those ends.

Robert Millikan⁴ in his *Autobiography* places a challenging responsibility on our high schools when he says: "The key to the future of America clearly lies in the secondary school because it is the only American institution that now reaches practically the whole oncoming generation." With that responsibility in mind, here are some suggestions

to the teachers and leaders in secondary education.

1. Continue emphasis of training students for responsible citizenship; it is a necessary program.
2. Continue to adapt courses to students through experimentation, but use a more scientific approach in judging the new and the old.
3. Give better training in the fundamentals of rhetoric and arithmetic for better understanding and progress in a technological age, and for future learning.
4. Promote a program to recognize, train, and reward the better minds and personalities for potential leadership, as in athletics. Don't level the mountains to fill the valleys.
5. Because of the critical importance of science in this day, use the guidance program to swell the ranks in that field with students having the proper aptitudes and intelligence.

Next, to the college and university group, on whom rests the actual production of professional personnel, and with obligations to promulgate and to promote science, these recommendations:

1. Recognize that research in educational methods does produce better insight into the teaching-learning process, and adapt college methods to produce better results.
2. Never forget that college classes are made up of individuals with different needs and aims, and are not amenable to "turn the crank" procedures.

⁴ Millikan, *The Autobiography of Robert A. Millikan*: New York, Prentice-Hall, p. 43, 1950.

Be open-minded and fair, tolerant and considerate.

3. Abhor slothfulness in teaching; permit no other activities and interests to assume primary attention. Give the best efforts and expect them in return. There is no substitute for competence and sincerity in college teaching.
4. Sell science and recruit the best prospects.
5. Hold to high standards, even in a declining environment. Require results and understanding, not merely efforts.
6. Inspire a respect for truth, ethics, accuracy, exactness, and clarity. Emphasize principles over facts and reasoning over memory. Above all, try to make students think.

Finally, those who control the destiny and ultimate use of scientific manpower can easily nullify the best efforts to recruit for, and enhance the quality of, those ranks. They must recognize that recruitment to a course of difficult subject matter, demanding intensive effort, is of little avail unless the student can be assured that his talents will be used in a professional manner that will yield personal pride, dignity, and security.

To that end, industrial, military, and political leaders should:

1. Define a program for the future that can be relied upon rather than one that is full of uncertainties for the college science student.
2. If science is one of the backlogs of national security, and if a

period of national service is to be required of all young men, set up a program of science service that would parallel military service with equal prestige and relief of obligation.

3. Encourage young people to choose science by making conditions of employment attractive, professional, and dignified. Raise the ethical standards of business so that employment will engender a feeling of pride and even of service.
4. Recognize the importance of public opinion and promote a program that will substitute knowledge and understanding for superstition and fear.

Henry D. Smyth, of the Atomic Energy Commission and previously of Manhattan Project fame says: "Basic scientific research is the foundation of modern technology. A vigorous technology is essential for economic welfare in the world of today. It is necessary for the defense of a free society. It has become the very sword and buckler of freedom."⁵ If that be true, all of us in the production line of future scientists should make every effort to expand and improve our work, so that we need not "view with alarm" but rather can continue to "point with pride" to our national preeminence in scientific achievement, and to the products of our schools, the young men and women who can make that possible.

⁵ Smyth, *Am. Sci.*, vol. 38, p. 436, 1950.