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Operation Infinity

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INTRODUCTION

As scientists, teachers of science, students of science, and amateur scientists here--as elsewhere--we occupy an anomalous position in the world today. Scientists have created situations and things which can save the world and greatly improve it, but by the same token these same things are capable of destroying the world. The anomaly is that scientists, in working for good ends, now find themselves among the victims of many adverse results. Be that as it may, I did not come here tonight to discuss this problem *per se*, but what I have to say does have a direct bearing upon it. Actually, I do not wish to raise a question so political or so ponderous, nor one of such international flavor. I believe we can afford to think for a few minutes about something fundamental, something simple and very much with us.

"The time has come," the Walrus said, "to speak of many things. Of shoes and ships and sealing wax, and of cabbages and kings." I refer to science teachers and students, without any immediate interest as to which of these is "cabbage" or which is "king." Rather, suffice it to say that each is important.

Certainly you, as teachers of science, are not gathered at this time and place to hear me tell you how or what to teach. I have my ideas on these points but you wouldn't appreciate them, I'm sure. For some reason, this consideration reminds me of the story about an Agricultural Extension Service worker who visited a farmer who was cultivating his crop of peanuts. Said he, "My friend, you are doing this work rather crudely and with far too much expenditure of effort. If you will follow directions as they are printed in this bulletin you will not only conserve your energy but you will receive a better yield from your crop." To which the farmer slowly replied, "Naw, thank you. I don't need no bulletin or no advice, 'cause I ain't doin' half as well as I already know how anyway." No, you don't want me to give you advice (although I have a lot of it in a completely unused condition), but we might all ask ourselves whether we are now really "doin' half as well as we already know how anyway."

What are some of the goals of teaching--science teaching in particular? The pay check? The relatively easy life? Love of leisure time? Lack of ambition? Pleasant surroundings? Good living conditions? Good place to raise and educate a family? Interest in subject matter we are teaching? Interest in young people? Character building? Lack of strict supervision? Respectability in the community? Others? What are the drives that motivate a really good teacher? Perhaps it is easier to get an answer by looking closely at those teachers who are not so successful. What do we mean by success? "Ah, there's the rub!" What are we driving toward? Is it to teach subject matter? Gain personal happiness? Each of us might have a different answer to these questions, but all will agree, I believe, that the real goal of teaching lies outside ourselves. Its focus is society--better educated young people make better citizens, a better country, and a better world. So, we must conclude, the unsuccessful teacher does not contribute his or her full share to this most important of all processes. To put it crudely, any school, college, or university is, in last analysis, a manufacturing plant and students are its products. Poor machinery, poor management, and poor labor in the plant yield poor products. Of course, the quality of the raw material brought to the plant also is important. Here the circle begins to close--better school products yield better raw material, so on *ad infinitum*--"Operation Infinity." Well, this carries the analogy far enough. As the links in this chain of events become stronger, everything improves all along the line.

Let us draw the focus a little sharper.

THE PROBLEM

The heart of the problem which I wish to discuss briefly is the shortage of scientific manpower in the United States. ("Man" in the generic sense!) It is the most important problem of education when viewed in the light of present world conditions. Not for one moment do I mean to imply that manpower in the humanities and in the social studies is not important. In fact, one could give good argument for the overriding importance of these fields, but that is another story.

"Under conditions of cold war economy (which most prognosticators predict will be with us for the next 10-20 years), the over-all need for trained personnel is perhaps greater than it would be under full-scale mobilization. This results from a 'guns and butter' economy in which the country attempts to keep the civilian economy as nearly normal as possible, while at the same time it carries the burden of a huge defense program. Under full mobilization much civilian production would be curtailed or suspended, releasing trained personnel for the war effort."[1]

Statistics are often dull, but worse than that they are just as often misleading when removed from context. Dr. George R. Harrison, Dean of Science at M. I. T., on March 12, presented a famous case in point in an address before the American Academy of Arts and Sciences on *The Role of the Secondary School in the Teaching of Science*. "In March of 1951 the Bureau of Labor Statistics estimated that from 70,000 to 105,000 first-year college students are needed each year to enroll in scientific curricula, including engineering. Thus, the 25,000 secondary schools should be turning out about 100,000 graduates a year oriented toward science. They actually turn out less than half that number. Out of a total of about 1,600,000 secondary-school graduates per year, 300,000 or some 20 per cent enter colleges, but of these not more than one out of five or six makes science or mathematics a career. Allowing for 50 per cent depreciation in college, we see that not more than one high-school graduate out of 50 becomes a scientist or a mathemetician of any sort." Dean Harrison asks, "Why is this?" He lists some possible answers as follows: "One immediate reason is that only about 6 per cent of secondary school teachers teach science, and of this number many are not trained as science teachers. Another [reason] is the plentiful job situation at high pay for high-school graduates, so that many who might go into science and engineering take immediate jobs in industry. The most common scapegoat is the poor old Bureau of Labor Statistics, which had the misfortune to announce some years ago that the engineering field was becoming overcrowded. Some high-school teachers undoubtedly are still affected by this pronouncement in their counselling of students, but I [Dean Harrison] am inclined to agree with Fletcher Watson of Harvard, who feels that the present lack of science candidates is mainly the result of having the good science teachers in the secondary schools drawn away from teaching during the war years, so that the pupils in these schools did not come in contact with teachers who were really interested in their subjects, but were taught science by teachers whose main interests lay in other fields. Unfortunately, there appear also to be long-term trends in this direction which bear little relation to the emergency."

Dean Harrison, following Fletcher Watson, has undoubtedly voiced an important factor of influence in the current shortage of scientific personnel, *but* if you will look at the trend in all fields as well as the sciences and engineering you will find a striking parallelism. All fields, with minor exceptions, suffered the same changes. The point is that one obtains a distorted picture when he views only one isolated statistic.

This, however, does not lessen the problem. It is true that industry, quite apart from the present emergency, requires 20,000 to 40,000 new engineers a year. About 25,000 will be graduated this year (1952), but the falling off in enrollments indicates that we will reach a low point of about 15,000 per year 5 years from now, and, according to Dean Harrison, "Much more serious shortages of engineers than the present one can be expected in the next decade." Yet many counsellors in high school and some in colleges still advise their students that there is an excess of engineers.

[1]National Science Foundation, First Annual Report, 1950-51, p. 19.

During the past 12 years chemical industries have quadrupled, while the member of chemists and chemical engineers has not even doubled in that time. Similar facts and proportional figures can be given for most sciences. These facts are disturbing and they may be devastating--ultimately. As isolated facts, separated from those about other fields, they do present, however, a distorted view.

We are entering, or have entered, a time when there is an increased competition for highly trained minds in all fields. Science shortages are acute and serious but they certainly are not the only shortages. The population of this country has increased 60 per cent since 1900. During this time students specializing in science and engineering have increased 700 per cent, but during the same period the number specializing in modern languages has grown 800 per cent. In 1890 only 7 per cent of our youth attended high schools; today the percentage is 80. In 1890 the percentage of high school graduates going to college was around 2; today it is nearly 20.

Critics of our high schools are legion and the cited causes of their difficulties are equally numerous--underpaid teachers, poor teaching, schools of education, state boards of education, city governments, parents, progressive education--and many more, *all* indicating deterioration. We have all heard this as far back as we can remember, and strangely enough it has always been so--in varying degrees. Nevertheless, during this period our high schools have turned out the brightest and best trained students ever known *and* they have also graduated some of the most poorly trained. This paradox is a matter of numbers and distribution.

Why have I brought all of this high school material into this discussion? Because our high schools train our future college students, the well-spring of future scientists and some of our college graduates will be high-school teachers.

So to summarize, our problem as teachers of science, research scientists, and science administrators is to do all within our power to meet fairly the competition for manpower and to do all we can do to meet the ever-mounting demand.

WAYS OF SOLVING THE PROBLEM

The problem for scientists is clear, but we get relatively little sympathy from other knowledge groups because they too have similar, although we believe less acutely-threatening, problems. Reduced to its simplest terms, the obvious answer is obtained by putting more persons in the educational stream at the source if we desire to have more trained people at the end of the stream. But this is the real nub of the difficulty.

How can we interest more than 20 per cent of our eligible youngsters to enter college after high school? Should we double this figure, or increase it still more, even if we could? No one knows, but most of us will agree, I suppose, that to have twice as many college graduates as we now have would do no great harm--and it should, theoretically at least, do considerable good. At any rate, that's what we're clamoring for. Now, I suppose it follows that in this event we would eventually have twice--three times--as many Ph. D's. as now and I'm not sure that we could take that! But even that is not too bad a goal.

The big question is "How?" How will we increase the percentage of college science graduates even one per cent, much less 20, other than to rely upon population increase? In other words, how can we proselyte from other fields, since the population-increase curve is too slow to meet present needs?

Briefly, the answer is get 'em young, treat 'em right, and tell 'em everything, to paraphrase an old addage. Here again we come back to good teaching and counselling at all levels. A good teacher should "know his stuff," as the boys say, and he or she should have interest, drive, and personality enough to put it across. Surprisingly small events sometimes have changed the entire course of our lives. A recent study reported by Professor G. W. Stewart (Physics, University of Iowa) in the February, 1952, *Journal of Higher Education*, (p. 75) says that 94 per cent of 72 distinguished graduates of the University of Iowa declared that teachers played an outstanding part in their accomplishments. In answer to: "What about them influenced you most?" there were 3 categories: the majority said "personality," second high was "manner of teaching," the third

"interest in students." Interestingly enough, only 6 per cent credited "mastery of subject-matter" as an important factor of influence. Yet several of the graduates came from professional colleges.

Dr. Stewart reports his own questioning of 12 distinguished members of the National Academy of Science regarding "the most easily identifiable turning point in [their] careers." Each scientist indicated some "turning point remembered wholly as occasions of self-discovery in connection with science." (1) A physical chemist, while expressing appreciation for a college teacher of botany, attached greatest significance to a "6th grade teacher of history who showed him that he could understand an assignment by reading it just once." This discovery led to a habit that was invaluable in his study of science. (2) A physicist was angered by the fact that he failed to pass his first college course in physics. This made him drive through the course a second time and taught him a lasting lesson. (3) A chemist thought his first elementary course in chemistry was a "ghastly subject," but was captivated by chemistry when a teacher helped him see what just one element, copper, could actually do. (4) A president of a leading institute of technology discovered himself when, without mental brilliance, he realized that he was really making progress. This encouraged him to continue. (5) A Canadian physicist found his turning point in the event when he received a contest prize in his undergraduate college. (6) A theoretical physicist was made to realize that the solution of mathematical problems was relatively easy. (7) One physicist doubted the truth of a textbook statement and set up an experiment to prove his point. (8) Another physicist at about 7 years of age "discovered" independently the principle of the siphon. (9) One of the most distinguished physicists said an accidental assignment to teach preparatory physics turned him from physical education to physics. (10) The head of a large industrial laboratory says much of his success resulted from the opportunity given him by his teacher to perfect a piece of apparatus. Actually he ruined the apparatus, but then he felt the obligation to analyze his error and this was his real turning point. "His teacher gave him rein." (11) An industrial physicist entered engineering school against the advice of his high-school principal, and during his first semester discovered that it was not too difficult to make good marks. This self-discovery shaped his life. (12) One famous research scientist, as a sophomore, asked his teacher a question in pharmacology. The teacher said he could not answer it and doubted that it could be answered by anyone at that time, but he invited the student to work on the problem with him during the summer. This experience with an understanding teacher turned his life into one of great research accomplishment. Thus, we see that relatively small events often "make" good scientists. Dr. Stewart says that teachers who can assist students in ways such as those cited is a real catylyst in the educational reaction.

In *The Education of Henry Adams*, we read: "A teacher affects eternity; he can never tell where his influence stops." This I submit is *Operation Infinity*.

LOCAL RESPONSIBILITY AND OPPORTUNITY

The problem of scientific manpower scarcity is a national problem and, thus, each and every one of us must bear our share of the responsibility for doing what we can to remedy the situation. Every responsibility creates its own area of opportunity. Certainly, the State of Arkansas has always met its share and more of the nation's emergency demands. The present urgent need for more well-trained scientists should certainly strike a responsive chord in Arkansas and the advanced echelon of the attack on this problem resides in those here and others with interest represented by the Arkansas Academy of Science. This Academy, founded in 1917, is one of the older state academies.

I have examined Volume IV of the Arkansas Academy Proceedings for 1951, and in this attractive publication I find ample evidence of a diversified research interest. This is an expensive publication and its real value depends on the use to which it is adapted. May I suggest that its pages could be devoted to better use if most, if not all, of the technical papers were published only in abstract form in Part I and a Part II be added which would be devoted to the work of young scientists--students in high school (a Junior Academy Report) and perhaps in undergraduate colleges.

Arkansas has made a creditable beginning on scientific matters for youth. You have 98 high-school science clubs affiliated with Science Clubs of America. This year a student in North Little Rock High School received Honorable Mention in the Eleventh Annual National Science Talent Search. John A. Doughty did a good job on this program. Only 37 states had Science Talent Search winners in the Honorable Mention category this year. In 1951 only 17 states received one or more Honorable Mentions.

Twelve students whose home address is in Arkansas applied for National Science Foundation Predoctoral Graduate Fellowships this year. In competition with more than 3,100 applicants from every state in the union two of these applicants were awarded fellowships. They are Bowman S. Garrett of Springdale, Arkansas, a student of chemistry at Louisiana State University, and Robert J. Mackin, Jr., of Little Rock, a student of physics at California Institute of Technology.

These examples of attainment on the high-school and college levels indicate to me that good basic training in science is available in many places in Arkansas.

Do you, as Academy members, as an organized unit of scientists, desire a worthy objective for 1953 and succeeding years? Much better than a strictly scientific project--a river valley study as the Virginia Academy did, a marine biological station as the Mississippi Academy established--nothing of this kind can compare with the importance of the cause of young scientists in this state. If this body would throw the weight of its talent and its prestige behind the Science Club Movement, already so well started (98 clubs), and make a conscientious, well-organized effort to obtain more entries in the National Science Talent Search, there is every reason to believe that you could get a national winner. This would bring more legitimate national honor to the State and its science teachers than any single effort the Academy can make. It would make a larger contribution to the scientific prestige of Arkansas than all the research reported in your Proceedings. This is certainly not intended to be a derogatory statement. In 1952, Arkansas entered the Science Talent Search program and you had an Honorable Mention. From this beginning, this Academy could organize a real program--if you really want to help your nation and yourselves. Arkansas should have an Annual State Science Fair, probably in Little Rock as a central location. One or more city newspapers could sponsor the idea as city dailies have done in many states. Then you could have an entry in the National Science Fair for 1953 or 1954. These programs are well organized on a national basis through Science Service and much has been done to assist local groups. The Arkansas Academy should set up a state organization to really help these 98 teachers who sponsor Science Clubs throughout the state--and twice that number of clubs probably could be developed. The results reported in other states indicate that there has been a revitalization of science education on all levels when university and college scientists join with high-school science teachers in these programs. Don't believe for a moment that this work is elementary and therefore below your scientific dignity. Young people in high schools today--many of them--are far better informed on science than a lot of oldsters who were coming out of college, and even graduate school, 20 to 25 years ago. It's the obvious result of our improved communication methods and our general advance in matters scientific. America is casting off its scientific swaddling clothes and is emerging into scientific maturity.

A second goal for this Academy is an organized membership drive with a program styled to interest new groups. A. C. Bevan,[2] in discussing the Modern State Academy of Science in Cleveland in 1951, directed attention to many things being done by progressive academies and he clearly designated activities appropriate for Academy undertaking. Uppermost among these suggestions were provisions for several membership categories: (1) professional scientists, (2) high-school science teachers, (3) graduate students, (4) college and university undergraduates, (5) high-school students, (6) science amateurs, and (7) laymen who wish to keep abreast of scientific developments. Dr. Bevan describes each of these categories and cites academies which are developing these opportunities. As you would expect, these academies are in the states that win the Science Tal-

[2]Bevan, A. C., *A Modern State Academy of Science*, Scientific Monthly, Vol. 73, pp. 255-260, (October, 1951).

ent Search awards, *but* (this is important!) some of these states just recently have entered the winning column as a direct result of academy effort. Dr. R. A. Millikan,[3] Nobel Prize-winning physicist at California Institute of Technology, recently said, "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." Bevan used this quotation from Millikan and added, "Here is a challenging opportunity for a modern state academy of science."

I hope you science teachers in the universities, the colleges, and the high schools of Arkansas will take this challenge seriously. There are dozens of laymen who will help you with their time and their money if you organize along this line and show them that you really mean business. Scientists and science teachers *must* take the lead.

Truly, "A teacher affects eternity, he can never tell where his influence stops." This is indeed *Operation Infinity*.

[3]Millikan, R. A., *The Autobiography of R. A. Millikan*, New York, Prentice-Hall, p. 43, (1950).