

ORGANIZATION OF RESEARCH & DEVELOPMENT FOR NATIONAL SECURITY

19 SEPTEMBER 1946

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THE INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

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ORGANIZATION OF RESEARCH & DEVELOPMENT FOR NATIONAL SECURITY

SEPTEMBER 19, 1946

CAPTAIN WORTHINGTON:

Admiral Radford, distinguished guests, officers of the Industrial College: This morning The Industrial College of The Armed Forces is greatly honored to have Dr. Vannevar Bush give the second of a series of lectures on Research and Development.

As all of you know, Dr. Bush--the inventor of the differential analyzer, the former Dean of Engineering of M.I.T., and the President of the Carnegie Institution--was Director of the Office of Scientific Research and Development during the entire war period. In this capacity he was responsible for the larger part of the national research program which was conducted on a scale hitherto undreamed of. He played an extremely important role in major wartime developments from the "duck" up through the proximity fuse to the atomic bomb.

Dr. Bush is now the Chairman of the Joint Research and Development Board.

The subject of his lecture today is: "Organization of Research & Development for National Security."

DR. BUSH:

Gentlemen, the subject of the "Organization of Research and Development," even when we confine ourselves to research that is connected with military matters and think about research from the standpoint of governmental organization, is such a broad question that in a single lecture I can only hope to touch some of the high spots. I do, however, plan to try to cover a considerable amount of ground as well as leave plenty of time for questions; and if I touch things lightly, I hope that that will inspire questions that are of real interest to you.

First, I think I ought to define what we are talking about. Research is often defined in many ways. Many activities masquerade under the title of research that in my opinion are not research at all.

I would like to define research in a very broad fashion as the ordered pursuit of new knowledge. Note, however, that this excludes library work that is merely the gathering in one place of data already existing, but

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would not exclude the gathering of such information provided it resulted in a new formulation, a new law of nature, or a new relationship of any sort.

Development, on the other hand, is for our purposes the creation of new instrumentalities ready for production for use. From a military standpoint, I think that will suffice; from an industrial standpoint, one would make it a little broader. The split between these, therefore, is fairly clear and this is fortunate, because the methods of handling the two are quite different.

I shall not spend a great deal of time in saying why I think the subject of research and development in the military field is important today, because I don't think I need to. We are in a new era. Scientific research in the natural sciences and their applications is now established as an essential element of national strength. Every country is going to put great weight, in the future, on the natural sciences, research in the fundamental sciences, and on the applications. There is no doubt that the world is entirely awakened to this fact. There is no doubt that it is going to result in an extraordinary stimulation of activity throughout the world. There is, however, surely going to be a great change in the way in which the matter is handled because it has become, for the first time, a recognized matter of national importance from the standpoint of national security.

Now there are dangers. There is danger of limited understanding on the part of non-scientists that may unbalance the effort by overemphasis on applied phases. A vigorous, extensive, well-rounded national program is essential for security, but if it is going to be well-rounded, it must give full scope to fundamental research. No man knows today what basic research that is currently being carried on may be of great defense importance, or of great importance from the standpoint of national security, a generation hence.

Let me pause to give you just one example. A generation ago there were in this country a large number of people working in nuclear physics, sorting out the forces that bind the atom together. Very few people felt that that had anything whatever to do with national security, yet that was a direct step toward the atomic bomb.

Who can say whether some biologist today working in a laboratory on a new problem in genetics may not be carrying on a part of a program which a generation hence may be exceedingly important in connection with the national security? I, therefore, throw out this word of caution: our premature judgment as to what is and what is not important is dangerous.

Allied with this is a second danger and that is that laymen will try to dictate to scientists what to do and how to do it. We are bound to have a

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great deal of Federal support. Support and control often go together. Hence there is the real danger that control may be overdone and may rob the scientist of that freedom which is an essential in creative research. I think these dangers will be avoided, but I must point them out.

Before I comment on the way the government is or may be organized in this regard, let me state one or two principles which I think are rather fundamental, which come from experience, and which are well to have in mind. Industry learned in regard to the organization of research, fairly well and some time ago, that to place research under production, or under the purchasing department, or under sales is to wreck it. This is not fully understood, even today, even in industry, certainly not in government. The only way in which research and development can prosper is to have independent status and to be coordinated with these other branches of activity by an individual who understands all of them. That means that research, in an industry, needs to be independent of production and independent of sales, and that the company which has a chief executive who understands all three will proceed rapidly and effectively.

In military affairs, research and development must be at the top echelon with procurement and be coordinated by men who understand both fully; and the difficulty, of course, is the scarcity of men who do understand fully such diverse branches of effort as these.

In order to get results in organizing a research program, we have a very simple formula: find the right man and give him his head. That is the full text of internal research organization. Charts, diagrams, flow charts, all the rest of the paraphernalia that go with the organization of many things and produce their effects are entirely subsidiary to that principle when it comes to a research organization.

There are plenty of corollaries. One is if you don't have the right man, you cannot possibly get the results whatever you do; and another corollary is if you secured the right man, you would get the results in spite of thunder, you, or anybody else.

Finally, let me say one thing which I think is quite important today. It is that the valuable results almost never come from mediocre teams; and when they do, it is an accident. We have as a principal national resource a certain number of men capable of carrying on research effectively. We have a national program of research in government, in industry, and in the universities. At the present time, these are not correlated. And I believe, although I can't prove it today, that we have a program far in excess of the capabilities of available manpower. If we have, the result will be what, in my experience, it has always been: to force research into the hands of mediocre teams.

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That leads me to the next point. Research and development are powerful and essential tools for progress. They are also a potent way to waste money. The rate at which money can be wasted in research and development increases as one proceeds from fundamental research to applied research, development, engineering, and finally toward experimental production and tests. I believe, therefore, that in this country today, we need to pay a good deal of attention to trying to carry on a program in which we will not exceed our natural resource of properly skilled manpower, force ourselves into mediocrity, and thus into waste and discredit the whole affair.

Before we come to detailed discussion of how we can get it, let us reckon what we actually need in this country. Of course, the vigorous program of basic research is principally in universities, and principally, from our standpoint, in the natural sciences. Today, on the necessarily expanded scale, this requires a sound system of federal support. Second, we need a sound and extensive program of research in industry. If industry in this country is healthy, such a program will be carried on; and if industry in this country is not healthy, there will be no such program. The national security of this country, therefore, demands a healthy industrial situation. We need a sound progressive thoroughly integrated program of military research, drawing on universities and industries, and adding to the prosperity of both as it does so. This should be primarily in the hands of the services but supplemented by a civilian organization. On this I have a great deal to say. Finally, among fundamental needs, there must be an adequate supply of well-trained research men.

Now where do we stand concerning these needs as we look toward the future?

First, we have a deficit of around 100,000 trained scientists and engineers as a result of short-sighted draft policies. We were the only nation so blind to modern trends as to sacrifice the future for the present to such an extent. Hence we enter the post-war period with an exceedingly serious deficit in trained manpower.

Second, we have expanded plans for research in universities, industries, and government, as I have said, beyond, I think, our capabilities.

Finally, we have a thoroughly awakened appreciation on the part of the people and their government of the potential value of research in the natural sciences, but not a commensurate understanding, and a tendency - of course - always to pay undue attention to the spectacular and the superficial.

Now from the standpoint of National organization, where do we stand?

First, both Services, since the war, have organized internally the handling of their research and development programs on a new basis and, I

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think, a very sound basis. I won't go into this phase because you are to have lectures that will discuss it explicitly.

Second, we have vigorous programs in most important fields, in both Services. A tendency exists to sell these to the public and hence to Congress by publicity from various sources, which carries with it a very great danger to security. For instance, I picked up a New York Times this morning and read about a piece of work that was partly done under my organization during the war that is now lectured about. The work was the development of some new toxic materials of very high potency. I don't think it does this country any good for such information as that to be put before the general public. The object of such publicity might be to scare the public as though it were not sufficiently scared already. The object might be to secure funds for further support of the particular job. If so, I think that is unnecessary, and an unwise procedure. I was aghast to read that particular story, and I have been aghast for similar reasons a hundred times in the past twelve months. I think that such publicity is going to backfire.

Returning to discussion of organizations of the military for military research, we have the National Advisory Committee for Aeronautics which has been in existence for a generation and which supplements the work of the Army and Navy in the field of aeronautics. By agreement with the Army and Navy, it pays attention to basic research whereas they put their attention on development. That division prevents overlapping and duplication to a very considerable extent. The NACA has a governing body made up of Army and Navy officers plus representatives of government departments plus a group of independent civilians. I have been associated with it for a long time. I have never seen it subjected to political pressure in any way that was injurious to it. It has never seemed to starve for funds when it really knew what it was trying to do. It has been a salutary agency. I think that its presence has aided greatly in the past generation in bringing us to the forefront in the aeronautical field, primarily because NACA has kept emphasis on basic research which might otherwise have been lost on the shelf.

We had during the war the Office of Scientific Research and Development which was doing the same sort of thing in other fields except that it was, under the necessity of war, almost entirely in the applied field. And, during the war, as you know, we drew on our scientific capital and did not replenish it. We applied everything we knew how to apply and we didn't foot the bill. The result, of course, is that in the basic fields we are now behind where we otherwise would not have been and we need concentrated attention to catch up. The Office of Scientific Research and Development, while it has not yet gone out of existence and will not until it has finished clearing its final contracts, has ceased all research and development work. The work that it carried on has been, in some instances, transferred to the Army and Navy and the rest of it has been terminated.

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In the past session of Congress legislation was proposed for the creation of a National Science Foundation that would, if created, bring federal subsidy to basic research in this country. It would include a section devoted to military research. The status of that legislation I do not need to go into at length. It failed of passage in the last session of Congress simply for lack of time. There was considerable disagreement in Congress on details - for example, on whether the board should carry the power or should become simply advisory to an administrator, the question of the handling of patent clauses and contracts, the inclusion of the social sciences, and a number of other points. There was enough division of opinion so that the vote of the Senate was very close on the form of the bill but overwhelming on passage of a bill and the House, when it was supposed to have acted on the bill, simply did not have time after the Senate got through. We will have legislation for a foundation, perhaps, in the next session of Congress, and I believe it will be sound legislation. Though it may not agree with all of my own ideas, there are very capable men in both Houses who have given the matter their earnest attention. That means that we will get a sound act.

When it is created, the Foundation can do several things: One, it can increase our supply of available manpower in the sciences by subsidizing outstanding students. Doing this is very necessary to the nation now. It may seem revolutionary from the standpoint of how we conventionally handle our educational system. But the principle of continual selection and continual subsidy, all the way through the top lines of education, comes to us from clear back in the days of Thomas Jefferson. It has been carried into effect thus far in this country only in the schools of the Army and Navy, and has been effective. Now it may wisely be extended.

Second, the Foundation can and will subsidize basic science in the universities. By doing so it will help to keep our universities healthy and able to train individuals because it will enable the universities to compete with government and with industry for the best men--which they must be able to do and which they cannot do on the basis of their endowments and their income, and on the present scale of research.

Finally, the Foundation will have a division devoted to military research with the explicit purpose of supplementing the work of the Army and Navy; and I believe that is important.

At the present time, in our national organizational scheme, we have as a stop-gap very considerable subsidies for basic research on the part of the Services themselves. That is an extraordinary development. It has been a fine development and it has been very salutary, because by bringing into the universities at just the critical moment that aid without which they couldn't have kept their research programs on a reasonable scale, it has prevented the programs which were built up during the war from being abandoned and the

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trained personnel from dropping out and going into the other fields. Both the Army and Navy have done that very well indeed. I think that is temporary and is a stop-gap because I believe that ultimately the flow of federal funds for basic fundamental research can occur in a better way than through the Services. I believe that the Services, once a full system is established, should put their concentrated attention on the applied phases and development. As a temporary matter, however, the present scheme is salutary indeed, and I believe it will carry over until the National Science Foundation can take up the load.

As a last item in this survey of national organization, we have, at the present time, no single national program of military research and development in any important field, and this is exceedingly important. As a result of that lack we have over-expansion and duplication in many fields. We have the staking of claims. We have uncontrolled competition and we have appeals to the public. But we have means now at hand for resolving this matter. It is an experimental means -- the Joint Research and Development Board is a new-kind of board. Whether it will work out successfully or not remains to be seen, but it is a new venture in the matter of bringing together diverse interests in the Services in this exceedingly important field, which in my opinion, is the central feature in our whole program of security during the next generation. The Board is constituted so that it can't become dead-locked. It operates by majority vote. Its decisions have the effect of orders by the two Secretaries in the two departments. Hence, it has the possibility of going through with decisions in regard to responsibilities in a way that I feel is highly necessary if we are to have a nationally integrated program on some of the important matters that we face, such as the whole field of atomic energy or guided missiles. It is operating by constituting subordinate bodies to which, however, it is delegating extensively so that it will give those bodies the support they need in the way of clerical help, aid from consultants, full information, budgetary and otherwise, to put together a coordinated program that makes sense--a program for the nation. One other thing: If those bodies disagree, they can get a prompt and binding decision.

I see that I have about five minutes more before I open questions. I could not very well treat this matter of governmental organization for research and development without treating the question of a possible merger of the Armed Forces. This in its generality is not our subject, however, and it would be very difficult therefore for me to treat the research and development aspect of it as a separate entity without getting into the whole affair, for which I certainly have not time.

But I can say this: the steps that have been taken in the past months were: First, for better centralized cognizance in each service of research programs within the Services and, second, for authoritative means for

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resolving differences and national problems. The result of these steps could be carried over without the slightest difficulty into any form of merged department that I have examined and could thereby be effective, if the merged department is effective at all. It would in fact be more effective because of the simpler organization than would otherwise result for the same purposes.

One of the primary arguments, of course, for a merger is that warfare today has become such an entwined affair that it can't be separated. As far as research and development of military devices for the future is concerned, that is most certainly true. It is clearly within the interest of the three primary branches, and if every branch has an interest in the field, there must be means for coordination. This means more than a unanimous agreement brought about by including everything that everybody is interested in, that is more the type of thing that comes out of a debating society without authority. We need, and must have, an authoritative, definite, effective system for bringing about unity of action, coordinated effort, elimination of unwise duplication, perpetuation of competition where it is really desirable and effective, if we are going to have that part of our national security in sound shape. As I see it, if the present board is successful, it can produce much of that result, but it can be produced also under a combination which brings similar unity in other fields. I believe the present efforts toward organization in the respective services and coordinated effort in the Joint Board could form a transition into a later form without great jar and within the compass of any proposal for merger that has been sincerely advanced.

Now, gentlemen, that has taken me just a half hour. I have talked about a great many things, covered a lot of ground, as I know, very superficially, and I planned to do just that because I believe that the most valuable part of any such session as this comes in the question period. I don't know just how you conduct your question period--

CAPTAIN WORTHINGTON:

Go right ahead, sir.

DR. BUSH:

Now questions from the floor. I will be glad to treat anything within the scope of the subject that I know anything about.

A STUDENT:

When does duplication in the research field become unwise?

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DR. BUSH:

When it becomes wasteful, of course.

A STUDENT:

That is the point; we couldn't tell when it became wasteful.

DR. BUSH:

Well, there are very few good research directors in this country. Of course, directing a research program is an art rather than a science. But that is the thing the research director of a large organization is up against.

However, I will say this, as a guide. Any plan of research and development leading to the use of a new device goes through many phases; first, the basic research, the fundamental research that lays the groundwork for new knowledge and advances; next, the applied research which draws on that; then engineering joined with it; then the building of prototypes for production; and finally production, training in use, and all the rest.

Now as one proceeds down that path, it becomes more and more expensive. The basic research may mean no more than subsidizing some chap who uses pencil, paper, and brain, who gets enough money to live on and doesn't need any assistance of any kind. But when you come to prototypes, it may cost two million dollars a shot and you may need a number of them. Therefore, duplication of effort can be relatively inexpensive in the early stages and very expensive in the later stages. And by the same token it can be very beneficial in the early stages and it is not nearly so likely to be beneficial in the late stages. Hence, as a general guide, I believe, it is sound to stimulate competition in the early stages when plans are completely nebulous and people are looking for good solutions, in order to get the effect of three or four groups of keen minds trying to find the path that will go somewhere. That doesn't cost much and it really starts the show going in a hurry.

It is very seldom that prototypes are built for production in a competitive fashion. By that time it ought to be possible to decide what is wanted and build that.

Does that cover what you had in mind?

A STUDENT:

Yes, sir. You shouldn't duplicate in the development?

DR. BUSH:

Very seldom in the later stages of development.

A STUDENT:

You spoke of subsidizing students during college years. I understand that is the practice of Standard Oil, DuPont and several of the large organizations now.

DR. BUSH:

Yes, it is done by scholarship funds. The Rockefeller Foundation has a lot of programs going; The Guggenheim fellowship program has been very salutary in this country; there is a Westinghouse program underway; several others have been formulated; universities do it themselves under private funds. But there is not flowing into that field, in the aggregate, more than a tenth of the money that this country ought to spend for that purpose and I don't believe it could come out of private funds.

A STUDENT:

My question was, since industry can afford to pay more than government can on Civil Service wage scales, do you think it necessary to make a revision of the Civil Service Laws in order to permit higher scales?

DR. BUSH:

Now wait a minute, so can industry pay more than universities can afford to pay. When you are talking about research men, remember that salary is only one element that they consider when they want to work and operate.

I have seen time after time, when I was in university work, key men offered three times what the university was paying and industry failed to get them. The freedom and the possibility of going ahead in the profession by becoming nationally known are elements which any youngster ought to consider when he finds out where he is going to be.

The chap who takes four thousand a year at the university may go to the head of his profession where if he stepped out and took eight thousand in industry he would become a cog in a very large wheel and never be heard of on a national basis. It is not universally true, but it is an exceedingly important element.

I think therefore that there is no need--no need whatever--for the university salaries of the scientific personnel to be on a par with what industry will pay to those same men, because industry of necessity, by reason of its nature, by reason of what it is trying to do, has to impose restriction on freedom of action that the universities do not impose. There are plenty of good scientific men in the country who would rather have lower salaries and freedom.

Now as applies to Civil Service, you have opened a very large question, indeed, because you have opened the entire question of scientists in government. I would like to give a lecture on it, but wouldn't want to answer it in one question. The same elements come in, of course.

A STUDENT: . . .

It seems to me that intelligence, technical and scientific, of foreign services plays an important part in organizing a research and development program. Would you care to comment on our present organization and what you think the possibilities are, and how they could be improved?

DR. BUSH:

I wouldn't want to attempt offhand to go through the analysis of what our present intelligence organization is in this country, because it is a subject that is rather controversial. But certainly it is true that intelligence today, on the subject of weapons, cannot be carried on adequately without close participation on the part of men who are highly competent from a scientific or technical standpoint. The problem of how to integrate such men into an intelligence organization is quite difficult. The reason why we carry on intelligence, however, is not usually to aid our own research and development program but to know whether or not we are ahead of the competing country in a particular scientific or technical development. We certainly ought to be ahead of what can be found out about their affairs through any conceivable intelligence system, so that the purpose is hardly to aid our own program.

As an illustration: If industrial development is underway, the company concerned will follow issued patents very keenly in that field but usually not for the purpose of finding out how to do what the patents disclose. They will be well ahead of that. The things that they would like to consult are in the form of applications which will not be available for several years, if you are concerned with that aspect. They will consult the factual situation because from it they have to map out their program as to where they go in competition.

Similarly, our intelligence program which has its very important purposes in regard to overall program planning needs to have great attention

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today on technical progress in various fields made all over the world, for example, on atomic energy. But one should not expect the uninitiated to learn anything that will greatly help our scientists and technicians. Hence, the problem of bringing in the scientific point of view, the scientific knowledge, into that type of effort is a different problem. We do not need for that purpose men who are creative scientists in their own right. We need men who know science, and those are men that can be brought in and are being brought in.

A STUDENT:

We have heard arguments for and against the methods that were used in the atomic energy development. I wonder if you would comment on the method of compartmentalizing activities of one individual in one field.

DR. BUSH:

Compartmental organization--security information, well, you gentlemen ought to be thoroughly familiar with that. I ought to be a neophyte at it. There is a fundamental principle of security: The man working in any field, highly classified field, is given that information which he needs to do his job and no more. Now whether that was violated in the conduct of the atomic energy job, whether or not we were holding information from men who needed it in order to carry on their work, I very much doubt; and I very much doubt if it was violated in the other way of giving to men information that they did not need but which they merely wanted for purposes exterior to their jobs, curiosity or otherwise. I think the handling of compartmental organization of information on our research and development during the war was accepted by the bulk of sound scientists in this country and carried out with their full collaboration--their full understanding. Since the war, I have heard a few squawks. And I think if you consult the party of men who really did the job you will find that they themselves put the system into effect and that they believed in it thoroughly, in spite of inevitable errors in detail in carrying it out.

LIEUTENANT COLONEL TAYLOR:

Dr. Bush, this is a course on economic mobilization. Would you care to comment on what major economic or industrial steps the country should take in the light of new weapon developments during the war?

DR. BUSH:

Well (pausing), certainly we are talking about economic mobilization for the war of the future. We must first specify when that war is going to occur, because our plans would be utterly different depending upon what our

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predictions are in that regard. If there is going to be a war in a few years, we would most certainly approach the problem of our economic mobilization on the basis of a slight extrapolation of where we stood on weapons at the end of the war. That would mean attention to some strange things because there are a few affairs that are just opening up beyond those that were actually used.

On the other hand, if we are planning for economic mobilization for war that is going to occur twenty years hence, I haven't a ghost of an idea as to how to go at it, because I haven't a ghost of an idea what kind of war that is going to be.

The principle that I would have fully in mind is this: definite formulation on a short term basis, based on the situation when we stopped at the end of the last war, extrapolated, with careful attention to the point that the next war will certainly be different from what the last one was, but not what the last one would have been in a year; combined with great flexibility because of the changing nature of the whole affair.

A STUDENT:

What is your evaluation of the methods and epitome of dissemination of scientific and developmental information now. I am thinking, for example, of the Office of the Publication Board of the Department of Commerce as something more needed?

DR. BUSH:

Of course, at the present time, they have completely bogged down. An enormous amount of information was dammed up for five years, and then a great part of it was suddenly released and the publication facilities in this country can come nowhere near coping with it. Moreover, if they could, nobody could possibly read all the material so we are just in a log jam. Ultimately, that will sort itself out without any question but consider for example one little element in the field of radar--when the group in the radiation laboratory at MIT finished up and planned to publish the things that were in the clear from the security standpoint, they proposed a program of 54 volumes of monographs. When they wrote the technical historical account of what occurred, they wrote 500,000 words to link the thing together.

Now that is inevitable. If several thousand very active men who are conducting research aggressively in a field for four or five years do not publish it, what is going to happen to it? Well, McGraw Hill is going to publish the monographs. Little Brown is going to publish the summary. There will be a lot of it getting out. From the other standpoint, take the

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young fellow just graduating from college; he is going to get mental indigestion for some time to come. It will take a long time for this mass of material to become the accepted principle in the art known by everyone.

So while we recognize that our programs, for example, of getting information obtained from Germany into the hands of our scientific men are moving very slowly, I recognize also that the bulk of it is such that it is an enormous job to get it out at all. And I call attention to the fact that even though the rate of publishing is slow, we are probably keeping up with the ability of the country to digest it.

A STUDENT:

Doctor, how far do you feel the Services should try to go in the education of their personnel to act as technicians as opposed to administrators in this program?

DR. BUSH:

Well, why oppose those? Why cease becoming an administrator? I don't have to become a technician; at least I won't; if something happens to me, I think I can go back to the bench and earn a living. Your comparison is on the wrong basis. How far should the Services go in attempting to introduce among them men of genuine professional attainments in the field of science and technology? I say, just as far as they possibly can in this kind of a world. We most certainly would not want our entire Army and Navy to be staffed by men who are professional scientists or professional engineers. On the other hand, the fighting of a war or the planning for it can obviously, in view of the developments of the last five or six years, be done only by groups that contain men who can think adequately in the scientific and technical fields as professional men of competence themselves; so that there must be a sprinkling of men, particularly at the higher echelon, who have those qualifications and who are accepted in this country by scientists and engineers generally as colleagues and partners. And I believe that with the best attempts in the world we can't possibly go too far in that direction because while we need only a portion of our people thus trained, that portion is great enough so that in the natural course of events we won't exceed it.

Now you would say, why cannot the thing be done by calling in, as consultants, men who are thus scientifically and technically qualified? You can do it that way, but you can't do it well. The real solution is that the Army and Navy themselves in time shall contain, particularly in the higher echelons, men who are accepted throughout the population as men of standing in diverse scientific and technical fields so that when they do call for consultation they will talk to consultants as professional partners and will get somewhere.

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COLONEL GODARD:

Dr. Bush, bearing on your last question, I believe there is a tendency, an increasing tendency, on the part of the Services to intrude or venture into the field of basic research and away from the fields in which they stayed so long, namely, development. Some people are disturbed by that tendency. I would like to have your comments if you will give them to us.

DR. BUSH:

No, I am not disturbed by it because, as I say, I think it is a salutary passing phase. If we were going to stop it, if this was the end of the path, then I would be disturbed because I think the natural field for the Services is in the plant aspects and in development, leaning on fundamental work done elsewhere.

But in this interim right now, when we have finished with the support my organization was able to give, and before we have a National Science Foundation, the Services very fortunately have come to the support of basic research and they have done it very well. They have done it very intelligently. They have done it without alienating the scientists or attempting to control in arbitrary ways the thing they should not control. I regard this sort of functioning by the Services as a temporary but salutary thing, which in the next few years will certainly give place to another form where the universities and industries will be carrying on the fundamental research and the Services' major attention will be on development and use. I hope that this present interlude will lead to that separation's being made in such a manner that the Services will in no sense lose contact. And I am quite sure they will not.

One of the most important facts is that in this interim we are continuing a very close community of interest between scientists throughout the country and the Services that existed during the war. It is very essential that that be perpetuated well into the peace.

COLONEL McCARTHY:

Would you be kind enough to comment on the progress that has been made, and that you expect may be made, in the use of atomic energy knowledge and material in the treatment of disease?

DR. BUSH:

Yes. I would be quite willing to comment on that, although, as you know, I am not a medical man. Of course, in the first place, that progress is an incidental which happened because a by-product happens to be useful

medically. But because atomic energy was developed during the war in the way it was, we now have an adequate supply or can have an adequate supply of a very large variety of radioactive isotopes. The direct application of that fact is interesting; the indirect application of it is decidedly stimulating. On the direct side we have the possibility, for example, that in the attack on cancer it might be possible among the hundreds of thousands of organic compounds to find a non-toxic substance which, if introduced into the system, would become concentrated on cancer tissue. It is not unreasonable to expect that that might occur because we can, for example, introduce compounds that will become concentrated on one of the glands almost completely; note iodine compounds and the thyroid. Now any one of those compounds can today be made radioactive and, moreover, with very great flexibility the intensity and duration of the radioactivity can be controlled.

Let's see what that means. One of the principal attacks on cancer, in the past, as you know, has been by radiation methods, using radium and high voltage X-rays. And that has been known to do damage to the cancerous tissue. Since it does a great deal of damage to the system generally, the only reason it has been used is that the normal tissue recovers a little faster than the cancer. Hence you knock the whole system down and depend on the balance between normal and cancerous growth. On the other hand, if a selection compound were discovered and made radioactive, then radiation could be applied on just the point necessary so that hundreds of times the effect could be secured on cancerous tissue. This might change that balance very importantly.

That is one of the direct lines down which we can now go because of the development of atomic energy. I don't predict its success. It merely looks very attractive at the outset. But, I know that such an approach may be very important in the long run.

For years in medical work and in organic chemistry, we have made progress because of the fact that by using radioactive isotopes we can tag molecules and see where they go. By that means we have sorted out many a problem in organic science. Today we have tagging materials for that purpose in quantity and we can use the technique on a scale never before possible. That, I am sure, is a great advantage. For example, if you happen to be a farmer, do you know what happens when you put fertilizer in the soil? Well, nobody else does. But you can tag molecules of the stuff, go around with a simple instrument and find it a month or two later, whether it is in your cattle, in the ground, or in the water supply. You get the end of a story in a very simple manner. That is a rather crude illustration, but it roughly parallels what is now going on in hundreds of laboratories.

A STUDENT:

Getting back to your earlier question, at what stage or what level of coordination does there now exist machinery for deciding when duplication becomes wasteful; does it exist in your Joint Board or a lower board?

DR. BUSH:

It exists in the Joint Board and in the bodies subordinate to it.

DR. WILLIAMS:

Dr. Bush, would you comment on the proposal to include the social scientists in the National Science Foundation?

DR. BUSH:

That is quite a story. When President Roosevelt called on me for the report that was submitted to President Truman after President Roosevelt's death, his call explicitly pertained to the natural scientists; and, hence, my report applied entirely to that.

At the time of President Roosevelt's request, I made it clear that if he wished a similar program worked out in the field of the social sciences, he should make his call for that purpose on the social scientists, which he did not do. Hence, when the matter came before Congress, Congress, in my opinion, quite appropriately formulated the thing fundamentally around the natural sciences. I advocated that the question of the manner of inclusion of the social sciences should be studied by the social scientists and gone into only when a definite program had been thus formulated.

Now it would be possible for that legislation to put the social sciences in at the outset as a division, or to enable the Board to introduce them after proper study and at their discretion, or it would be possible for the legislation to exclude them entirely. I have advocated the second, intermediate path because I think it, on the one hand, avoids doing things hastily before there has been an adequate study, and, on the other hand, avoids exclusion. Congress, however, I am rather sure, would now take the third path and drop them out. That, in my opinion, does not mean that they cannot be included later under special legislation, but I am dead sure that if they are thus to be included later, the social scientists themselves, of whom I am not one, must produce a study, a program, that will draw support, and I don't believe that that has been done yet.

A STUDENT:

: Will you comment on the feasibility and methods of coordinating private research for the benefit of the military?

DR. BUSH:

Private research for the benefit of the military is very easy. If the military research is self-coordinated and private research is being carried on for the Services by contract, of course, then that is straightforward. If it is not thus under contract but is quite independent, you can't coordinate it except by persuasion because there is no control at any point, that is, if it is entirely independent research at the university. The only way of coordinating that is the way in which highly independent entities have coordinated their affairs for generations and that is, to get together in the scientific organizations and argue about them. That goes fairly well, as a whole. It avoids duplication pretty well because chaps will find out what the other fellow is doing. They will find out who is ahead and shy off and let the fellow in the lead stay there, rather than enter a race where they would be sure to come in second. It also causes a considerable amount of backscratching, give and take. The important issue is, if military men are going to participate, then they have got to share in the party. The only way to share in the party is by sending men to it. There are many scientists in the Services now; I hope there will be more.

CAPTAIN WORTHINGTON:

Dr. Bush, I am afraid we have imposed on you long enough. We certainly appreciate the splendid talk you have given us.