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What are his tasks, duties and functions?

What does the nation need from him—and what can it expect of him?

by L. A. DuBRIDGE

IT IS RATHER STARTLING for some of us to realize that probably over half of the active research physicists of the country today are under 40 years of age. And it is still more startling to note that this younger half received their Ph.D. degrees *after* Pearl Harbor Day in 1941. In other words, about half of the nation's physicists have never had any experience with the days when their science had no noticeable—or certainly no widely noticed—relation to national defense.

In those days there was no Pentagon, no AEC, and the number of physicists who had ever visited the old Navy Building or the Munitions Building could certainly be counted on your fingers. Physicists knew that the Navy existed mostly because of the Naval Research Laboratory, some of whose members regularly attended scientific meetings and gave interesting papers on subjects which appeared to have no military interest whatsoever, such as bouncing radio waves off the ionosphere (the forerunner of radar, we know now).

One gathered that there were things going on at NRL that no one was supposed to know about—but the word "secret," as applied to scientific matters, was quite unknown. The phrase "classified research" would have been wholly without meaning. The term "security" meant either "safety" or something you bought on the stock market. Loyalty was a characteristic like virtue, or honesty, or chastity; something which one took for granted, but never talked about or questioned. "Security risks," "loyalty cases," "clearance procedures" were terms not even yet invented—or at least unknown outside of a military headquarters.

The scientific world has been rudely and radically shaken and transformed since 1940. In 1940 the only rule the scientific world was aware of (and the non-scientific world was hardly even aware of the scientist at all) was to teach, to do research, to announce and publish the results and discuss them with others.

In 1955 the scientist also faces other tasks. Yet one of the great dangers of 1955 is that the scientist himself will forget that his primary functions are still to learn, to teach, to experiment, to seek understanding, to discover ignorance and errors, to gain new ideas and then to challenge them, to prove or disprove them; and always to exchange ideas with others—fully, freely, honestly, vigorously.

This *is* science. This is its mechanism of operation, of advance. This is the way, the only way, it uncovers the truth. Whatever else may happen, whatever other demands may be made or restrictions imposed, these mechanisms of free inquiry are essential to the pursuit of knowledge and the advancement of understanding; they can never be forsaken if science is to survive.

Of course, no one of consequence actively or explicitly opposes the advance of science. But there are many who, through ignorance or absorption in other matters, exhibit little interest in resisting the forces which are eroding away the base on which a free and thriving science rests. There are many fearful souls who believe that science is moving "too fast." There are those who are unaware of the nature of free inquiry, but who yet can participate in destroying it. The power to protect science lies no longer solely in the hands of scientists or even of those who understand its methods and aims.

We can see in retrospect that basic science in the universities of America was, before 1940, in a position which might be described as one of "respectably independent poverty." Needless to say, the hope has been

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expressed that we might have lost the one without losing also the other. We have, indeed, lost most of the poverty; the independence is still in the balance.

World War II brought to the attention of the American people the fact that science was of vital importance to national security and hence should be more adequately supported. Both private and public support have largely increased. However, the scientist worries because the increased support of science has come about partly for the wrong reasons. The nature of the support is thus unbalanced. Hence, the conditions sometimes imposed are unrealistic. Consequently, there is fear that if unrealistic expectations are not fulfilled, if improper conditions are resisted, a part of the machinery may fail and disaster result.

The weak point is, of course, that basic science is being supported primarily—or at least entirely too much—because of its potential military value.

Now I would be the last one to deprecate the military value of science, or the importance of the military objective. The military strength of the nation is absolutely vital to the survival of all freedom—including the freedom of science. A strong, free science is absolutely essential to military security. At no time in the past 15 years have I personally not been engaged in some activity aimed at bringing scientific resources to bear on the nation's defense problem. And I have nothing but admiration for the way in which most military agencies have carried out their activities in support of basic science.

Nevertheless, if the sole reason for support of science is the military one, we have real reasons to be concerned. What are these reasons?

In the first place, under such conditions research activities not having clear relevance to military problems will be neglected; vastly important areas of science will thus suffer.

Secondly: As, or if, military needs are reduced or budgets cut, then research funds will be cut in proportion; indeed, in order to conserve ready fighting strength, the cuts made by defense agencies in research allowances will be relatively large.

Thirdly: Military activities involve secrecy; and secrecy in basic science is a dangerous and subversive influence.

Finally: To label basic science in terms of any specific practical end is to misunderstand and distort its whole spirit and purpose. Basic research means exploration of the unknown. Since what will be discovered in an unexplored field is, by definition, unknown, the practical consequences cannot be foreseen, and we must not pretend that they can be.

Basic science

It is my conviction that basic science is one of man's highest and most noble and most successful intellectual efforts; its activities are among the highest achievements of the human spirit. The advances in scientific knowledge during the past 300 years have laid the basis for the whole pattern of modern industrial civilization. At the same time, I believe that even without such practical results the pursuit of knowledge is valuable in itself; for it liberates the human mind from ignorance and consequent fear. Knowledge is good for its own sake. In addition, it helps us to live better lives—and, incidentally, to improve our military strength.

The support of basic science then, if it is to be stable, useful and stimulating, must be based on a full and not a partial conception of science's values.

Please note that I am not arguing for a reduction in support of science by military agencies. Rather, I wish to advocate increased support by other agencies and increased understanding by everyone.

Not all scientists are engaged in doing basic research —or are occupied exclusively with such work. Many brilliant and well-trained scientists have, especially in recent years, chosen careers in applied science. Many others give a portion of their time to applied science and during World War II of course, most scientists left their basic science entirely to engage in war work.

This response of scientists to patriotic duty has, ironically enough, been a primary cause of misunderstanding of the role of science and scientists. Because scientists left their science to help develop weapons, many people have concluded that science is the development of secret weapons; hence, that science is secret! Nothing could be further from the truth. Science is the search for knowledge. The first and primary thing one does with a new discovery in science is to *publish* it. This is absolutely fundamental and absolutely essential. Only when it is available to all other scientists does it become a part of the structure of science. And only when it is published can it be openly examined, criticized and tested to find out if it is really *true*. A piece of structural steel may be nice to look at, but it does no one any good until it becomes a part of a structure—a building, a bridge or a ship. Isolated bits of knowledge tucked away in a private notebook are not science. But when published, tested and related to other knowledge, that notebook entry may be of great importance.

All of this is in sharp contrast to the business of inventing military weapons. It is true that scientists have proved to be pretty good inventors. Some devote full time to it and others part time. But the design of a new secret weapon is tested and made useful *not* by publishing it, but by *making the weapon* and seeing how well it works. There is no point in publishing the design *before* making the weapon. If the weapon works, you will certainly not publish it and give it to potential enemies. If it doesn't work, there is no use publishing it at all.

This all seems very elementary to a scientist. Yet there are many people who really believe that because scientists habitually publish their scientific findings, *therefore* they are not good security risks because they will probably want to give away weapon secrets. This is like saying that anyone who can *talk* is a poor security risk because he might talk about secret things!

The curtain of secrecy

As far as I know, no American scientist has given away any secrets. It seems clear then that scientists understand this whole problem very well. All they ask is that the public understand the difference between weapon information and scientific information so that the curtain of secrecy which properly surrounds the first will not be improperly extended to cover the second. It needs to be repeatedly emphasized that what the German-born Klaus Fuchs was convicted of in England was not giving away scientific information, but giving away information on the design and manufacture of weapons. That was treason, which no one excuses or condones.

Possibly the distinction between open scientific information and secret weapon design information can be made clear by an example in the field of radar. Radio waves were discovered by Hertz in 1887. He discovered how to produce and detect them and he found that they could be reflected from various objects. He published his results. Marconi used these results to develop wireless telegraphy. For the next 50 years thousands of people experimented with radio waves, measured their velocity, learned of their behavior, designed equipment to generate and detect them, exploited them as tools of science and of technology and published the results. It never occurred to anyone—and doesn't occur to anyone today—that any of this should be secret.

But in 1937 and 1938 some engineers in the United States and in England evolved an idea of how to use radio waves to detect hostile airplanes. The device was built, was tried and it worked. Here was a military weapon—and, obviously, the design was not published. All those concerned, scientists and military, saw that this new device was an important military secret. Not until years later, at the end of World War II, after thousands of soldiers and sailors on both sides had used such equipment, was there anything published about radar. After the war, a great deal about it *was* published, because it was clear that there were many possible peacetime applications. But even today, though the general science and technology of radar are "unclassified" and freely published, the designs of certain military equipment are still secret—and properly so. But, because the design of the radar bombing equipment on a B-52 is secret, it does not follow that all the science and technology of radio and radar are also secret.

In the radio field there is usually very little difficulty in deciding where the boundary lies between secret and non-secret. The layman is quite willing to leave the decision to the experts.

Neither is there any argument about the open nature of the science and technology of metallurgy; we do not keep secret the properties of steel simply because secret types of guns or tanks or ships are made of steel.

Nevertheless, for many years after the first atom bomb, there did exist in many quarters the delusion that now *atoms* were secret—or at least atomic nuclei were. Physicists, of course, had been publishing results in the field of nuclear physics for 30 years before 1945. That is the reason there *was* a science of nuclear physics. Yet there were even misguided attempts in 1946 to "classify" material which had actually been published many years before!

Open science and secret technology

Nuclear physics was a field relatively unfamiliar to the public—and to Congress and the military agencies—and because the atomic bomb was clearly a weapon of such commanding importance, it was natural that there should be some confusion for a time as to where the boundary lay between open science and secret technology. For a while there were warm battles. Scientists who wanted science kept open were falsely accused of trying to give away weapon secrets. Military and government officials charged with guarding our weapon secrets were falsely accused of trying to destroy science. However, reasonable men eventually came to agreements. And though the boundary between them—like the boundary between the East and the Middle West—is still hazy, it is, nevertheless, obvious that even a hazy boundary can separate two large areas within each of which no arguments can arise.

Fortunately, the fact that it is now becoming evident that atomic energy will some day have a substantial dollar value to American industry is stimulating a more widespread agreement on the desirability of openness in the field of nuclear physics. Apparently the dollar can open gates that the scientists' earnest pleadings had failed to budge! Industry knows that rapid progress in science and technology is impossible under secrecy. Free enterprise and competition are as important in the intellectual field as in business. Now that it is clear that the Russians have learned from nature the same "secrets" we have learned about atomic nuclei, the reasons for being so fearful of our former "secrets" have largely evaporated.

It may be too much to expect the public to grasp the idea that secrecy does not necessarily keep things secret. This is not because there may be spies. It is because the secrets in science and technology are wrested from nature. And nature gives the same answers on both sides of the Iron Curtain. All that our secrecy can do is to slow down the enemy's progress. Since it also necessarily slows down our own, the relative risk or advantage is often difficult to weigh. Again the public must be willing to trust the decisions made by the experts.

These relatively soluble problems I have been discussing lead inevitably into other problems which are not easily solved—or at least have not been solved. The first of these is the matter of personnel security.

Personnel security

As long as scientists are called upon to engage in weapons technology, there will be *real* reasons for worrying about who can be trusted with secrets. As long as there is the illusion that science itself is secret, there will be also *false* excuses for so-called "security" measures.

We need not waste time on the false issue—even though it is a serious one. In the non-secret areas of science, security cannot be a problem or an issue; hence real personnel security questions cannot arise. If they do arise, they are false issues and should be exposed as such. It just doesn't make any difference what the political affiliations are of the man who finds the cure for polio. In fact, I would be in favor of offering a handsome bonus and a fine salary to any Russian scientists who will escape from behind the Iron Curtain and come over and help us solve this and other problems in the field of public health and other non-secret areas of science and technology. I would keep a close tab on any Communists around, but I surely would like to pick their brains! And I would surely like to deprive the Soviets of the benefit of their talents.

But there is a *real* issue to be dealt with. How *are* we going to determine who can be trusted to work in the areas of weapon technology where there are secrets to be kept?

The process which the appropriate authorities go through to determine whether a given individual is to be trusted with secrets is called the "clearance procedure"—"investigation," or collecting information about the individual, and "evaluation" of this information. The evaluation may be by a person or a committee. The "file" does not always indicate the degree of reliability of the various pieces of information; its reliability is indeed often unknown. But the evaluator must decide from the information available whether the individual should be "cleared" or not.

Now just what is the evaluator really trying to decide? What criteria does he use in weighing the significance of the various pieces of information? The latest information I have seen lists 21 such criteria for denial of clearance. Naturally, clearance is denied to one who associates with Communists. But how serious is a casual association with one Communist? or a former Communist? or a suspected Communist? A habitual drunkard or pervert would be a serious risk. What about the occasional drinker? Does one expect that a cleared person shall be wholly without sin or blemish? Is a security clearance the same as a character certification? One criterion for denial is "any behavior, activities or associations which tend to show the individual is not reliable or trustworthy." What does that mean? And what about the organizations an individual has belonged to? Does it matter *when* he belonged? Why he belonged? When or whether or how he quit? What about doubtful or disputed information? Shall the word of any unknown informant be given more weight than the sworn statement of the man himself?

The answers to these and many other questions are exceedingly vague. Some are unanswerable. We must realize, in fact, that by the very nature of the problem such criteria cannot be laid down and adopted once and for all. Conditions change. In 1942 a Communist was, presumably, less of a risk than a Nazi. When a war is on and lives are at stake we are, oddly enough, willing to take more of a risk in order to get the job done quickly. People who served competently during the war were disqualified later from classified work. The very term "risk" itself implies a danger not fully defined.

Security risks

The fact is, of course, that every human being is some security risk. No one is perfect; no one is immune to being deceived or blackmailed or tortured into giving information; no one is certain never to commit a slightly careless act in handling secret material. (After all, perfectly decent people are sometimes careless enough to break their own necks!) Very often the question of the best way to guard a secret is a matter of delicate judgment in balancing risks; even the best person makes mistakes in judgment.

At the same time there are urgent jobs to be done. If we trust no one with secrets, then there will be no secrets—for secrets are invented in the brains of fallible human beings. If we disqualify every competent but slightly "imperfect" scientist from working for the government, then we shall surely fail to survive as a nation in the modern world. For scientists are essential and few of them are wholly "perfect."

This is especially true if the definition of perfection includes the requirement that we have never known—or "associated with"—the "wrong" people.

There is a crying need today for a reformation of the concept of a "security risk." Not all character blemishes should be included in a term which clearly implies in the public mind either disloyalty or at least inexcusable ignorance or carelessness. You may fire a man convicted of petty larceny; but you should not call in the security board. We must also formulate the criteria for judgments in security risk cases; clarify the significance of "associations"; define the criteria for admissibility of derogatory evidence. All the appeal procedures and review boards in the world will be to no avail if no one knows what is being decided or what the rules of evidence are.

Security procedure

It is often said that security procedures may be justifiably arbitrary because in any case "federal employment is a privilege, not a right." As far as most scientists are concerned, it is *neither* a privilege nor a right but only a burdensome patriotic duty. As far as selfish desires are concerned, most scientists would prefer not to work for the government. Often they aren't paid at all for their advisory services. Scientists are scarce, especially the really good ones that the government so often needs. The government ought to be out offering positive inducements to them. Often the services of a valuable man can only be obtained for a short period or on a part-time basis. Why waste most of the period on unnecessarily elaborate security clearance procedures—especially if he has already been cleared by other agencies a dozen times before? Yet we do. A prominent industrial engineer in charge of a large, new, and terribly important development program recently told me that the primary cause of delays in the program had been the security clearance procedures. What a perversion of the concept of security! We would prefer not to have an important new weapon at all than to have it invented by someone of whom some security officer doesn't approve!

Now I do not want to be misunderstood. There *is* a danger of losing classified information and we must adopt reasonable precautions. There is also a danger of losing the technological race for military security. We need to find a balance between these two risks—a balance which is more advantageous to the total safety of the United States.

I turn now to the subject which is at the heart of the problem of scientific leadership in modern America, the question of just what are the tasks, the duties, the functions of a scientist in America in 1955. Just what does the nation need from, and what can it expect of its scientists? A clear understanding of this question will do much to clarify the other problems we have been dealing with.

There are about 50,000 scientists in the country, plus about 200,000 engineers, working in universities, in industry and in government. Wherever they work they may be doing basic science, or either military or non-military applied science. In universities the emphasis will be on basic science, though universities also carry on or manage applied science, including military projects. In industry and in non-military government agencies the emphasis is on non-military technology, though industry carries also a large load of military development; especially in aeronautics, electronics and atomic energy.

A young Ph.D. in physics or electrical engineering, for example, may choose any of these various careers. His financial rewards are the greatest, both at the start and in the future, in industry. His freedom of choice of research fields will usually be greatest in a university. Patriotic motives may attract him to a government laboratory. There the starting salaries are moderately good, but the ultimate ceilings are lower than in either industry or university.

But the patriotic motive may attract a man to military projects in industry too, or even in some universities. What then do the government military laboratories have to offer the bright young graduate? To tell the truth, they are not in a good competitive position at all. Some individuals will be attracted to them by geographic factors; others will have a special interest in a particular line of work (for example, radar). On the other hand, civil service rules and security rules constitute fairly effective repellents. Hence, with a few notable exceptions, the government laboratories do not secure the top-grade young scientists. (The Atomic Energy Commission laboratories come in a special category. They are all operated under contract, outside of civil service, and they offer unusual appeal because of the glamour, the newness, the intrinsic interest and the importance of the field.)

Here is a major problem for the government: How to make its own military laboratories more positively attractive to the best young scientists and engineers. In view of complex government red tape, the rigidity and inappropriateness of many civil service and clearance procedures, the problems of fluctuating budgets and unnecessarily rigid purchasing, reporting and hiring procedures, it is doubtful whether there is much hope that the government will regularly attract the best brains of the country into its own establishments.

Attracting the best brains

But why shouldn't we have the best brains working for national security? A Congressman who has just exhausted himself to be elected to a government job cannot believe that some people don't *want* government jobs; hence, he sees no necessity for trying to make them more attractive. As a result, a scientist will be far better off, far freeer and just as patriotic in accepting a job with industry or a university.

My suggestion is then that the government, in the future, contract this task of military research to private organizations who know how to attract good people. Weapon evaluation and test centers and field stations must, of course, be operated under military command, but weapon *research* is a civilian job and had better be done under private auspices.

Whatever is done here, however, it is evident that the government today actually uses the services (directly or on contract) of some 50 percent of the nation's scientists and engineers. That many are required for the work of research and development and engineering of military weapons, atomic energy, public health, agriculture, standards of measurement, and other direct scientific functions of the government. This is clearly a vast change from prewar days—days when possibly only 10 percent of the nation's scientific strength was so required. Furthermore, the 50 percent not directly engaged in government service are still serving the country in direct and indirect ways. They are uncovering the basic knowledge which is essential to future welfare and security. They are increasing the nation's technological strength, its industrial productivity. They stand, furthermore, as a ready reserve, able to turn quickly to the more pressing tasks of war when that becomes necessary.

Encouraging the best brains?

With this great army of scientists, engineers and scientific workers—in every field of science—working so continually for the public welfare and security one might ask what steps the government has taken to insure that these men are effectively used; that more are being educated; that the results of their work are made available promptly and are intelligently employed; that national policy and planning keep step with the rapid advances in both peacetime and military technology.

The answers to these questions are not very encouraging. I will mention only a few examples of ungenerous or misguided attitudes:

1. The National Science Foundation has been given inadequate appropriations, yet it is the only government agency dedicated to the support of science for its own sake (rather than for its military or other direct value).
2. There have been many sweeping and false accusations in government circles of disloyalty or spying by scientists, thus breeding distrust and fear, and repelling scientists from government work.
3. Selective Service policies and procedures, though they give lip service to the importance of scientific strength, actually make little effort to see that men of talent are effectively used. The draftee in uniform has only a small chance of employing any scientific talents or training he may have—even though a military laboratory a few miles away might have been delighted to hire him.
4. An official report of a Congressional committee labels as subversive the activities of some of the great foundations which have been mainstays in the support of science for many years. Even though the report is so outrageously false as to be promptly discredited,

it hardly encourages the formation of new foundations or the continued enlightened support of pioneering scholarly activities by private funds.

Now all these and many other examples of government ineptness or failures in encouraging science can be traced to a lack of any machinery—indeed the lack of any desire for machinery—to bring scientific advice to bear in the policy-making agencies of the government. It is true that the military agencies have quite generously provided themselves with scientific advisory committees to assist with the planning of research and development programs. Scientific teams have been assembled to carry on "studies" of national defense problems in which new weapons and techniques were important. Some of these studies and committees have been spectacularly successful. Some of the "operational research" groups have also successfully brought scientific and analytical techniques to bear on military problems.

All this is fine but it is not enough. In these days when the whole military posture of the country—and consequently its whole foreign policy—is based on military weapons and techniques and on industrial transportation and communication technologies which existed, if at all, only as laboratory curiosities some 15 or 20 years ago, it might be expected that a deep understanding of these technologies should be found somewhere in prominent places at high levels of government. Do we find it?

Scientific resources

There are of course hundreds of scientists and engineers directly employed by the AEC, the Department of Defense, the Public Health Service, the National Advisory Committee for Aeronautics, the Smithsonian Institution, the National Science Foundation. Surely no national government in the world is so richly equipped with scientific resources.

And yet a couple of years ago the head of the National Bureau of Standards was suddenly dismissed because of the allegation by a small manufacturer that his product had not been "objectively tested." The charge was later investigated (why not before?) and disproved, and the director was reinstated—but not before the world's finest laboratory of standards had been shaken to its roots, its morale shattered, and an untold number of valuable man-years of effort wasted in putting things together again. Does the government *have* to insist that working for it shall be unpleasant and distasteful?

The Public Health Service has rendered enormous aid to medical research by its unclassified research grants to universities and medical schools. But because of fear of a Congressional committee, it eliminated from its list of grants the names of certain research workers about whom questions of political conformity might be raised. (No Communists were involved.) The men eliminated were usually not informed as to why their admittedly valuable work no longer merited support—or why the support had to be given in the name of a co-worker or assistant. It has never been explained why politics should encroach upon non-secret medical research or be a test by which universities shall be deemed worthy of encouragement. These "administrative decisions" of the Department were opposed by almost the entire scientific staff of the Public Health Service; but the scientists were apparently not consulted nor their advice followed.

In a very different field: There exists no regularly established mechanism whereby the scientific talent employed by the AEC can be brought face to face with national policy problems which depend critically on our atomic strength. Those who create our atomic weapons and who therefore, presumably, best understand them are not brought into the high councils of government when the impact of these weapons upon national policy is being discussed. It is true that when need for technical information becomes apparent it can be asked for and, after filtering up through a few layers of non-technical officialdom, it is brought into the high councils—at which point it is often disputed by someone who has heard a different story from *his* experts. But why does not Congress have its own scientific advisors? Why doesn't the Cabinet? The National Security Council? The Department of State?

Scientific advice

It may be simply that it is too new a thing that highly technical matters which are not easily reduced to non-technical terms may have a decisive effect on a nation's affairs. Problems, ranging from the question of whether to draft scientists to whether tactical A-bombs could be effectively used in a small war, are being debated without full access to the scientific facts—without, indeed, any realization that such facts may be important. Worse still, when such facts are brought forward by men of competence they are often ignored, because anyone who knows what he is talking about "must clearly be prejudiced." "Anyway," it is said, "scientists should stick to their knitting." They "should be on tap and not on top." (When was one ever "on top"?) One senator recently suggested that scientists had no business expressing their views on the immigration laws—even to point out that these laws are sometimes used in a way to keep top foreign scientists from visiting the United States and thus to weaken our scientific strength.

I believe scientists themselves are partly to blame for this situation. We ourselves have not been able to devise a suitable mechanism whereby the best and most balanced scientific thought of the country can be focused on the country's most important problems. We must find such a mechanism. For problems of large technical content cannot be satisfactorily solved by Gallup polls or even by the election returns. They can be solved only by intelligent leadership which is democratically chosen, and then given the full support of the finest brains and the finest and most broadminded citizens of the nation.