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WHAT SCIENCE REQUIRES OF THE NEW WORLD[1]

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Fellow Americans:

PERMIT me to say a word first to the members and affiliates of the American Association for the Advancement of Science, whose number approaches a million.

Once more, because of the rigors of war, we have found it impossible to hold the annual meeting that has been our tradition for almost a century. My own colleagues, as typical members of our association, are this afternoon in their laboratories, engaged as devotedly as any member of the armed forces in the effort to preserve our country's freedom. Yet the world comes to us as representatives of science with searching questions. We must pause to give a considered answer. "This is a war of science and technology," they tell us. "Do the forces of freedom have the knowledge, skill and technical resources needed to bring victory?" "After the war is over how will science have changed our world?" The nation asks us, "What of the night, and what of the day that is to dawn?"

Unconditional answers to these questions can not be given. Yet it is possible to say something about the present balance of scientific power and to point the direction in which science makes it necessary for the world to move.

I have accordingly chosen as my subject for to-day, "What Science Requires of the New World." For science is not only a servant; it also gives orders. There is a legend that Daedalus, the Greek hero who first learned how to work with steel, toiled long and hard with his forge and anvil to fashion a sword. This he presented to King Minas to replace his old one made of bronze. The citizens of Crete came to him in consternation. "This sword will not bring us happiness," they complained, "it will bring us strife."

[1] Address of the retiring president of the American Association for the Advancement of Science, January 1, 1944.

"It is not my purpose to make you happy," replied Daedalus. "I will make you great."

Science is the steel of Daedalus. His sword is the weapons we are fashioning with the aid of science. As his steel, so likewise science brings new social conflicts and changes in treasured traditions. But also like the steel of Daedalus, science is compelling man to follow the sure road to a greater destiny. Let us try to catch a glimpse of this new world that science bids us enter. Can we attain a stable peace? In the post-war world, what changes in our mode of life does science demand?

First, let us note that science affords real hope for a stable peace. We find ourselves in a world conflict with the mighty powers of science strengthening the arms of both contestants. "A hundred physicists in this war are worth a million soldiers." This oft-quoted statement was made by one of our leaders early in the struggle. Consideration of the military significance of radio, magnetic mines, methods of submarine detection and a variety of new weapons which the physicists have initiated or developed indicates that this estimate may not be greatly exaggerated. With equal justification, however, one might have singled out the vital contributions to the war effort made by research in chemistry, mathematics, immunology, aerodynamics or some other field of science and technology. We have learned that knowledge is strength, and that intensive scientific research is the only way of supplying certain types of knowledge that are essential to waging modern war.

The fact is that science and technology are now spending extraordinary efforts on supplying means of destruction and methods of protection against attack. At first it was our enemies who had the scientific advantage. This was because for a prolonged period the Axis powers had been making extensive scientific as well as military preparations for the war. There is evidence, however, that in most fields of military operations our technical advances are now coming more rapidly than are the enemy's. When added to our overall industrial advantage and our superiority in supply of materials and men, if this scientific advantage can also be maintained, there is little room for doubt of the success of our armies.

We do not discount our opponent's strength. We know the high quality and resourcefulness of his scientific and technical men. We accordingly expect reverses as well as successes. Yet the Allied Nations are in a superior position with regard not only to availability of materials, industrial capacity and numbers of fighting men, but also with regard to scientific and technical strength. Because we have this strength, and are determined to preserve our freedom, we may lay our plans for the future on the assumption of victory.

When peace has then been won, can the world be kept stable?

Let us assume that the United Nations have gained a complete victory. All indications are that the world will still be actively war-minded. However successful may be our armies and the efforts of the negotiators of peace, a great conflict such as the present war will leave many wrongs unrighted and large groups of people resentful at their fate and filled with fear and hatred toward their neighbors. Weapons of destruction are being developed of hitherto unheard-of power. No one can consider the armadas of mighty bombers, with flying range to reach any target, and the increasing amount of destructive bombs they carry, without fear of a yet more disastrous war to come. There will be a nation smarting under the restrictions placed upon it and ambitious for power. What will prevent it from welding these weapons into a war machine with which it will snatch the mastery of the world?

The only answer to this threat is preparedness and vigilance by the powers in control. Preparedness and vigilance have always been the price of continued peace. What science and technology have brought into the picture is a change in the type of precautions that must be taken. Improving the chance for stable peace is the increasing time and magnitude of the preparations required to wage successfully a modern war.

Consider what is needed to exploit the power of airplanes. Here is a weapon whose development and production strains the technical resources of the greatest nation. The same is true of the factories that would build tanks or the laboratories that would develop electronic devices superior to those of an ingenious and highly skilled enemy. It is one of the great safeguards of the stability of modern society that the weapons with which wars are now won are the product of cooperative research and manufacture on so large a scale that the effort can not be hid. If precautions to maintain peace are to be taken, we must assume the establishment of a world policing system with power to learn what nations are doing that may constitute hazards to the public safety, and determination to stop unlicensed building or accumulation of arms. The large scale of modern military preparations makes such policing much more practicable than was true before technology became the basis of military power.

But, we are asked, can not some new weapon be developed secretly on a small scale which is nevertheless so powerful that those who hold it will have the world at their mercy?

Here again the trends of modern science give us considerable assurance. More and more the major inventions and industrial developments are the result of the cooperative efforts of large groups of research

men. An idea may emerge in the mind of a lone inventor, but it passes through many hands before it is ready for use. Also, parallel developments by competing groups are the rule. It is rare indeed that a completed new industrial development catches the world by surprise. If this is true in industry, it is yet more unlikely that the balance of the world's military power will be upset by an idea kept secret from a vigilant enemy. To be of conclusive military significance not only must the idea be perfected; the new weapon must also be adapted to industrial production and be manufactured on a major scale. But such a development is difficult to hide. In spite of airplanes and radios, the world is still a big place, and a weapon that would conquer the world must be ready for widespread use. If we are alert we should know of any new military development of this kind before it has become a hazard to nations organized to protect the public safety.

One of the most necessary aspects of vigilance is the active cultivation of science. Not only is science the foundation for present military developments; it is also the means of opening up of new possibilities. It is an absolute "must" for a nation that would maintain its place in a warlike world that it shall keep its science in the front rank. The possibilities of present and new ideas of military import must be explored to be sure no competing nation will gain the advantage of being first in the field. Only by maintaining an active body of scientists can the foundation be laid for a strong military structure when it is required. Stability and peace in the new world thus can not be ensured unless the dominant world power keeps up a vigorous and continued growth of science.

Equally essential to military superiority is industrial strength, factories accustomed to doing large tasks rapidly, sources of raw materials and good communications. These are the tools that will make effective use of the ideas developed in the laboratories. Possession of large armies, navies and air forces are needed to start a war, but if the struggle is prolonged mere accumulation of such forces can not bring victory. Ultimate fighting power depends rather upon knowledge and facilities for building this knowledge rapidly into weapons as best fitted to changing conditions. Careful attention must thus be given to both the scientific and the technological foundation of military might.

The net result is that with the use of a world police force of a feasible size, it should be possible for a dominant governing body to maintain a stable peace in the new world that science builds. In spite of mighty new weapons that may tempt some ambitious leader to try again to snatch control of the world, the need for vast scientific and technical development to produce such weapons gives a stability adequate for a vigilant governing power to keep the peace.

So much for the *negative* side. We have seen that in the world that science is shaping an alert government should be able to prevent serious wars if only it will maintain the strong science and technology that are the basis of modern military strength. What now of the *positive* side?

Scientific men are becoming increasingly conscious of their social responsibilities. They begin to realize more clearly the tremendous human implications of the forces which their investigations are introducing. A parent is eager that his child shall contribute something worthwhile to society. So the scientist is eager that his science shall work for human welfare. He sees vast new possibilities for betterment of life, and he is impatient to see these possibilities become realities. More and more those concerned with science are endeavoring to ensure the wise use of the products of science.

But I am not concerned to-day with what we as members of the American Association for the Advancement of Science may *want* our sciences to do for humanity. I would call attention rather to those changes in society which growing science and technology make inevitable. I am not referring to new gadgets or improved standards of living, nor even to better health and longer life. These are the obvious and direct results of applied science. We know they will come as science continues its task, and they are welcome gifts, indeed. But I am thinking rather of the inescapable trends that follow the principles of evolution. Only those features of society can survive which adapt men to life under the conditions of growing science and technology.

There are three such features which I shall use as examples. These are (1) increasing cooperation, (2) better and more widespread training and education, and (3) rise of commonly accepted objectives toward which society will strive. Note that such changes mean growth to greater manhood. That science makes them inevitable was what Daedalus meant when he said his steel would make men great.

Finding ourselves then in a stable new world, how will the conditions of life be changed?

Perhaps the most significant change in the life built by science and technology will be the increased organization of people into larger groups concerned with performing common tasks. People will become yet more specialized, and consequently will be increasingly dependent upon each other.

H. G. Wells has called attention to a remarkable example of evolution, in which during the short period of a thousand generations an organism has been observed to change from an individualistic animal like a

cat to a social animal like a bee or ant. He refers, of course, to man, who twenty-five thousand years ago lived in caves with his loosely bound family, and now lives in vast communities in which each works for the group and depends upon the other for most of his means of living. Here is evolution in progress—social evolution, if you please—man becoming civilized.

My present interest in this process is that the chief forces bringing about the socialization of mankind have always been those of increasing knowledge and techniques, of which the characteristic present-day representatives are science and technology. For thousands of years each village has had its butcher and baker and candlestick maker, specialists in their trades who supply others with their wares. The scientific age has greatly increased this specialization. It is not enough now to be a chemist or an engineer; one becomes an organic chemist specializing on long chain esters, or an electrical engineer specializing on echoes of short electric waves. The nation needs this special knowledge, and supports the few who have it by the efforts of millions of others. In fact, the world itself is not too large a unit to support and use effectively the work of such specialists.

Were it not for technology, by which the work of each person is greatly multiplied through use of power machines and methods of mass production, the work of many highly specialized individuals could not be supported. Were it not for science, which has made possible such developments as steam engines, airplanes and the radio, there would be no markets of continental extent which absorb technology's mass production. Combining the specialization of science and the mass production of technology, a society is built of unparalleled richness and strength.

A noteworthy feature of this modern society is that its strength depends to an unprecedented extent upon the cooperation of its members. Since the specialist can live only through the help of others, cooperation is the corollary of specialization. We have learned that the automobile demands sobriety, and that congested life in a city requires careful attention to sanitation. Similarly, we are now learning that life in the world built by science and technology is possible only with widespread cooperation.

In the fight for survival by various forms of society one sees the evolutionary process operating in full force. During times of stress weaker societies are absorbed or replaced by stronger ones. Cooperation thus becomes essential to the survival of any social régime.

Effective means of securing cooperation accordingly becomes a major objective of political systems. Breakdown of cooperation in the ranks of the enemy becomes a most useful method of weakening an enemy in wartime. Replacing a monarchy with a democracy, introducing the military rule of fascist dictators, rallying a nation to support of a communistic state, all are examples of attempts to secure a more effective basis for cooperation in the common tasks of society.

The first essential in securing widespread cooperation is to develop a widespread desire of people to work together. Several methods of securing such will to cooperate are effective. The most certain is to present people with a common danger, such as attack by an enemy. It is this that has built a nation out of the Chinese people, and that has made the strength of our nation grow beyond our dreams during the present conflict. Another powerful method is to present the group with an inspiring objective. Thus Hitler calls to the Germans to make of themselves a master race, Lincoln challenges his countrymen to strive "that freedom shall not perish from the earth." With such an ideal men and women lose themselves in working for the common cause.

But also in the more prosaic periods of normal, peaceful life the cooperativeness of a community depends upon having common interests. If specialized science requires cooperation, cooperation in a society of free people requires the will to work for the common welfare. "Without vision the people perish" applies with tenfold force to the modern world. Whether this vision comes from the loyalty bred of a common danger, from political or economic expedience, from philosophical principles or from the inspiration of religious teaching, the will must be there. Otherwise the inhabitants of a specialized community can not obtain their needs without conflict, and the great advantages of technological society have turned into tragic liabilities. Science thus requires of the new world that its people shall want to work together for the common good.

Let us note further that the extent of the social unit in which this cooperation occurs is being increased rapidly by science. Typical of the forces working in the direction of expansion is the radio. Its music, stories and news are heard over large areas. The radio advertisements make possible the sale of products over a market of continental size. As a result the optimum size of a strong political or economic unit is rapidly growing. Eighty years ago our country was almost split asunder by divided interests. Now its continental size gives great advantages in both industry and government, and the divisive forces are lost amid the concern with mutual trade and the technical and military strength that comes because the country is big. Science itself is as extensive in its interests as the human race. So also is religion. Nations may try to make themselves

self-sufficient, but this is in the interest of security as opposed to an advantageous economy. Economic considerations alone would make trade extend freely throughout the globe.

The advantages of such global extensiveness are evident in the British empire, and to lesser extent in our own country. A phone call to a distant city brings at once the information needed to complete a design. Tools for an emergency repair are flown across the continent. An international misunderstanding is quickly cleared by flying a statesman ten thousand miles across the sea. Pictures and stories and songs representing the life of one people become familiar to all the world. Such are the forces with which science is drawing the world together into one great community. The fate of the world from here on is a common fate.

It is the American men and women of science who are pioneers in shaping this world community. In no other part of the world is life so dependent upon the products of science as among ourselves. This is clearly demonstrable in terms of the number of kilowatts or of radios or of tons of steel or gallons of gas or telephones per capita. People in other parts of the world look with dread to the time when their lives will be altered by technology. It will upset their ancient customs. Things long cherished will disappear and be replaced by things new and strange. We do not dread science and technology; it is natural to us as a part of our lives. Of necessity the world must look to America as the pioneer in finding how to live a satisfying life in a society based on science.

Amid the standardized products of mass production, how are the ultimate values of individual life to be attained? How can we best cultivate the spirit of mutual helpfulness so highly important for a satisfactory life in a technological régime? What type of education will fit citizens for a useful and satisfying life in such a world? We in America face these questions first and in their most acute form. We who represent American science are those who have perhaps had most first-hand experience in hunting for the answers. The world looks to us to point the way.

One thing we have already found is that technology and science place unprecedented value on education. The use of steam and electric power has decreased the need for common labor, while growing specialization has increased the need for those who coordinate our activities. Skilled labor, however, remains vital to American society for building and operating our machines, and is rewarded with shortened hours and higher pay. Business requires middlemen to handle its varied commerce. Vastly increased numbers of professional men and women have been absorbed in occupations of responsibility which before the era of technology were hardly known. Here we find the engineer, the secretary, the economist, the patent lawyer, the research scientist and many others. Those responsible for planning the work of society have never been so driven by ceaseless demands as in today's America. Reflections of this pressure are to be seen in the multiplication of governmental offices, in the rise of schools of business and public administration and in the growth of the army's staff of supervising officers. The masters of society have indeed become the servants of all, in an unresting labor that knows no release. By emphasizing the need for intelligent direction, and reducing the need for unskilled labor, technology is thus spurring Americans of all levels toward an ever higher standard of training and education.

Most significant, however, of the factors that make life worth while is the vision of a goal that one recognizes as worthy of his supreme effort. Now in wartime Americans find that goal in the victory that will preserve our freedom. When peace comes, what will be the objective that will unite our efforts? Will we be inspired by the new possibilities presented by science for making the world suitable for the highest needs of man? Here is a challenge of a millennium that science presents to religion. For is it not the great task of religion to show us the goals for which we should strive?

But whether we call it religion or humanism or social expediency, acceptable objectives must and will be found. This follows again from the fact that the will to cooperation needs a challenging purpose, and cooperation is essential to the survival of a social system. If we fail to develop adequate objectives our society will be replaced by another that has such objectives. It was Hitler's call to the youth of Germany to lose themselves in the greatness of the German Volk that gave such strength to what had been a sick nation. It was Lenin's challenge of a great new society based on equality of all and the glory of work for the common welfare that has made of modern Russia a mighty power. To Americans the values inherent in freedom had been almost forgotten. We were weak from lack of objective, until the Japanese attack united us to meet a common danger.

Perhaps the great objective for us will be that of the common welfare, as discovered by a hundred million citizens who become educated to the possibilities of common men. Leaders we have, and new ones must arise, who will give us the inspiration of great ideals.

As scientists, it is our primary task to give our country the strong foundation of science necessary for her proper growth. If we can also find for ourselves the way to useful and satisfying citizenship in the society built on that foundation of science, the world will follow our leadership.

To Daedalus, steel was much more than metal for

fashioning swords. It was the means of making men grow to greatness. So likewise science.

We have in science a powerful weapon with which to fight our war for freedom. If the powers in control will be vigilant and will establish a suitable policing system, science and technology are giving us a world in which a stable peace can probably be maintained. But science requires changes in our mode of life. The specialization of our society based on science must be matched by ever closer cooperation on a rapidly increasing scale. Growing attention to special training and more extensive education for leadership is inevitable. Such developments give promise of a truly great society. We are, however, in need of the inspiration of a commonly accepted social objective that will unite our willing efforts.

Never has man had so real an opportunity to master his own destiny. With the new ideas of science, the new tools of technology and the new view of man's place in nature that science has opened, we see ever more clearly how we can shape our world. May God grant us a vision of the possibilities of man which will challenge us to the worthy use of these great new powers.

OBITUARY

HERMON CAREY BUMPUS

May 5, 1862–June 21, 1943

THE long full life of Hermon Carey Bumpus was brought to its close on June 21, 1943, at Pasadena, Calif., the home of his elder son. He is survived by his widow, the former Ella Nightingale, and two sons, Dr. Hermon Carey Bumpus, Jr., and Dr. Laurin Dudley Bumpus.

Dr. Bumpus was bred and educated in New England traditions. He was born in Buckfield, Maine, and reared in Dorchester and Boston. His father was a much beloved Boston city missionary—an unordained pastor, his mother a woman of marked ability and vision, a former teacher.

Nature endowed him with exceptional charm of appearance, and manner, with dynamic, tireless energy and exuberant vitality that lasted well beyond the scriptural allotment of years.

He had a clear mind, wide intellectual interests and an exceedingly lively creative imagination which he relied upon, rather than upon tradition, habit or counsel to direct his course of action. This explains his proverbially direct and original approach to a problem. His own predilection for things which can actually be seen accounts for his confidence in the effectiveness of laboratory work in contrast with the lecture as a means of teaching and for the fact that his really great contribution to education in America must be attributed mainly to his genius for ocular demonstration in the laboratory, the museum and under the open sky.

His instinctive desire to point out to other people what had been discovered took on serious and ever-increasing importance. It inspired his teaching and, when he became responsible for the uses to which great educational resources both in materials and in scholarship were to be put, it became to him a prime moral obligation.

To Dr. Bumpus the mental habits and traits of human beings were important natural phenomena to be accepted and dealt with realistically and sympathetically; this attitude added a fine touch to the quality of his teaching, his museum work and his administration. As a teacher, he was inspiring and simply unforgettable. His methods were original, usually unorthodox, but always effective. His aim was to inspire and orient; it was never indoctrination. His advanced students and his junior colleagues still remember with gratitude how he kindled their enthusiasm and constantly encouraged and generously commended their individual initiative. He was a constant advocate of purposeful research in both the theoretical and the practical fields and he himself worked with equal enthusiasm in either field. As an administrator, Dr. Bumpus was singularly free from a desire for power, personal credit or substantial reward. His heart's desire was to "see things go." He was generous in giving credit to others for the success of mutual undertakings and in assuming blame when things went wrong; yet, when occasion required, he would fight to the last with ardor and enthusiasm for what he considered a matter of principle.

After Dr. Bumpus was graduated from Brown University in 1884, he spent two years there as assistant in zoology, taught zoology at Olivet College for three years, went as fellow to Clark University in 1889, and was the first recipient of a degree from Clark, a Ph.D. He returned to Brown to teach biology in 1890, and during his ten years at Brown he continued his very active teaching, organizing and administrative work at the Marine Biological Laboratory at Woods Hole until 1895. Later, at the U. S. Fish Commission, as scientific director, he restored the scientific features envisioned by its founder, Spencer F. Baird. Then followed ten years at the American Museum of Natural History, of which he became the first director, three years at the University of Wisconsin as the first business manager and five years as president of Tufts College. From 1924 until 1940 he was engaged in