THE NATION AND SCIENCE[1]

I SHOULD like to discuss with you for a few moments certain relationships of pure and applied science research to public policies and above all the national necessity for enlarged activities in support of pure science research.

Huxley was perhaps not the first but at least he was the most forceful in his demand that preliminary to all understanding and development of thought was a definition of terms. Men in the scientific world will have no difficulty in making a distinction between the fields of pure and applied science. It is, however, not so clear in industry or in our governmental relations and sometimes even in our educational institutions.

At least for the practical purposes of this discussion I think we may make this definition—that pure science research is the search for new fundamental natural law and substance—while applied science is clearly enough the application of these discoveries to practical use. Pure science is the raw material of applied science. And the two callings depart widely in their motivating impulses, their personnel, their character, their support and their economic setting. And these differences are the root of our problem.

As a nation we have not been remiss in our support of applied science. We have contributed our full measure of invention and improvement in the application of physics, in mechanics, in biology and chemistry and we have made contributions to the world in applied economics and sociology.

Business and industry have realized the vivid values of the application of scientific discoveries. To further it in twelve years our individual industries have increased their research laboratories from less than 100 to over 500. They are bringing such values that they are increasing monthly. Our federal and state governments to-day support great laboratories, research departments and experimental stations, all devoted to applications of science to the many problems of industry and agriculture. They are one of the great elements in our gigantic strides in national efficiency. The results are magnificent. The new inventions, labor saving devices, improvements of all sorts in machines and processes in developing agriculture and promoting health are steadily cheapening cost of production; increasing standards of living, stabilizing industrial output, enabling us to hold our own in foreign trade; and lengthening human life and decreasing suffering. But all these laboratories and experiment stations are devoted to the application of science, not to fundamental research. Yet the raw material for these laboratories comes alone from the ranks of our men of pure science whose efforts are supported almost wholly in our universities, colleges and a few scientific institutions.

We are spending in industry, in government, national and local, probably $200,000,000 a year in search for applications of scientific knowledge—with perhaps 30,000 men engaged in the work.

I should like to emphasize this differentiation a little more to my non-scientific audience. Faraday in the pursuit of fundamental law discovered that energy could be transformed into electricity through induction. It remained for Edison, Thomson, Balle, Siemens and many score of others to bring forth the great line of inventions which applied this discovery from dynamo to electric light, the electric railway, the telegraph, telephone and a thousand other uses which have brought such blessings to all humanity. It was Hertz who made the fundamental discovery that electric waves may traverse the ether. It was Marconi and DeForest who transformed this discovery into the radio industry. It was Becquerel who discovered the radioactivity of certain substances and Professor and Madame Curie who discovered and isolated radium. It was Dr. Kelly who applied these discoveries to the healing art and to industrial service. It was Perkins who discovered the colors in coal tar by-products. It was German industrial chemists who made the inventions which developed our modern dye industry. It was Pasteur who discovered that by the use of aniline dyes he could secure differentiation in colors of different cells, and this led to the discovery of bacilli and germs, and it was Koch and Ehrlich who developed from this fundamental discovery the treatment of disease by anti-toxins.

And so I could traverse at great length these examples of the boundaries and the relations of these fields of pure and applied science.

There is a wide difference in the mental approach of the men engaged in these two fields of scientific work. The men in pure science are exploring the frontiers of knowledge and they must necessarily do so without respect to reward or to its so-called practical benefits, whereas the men engaged in applied science research have long since demonstrated that it pays in immediate returns. It brings such direct rewards as to generate its own steam mostly through the Patent Office. There is seldom any direct financial profit in pure science research, although its ultimate results are the maintenance of our modern civilization and are the hopes for the future.

For all the support of pure science research we have depended upon three sources—that the rest of the world would bear this burden of fundamental discovery for us, that universities would carry it as a

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by-product of education, and that our men of great benevolence would occasionally endow a Smithsonian or a Carnegie Institution or a Rockefeller Institute. Yet the whole sum which we have available to support pure science research is less than $10,000,000 a year, with probably less than 4,000 men engaged in it, most of them dividing their time between it and teaching.

Some months ago our leading scientists in reviewing the organizations of pure science of the country were discouraged to find that their activities had been actually diminished during the last decade, whereas if these laboratories are to furnish the increasing vital stream of discovery to our nation, and our normal part to the world, they should have been greatly enlarged. Moreover, they discovered that the pressures of poverty in Europe were taking a worse toll of pure science abroad.

The causes in the United States are not far to seek. They arise from two directions: First, 80 per cent. of the men devoted to pure science research with us are in our scores of universities and colleges. Our universities have doubled in the number of their students. Their pre-war endowments and income have been depreciated by the falling dollar. New resources have been given many of them, but not enough to handle their new burdens of teaching. All of this has led them to more and more curtailment and the suppression of expansion in pure science research in order that they might attend the immediate problem of education. Thus the four or five thousand men in the United States who had demonstrated their ability for research of this character are not applying themselves in this direction so much as they are applying themselves to the education of the youth. Teaching is a noble occupation, but other men can teach and few men have that quality of mind which can successfully explore the unknown in nature. Not only are our universities compelled to curtail the resources they should contribute in men and equipment for this patient groping for the sources of fundamental truth because of our educational pressures, but the sudden growth of industrial laboratories themselves and the larger salaries they offer have in themselves endangered pure science by drafting men from the universities. This is no complaint against our great industries and their fine vision of the application of science. It simply means we must strengthen the first line of industrial advancement—pure science research.

These men of pure science are the most precious assets of our country and their diversion to teaching and applied science reduces the productivity which they could and should give to the nation. It is no fault of their own but it is the fault of the nation that it does not give to them and to the institutions where they labor a sufficient support.

There is no price that the world could not afford to pay these men who have the originality of mind to carry scientific thought in steps or in strides. They wish no price. They need but opportunity to live and to work. No one can estimate the value to the world of an investigator like Faraday or Pasteur or Millikan. The assets of our whole banking community to-day do not total the values which these men have added to the world's wealth.

Some scientific discoveries and inventions have in the past been the result of the genius struggling in poverty. But poverty does not clarify thought, nor furnish laboratory equipment. Discovery was easier when the continent was new. Discovery nowadays must be builded upon a vast background of scientific knowledge, of liberal equipment. It is stifled where there is lack of staff to do the routine and where valuable time must be devoted to tending the baby or peeling potatoes, or teaching your and my boys. The greatest discoveries of to-day and of the future will be the product of organized research free from the calamity of such distraction.

The day of the genius in the garret has passed, if it ever existed. The advance of science to-day is by the process of accretion. Like the growth of a plant, cell by cell, the adding of fact to fact some day brings forth a blossom of discovery, of illuminating hypothesis or of great generalization. He who enunciates the hypothesis, makes the discovery or formulates the generalization, and thus brings forth the fine blossoms of thought is indeed a genius, but his product is the result of the toil of thousands of men before him. A host of men, great equipment, long patient scientific experiment to build up the structure of knowledge, not stone by stone but grain by grain, is now our only sure road of discovery and invention. We do have the genius in science; he is the most precious of all our citizens. We can not invent him; we can, however, give him a chance to serve.

And the more one observes the more clearly does he see that it is in the soil of pure science that are found the origins of all our modern industry and commerce. In fact our civilization and our large populations are wholly builded upon our scientific discoveries. It is the increased productivity of men which have come from these discoveries that has defeated the prophecies of Malthus. He held that increasing population would constantly lower the standard of living amongst men until the pressure of subsistence upon population would limit its number by starvation. But since his day we have seen the paradox of the growth of population far beyond anything of which he ever dreamed, coupled with a constantly increasing standard of living. This result would be impossible but for the men

of fundamental scientific research and discovery. In fact there is for the future but one contestment in the race with the principle of Malthus, and that is in pure science. If we would have our country increase in its standards of living and at the same time accommodate itself to an increasing population at the rate of more than 15 million each decade we must maintain the output of our pure science laboratories.

The wealth of the country has multiplied far faster than the funds we have given for these purposes. And the funds administered in the nation to-day for it are but a triviality compared to the vast resources that a single discovery places in our hands. We spend more on cosmetics than we do upon safeguarding this mainspring of our future progress.

But to return to my major theme—How are we to secure the much wider and more liberal support to pure science research? It appears to me that we must seek it in three directions—first, from the government both national and state; second, from industry, and third, from an enlargement of private benevolence. We have long since accepted the obligation upon the state to provide universal and free education. We have advanced it further than any nation in the world. Yet the obvious function of education is to organize and transmit our stock of knowledge—it is not primarily concerned with the extension of the borders of knowledge except so far as the process is educational. It seems to me that we must accept the fact that the enlargement of our stock is no less an obligation of the state than its transmission. As a nation we must have this enlargement of stock if we would march forward. And the point of application is more liberal appropriations to our National Bureaus for pure science research instead of the confinement as to-day of these undertakings for applied science work. And we must have the more liberal support of pure science research in our state universities and other publicity-supported institutions.

Our second source of support must come from business and industry. You are aware of the appeal in this particular from the National Academy of Sciences of a year ago—that they might be entrusted with a fund largely for the better support of proved men now engaged in such research in our universities and elsewhere. It is no appeal for charity or benevolence. It is an appeal to self interest, to insurance of every business and industry of its own future. That appeal has been met generously by some of our largest industries; it is under consideration by others; it has been refused by one or two largely because they have not grasped the essential differences between the applied science investigations upon which they are themselves engaged and the pure science which must be the foundation of their own future inventions. A nation with an output of fifty billion annually in commodities which could not be produced but for the discoveries of pure science could well afford, it would seem, to put back a hundredth of one per cent. as an assurance of further progress.

Nor is the interest of a particular industry confined to the science research which appears on its face to be directly in the line of that industry. Practically all industry and all business gains by scientific discovery in any direction. The discoveries which led to the invention of the internal-combustion engine and thus to the automobile have benefited every industry and every business in the United States. Business and industry have an interest in the common pool of scientific research irrespective of its particular field. Those fundamental discoveries of the germ basis of disease, with the load of mortality they have lifted from the race, have lowered the rates of insurance and thus contributed directly to business.

From benevolence we have had the generous support of some individuals to our universities and scientific institutions, but this benevolence has come from dishearteningly meager numbers, as witness the discouraging results of recent appeals from the Smithsonian—the father of American science—and failure of appeals from some of our universities. In a nation of such high appreciation of the value of knowledge, and of such superabundance of private wealth, we can surely hope for that wider understanding which is the basis of constructive action.

And there is something beyond monetary returns in all this. The progress of civilization, as all clear-thinking historians recognize, depends in large degree upon "The increase and diffusion of knowledge among men." Our nation must recognize that its future is not merely a question of applying present-day science to the development of our industries, or to reducing the cost of living, or to eradicating disease and multiplying our harvests, or even to increasing the general diffusion of knowledge. We must add to knowledge, both for the intellectual and spiritual satisfaction that comes from widening the range of human understanding and for the direct practical utilization of these fundamental discoveries. If we would command the advance of our material and, to a considerable degree, of our spiritual life, we must maintain this earnest and organized search for truth. I could base this appeal wholly upon moral and spiritual grounds; the unfolding of beauty, the aspiration after knowledge, the ever widening penetration into the unknown, the discovery of truth, and finally, as Huxley says, "the inculcation of veracity of thought."

No greater challenge has been given to the American people since the Great War than that of our scientific men in the demand for greater facilities. It is an

opportunity to again demonstrate in our government, our business and our private citizens the recognition of a responsibility to our people and the nation greater than that involved in the production of goods or trading in the market.

HERBERT HOOVER

ARNOLD EDWARD ORTMANN

ON the afternoon of January 3, 1927, Dr. Arnold E. Ortmann, curator of invertebrate zoology in the Carnegie Museum and professor of zoology in the University of Pittsburgh, died in the West Penn Hospital, Pittsburgh, in the sixty-fourth year of his age.

He was born in Magdeburg, Prussia, April 8, 1863. He studied at the universities of Kiel, Strassburg and Jena, receiving the degree of doctor of philosophy in the latter institution in 1885. During 1883 he served for one year in the German Army Reserve and retired with the rank of lieutenant of infantry. He was a favorite pupil of Dr. Karl Haeckel, of Jena, and was with him as an assistant on the expedition which Haeckel made to Zanzibar. He subsequently served for a time as instructor in the University of Strassburg. He came to the United States in 1894 and served as curator of invertebrate paleontology in Princeton University from that date until 1903. He became a naturalized citizen of the United States while living at Princeton. From 1909 to 1910 while retaining his position in the Carnegie Museum he served as instructor in zoogeography, and from 1910 until 1925 as professor of physical geography, and from 1925 until his death as professor of zoology in the University of Pittsburgh.

While at Princeton in 1899 he was a member of the Princeton Arctic (Peary Relief) Expedition. He was a member of the American Philosophical Society, of the German Zoologische Gesellschaft, of the Leopoldinisch-Carolinische Akademie der Naturforscher, of the American Society of Naturalists and of the Ecological Society of America. He was a fellow of the American Association for the Advancement of Science, and held membership in many other learned societies. He was the author of numerous monographs and papers upon botany and aquatic invertebrates. He contributed to Bronn's "Klassen und Ordnungen des Tierreiches," writing the portion of that great work which relates to the Decapoda. His report upon the Tertiary Invertebrates of the Princeton Expedition to Patagonia was published in 1902. He made many contributions to the literature of zoogeography and conchology in German and American periodicals. He was the author of a number of important monographs and scientific papers which have been published in the Annals and Memoirs of the Carnegie Museum. During the last twenty years of his life he devoted himself with intense interest to the investigation of the molluscan fauna of the Ohio River and its tributaries, extending his investigations to all the rivers of the eastern United States from New England to the Carolinas and partially exploring the rivers of Georgia, Alabama and Mississippi. His researches have thrown a great deal of light upon the geology and transformations of the rivers of the eastern half of the United States. His latest research, carried on in the summer of 1926, led him to believe that some of the streams, now discharging their waters into the Atlantic Ocean south of the Chesapeake, originally were tributaries of the great tertiary river represented to-day by Chesapeake Bay, which is a submerged river, and which in Tertiary times drained not only a large portion of eastern Pennsylvania, Maryland and Virginia, but also the northern part of North Carolina.

The death of Dr. Ortmann robs America of one of her most competent and richly informed zoogeographers and students of invertebrate zoology. The list of papers which he has published is long, and his place as a writer upon his favorite themes is firmly fixed in the literature of science. As a field investigator he was scrupulously exact and untiring. As a student in the laboratory he was painstakingly industrious and most scrupulous in keeping his records above reproach. He made extensive collections of the freshwater mussel-shells of North America and other mollusca, which are contained in the Carnegie Museum. He also classified and arranged the mollusca and other invertebrates belonging to the great collections which have been amassed from various sources by the museum as the result of purchase, exchange and collection by expeditions in various parts of the world. As a teacher he aroused enthusiasm, and many postgraduate students in the University of Pittsburgh pursued courses in zoology and physical geography under his care, his classes being for the most part instructed in his laboratory in the museum. In recognition of his attainments and of his contributions to science the degree of Sc.D. was conferred upon him by the University of Pittsburgh in 1911.

Dr. Ortmann made his home during the latter years of his life at No. 6310 Monitor Street, Pittsburgh, Pa.

He is survived by his widow, Anna Zaiss, whom he married at Achern in Baden, December 5, 1894; one son, A. E. Ortmann, Jr., who lives with his mother; and two married daughters, Mrs. Hilda Borgman, of Pittsburgh, and Mrs. Bertha Raeber, of Gloucester, N. J. His sister, Mrs. Hildegarde Ernst, of Pittsburgh, his brother, Dr. Konrad Ortmann, of Torgau, Germany, and four grandchildren also survive.

W. J. HOLLAND