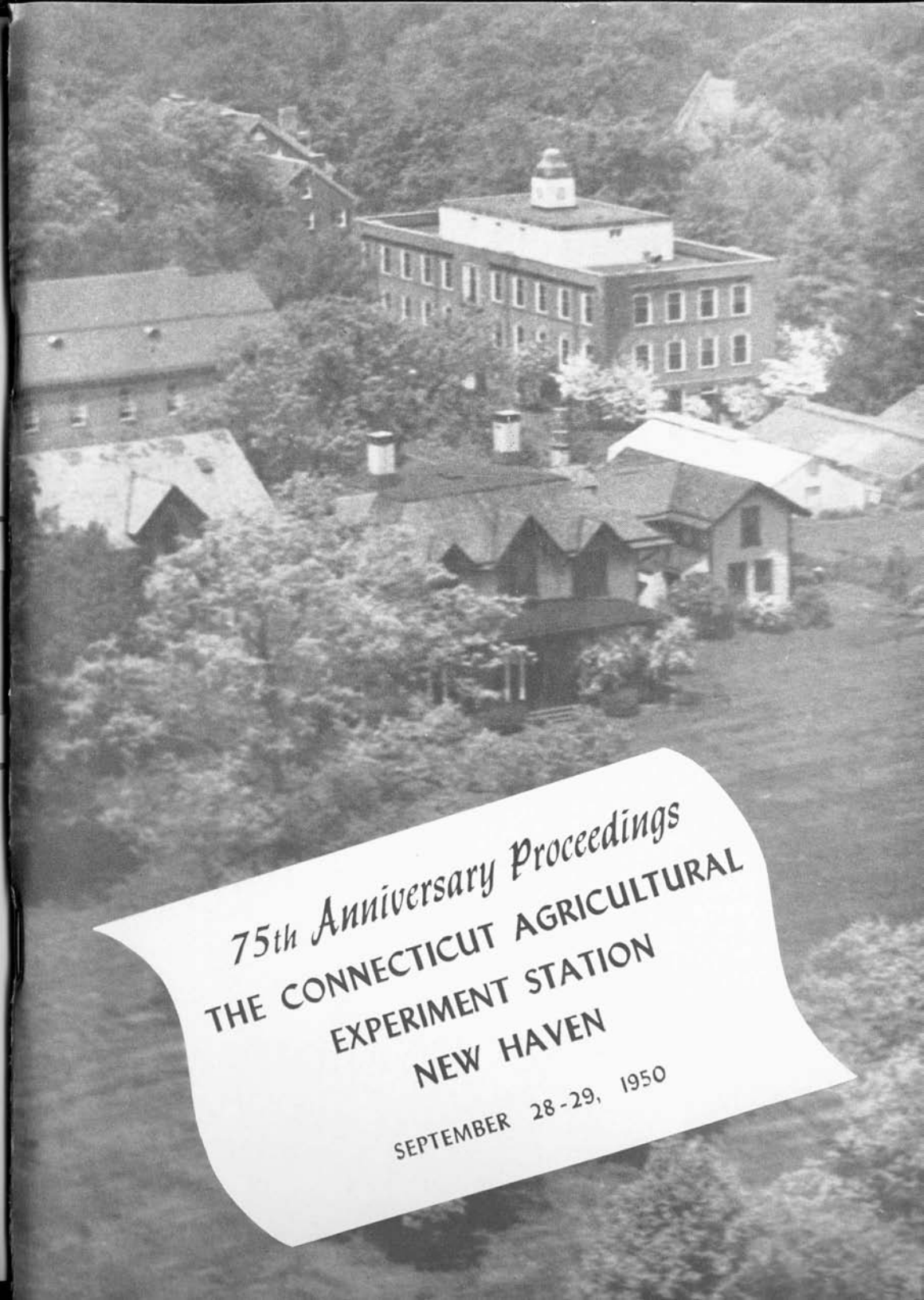
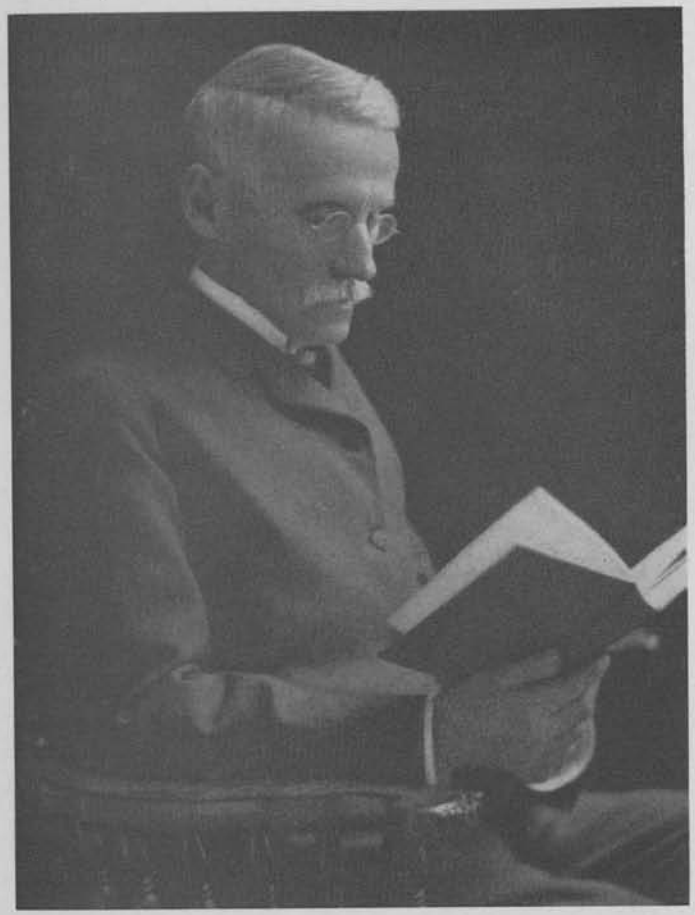


75th Anniversary Proceedings

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION NEW HAVEN

SEPTEMBER 28-29, 1950



SAMUEL W. JOHNSON

Founder of The Connecticut Agricultural Experiment Station and Director, 1877-1899.

75th

Anniversary Proceedings

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION NEW HAVEN

SEPTEMBER 28-29, 1950

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

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FOREWORD

It is now more than a century since John Pitkin Norton presented the idea of an agricultural experiment station to American readers. There followed 30 years of effort by Norton and his successor, Samuel W. Johnson. When, in 1875, the Connecticut Legislature founded this Station, a new public policy was established in America — that the support of scientific research is a proper function of society.

Today, no questioning voice is raised. Both state and national governments are firmly committed to this policy. Public and private funds in large amounts are now available. America's research effort is a vast and growing enterprise. The place of the agricultural experiment station in these changing times is a matter that concerns all.

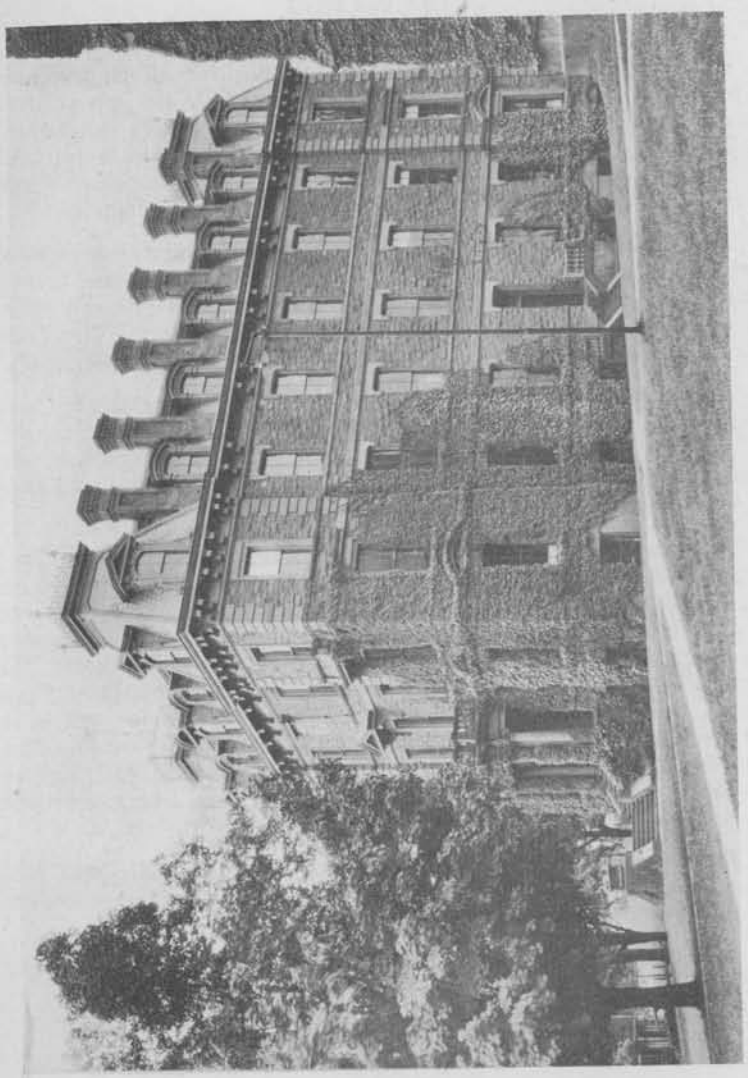
Therefore, the Board chose this, the 75th anniversary of our Station, as a fitting occasion for a commemorative program, with two purposes in mind: that we think again of those who laid the foundations and set the pattern; and that we pause to consider how best we can serve in these serious times.

The program reproduced on page 1 was developed with these two purposes in mind. Invitations to attend the ceremonies on September 28 and 29, 1950, were sent to representatives of other experiment stations, research institutes, national scientific societies, Connecticut universities, agricultural organizations in the State and others. The program included a symposium on "The Research Institute in Modern Society", conducted by four eminent scientists. The major addresses were given by Dr. Detlev Wulf Bronk, president of the Johns Hopkins University, and Arnold Nicholson, managing editor of *Country Gentleman* magazine. An open house on the first day gave those attending an opportunity to see our laboratories in operation.

The final session was a banquet for the staff, delegates and guests at which greetings were brought to the Station by representatives of several scientific institutions and organizations.

An account of the official proceedings is contained in the pages which follow.

John Christensen
Secretary
For the Station Board of Control



Orange Judd Hall, Wesleyan University, Middletown. This building housed the Station during its first two years, 1875-1877.

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The BOARD OF CONTROL and the STAFF

of

THE CONNECTICUT AGRICULTURAL

EXPERIMENT STATION

request the honor of your presence

at the celebration of the Seventy-fifth

Anniversary of the founding of the

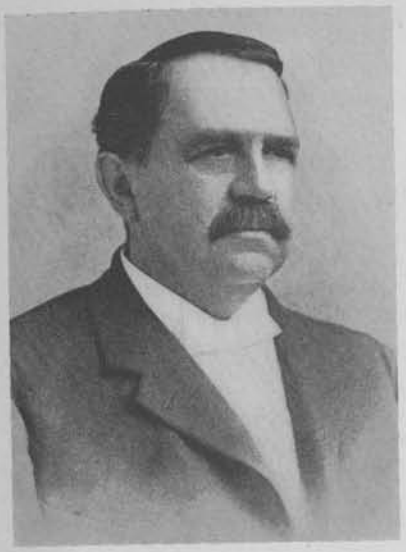
Station, to be held on September 28

and 29, 1950.

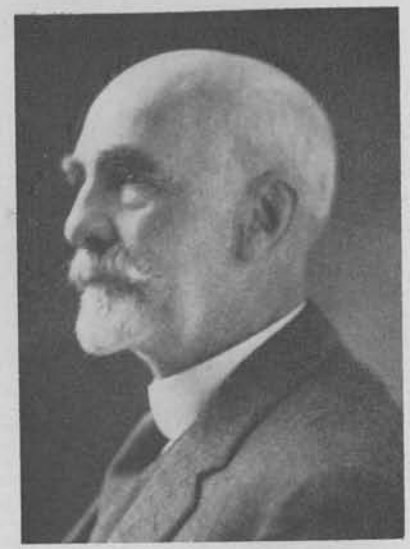
Reproduction of invitation to the 75th Anniversary Celebration of The Connecticut Agricultural Experiment Station.

PROGRAMME

Thursday, September 28	
10 - 12 A.M. and 1 - 3:30 P.M.	OPEN HOUSE AT THE STATION
3:30 P.M.	PROGRAM IN BRITTON AUDITORIUM Greeting by Director JAMES G. HORSFALL. Address, "Why An Agricultural Experiment Station?" by ARNOLD NICHOLSON, Managing Editor, *Country Gentleman.*
4:45 P.M.	UNVEILING OF COMMEMORATIVE TABLET Presentation by RAYMOND A. LORING, State Development Commission. Acceptance by JOHN LYMAN, Station Board of Control.
8:00 P.M.	ADDRESS IN LAW SCHOOL AUDITORIM, YALE UNIVERSITY "Science in a Democracy" by DETLEV W. BRONK, President, The Johns Hopkins University.
Friday, September 29	
2:00 P.M.	SYMPOSIUM IN BRITTON AUDITORIUM—"THE RESEARCH INSTITUTE IN MODERN SOCIETY" Moderator, EDMUND W. SINNOTT, Director, Sheffield Scientific School, and Dean, Graduate School, Yale University. "Industrial Research" by GEORGE O. CURME, JR., Vice-President in charge of Chemical Research, Union Carbide and Carbon Corporation. "Governmental Institutes" by SELMAN A. WAKSMAN, Chairman, Microbiology Department, New Jersey Agricultural Experiment Station. "Endowed Institutes" by ALEXANDER WETMORE, Secretary, Smithsonian Institution. "Universities" by EDMUND W. SINNOTT.
6:30 P.M.	DINNER FOR OFFICIAL DELEGATES AND STAFF



WILBUR O. ATWATER
Director, 1875-1877



EDWARD H. JENKINS
Director, 1900-1923

WILLIAM L. SLATE
Director, 1923-1947

JAMES G. HORSFALL
Director, 1948-

ADDRESS OF WELCOME

JAMES G. HORSFALL
Director, The Connecticut Agricultural Experiment Station

On behalf of the Station Board of Control and of the Staff it is my privilege and pleasure to welcome you to the celebration of our 75th anniversary.

The establishment of this Station in 1875 was an event of far more than local significance. It marked the acceptance in America of an idea, the adoption of a public policy—namely, that society has a real stake in scientific research.

To be sure, science and its application to agriculture had been fostered here by some college teachers and by amateurs; and in Europe, a few states had contributed to the support of experimental laboratories and farms; but little Connecticut was first to give the idea formal and legal approval in America.

Scientific research is now generally accepted and approved by the American public. We are quite science conscious. Many large corporations advertise their research laboratories in glowing terms. The press gives ample space.

But the citizen is interested chiefly in the end product; in the application of science to his health, wealth and happiness. It is estimated that the Federal Government alone now spends one billion dollars on research. A considerable portion of this is on a contract basis. Industry spends another 400 million. Add to that expenditures by foundations, colleges and universities, the states, and we have a very large sum. Of this, the lion's share is for applied or developmental research, and this presents a problem in which we are all gravely concerned.

Considering the state agricultural stations alone, we find their expenditures in 1949 total 57 million. Of this the Congress contributed 11 million and the states 28. Eighteen million were derived from other sources. One might say this is a small part of the total, but 57 million is a considerable sum and places on us a real responsibility.

So it seemed fitting on this occasion that we pause to look back over the road we have travelled these 75 years, taking pride in achievements; that we examine our present place in this vast research activity; and especially that we try to look into the future.

This afternoon Mr. Nicholson will answer the question, "Why An Agricultural Experiment Station?". This evening Dr. Bronk's topic will be "Science in a Democracy"; and the subject of tomorrow's symposium is "The Research Institute in Modern Society".

You may wonder why this symposium topic was chosen. The term "Research Institute" is used rather loosely and not commonly applied to our state agricultural stations. We have always thought of our Station as an institute. Our thinking stems from Samuel W. Johnson who in 1873 described a station as a place where scientists "make a regular business of discovery". This conception of a research institute was not new. Francis Bacon in his *New Atlantis* proposed what he called "The House of Salomon". This, he wrote, would be manned by a great company of scholars. Laboratories and libraries would be provided. Bacon introduced two other ideas that have had profound influence—that knowledge is to be acquired by observation and experiment; and that this new knowledge could lead to practical results. But to find the roots of Johnson's thinking and the seed from which the Station grew, we must go back to John Pitkin Norton and the Agricultural Chemistry Association of Scotland.

In 1842 Benjamin Silliman, Jr., fitted up a small private laboratory in New Haven and offered instruction in chemistry. This was a departure from the lecture-demonstration system of the elder Silliman, who viewed this venture at first with tolerant curiosity, but shortly became sympathetic.

One of the first students was John Pitkin Norton of Farmington, son of John Treadwell Norton, a well-to-do land owner and gentleman farmer. Young Norton, born in 1822, elected to become a farmer. His parents agreed but insisted that he be well educated. Always interested in natural science he found his real career in chemistry, especially its application to agriculture.

The elder Silliman encouraged Norton to study abroad and in 1844 he went to Edinburgh to work with J. F. W. Johnston in the Agricultural Chemistry Association.

This Association deserves far more notice than it has received, as does Johnston, its chemist. Perhaps the fact that it existed for only five or six years is the reason it has been passed over, here and abroad.

Begun in 1842, it predated the first German experiment station at Mockern by nine years and furnished the inspiration and pattern developed later by Samuel W. Johnson. The Association and its operations are described in the Transactions of the Highland and Agricultural Society of Scotland for 1845. The Association had its origin in a group of tenant farmers. They and the landlords furnished its chief support.

While abroad, Norton wrote a monthly letter for the *Albany Cultivator*. In the number for April, 1845, appears Letter No. IX, which deals with the Association. Norton in this letter stressed the origin but also the purposes in these words: "The leading objects are the diffusion of existing information, theoretical and practical; and the enlargement of our present knowledge."

Later:—

"So far it has been successful, but—it only opens the way to vast fields for research, yet untrodden."

and:

"I would recommend it to the notice of my countrymen."

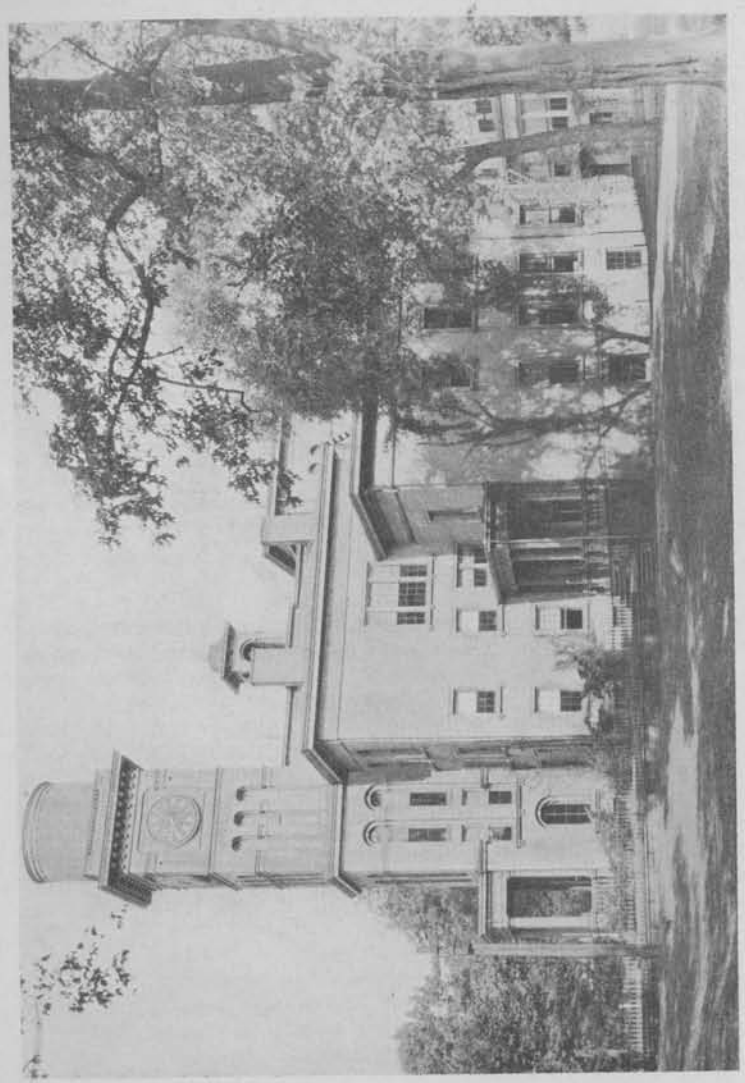
Thus, to Norton goes the credit for the introduction of the station idea to America.

In 1847, with the younger Silliman, Norton won the approval of the Yale Corporation for establishing a School of Applied Chemistry. This later became Sheffield Scientific School. Norton held the post of Professor of Agricultural Chemistry. After five years of brilliant and exhausting labor as teacher, writer and lecturer, he died at the early age of 30.

But fortune brought to Norton a disciple and worthy successor. In 1850 young Samuel W. Johnson began two years of study with Norton, who passed on to this brilliant pupil his hopes and plans for an experiment station. As early as 1851, Johnson had picked up the torch. In the *Albany Cultivator* for that year we find him advocating an experiment station which he insisted must be a legal entity and should be located near an academy. Although his thinking matured during the 24 years that followed, Johnson held firmly to these two principles. This Station still conforms to his pattern, as did most of the early state stations.

Thus, we see an agricultural experiment station as a research institute whose purpose is not only to apply existing knowledge, but also to enlarge it. How to preserve these basic concepts, how best to serve society is the purpose of our program on this occasion.

We have alluded to the fact that the *Albany Cultivator* published the letters and discussions of Norton and Johnson on the subject of an experiment station. The *Albany Cultivator* was the precursor of the modern *Country Gentleman*. We have, therefore, invited Mr. Arnold Nicholson, managing editor of the *Country Gentleman* to discuss in 1950 terms, the concepts proposed in his magazine in the eighteen fifties —"Why An Agricultural Experiment Station?"—Mr. Nicholson.



Sheffield Laboratory, Yale University, New Haven. Second home of The Connecticut Agricultural Experiment Station, which had its quarters in this building from 1877-1882.

WHY AN AGRICULTURAL EXPERIMENT STATION?

ARNOLD NICHOLSON
Managing Editor, *Country Gentleman*

The progeny of this institution have come to serve society in every state of the union, and even in our territories overseas. It has been an amazing growth, and an even more memorable record of performance has resulted. The facts threaten to overwhelm anyone who asks the question I have selected for this address. One answer to "Why An Agricultural Experiment Station?" leads to a mountain of statistics about millions of dollars spent, and billions—not millions—in profits received by the public. The question is also very eloquently answered in this year of great danger—this time of crisis for free men—by the health and vigor and stockpiles of the nation's farms. Alone, of all industries, agriculture answered "we are prepared" when the day of decision arrived this past summer. The agricultural experiment stations, as I hope to show, can take a great share of the credit for that preparedness.

But, urgent as they may be, the problems and accomplishments of the moment seldom combine to give a complete and significant picture. I suggest that we turn back from them, and forego the statistics, to acquaint ourselves with the mode of life and agriculture that led Professor Samuel William Johnson first to propose an experiment station. In the intervening 75 years, the world, this nation and its agriculture have traveled a long, long way—a distance out of all proportion to the elapsed time. In 1950 we stand at a point on the calendar of human history far removed from the long ago of 1875. Science and the ambitions of free men have moved us at an ever faster pace.

Where, then, does the agricultural experiment station fit in the scheme of this rapidly moving picture? Can we locate ourselves on the map of time to see where we have arrived? And to see what might be ahead? Professor Johnson had a ready answer for all who asked why agriculture needed experiment stations. His clear exposition of the need for such establishments not only fixed the purpose of the experiment station in his time, but also charted the course for all that followed. How valid are his arguments today?

First, let's orient ourselves from a known point, the world of Professor Johnson, and examine the experiment station idea with relation to the forces at work in that day. If we can locate our starting point, we can follow the trail we traveled and see where we are now. Johnson was, first and foremost, a man of science—and that fortunate man of science, a pioneer in his field. He was a chemist, and in his

student years at Yale the chemist's science stood almost alone in the agricultural field. Europe's problems of soil fertility had inspired the fundamental discoveries and research of leaders like Liebig and Gilbert and Lawes, and it was in this pattern that Yale's Doctor Norton, and his pupil, Johnson, pioneered in America. The soils of the Eastern seaboard, and of southern New England in particular, were never rich. By the middle of the nineteenth century, after 100 years of intensive farming, their response to chemical fertilizers was hardly a matter for dispute among scientists. But improvements in the practice of fertilization, or of any other part of his business, came slowly to the farmer of that day. He could read of the experiments of the professors and the experience of others in agricultural journals; but they all too often were either obscured by theory that he distrusted, or by circumstances unlike his own. His world, limited by the distance a horse could travel between chores, centered about the trial and error of his own farm and those of his neighbors.

As sophomore Johnson, in his initial advocacy of an experiment station in *The Cultivator* in 1851, wrote: "All the existing means of education exercise but an exceedingly trivial comparative effect on our agriculture. Single farms are models, but no district of several thousand inhabitants can be found uniformly presenting an enlightened system of husbandry."

"The State Agricultural Schools that are contemplated promise much to the farmer," he added, "They will afford greater facilities for experimental agriculture; for testing the inductions of theory, by trials made under competent direction; for advancing mechanical agriculture —the processes of farming, and for improving the breeds of livestock. They ought, also, to provide men and means for striking out into the path of discovery, for increasing as well as diffusing knowledge."

That was an amazingly accurate prophecy for a young man. Note, however, that Johnson also urged "we cannot wait for legislative action". He was in error in that. Private funds indeed gave the impetus for an appropriation of tax money from the Connecticut Legislature 24 years later; but the experiment station, as he conceived it and others soon advocated, was built upon the idea of public service. In America that means public support.

Not until after the Civil War, and the establishment of the land grant colleges, did legislators begin to consider support for such an undertaking from the public funds, however. It was in this decade, 1865 to 1875, that Professor Johnson's idea really took root.

The world of that day was the era of Queen Victoria, and the supremacy of Great Britain. In Russia, the Tsar Alexander II had approved a $7,000,000 real estate deal which today permits us to gather here instead of frantically digging bomb shelters—that was the sale of a so-called worthless chunk of ice, Alaska. In Austria, an obscure monk

named Gregor Mendel experimented on the cross-breeding of peas. And it was the decade in which Karl Marx wrote "Das Capital".

For all its advancement, the United States was regarded by the rest of the world as only then emerging from a state of wilderness. As a political body, it was looked upon as being immature, crude, and as gawky as a galloping colt.

Within our borders, three great movements were underway, all of which had the profoundest influence on the agriculture of southern New England. First was the continuing and rapid industrialization of this section; second was the settlement of the Western prairies, with the vast productive capacity of their virgin soil, and third was the linking by rail of that great corn, wheat and cattle country to the industrial East.

Now the impact of these developments on Connecticut agriculture has been the subject of classic study, but let's consider it from the standpoint of how these circumstances helped bring about the establishment of this experiment station, and how they shaped its early character.

The situation had been developing since New England industrialization first got underway about 1810. Connecticut farmers who had been engaged in a self-sufficient agriculture for generations found themselves selling more and more of their produce to the new factory towns. They became commercial farmers, producing food to be sold at a profit in addition to that which they produced for their own use. This involved the selling of crops and buying of supplies, and they often were the victims of sharp practices at both ends of the process.

Then, beginning in about 1850, the building of the first railroads brought a volume of competition from the more fertile farms of Western New York State and Ohio Valley. Cheap rail transportation began bringing in wool, wheat and pork at prices which the Connecticut farmer simply could not meet.

But it was the great surge of homesteaders into the West after the Civil War that all but drove him to the wall. Under the Homestead Act of 1862 a man could get title to 160 acres of the most fertile land in the world simply by living on it for five years. A vast area, section after section of unbroken sod, suddenly began competing with the depleted soil of New England that had been farmed for generations. Much of the western land was in lush grass that provided boundless grazing for the expanding cattle industry. And its flatness, or gentle rolling hills, provided ideal conditions for the new mechanical marvels of that age—the reaper, harvester, cultivator, and mowing machines. Farm mechanization, with its developing capacity for cultivating great areas, went hand-in-hand with the settlement of the West.

And it was land linked to the expanding Eastern markets by bands of narrow iron rails. By 1869 the last spike had been driven in the

transcontinental road of the Union and Pacific. Whereas a generation before probably nine-tenths of all food consumed in Connecticut had been grown within 25 miles of the place where it was eaten, it now could be produced and hauled a thousand or more miles cheaper than it could be grown on home ground.

The once self-contained agricultural unit of Connecticut and southern New England had vanished.

As Professor William H. Brewer, secretary of this Station's own Board of Control, said a little later: "The New England farmer has found his products selling at lower prices because of the new, fierce and rapidly increasing competition. One by one, he has had to abandon the growing of this or that crop because the West crowded him beyond the paying point."

Here was a problem immediate and urgent that must have contributed to the founding of this Station. Professor Johnson, and the group of which he was the leader, had their answer in science. I think it likely he echoed arguments of the day in one of his early Station reports, when he wrote: "That our farms can hold their own against those of the great West, can in fact derive immense advantage from Western competition, is not a matter for doubt.

"To do this, however, intelligence must both hold and drive the plow. We must learn and use all the best methods of planting and harvesting, and the best modes of making, saving and applying home manures, the best systems of farm management, of tillage, of rotation of crops, cattle feeding, handling of milk, that exist, or can be devised which suit our circumstances."

And so the culmination of Johnson's efforts was reached. Since 1851, he had been the leading apostle of the benefits that science could bring to agriculture, and he had pleaded the cause at scores of places all over the State and elsewhere in New England. As chemist for the Connecticut State Agricultural Society and later for the Connecticut State Board of Agriculture, he had demonstrated on a small scale what an experiment station could do for agriculture. His reports on the monetary value of commercial fertilizer based on the cost of their essential elements, constituted valuable protection for the farmer, and in two highly successful books, "How Crops Grow", and "How Crops Feed", he outlined in simple, concise language the composition and physiology of plants. Always his work was directed toward developing practical aid for the farmer, for he appreciated the fact that for the state to appropriate public funds for an experiment station, its immediate value to the farmer would have to be apparent to all.

And yet he could not, and did not, as a man of science, permit sacrifices to expediency. Writing from Munich, in 1855, on agriculture's need for both theory and practice, he concluded, "Agriculture will flourish from that day, when practical men shall be philosophical

enough to appreciate the philosopher's thoughts; and philosophers practical enough to calculate the farmer's profits."

In this spirit the drive for an experiment station climaxed in 1874. A committee headed by Professor Johnson inspired the formation of a permanent State committee, with representatives from every county, to push the project. Meetings were held and petitions circulated, and a bill drawn up in the General Assembly. At this stage the legislators, as they always have and always will, backed away. The bill was shelved until the following year.

The Assembly, again in 1875, to use the language of the record, was dismayed by the "largeness of the appropriation". That appropriation was $8,000. It was then that Orange Judd came forward with a compromise and his gift of $1,000. The result was the establishment of the Station, with a two-year appropriation of $2,800 per year from the State at Wesleyan University, where Mr. Judd was a trustee. Johnson's student in chemistry, W. O. Atwater, then professor at Wesleyan, became director. At the end of the two years, the Assembly passed new legislation, establishing a permanent Station in New Haven, where the Sheffield Scientific School provided quarters. Financial support was increased to $5,000 a year, and a governing board set up. This board named Professor Johnson director.

So the long fight was won with the establishment of this first American agricultural experiment station, and its early success, even with the most limited means, is a matter of record. It continued the work of chemical analysis of fertilizers and other inspections, and control work later included examination of milk and butter. Field experiments were conducted in all parts of the State to answer farmers' questions; and studies of blights, rusts, smuts and mildews were undertaken.

This was the modest beginning in Connecticut, and typical of the programs launched in other states in the next few years. By 1887, when Congress endorsed the experiment station idea with Federal funds, through the Hatch Act, fifteen state stations had been established. The Hatch Act with its appropriations available to every state, recognized the need for experiment stations in the land-grant college system, and assured their spread across the nation.

It would be hard to find, in history's pages, a development as perfectly matched to the times as the flowering of the experiment station idea in the last quarter of the 19th century. That was when we built the foundation for the industrial might that makes this nation great today; and our complex of iron and steel, steam power and transportation grew on the release of manpower from the land. Science and mechanical invention were the means for that release.

The year this Station was established, 75 years ago, there were eight Americans employed directly in agriculture for every 10 in other

pursuits. That figure had not changed greatly from Colonial days, when 19 to 20 was the ratio. By 1917 only one in four owed a living to agriculture, and today the figure is one to 14½.

Now there is no warranty in history that the initiative and diligence of our farmers couldn't have reached this state of productivity without the help of experiment stations. But I doubt that it could have happened any other way.

In a nation of free men—of millions of economically independent farms that provide both home and livelihood—some system of central direction for education, for research, and for dissemination of science's findings was a necessity, if this segment of the population was to keep pace and play its part in the industrial revolution.

To that end the experiment stations built the structure of agricultural science in the long period of "normalcy" that stretched from the last years of the 19th century up to the first World War. Their scope expanded to include many new departments as the world of science grew. In some categories—agricultural engineering, for instance—the department was created from an amalgam of sciences and practical knowledge to meet specific farm needs.

The business of agriculture, as the pattern of farming shaped itself to climate and soils and population much as we know it today, became more and more complex. Cattle, wheat, corn-hog, tobacco, cotton, truck and dairy regions emerged, extending the process that began in New England clear across the continent. This specialization decreed more intensive operations; and they in turn, with their concentrations of crops and animals in given areas, brought problems of fertility and of disease either unknown or not apparent before. The discovery of breeds and varieties to meet special market needs grew in importance.

The experiment stations not only kept pace, largely through the development of new techniques; their fundamental discoveries and pioneering in many instances determined the future of whole regions. A classic example of valuable techniques was the Babcock butterfat test developed at the Wisconsin Station in 1890. For an example of research's impact on the future, we have only to look at the shade cloth tobacco fields here in the Connecticut Valley. That method was introduced by this Station, and became the basis of a whole new industry.

But the full force of the industrial revolution and of science had yet to reach our farms at the time of the first World War. Agriculture was still tied to the horse. The farm home had practically none of the conveniences commonplace in city life. Refrigeration, despite the importance of ice in the transportation and marketing of meats and other perishables, was a luxury that few farms could afford. The foundation stones for genetics and organic chemistry were just falling into place. The physicists were only charting the road into nuclear science and electronics.

It may have been coincidence, but the troubled times for agriculture that marked the next two decades—the economic and political upheaval of the 20's and the 30's—came at the same time as the internal combustion engine, electric power, genetics and organic chemistry were transforming the farm scene. I do not think it was a coincidence—particularly when I remember the relative efficiency of farm workers today as opposed to their output in 1917. One farmer today does the job that three and a half performed just 33 years ago.

I will not attempt to enumerate the accomplishments of the experiment stations in this period. They are legion—and coupled with the steady growth of agricultural education and extension—have influenced and benefited nearly every farm family in the land. A few examples will suffice to highlight the direction we have been headed.

The corn harvest today is half a billion bushels larger on 25 per cent less acreage, than we would have without the hybrid varieties now almost universally planted. This is on the order of a 30 per cent increase. The double-cross method of seed production, developed by Dr. Donald F. Jones at this Station in 1917, opened the way for agriculture to profit from the basic work in corn genetics by Doctors Shull and East. Doctor Jones' discovery was immediately useful to the sweet corn growers of this State, but the field corn producer of the Midwest profited far, far more.

Here is the classic example of the national benefits of experiment station research, even though that research was primarily undertaken to benefit the farmers of one state or one locality. Federal appropriations to the experiment stations under the Hatch Act, the Adams Act of 1907 and the Purnell Act of 1925 all specify that research so aided shall be conducted with due regard to the varying conditions and needs of the respective states. Beginning with the Bankhead-Jones Act of 1935, and more recently under the Research and Marketing Act of 1946, the Congress recognized, with appropriations, the national importance of basic research, and of cooperative effort between the states.

We know now that most of the projects in agricultural research that bring widespread benefits are long enduring, and seldom confined to the efforts of one group of scientists. Rather, the discoveries come piecemeal, and the goal is attained much as if the various minds were at work on the same jigsaw puzzle.

Again, let me turn to the work of this Station for an example in the vitamin A discoveries of Dr. Thomas B. Osborne, co-worker with Dr. Mendel of Yale. Placed in the proper relation with discoveries elsewhere, this work forms a part of the great nutritional puzzle which we are still seeking to complete. Often, as in this case, the discovery has immediate practical application, as well.

Co-operative research, with many experiment stations parceling out the work in attacking regional, or even national, problems, is a devel-

opment Professor Johnson scarcely could have foreseen. It is a logical, modern addition to the answer we should give when someone asks "Why An Agricultural Experiment Station?". But there's another, to my mind, far more challenging role for the experiment station uppermost in the minds of farmers and already under way through the provisions of the Research and Marketing Act.

Let me inject a personal observation here. In an acquaintance with agriculture that began in the 1920's I have witnessed the very thing that I have tried to convey to you in the past few minutes—the flowering of the experiment station idea in the farming regions of our nation. The state colleges and experiment stations have a place in the life of a majority of farm families that is unprecedented in its influence. Twenty years ago this was not true, except for a minority of the most prosperous families. Our educational system, which in so much of the country heads up in the state universities and colleges; the 4-H leader, the county agent and other extension workers have done a superb job in taking the work of the experiment station to those for whom it was planned. I have been in plenty of farm homes and communities where facts are not facts unless the state college and experiment station give their OK.

The farmer's faith has been won by the experiment stations for their answers to his production problems. And a review of station accomplishments reveals that, with few exceptions, they have as their goal the production of more, and better food and fiber; or if not that, a lowering of material and labor production costs.

Such confidence brings a heavy responsibility. It was ably discharged during the years of World War II, when many long-range programs and avenues of intriguing research were detoured by the experiment stations to put our farm plant in high gear to supply not only ourselves, but our allies.

The success of that effort, and an uneasy look at the tapering off that had ended so disastrously after the other war, led farmers and their elected representatives to turn to the experiment stations for help in a different direction. Instead of aid in production they have asked for help in processing and distribution. "Marketing" is the all-inclusive term that has been used.

The work has begun, but not nearly enough is under way to meet the needs of the situation. I am not qualified to say to what degree this should become the job of the agricultural experiment station. Nor am I qualified to say how. I do believe, however, that the request is within the scope of Professor Johnson's idea of an experiment station's prime function. In one of his early reports he wrote: "In almost every direction in which the farmer prosecutes his search for more light, he is confronted by a darkness which for thousands of years has resisted the

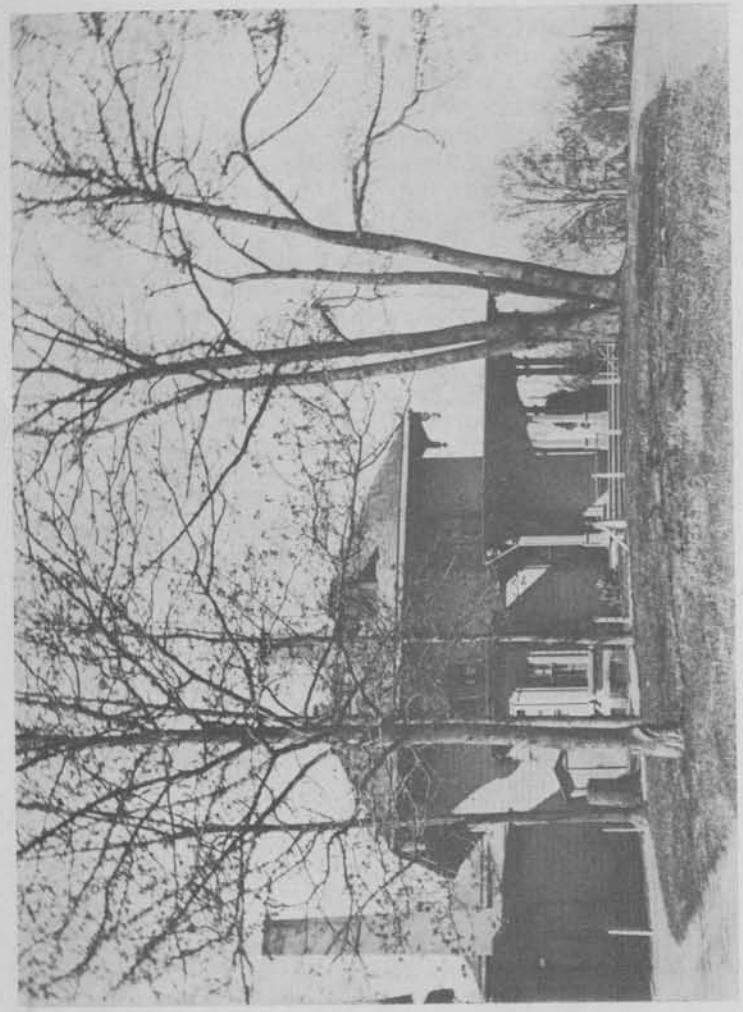
utmost efforts of those who have gone before him, and now equally resist his attempts to dispel. He has but one resource left, and that is science . . ."

A great deal of darkness has been dispelled, but not all; and certainly there is gloom in the marketing field. Farmers would prefer the light of science to political tampering with our economic system; and their faith that they will obtain that light is very real. That much I know. I also know that the fruits of discovery can be attained in this field. We have only to look to Florida, where applied science has rejuvenated markets for the citrus industry through a process for frozen orange juice. Who knows what our widespread zero-degree storage facilities may inspire next?

I would not imply that the production job is finished, or that the custodians and developers of science to that end should in any sense relax. The responsibility of maintaining ample food supplies extends not only to the farmers, but to our entire nation today. As the relative number of farmers continues to decrease, as I believe it will, the productivity of those that remain must rise and be protected against increasing hazards. Better health for our nation, built on increased nutritional qualities in the produce of our farms, is both a challenge and an opportunity for agriculture that the experiment stations must resolve.

This examination of the question "Why An Agricultural Experiment Station?" in the light of present conditions could not conclude without looking beyond our borders. Whether we like it or not we are today a world power, and the fortress for free men everywhere. Authorities who should know have reiterated that one of the golden keys to democracy is an ample food supply. We, as a nation, cannot feed the world. But we can, and should, and already have begun, to export Professor Johnson's great idea and our technical help to aid free men in other lands. To quote him in conclusion:

> *"Science is from its nature peculiarly adapted to flourish among, and to make flourish a free and aspiring people. Science is not necessarily an aristocracy of intellect that condescends to dole out the crumbs of knowledge to the common herd, but is an organization of all available forces for the pursuit of knowledge."*



First building on the Station's present location, 123 Huntington Street, New Haven.

SCIENCE IN A DEMOCRACY

DETLEV W. BRONK
President, Johns Hopkins University

This is no ordinary occasion, for the founding of The Connecticut Agricultural Experiment Station seventy-five years ago was a unique event.

Our youthful nation was then deeply rooted in a fertile soil and richly nurtured by a vigorous agriculture. Our ancestors were still occupied with the practical duties of pioneers on geographical frontiers. The development of each new frontier opened up others still to be explored. Amidst such an abundance of natural resources to be exploited, there was little obvious need for conservation of those resources through greater understanding of the laws of nature. Nor did the duties of pioneers leave to many abundant leisure for scientific inquiry. But Samuel Johnson saw resources that lay beyond the limits of geographical frontiers. He had the vision of how our agriculture could be enriched by the utilization of knowledge to be discovered by investigation of the properties and forces of nature.

Scientific research was then still fostered mostly in the European countries from which we came and whence came most of the scientific knowledge which we used for the development of our new nation. Even there, in the birthplace of modern science, research as we now know it was the leisure occupation of the teacher or the exclusive occupation of but a few isolated workers supported by their own fortunes or by the generosity of a patron. It is significant for such an occasion as this that the furtherance of the investigations of scientists for 250 years had been largely due to the academies of science and associations of scientists which they themselves created, as was this Station, rather than to the universities.

The separation of the majority of scientists from the universities, in the early days of modern science, was largely due to the conservatism of the educational fabric. No change was made from 1570 to 1858 in the statutes of Oxford; no essential change from 1558 to 1830 in the organization of the University of Leipzig to accommodate the development of scientific inquiry. In Germany, for example, the University of Innsbruck in 1740 refused the establishment of a professorship in botany, and in Erlangen the professor of chemistry had to give all laboratory instruction in his own house and with his own apparatus, from 1754 to 1769. "The European universities were born at the high tide of the Middle Ages, and their institutions corresponded to the medieval attitude of transmitting the sum of knowledge in fixed forms. The

academies, or institutes of science, on the other hand, belonged to the epoch which began in the middle of the 17th Century and their institutions were an expression of the new spirit which was thenceforth to attain its power in the realm of thought and life." (Harnack)

Because the universities were incapable of adapting themselves to the needs of the new times, there was a necessity for groups of scientists banded together in institutes and academies capable of centralizing the efforts of their workers and of supplying funds for expensive experiments and for the expenses of scientific publications. Accordingly, "the scientific societies provided the advance guard of civilization in the second half of the seventeenth century, much as the universities had done before the scientific revolution. They typified that age drunk with the fullness of new knowledge, busy with the uprooting of superannuated superstitions, breaking loose from traditions of the past, embracing extravagant hopes for the future. In their midst the spirit of minute inquiry was developed; the charlatanry and curiosity of the alchemist and magician were by the societies of scientists transformed into methodical investigation; the critical faculty was developed so that the disclosure of an error became as important as the discovery of a new truth; the individual scientist learned to be contented and proud to have added an infinitesimal part to the sum of knowledge. The scientific societies and academies not only put modern science on a solid foundation, but in good time revolutionized the ideals and methods of the universities and rendered them the friends and promoters of experimental science instead of the stubborn foes they had so long been." (Ornstein)

The scientific societies rendered another service of significance for the present role of science in a democracy. Intellectual activity had been inseparably connected with a mastery of Latin and Greek which was an insurmountable barrier to those whose circumstances prevented them from learning those languages in youth. Scholasticism and humanism had thus created a caste of the learned, and molded the realm of mental activities into an aristocracy. Experimental science, fostered by the societies of scientists, from its earliest stages stood for the popularization and hence for the democratization of knowledge. While previously the topics and modes of contemplation had been removed from everyday objects and the affairs of men, the subjects and methods of scientific investigation became closely connected with those of homely life. Thus, experimental science entered into competition with scholastic learning, and made its strongest appeal, not to the erudite university man, wedded to accepted tenets, but to the non-professional layman, who had been hitherto excluded from the privileges of mental activity. It was the influence of such institutions which laid the foundation for such an institution as this, the founding of which you commemorate tonight. As Sprat said in 1667: "The love of science is so strongly roused in the century in which we live, that it seems as though there is nothing more in vogue in Europe." That love of science, fostered by the academies,

stimulated the development of scientists outside university halls. But they were of necessity generally to be found in circles which were sufficiently wealthy not to feel the immediate urgency of gaining a livelihood and with sufficient leisure to follow their inclinations.

Benjamin Franklin, the greatest of American scientists, was such an amateur, and to him we are indebted for the early foundations of science in America. But Franklin and Jefferson were among the few Americans of that period who made significant contributions to scientific knowledge. In the evolution of our democratic social system, the role of science was still to be formulated. The American college was then largely concerned with the training of young men for the service of the church, some for the legal needs of a new society, few for science. In the development of new frontiers, there was little leisure for scientific inquiry. The promotion of useful knowledge appeared unnecessary to people who had available apparently limitless natural resources to be exploited merely by the use of scientific knowledge discovered in other nations. But the democratization of learning in Europe under the influence of science was continuing to prepare the way for the ultimate development of science in the United States that was to become necessary in order to utilize and conserve our limited resources. To prepare for such a need as well as to satisfy man's curiosity was the purpose of Benjamin Franklin's American Philosophical Society for the Promotion of Useful Knowledge.

The time when the national need for scientific inquiry was generally recognized was not long in coming. It was natural that in an agricultural nation "a regular business of discovery for the use of farming" should be one of the first organized scientific undertakings. Seventy-five years ago the era of free or cheap good land was drawing to a close. No longer could farmers readily exchange worn-out land for new. The opportunity to expand farm acreage indefinitely was gone, and the dramatic character of the final land rushes gave warning that the future needs of agriculture would have to be satisfied by science rather than by virgin acres. The geographical frontiers were being passed, but the limitless frontiers of knowledge awaited exploration by the sons of pioneers. Such was the vision of Samuel Johnson.

By founding The Connecticut Agricultural Experiment Station, Johnson laid the foundations for the development of a great national resource. In doing so, he created that which became the example for many institutions which have enriched our nation and the peoples of other nations. They can continue to do so without limit.

Because we were primarily an agricultural country in 1875, it was appropriate that this "business of discovery for the use of farming" should be one of the first scientific institutions to be supported by public funds for the public welfare. It is appropriate that there should be frequent debate concerning the relative role of the municipal, state and

federal governments in the furtherance of science. But this institution has for 75 years proved the value of state support for research devoted to the special problems of a region, carried on as part of the integrated pattern of science throughout the nation and the world. In these times when some fear the consequence of federal support of research, it is profitable to recall that the State of Connecticut founded this institution undeterred by the fact that the federal Department of Agriculture with its constituent agencies for research was already in existence. That action accents the fact that the surest guarantee against federal domination is the assumption of local responsibility by local governments, as is here done. Too many reach for the benefits derived from science while refusing to support scientific discoveries which will benefit us and our descendants in the future.

The local support of research is especially important in a country so extensive as ours. A wholesome national culture and a sound economy require that research be fostered throughout the nation, so that scientific personnel and scientific knowledge be dispersed to every region. The example of this Experiment Station has stimulated the creation of similar centers of research in many states to the benefit of their people. But many regions, we must admit, have suffered by the neglect of science, and the consequent migration of potential scientific talent. The concentration of able scientists in New England, the Middle Atlantic States, some areas of the Middle West and in California is unfavorable to the wholesome development of this nation. Fortunately, this is now recognized and more than research in agriculture is being supported in the Southeast, the Southwest, the Rocky Mountain States and the great Northwest. I, for one, will not be content until there are scientists of distinction working with adequate support in every state of the Union. The welfare of our whole nation demands it.

The widespread support of science increases every man's awareness of his dependence on science in this scientific age. The integration of science into American culture requires that many individuals recognize their status as participants in the advancement of science. That this is increasingly so is a healthy characteristic of our social customs. University departments of teaching and research are supported by great numbers of individuals who are conscious of their responsibility for the place of science in society. The stockholders of many industries are authorizing the expenditure of more than half a billion dollars each year on the discovery and development of new knowledge. Foundations for the furtherance of research now receive the benefactions of millions who, to the limits of their resources, follow the generous example of the wealthy few; such are the National Foundation for Infantile Paralysis and the American Cancer Society. I would add that more than money is derived from this widespread but untaxed participation in science. Participants gain some understanding of the meaning of science; they develop greater appreciation of the values of science because of their participation. Thus, our citizens are better fitted to exercise their democratic control of the scientific policies of the nation. This is a guarantee that the results of governmentally supported research will be devoted to the public welfare rather than to the increase of bureaucratic power.

There are potential dangers that could result from public indifference to the governmental direction of scientific inquiry. But I am convinced that federally supported scientific agencies are needed if they supplement, but do not supplant, scientific research under the citizens' more intimate, direct control. It is the function of government to further neglected areas of science and to integrate the applications of science for the welfare of the undivided nation.

The various divisions of our government have traditionally assumed responsibility for the development, and protection for the future, of basic natural resources, such as forests, water power, soil and fisheries. Research, to me, is not unlike such resources for it provides scientific knowledge of future value for the national welfare. Accordingly, the furtherance of research is a proper responsibility of government.

In our educational system, there is relevant precedent for the complementary support of science by individuals and by government. Privately controlled schools and universities and those supported by municipalities and states have, with little conflict, combined to satisfy the national needs. The privately endowed institutions have enjoyed a freedom for academic experiment and adventure that has enabled them to contribute much to the advancement of their more restricted, tax-supported sisters. A similar relationship in the furtherance of science will insure its wholesome development.

This I speak of here because this state-supported Station has from its genesis been associated with a great private endowment for education and research. It has been a fruitful partnership, fulfilled in the spirit of our finest democratic traditions. By the example of this affiliation between your institution and Yale, you have established a pattern for cooperation between governmental institutes and universities which has enriched them both. Through this affiliation, freedom for scientific inquiry has been assured, for universities have an ancient heritage of freedom for inquiry, expression and debate. In turn, the universities of today may be vitalized by contact with scientists concerned with "the everyday objects and affairs of men", as were the universities of the 17th century. It is a significant partnership in these days when state and federal support of research in universities is rapidly increasing. In this trend I foresee benefit to human welfare despite the fears of some. We need not look with fear upon this process, if universities champion freedom for inquiry and speech and individuals participate directly in the furtherance of intellectual adventure.

Universities play an important role in governmentally supported science by fostering research which is mere intellectual adventure. This has not always been a characteristic of American culture. Commenting upon this a century ago, Alexis de Tocqueville attributed the emphasis upon immediate, practical values to the traits of a democracy, where, said he, "men . . . seldom indulge in meditation . . . and require nothing of science but its special applications to the useful arts and to the means of rendering life comfortable". The observations of this distinguished observer of democracy in America were not far wrong, for fundamental research flourished less here than in Europe. But his assumptions as to the reason for our emphasis on the practical aspects of science have been disproved by the more recent development of basic science within our democracy. This is in large part due to the development of scientific inquiry within our universities. "If Americans had been alone in the world," de Tocqueville went on to say, "they would not have been slow to discover that progress cannot long be made in the application of the sciences without cultivating the theory of them." We are not alone in the world, but there has been an increasing realization that our international obligations and our national welfare and security require that we, too, must explore the frontiers of knowledge.

It would be unsafe complacency to assume that the significance of scientific exploration is widely understood or assured of secure support. In these times, when scientists are considered necessary for the preservation of our social order and the defense of our nation, it is essential that their objectives and the course of scientific progress be widely understood.

The primary and potent motive of a scientist is curiosity. Because of this, scientific inquiry is an intellectual adventure of individual scientists. This may seem obvious and undeserving of comment, but the free adventure of inquiring minds is considered by many still to be a bothersome trait which has got us into much trouble from the days of the Garden of Eden to Hiroshima.

Scientific inquiry will not, I think, flourish except in an atmosphere of intellectual freedom. No one directed Newton to discover the laws of gravitation nor restricted his freedom to think and speak about such matters. No group of social planners organized Faraday's discoveries of electro-magnetic induction to ease the labors of men. No one suggested to Roentgen that he discover X-rays for the diagnosis of human ills. No one instructed Willard Gibbs of this city to pave the way for modern chemical industry. Great scientific discoveries will usually be suppressed by direction and restriction, as would the creation of great music or poetry or sculpture and art. Scientific research is exploration of the unknown. It is not possible, I think, to direct the path of an explorer through unexplored territory.

We cannot emphasize too strongly the value of inquiring minds in these times when fear goads many to intimidate those who are curious. We who value American ideals so highly need to do everything within our power to strengthen our security against the threats of totalitarian states whose ways we abhor. I am persuaded that one of the vital elements of our national strength is freedom for intellectual inquiry and reasonable debate. The present danger to democratic freedom requires thought as a prelude to vigorous action to counteract the paralysis of fear.

Because curiosity is a fundamental characteristic of the human mind, science will develop without regard for social consequence. But it would be unrealistic not to recognize that the course of science is profoundly influenced by its social consequences. Scientists are men and women who, like other men and women, are social creatures. They possess the natural, human instinct to achieve something of value for other individuals and for the improvement of the social system. If this is often not apparent, it is because scientists cannot predict the social value of adventures into the unknown realms of nature. But faith in the ultimate spiritual, intellectual and physical values of scientific investigation is a fundamental faith of scientists.

Nor can we ignore the fact that scientists are members of a complex social system. Few scientists can live unto themselves alone. New ideas and new discoveries originate in the minds of individual scientists, but their ideas are catalyzed by the thoughts and discoveries of others. In our complex social system a scientist's choice of field for inquiry cannot escape the dictates of social needs and social pressures, even though the pressure be self-imposed. Such was the case during the past war when scientists willingly recognized their role as citizens of a threatened nation. And such is now the case, when democratic freedoms are at stake.

The opportunity and the facilities for scientific exploration will be increasingly dependent upon social and economic forces. Scientists will be tolerated and supported by the social system they have helped to form, only if their activities are understood and valued.

Some of the most important contributions of science to human welfare have no obvious practical usefulness. By science, we have been freed from the fear of natural forces that were mysterious and malevolent; we have been freed from slavery, ignorance and superstition. The pleasure which comes from an understanding of the beauties and forces of nature is a subtle value of science which extends the horizons of our intellect and enriches our lives. This will be, only if understanding of science, only if its meaning and its implications are better integrated with the humanities and social sciences in the pattern of our education and more widely disseminated through literature and through the press. As President Conant emphasized before a New Haven audience some years ago, much of our education still deals with the results of science; there is

little discussion of the methods and sequence of science. Until this defect is corrected, scientists may face popular demand that they mortgage their future usefulness by concentrating their efforts on the practical application of past discoveries. For the most manifest results of science are the changed material conditions of life. From the study of nature and the effects of natural forces, there has been derived the knowledge which now enables man to travel with undreamed-of speed in three dimensions; his range of speech has been extended to distant places; he has gained new power over life for its preservation and its destruction.

Such changed relations of man to nature have profoundly altered the relations of man to man. Whether such changes, achieved or promised, will be translated into human welfare depends upon the integration of science in the total effort for the increase of man's well-being. The need for such a synthesis is accented by the rapid change of social structure induced by science. Science has made possible the production of new materials and new sources of power. But science has thus posed new problems regarding the distribution and utilization of that power and those materials. Thus, there are raised new moral issues regarding human rights and human needs. The brilliant advances of medical science are clouded by economic doubts as to how they can be brought to benefit those who could be saved from pain and death, were it not for economic limitations. They raise new fears of over-population.

These are but instances which emphasize the new problems and conditions imposed on our social system by the progress of scientific knowledge. Accordingly, a primary social challenge of these times is the better utilization of scientific knowledge for the promotion of human welfare. We would be blind to the status of modern science if we did not recognize its critics and opponents; there are many who say that we have gone too far in our understanding of nature. Many are torn between fear of new horrors science may create and hope that science will build a better world.

Radio communication has become an instrument of propaganda and vicious power over the minds of men. But it is also an instrument for the free exchange of ideas which is the basis for mutual understanding; it is a means for transmitting to many the best of music that could before be heard by few. The engines which drive planes and tanks on missions of destruction carry people on peaceful journeys and cultivate fields for the maintenance of life.

Science provides the building stones of a better world—but the world will be as we choose to make it. Accordingly, the closer union of the natural sciences with the social sciences and the humanities is a hopeful trend. For scientists are partners of many others who seek to improve man's well-being. Science liberates men from the fear of unknown natural forces, frees them from grinding toil for mere survival, subdues pain and cures sickness. Science thus enables men to enjoy art and music and literature and the beauties of nature and religious faith.

The effects of science and technology on the structure of civilization require their integration into our culture. They pose new problems which must be solved if we are to preserve basic democratic values.

A democracy is a government of the people by the people. If our technological civilization becomes so complex that few can understand the thoughts and actions of others, few will be able to fulfill their democratic function of intelligent self-government. If juries must pass on issues which involve scientific principles they do not comprehend, a traditional mechanism for the preservation of human rights will be endangered. If many delegate responsibilities without understanding the nature of the responsibilities they delegate, we will not have a true democracy.

An understanding of science and its implications need not be restricted to a few if scientists will assume their responsibility as interpreters of science. It is appropriate on this occasion to speak of this Station's pioneering efforts in the assumption of that function by the wide dissemination of scientific knowledge.

Francis Bacon foresaw that "Science can enlarge the bounds of human empire, to the effecting of all things possible, through a knowledge of the causes and secret motion of things." But scientists and science can give to those who would limit "the bounds of human empire" awful power over others. Because of this, the progress and values of science are endangered by those who use scientists and science to achieve their selfish ends. To do so, they restrict the free statement of ideas and information. But science cannot flourish if the discoveries and thoughts of scientists are the secret knowledge of a few. Science cannot increase understanding and improve the welfare of all men and women unless free access to knowledge is recognized as a fundamental human right. To deserve that right, the peoples of the world must restore regard for truth and for the democratic determination of individual and national action. The spirit of science will not long survive in a world half free to investigate, to speak and question; half slave to prejudice and dictation. The survival of undistorted science, uncontrolled except by experimental test and reason, depends upon victory for democratic freedoms in this present conflict of ideals.

As citizens of a democracy, who are also scientists, we will doubly wish to align ourselves with those who guarantee the freedom of peoples everywhere. Great though a scientist's temporary sacrifice may be, his future right to inquiry demands it. But so the thought is needed to avoid unwise sacrificial actions that weaken our national strength and future welfare.

I have not, I think, misrepresented science as an important source of our national wealth, our health and the satisfactions which make life worth the living. If that be so, the maintenance of our internal sources of national strength demands that we maintain our scientific resources. Our military power in the defense of democracy likewise depends upon scientists and science in these days. Accordingly, the resources of science are strained and the objectives of science are divided. To preserve the vitality of science, freedom for scientific inquiry, and opportunity for the training of those who wish to fit themselves for scientific inquiry, will require wisdom of those who determine national policies affecting science.

I am sure that the totalitarian states have so much regard for science as a source of material and military strength that they will rejoice at every action of a democracy which weakens its scientific resources. To sacrifice sources of future strength, in order to gain immediate power, is dangerous policy. Calm thought is needed to balance the requirements placed on scientists to meet the present emergency, with the requirements for maintenance of conditions which will insure the wholesome development of science as a basis for future welfare.

We live in a time of conflicting needs and aims. The progress of science and its social values is based upon the free dissemination of knowledge. But at the present time there is scientific information which would certainly be of military value to potential enemies. To insist on freedom to speak of such matters would be traitorous and would aid those who would suppress all freedom. Other information, and indeed most of new scientific knowledge, could be of possible military assistance to our opponents. But if we should succeed in the well-nigh impossible task of pulling a veil of secrecy around much of science, we should weaken the construction of our own defenses, impede the progress of science and reduce the benefits it can confer on all mankind. Thus, we should aid the enemies of freedom to abolish freedom because of our fear of the power of our own knowledge.

Effective rearmament and alert defense against new weapons require the services of scientists, engineers and physicians. The greater the number of able scientists and appliers of science who devote themselves to the building of the military defenses of democracy, the surer will be our security against aggression. But there are already too few for the operation of our complex civilization and the maintenance of human welfare. Thus, our enemies, who envy the welfare of our people, could threaten our welfare by forcing us to allocate unwisely our scientific talent between the two bases of our national strength.

Allocation of scientists to specific duties within and without the Armed Forces has already been suggested, should the national need demand it. If the national need demands it, scientists will gladly acquiesce.

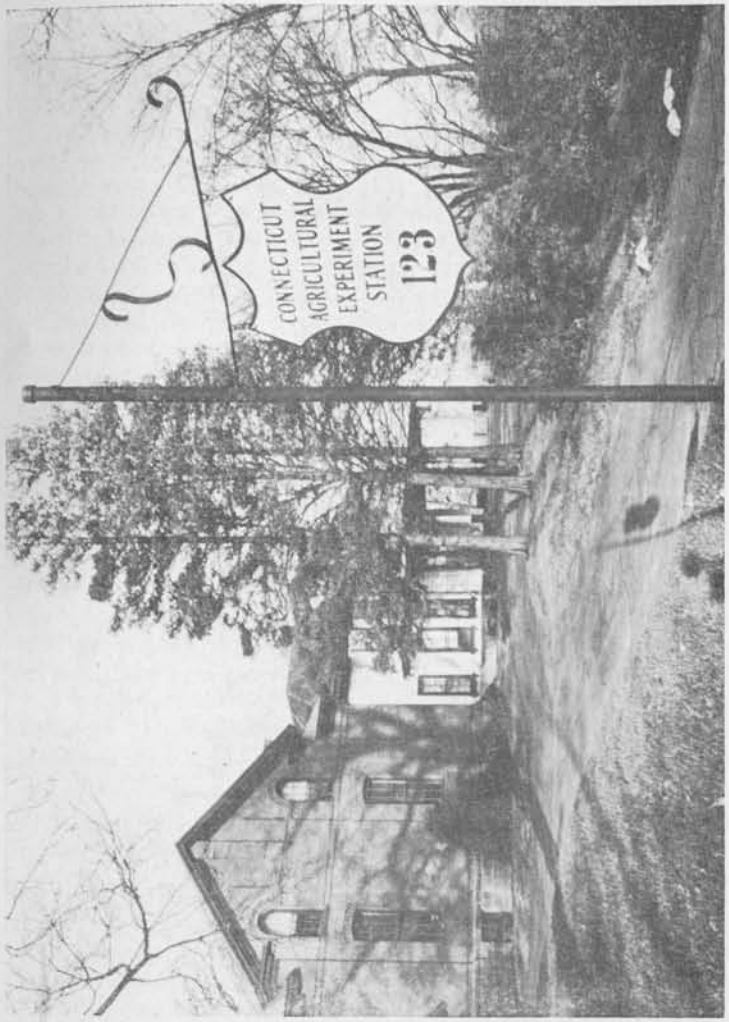
Indeed, the need for such an action may be required by the scientists' patriotic desire to serve the nation where the need is now most urgent without regard for less appealing future needs. Such allocation and assignment may be necessary actions, but they would be the sacrifice of a fundamental liberty. Science would not long prosper if scientists were not free to follow the direction of their own curiosity. This is one more instance of the subtle threats to freedom inherent in our efforts to defend our freedoms.

I would cite another. At a time when we gravely ponder how to use most wisely our inadequate supply of scientific personnel, we face the prospect of reducing the supply still further. Young men are needed for military duty. If they serve while they are young, none will have acquired the scientific competence some will need. If the service of those in scientific training is postponed, the democracy of the process will be questioned. One thing is certain. Skilled manpower in the armed forces and in industry is a desperate need for the survival of our civilization. Educated men and women are essential for the maintenance of a democracy. Some means must be found to insure the continued preparation of men and women for the duties of the future; otherwise, our future will be insecure and our present efforts of no avail.

I pose, but do not answer, grave questions. They are questions which face every citizen who is concerned with the internal and the external strength of our country and the ideals we hold so dear.

Of one other factor I am certain. We are committed to a course of national action which need not impede the progress of science nor the contributions of science to human welfare. Some of the greatest contributions to the advancement of our culture were made in times of turmoil. Because these are times when stress, bewilderment and fear encourage few to gain control of many, we must couple with our usual scientific effort vigorous defense of undistorted science. These are times that challenge our loyalty to those ideals that have made possible the intellectual adventures of the past. These are times that challenge us to double effort, but thank God we now see the issues clearly.

In this place, I am reminded of a great American patriot, Abraham Davenport, who was a member of the Executive Council of Connecticut, on that dark day in 1780, when many thought the world had come to its final end. As he entered the Council Chamber, he heard debated a motion to adjourn. To this, Abraham Davenport spoke as follows: "That day is either at hand or it is not. If it is not, there is no cause of adjournment. If it is, I choose to be found doing my duty. I wish, therefore, that candles may be brought." I have the faith that science and educated minds will be candles in these days that are not so dark as many would have us think.



The Station's first permanent home as it looks today. The building at the right now houses the administrative offices; the one on the left is the General Library.

SYMPOSIUM
THE RESEARCH INSTITUTE IN MODERN SOCIETY

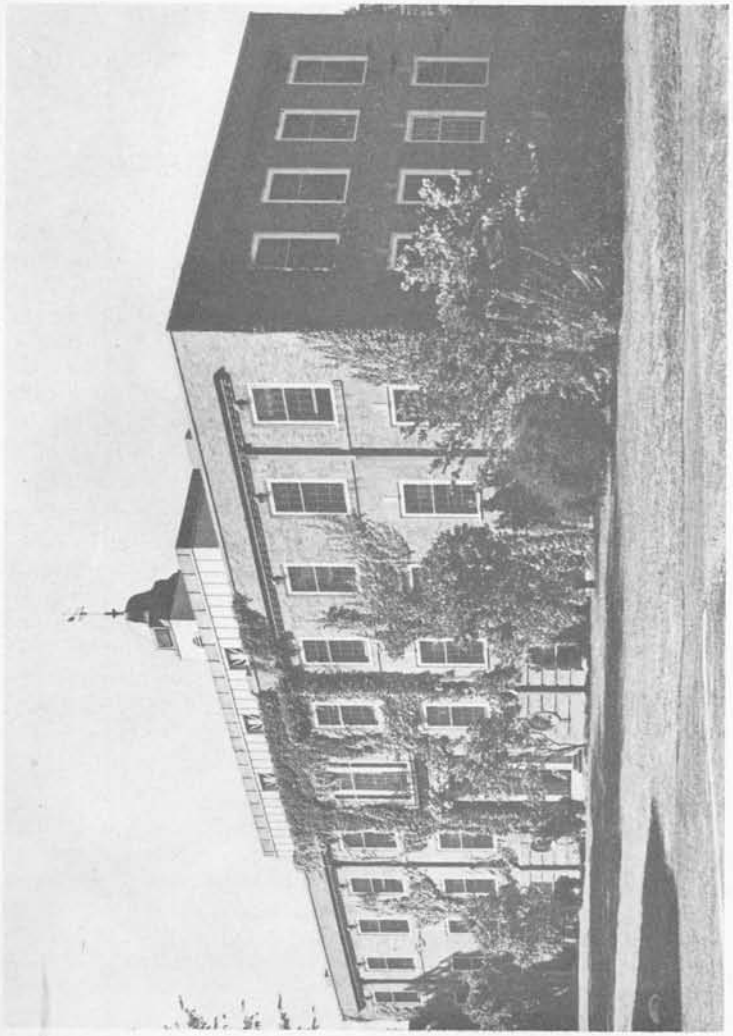
Introductory Remarks

EDMUND W. SINNOTT
Director, Sheffield Scientific School, Yale University

I am very happy to have a part in this birthday celebration of a notable institution. Its significance is greater than that of a mere birthday, however, because it calls attention to the importance of science and scientific research in every kind of institution. Science is of tremendous practical importance, as we all know—in agriculture and medicine and engineering. It has changed our lives in many respects; it has also changed our minds. In science there certainly is progress. We may debate as to whether the world has progressed ethically and aesthetically in the last few thousand years, but certainly in science such progress has occurred.

Science has altered the orientation of our minds. We are looking now to the future for the Golden Age instead of to the past. Scientists are the successors of the old explorers. Most of our geographical frontiers are now gone, but instead there is the tremendous frontier of scientific exploration across which we are pushing out, not into an unexplored wilderness, but into an unexplored universe. There is not only promise in all this; there is also peril. Atomic energy and the dangers of a materialistic philosophy and civilization are among these perils. Man must learn to avoid them. Science today is often condemned as the mother of many of our ills. We have not heard recently of the need for a ten-year moratorium in research, but I suspect a good many people would like to see it.

But there is, nevertheless, a tremendous hope in science for all of us—physically and philosophically. Scientists are men of peace, men of good will. If all people felt as scientists do, the world would not be in the sad state in which it is plunged today. Man's great task, I think, is to understand the universe, and himself as a part of it, and from this understanding to control himself and the physical world around him. Scientific research is one of his greatest responsibilities, and we are here today to discuss this great task that confronts mankind. Science has far outgrown its original limitations, and one of the major problems today is the wise and efficient conduct of scientific research everywhere. The purpose of this Symposium is to discuss the research institute in modern society, looking at the problem from four different points of view—that of the industrial laboratory, the government institute, endowed institute and the university.



Jenkins Laboratory. The Departments of Genetics, Entomology, Plant Pathology and Forestry are located in this building.

I.

INDUSTRIAL RESEARCH

GEORGE O. CURME, JR.
Vice-President in charge of Chemical Research
Union Carbide and Carbon Corporation

I am sure that all scientists who are devoted to making knowledge of service to society are happy to salute The Connecticut Agricultural Experiment Station on its seventy-fifth birthday. We extend congratulations to it for having inaugurated and maintained over three-quarters of a century a program which, itself, has been of great benefit. Also, it has provided a basis for the development of great scientists under the distinguished leadership of a succession of able directors and, by its example, has inspired many others to emulate its performance.

As an unofficial representative of industrial research, I wish to pay further tribute to the basic principle on which the eminent Samuel W. Johnson put his ideas into effect, namely, that of establishing an organization for the "regular business of discovery". I am sure that the establishment of this principle sharply defines the period of haphazard individual work which extended over all preceding efforts to make scientific knowledge useful to man, and the phenominal development of organized research which has characterized the period since 1875.

It is rather difficult to establish the date of the earliest industrial research laboratory, as there was a rather extended period of evolution from the free lance inventor and the part time industrial scientist to the establishment of an organized laboratory with more than one full time employee. The earliest industrial research laboratories would hardly be recognized as such today, but being most charitable to these early efforts, the first organized industrial research laboratories go back only about 65 years and the first of the modern industrial research laboratories of this country does not antedate the beginning of the first World War in 1914.

It is true that the idea of application of science to industry is very old and no one can attempt to estimate the date at which such basic principles as fire and the wheel were first applied to benefit man's condition. I have been very much interested in research in plastics for many years and have been pleased to note in the Good Book that an early record of the use of plastics was recorded. In anticipating an impending emergency of that day, it is stated that Noah "pitched the ark within and without". This could not have been done without some understanding of the situation and is good nautical practice even today. The

Metropolitan Museum in New York has some interesting exhibits of figurines and model equipment taken from the tombs of the Pharaohs which show the processes of milling grain, making bread, paper and other industrial products of that period. These processes could not have been developed without a form of scientific study. The results, while primitive by today's standards, must have represented in their day an advance over the methods which they superseded. It must have been, however, that each discovery was the result of the work of an individual and while the accomplishment was meritorious, it was not the result of a system of investigation which was a guarantee of further discoveries to come.

Similarly, our garret inventors of earlier days made some valuable discoveries and the early industrial urge in this country came from the work of gifted individuals of whom Whitney, the inventor of the cotton gin, and Goodyear, the inventor of vulcanized rubber, may be mentioned as examples. These men, however, suffered under a great disadvantage, once having conceived an invention which was a result of their individual genius. From then on they were forced into other fields such as finance, sales promotion, plant operation and the like in which they had little or no genius and which demanded their time and attention, thus interrupting their application to those activities in which they excelled.

In the records of industrial research there is as yet no one individual to whom is attributed the greatest of all inventions, namely, the system of organized research which permits each man to work at his highest skill and which includes a team not only of the scientific investigators, but of engineers, finance, sales and production executives to carry their ideas to fruition. This team work makes possible not only the practical application of a single discovery, but guarantees an unlimited succession of discoveries over the years. It may well be that industrial research is indebted to Professor Johnson for this great contribution and if not indebted to him as the original discoverer, at least as one who was brilliant enough to recognize, before it was recognized by industrialists, that the "regular business of discovery" is the preeminent principle of modern research.

When viewed from a distance, industrial research may seem a fairly definite thing, but actually it is quite complex and consists of many and various approaches toward the general idea of making scientific knowledge useful for the multitude of practical needs of modern society. As in many cases, the industrial research worker is standing on the shoulders of those who preceded him. Of course he draws heavily upon the pool of pure science research, existing in the literature as a result of publications from many sources, but principally from the academic institutions of the world. However, there are many gaps in such publications and more and more the industrial laboratories are doing substantial research in pure science to fill in such gaps. Also, the

industrial research worker must have a comprehension of economic principles, of engineering possibilities and, if he is fortunate, an intuition of social trends.

From a standpoint of practical operation, there still are a number of the free lance inventors who conduct their own experiments and endeavor to sell the results of their investigations to others. There are many consulting laboratories in which men of industrial research experience aim to serve their clients within the field of their specialization. Some of these consulting laboratories, such as Arthur D. Little, Inc., have grown into research institutes which endeavor to serve their clients on a larger scale and with more elaborate facilities than the usual consulting laboratory possesses. Certain trade associations conduct research for their member companies. Industrial research is done in universities, either within departments of science or engineering, or in a research institute which they have developed for themselves. Government laboratories frequently wander into the field of industrial research.

The largest and most effective branch of industrial research, however, is that conducted by substantial industrial concerns primarily for their own benefit. In most cases these industrial concerns have grown large because of the application of previous successful research and are fully aware of the vital importance which a continuation of such activities will play in their future growth and success. No one of these industrial research laboratories can possibly cover all branches of science or all phases of industry. However, in all principal industries there are not only one, but several companies which maintain their own research laboratories, and both the number and size of such laboratories are increasing rapidly.

Some statistics are available in this field which are illustrative of this growth. The number of industrial concerns maintaining laboratories in 1920 was approximately 400. Today it is in excess of 2,500. The expenditure for industrial research in the United States in 1920 was approximately $40,000,000 per year. Today it is estimated to be in excess of $600,000,000 per year. I agree with the majority that statistics constitute very dull reading and will not pursue this matter further, but I believe that such simple figures as I have given you indicate that, in spite of whatever errors may be involved, the rate of growth of industrial research in this country is great and as yet has shown no signs of having reached saturation.

This great upsurge of interest in industrial research is based on solid accomplishment. I can recall within my own experience that at one time my company was inclined to minimize publicity on our research activities. It was feared that investors would become alarmed if it were generally known that corporate funds were being used to employ scientists to carry on their experiments. Today, dealers in securities are particularly anxious to find out how large research appropriations are, as

investors now have the completely opposite opinion and are afraid to invest in securities of companies which do not maintain well conducted research departments.

The nature of industrial research is changing too. As the simpler and more obvious scientific discoveries have been made, they are of necessity removed from the field of future investigation and the condition is rapidly arriving that the apples that could be reached from the ground have already been picked. I feel no apprehension regarding the possibility of learning all there is to know, but to acquire new and valuable results of research requires better and more varied techniques. The result is that modern industrial research usually involves a task force conception rather than that of the individual genius. As we all know, the barriers between the various fields of knowledge are purely man made and there really are no dividing lines in nature. Consequently, research assignments may involve a knowledge of more than one science, together with techniques supplied by various branches of engineering. This multiple approach opens up wholly new fields of investigation which have heretofore never been attempted and is currently proving of great value. It does require larger and more extensive research organizations, but fortunately our universities are providing an increasing flow of well educated and highly trained specialists and the results are such that this situation should continue for an indefinite period.

Under our system of private initiative, where earnings can be negative as well as positive, it is the duty of those charged with the management of industrial research to find some measuring stick whereby the value in terms of earnings can be determined for completed experimental programs. By methods commonly in use, it can be ascertained whether a particular proposed program justifies initiation and when initiated, whether it justifies continuation. With such a system established, few research managers can resist the temptation to add up totals and find out what the total earnings attributed to research might have amounted to over a year or period of years. It is not infrequently the case that such totals show that earnings due to research are substantially greater than the total earnings of the entire company—which is obviously an impossible answer. Somewhat more careful study, however, quickly resolves the contradiction in that a substantial portion of the earnings of research have been passed on to the general public in the form of increased wages, reduced prices and better products. When one follows similar calculations in attempting to estimate what the buyer of the product developed by research does with it and what his customer and the ultimate consumer does with it, figures are obtained which are so large that they are practically meaningless in terms of dollars.

By looking at the techniques of another science, we find that the astronomers have been in a similar situation where the measure in miles of interstellar distances are so large as to defy comprehension. The

astronomers have chosen light-years as a measure of distance, and since light will travel 186,000 miles per second, this is a rather sizeable unit, but one which can be understood. The value to the public from cumulative industrial research is another of these prodigious quantities. Dollars no longer suffice as a unit of measure, but terms of social values, such as improved public health, wholly new possibilities in the facilities for travel and communication, more leisure for the individual to appreciate the finer things of life, and today, most important of all, our ability to withstand the sinister forces of despotism, are units of measure which we can comprehend and measure a situation for which we should be profoundly grateful.

It is quite true that certain results of industrial research have been trivial in nature and might be considered as scientific toys for adults, but these have passed as the novelty wore off and the main body of these scientific contributions is both permanent and cumulative and has been an important factor in determining the pattern of our civilization. As we analyze item by item in what our country's economic strength consists, we find a preponderating amount of it is the result of applied science. In most cases the discoveries were made in the interests of peaceful activities, but in view of the excellence of performance, they have been adapted to military uses where, in an emergency, our whole strength is needed. In spite of hundreds of millions of population and great natural resources, the ancient cultures of the Orient are today dominated by an invader with little or no hope of successful resistance by the efforts of their own people. Our country, constituting but 7 per cent of the world's population, is conceded both by our allies and by our adversary, to be of such great economic strength as to be the deciding factor in the outcome in the current world wide struggle between freedom and slavery.

In the day of Professor Johnson, it must have seemed that he was pioneering a wholly new field with the university as his only close associate in science. As I have stated, the industrial laboratories did not exist at that time and governmental institutes and endowed institutes, if they existed at all, were remote from his activities. It is interesting to note from the past seventy-five years that the agricultural experiment station is no longer remote from other organized research activities. Whereas each of these major groups still has their definite characteristics and proper field of interest, they are becoming more and more inter-dependent. Industrial concerns and agricultural experiment stations are on very friendly terms these days and have many common problems toward which both are making contributions. Both of these, as well as governmental laboratories, university laboratories and endowed institutions, exchange information and personnel frequently and in all major improvements, social advances or problems of national defense, cooperate freely to form a team which can meet any situation. It seems most proper that this should be the case. After all, we deal with the

same forces, atoms and organisms. Each has his vantage point and, with the free exchange of information, this is a great help since it enables the society which supports us all to have the benefit of perspective upon our nation's problems.

I believe we should all be indebted to Dr. Horsfall for arranging this significant anniversary celebration, as it gives us an opportunity to review the eminent accomplishments of three-quarters of a century. I do not feel that this is a time for boastful comment or for relaxing of effort, but perhaps by reviewing what has been accomplished by the establishing of the "regular business of discovery", we can better guide our organizations for making the discoveries which will be just as essential in the future as those already made have been in the past. Perhaps with our organizations for discovery as a business closer together and better friends, we can bring about in our social order a task force to answer the hard social problems which lie ahead, just as task forces of scientists and engineers are now being used to solve the hard research problems of the present day.

II.

GOVERNMENTAL INSTITUTES

SELMAN A. WAKSMAN
Chairman, Microbiology Department
New Jersey Agricultural Experiment Station

In no country in the world do research organizations, other than those supported by the government, play so great a part in the advance of fundamental science as in this country. However, here as well, for one reason or another, government agencies have become dominant factors in the initiation and support of research. Whenever a new field of science is to be developed and a new organization established, endless discussion ensues as to how this is to be carried out. Should it deal with problems pertaining to industry, the arguments are always brought forth that the government agency should concern itself only with the fundamental aspects and that industry should take care of working out the applications.

In only two fields;—namely, agriculture and national defense, is it generally agreed that government organizations should play a paramount role in the initiation, application and control of new scientific projects. Recently, there has been a strong movement toward gradually placing under government control a third phase of modern science. This is concerned with the health of our population. I should like to dwell, in the brief time at my disposal, upon the first two, and especially upon agriculture, since the institution which we are honoring today and the one in which my own life-work has been connected fall within this field.

Any attempt to summarize the contributions of the American agricultural experiment stations to scientific research during the last 75 years, would be tantamount to a presentation of a summary of virtually all the scientific progress made in this country during that period, a period which has been so prolific in scientific advancement. Such a summary would embrace not only all the biological sciences, ranging from agronomy to zoology, and their manifold applications, but also various physical and chemical, as well as engineering, sciences. This would be particularly true of numerous borderline sciences, which involve overlapping fields. It is sufficient to mention such sciences as that of the soil, veterinary science, animal and human nutrition, plant nutrition, heredity and microbiology, entomology and forestry.

Any attempt, further, to summarize all government-supported research, would have to include virtually the whole field of science. Have

we not devoted in recent years much time and energy to sciences hardly heard of a decade or so ago? Whether we designate this age as the "atomic" age or the "antibiotic" age, we must agree that science has reached out into every phase of human endeavor and that the scientist is expected, not only to delve into the unknown and to uncover facts hidden by Nature, but also to solve all problems of modern society, whether they be in the field of natural science or social science, or even national and international politics.

Far be it from me, one who has been accustomed to deal with the infinitesimal forms of life, the microbes, to attempt to evaluate or even to summarize all these sciences, their contribution to human welfare, and the role that government agencies, in general, and the experiment stations, in particular, have played in their advance in America and in their manifold applications. The most that I can do is trace the progress of only certain narrow or highly specialized subjects that have largely been confined, in this country at least, to experiment station activity, namely, soil microbiology and the chemistry of nutrition.

When this first Station was founded, microbiology was still in its infancy, soil science was hardly heard of, and the role of microorganisms in soil processes was only a matter of guesswork. Louis Pasteur was just beginning to make his fundamental contributions to our understanding of bacteria as causative agents of fermentations and diseases; Robert Koch was still a student absorbing from his teacher Ferdinand Cohn a knowledge of the structure and life cycles of bacteria; Schlosing and Muentz were only beginning to experiment on the biological nature of the nitrification process. The Rothamsted Laboratory, the mother of all experiment stations, was delving deep into the effect of various nitrogen sources upon crop growth and upon soil structure; Liebig's humus theory was still exerting a great influence upon current ideas of plant nutrition, and Hellriegel and Wilfarth were a decade or more away from their elucidation of the role of bacteria in the fixation of nitrogen by leguminous plants. Beijerinck and Winogradsky had not yet launched their epoch-making work on general microbiology and on the role of the various bacteria in soil processes, and Iwanowski had still not recognized the filterable nature of the viruses. There were still a few years to pass before the work of investigators like Irwin Smith, Burrill, Arthur, Halsted and many others which dealt with fungus diseases of plants. Most of the disease-producing bacteria were still unisolated and undescribed; tuberculosis and numerous other unrecognized infectious diseases of man and animals were rampant, and Theobald Smith had not begun as yet his classical studies on animal diseases.

Plant nutrition was still in its infancy, and soil science was dominated largely by the geological point of view. Samuel Johnson, the first director of this Experiment Station, stated, for example, in his classical book "How Plants Feed" that "*Air, Water,* and *Soil* are capable of feeding plants, and under purely natural conditions, do exclusively nourish all vegetation". He emphasized, however, that it is the various salts and gases, and not the organic materials, "which contain the ultimate elements of vegetation, but which require to be collected and worked over by the plant".

In order to emphasize the very narrow scope of science and of the scientific problems which received major attention three quarters of a century ago, it may be of interest to list the early projects considered by the first three Experiment Stations in this country:

The Connecticut Station lists in an 1875 report the following subjects: analysis of fertilizers, analysis of feeding stuffs, experiments to determine agricultual value of fertilizers, seed testing, analysis of bogs and peat, analysis of different types of manures, poison tests, analysis of foods, analysis of water.

The North Carolina Station lists practically the same projects: analysis of fertilizers and soils, analysis of foods, studies of insects injurious to vegetation.

The New Jersey Station, the third, lists fertilizer inspection, fertilizer testing, studies of diseases of farm crops, analysis of milk, studies of ensilage.

These were all practical problems connected with the immediate needs of agriculture in a young and growing country. All the stations had projects on fertilizer analysis and on the composition of waters and feeding stuffs. There were certain special interests. For example, Connecticut devoted projects to seed testing, to analyses of organic manures and peats, and to poison tests; North Carolina was interested in the study of insects; New Jersey emphasized the study of diseases of farm crops, of fruits and vegetables, and problems of ensilage.

The duties of the New Jersey Experiment Station, for example, were "to promote agriculture by scientific investigation and experiment" (practically the words that were used here by Samuel Johnson), and to "employ competent chemists and other assistants to analyze soils, fertilizers, and objects of agricultural interest, so as to properly carry on the work of the Station".

Contrast these meager projects dealing largely with a simple type of agriculture with the wealth of scientific information uncovered by the same experiment stations in recent years. This can be illustrated by a selection of some of the projects reported by them during the last year or two.

The Connecticut Station has numerous projects dealing with many problems of importance to fundamental science and to practical agriculture. It is sufficient to mention the study of hybrid corn, the toxicity of nicotinium compounds and DDT residues, fungicides and various plant diseases, control of root rots by plant residues, and a variety of others.

The projects of the North Carolina Station deal with a variety of problems, ranging from frozen foods and animal feeding to plant diseases and pests, fungicides, radioactive phosphorus, and other subjects.

The New Jersey Station deals with such subjects as antibiotics, Newcastle virus, problems of production and marketing, insecticides, root rot control, and plant and animal breeding.

Among the outstanding men who initiated and developed the great research activities of these experiment stations were Johnson and T. B. Osborne in Connecticut, A. R. Ledoux and W. A. Withers in North Carolina, and G. H. Cook and E. B. Voorhees in New Jersey. To these were soon added numerous others, as new stations were established and new problems were investigated. It is of interest to note that the first director of the first station was a chemist interested in plant nutrition; of the second station, a chemist, and of the third station, a geologist interested in soils.

This institution and the one to which I have devoted nearly all my scientific life offer excellent examples of the development of research at the experiment stations in America. Here, Johnson was followed by Osborne who, together with L. B. Mendel, not only carried further studies on problems of nutrition, but who also opened a new field of science, the chemistry of plant proteins. This work was continued with marked success by Osborne's student, H. B. Vickery; both teacher and student made fundamental contributions to protein chemistry in general and to plant proteins in particular. At New Jersey, Cook, the first director, was a geologist concerned with rock formation and soil structure; he was followed by Voorhees, a chemist who was concerned with fertilizer practice; then by J. G. Lipman, a bacteriologist who initiated many studies on the role of microbes in plant growth. Thus, we witness the logical sequence of scientific agriculture, from the rock to the soil, from the soil to the plant, from the growing plant back to the living soil, now known to be teaming with microscopic forms of life. It is of further interest to note that the present directors of both stations are plant pathologists, thus emphasizing the problems of plant protection against numerous plant diseases.

Both stations offer outstanding examples of how purely theoretical questions, which at first may have appeared to have no practical applications whatsoever, will in the end lead to some striking practical results. When, less than six decades ago, Osborne initiated the study of methods of isolating and analyzing proteins of plants, this problem appeared to be purely theoretical without any possible practical significance. Less than 30 years later and, fortunately, while Osborne was still alive to witness it, there was no field of human, animal and plant nutrition which was not affected by his fundamental investigations.

For another illustration, I would like to draw attention to the progress of our knowledge of the occurrence, distribution and activities of

microbes in nature and their role in soil fertility. None of the first projects of the first three stations had any remote connection with this branch of science. The problems of organic manures and peat bogs in Connecticut and the study of ensilage and crop diseases in New Jersey were the only ones that may have had some bearing upon microbiology. Nearly a quarter of a century was to pass before Voorhees decided to undertake a study of the problem of nitrification. With this in view, he appointed, in 1899, a chemist to determine how important this process was in most soils and how it is influenced by the use of stable manures. There was at that time a very pertinent need for a study of this nature. It had been shown only a year or two before in Germany by Wagner that when manure and nitrate are brought together in solution culture, the nitrate is rapidly destroyed by certain bacteria present in the manure and the nitrogen is liberated in a gaseous form. The fertilizer problem was a very important one as you have seen from the title of the projects I gave you and the nitrate was the major source of nitrogen. Stable manure was still available and was still used in large quantities. No wonder, then, that Voorhees was worried. Nitrification may be considered as the first true project in soil microbiology planned by any institution in this country. This was only 50 years ago. The results were astounding. Wagner's conclusions were found to be completely unfounded, since they were based upon the use of solutions, and all agricultural soils were found capable of producing nitrates quite effectively. It may be of interest to note that when Dr. Voorhees submitted this report to the Journal of the American Chemical Society he received the first Nichol award which was given at that time for the most outstanding paper published in the Journal during the year.

It soon became evident, however, that the soil harbors a very extensive microbiological population; that, in addition to the bacteria, other microscopic forms of life are very abundant and probably play very important roles in soil processes, such as the fungi, actinomycetes, protozoa, and possibly ultramicroscopic forms of life. It was also soon established that these organisms do not live in tightly isolated compartments, but exert a variety of influences upon one another. Not only are some of them useful to crops and others harmful to crops, but they may also be harmful to one another.

This gave rise to certain very interesting speculations. One of these was the "protozoan theory of soil fertility", and here we have a battle, on the one hand, between the Rothamsted Experiment Station in England, the oldest station in the world, with some of the stations in this country. The workers at the Rothamsted Station said that the protozoa consume bacteria and in doing so lessen soil fertility; any soil treatment which will result in the destruction of the protozoa favors the bacteria and leads to improved fertility. This was a very dramatic project. It held the concept of "good and evil". However, this theory was not universally accepted. It was the American experiment stations that played an

important part in uncovering some of the unjustified assumptions upon which it was based. In doing so, they discovered numerous fundamental facts which tended to clarify considerably our concepts of soil microbiology.

These studies brought out the fact that microorganisms tend to live in the soil in a state of equilibrium. Our knowledge of the numerous soil organisms was gradually enriched, so that, before very long, a new concept could be formulated concerning the soil microbiological population and its importance in soil processes and in plant growth. Not only the organisms themselves, but their physiology and biochemical activities, began to receive universal attention. The time has long passed when one could justify a lack of sufficient knowledge of certain groups of microorganisms on the grounds that "one does not keep in touch with developments of soil microbiology". It is largely work of the experiment stations in America that has shed considerable light upon the knowledge of these groups of microorganisms and their importance in natural processes.

I should like to quote from Dr. Lipman, the director of one of the stations, who said, in 1927, before the First International Congress of Soil Science: "But much as the student of soils may be tempted to ponder on man's past, he must leave this to the philosopher and the poet. It is his task, rather, to inquire into the relations of climates, soils, plants, animals and man. Soil science must build a foundation large enough and strong enough to support the study of plant food resources and their mobilization, of the inter-relations of soils and plants and of soil characteristics and peculiarities as reflected in the make-up of plants, animals and man. It is the duty of soil science to establish more clearly the relation of crops to soils in order that cropping methods may best conserve plant food, solar energy and human labor. Soil science should plan a more far reaching program of research and education in order that it might serve in a constantly larger way the needs of human society that from year to year is growing more complex in its organization and more exacting in its demand for such of the products of the land as are essential for maintaining the moral and spiritual values that are the final measure of human activities."

What has been said of soil science applies with equal and even greater force to numerous other fields of science, such as genetics, plant physiology, animal nutrition, entomology and veterinary science. It is often said that, had American experiment stations and other government agencies made only one of a few individual contributions, such as the Babcock test, Theobald Smith's work on the tick fever in cattle, the work done here on hybrid corn, the work on vitamin D, on streptomycin, on Newcastle and other virus vaccines, each one of them would have fully justified all the experiment stations in America. However, many contributions have resulted from the regular activities of the experiment station and federal government projects. Thus, from a few

limited attempts to solve practical problems of interest to rapidly growing agriculture, the American experiment stations and federal institutions have grown in stature, especially in the part they have played in the advance of fundamental and applied science. They, more than any other example, serve to emphasize the fact that small investments in science will bear great fruits, and that the government was very wise in going into agricultural research 75 years ago.

I should like to illustrate this again by citing certain data on the productivity of the American farmer.[1] Between 1875 and 1940, the percentage of farm labor force to the total population decreased from 17.5 to 7 per cent. Whereas in 1875, one farm worker in the United States supported 5.5 persons, this number increased to nearly 15.0 in 1945. The farmer output per worker increased from 100 in 1870 to 324 per cent in 1946. These achievements are largely the results of the research activities of the American Agricultural experiment stations and the United States Department of Agriculture with its many affiliates.

Looking back over these years, one is almost overwhelmed by the tremendous progress made in all these fields of science, especially in the biological and physico-chemical sciences. In every one of these branches, the experiment stations have made notable contributions. It has often been said, that in certain sciences, scientists started out to uncover scientific explanations to known practical applications. After all, as in many of the biological sciences, the search for explanation of known applications and efforts to improve accepted practices, and the uncovering of fundamental scientific facts have gone hand in hand; one or the other may first lead, then follow, or both may advance simultaneously.

This is well illustrated by some of my own work, namely on the actinomycetes of the soil. When I first started in 1915, there were not more than two or three persons in the world who were interested in these organisms and thought that they would ever amount to anything. However, only during the last three or four years, one of the products of the growth of these organisms has reached the astounding value of nearly 100 million dollars a year; about a half of this amount was exported abroad; in addition to this, numerous plants are being erected in various European countries. It is sufficient to mention also the other antibiotics that are now used to combat so many diseases of mankind that had never been subject to therapy previously; these are, in addition to streptomycin, chloromycetin, aureomycin, terramycin, and certain others. What I've said of antibiotics will apply, scarcely to a lesser degree, to the vitamins, such as B_{12}. Today, in America alone, more than one thousand investigators are said to be engaged in the study of actinomycetes.

This illustration emphasizes more strongly than any other I can think of that the line of demarcation between fundamental research

[1] U.S. Department of Agriculture Miscellaneous Publication 630.

and applied research is frequently a rather vague one. The study of vitamin B_{12}, for example, serves to emphasize this. Workers started out with the purpose of isolating a simple chemical substance and ended with an extremely important application to human welfare. Who can say, therefore, that any scientific facts will remain bare facts and will have no future application, or that public investments in fundamental research will not be fully repaid?

I wish I had time to discuss another important problem of modern society, developed largely in government institutes, namely, that of national defense. I should like to quote from J. R. Steelman, who in his volume on "Science and Public Policy", said: "In the War, the laboratory became the first line of defense, and the scientist—the indispensable warrior. A nation which is backward in fundamental scientific knowledge—which falls behind others in the exploration of the unknown—would be severely handicapped in any future war." The logical conclusion, therefore, was reached that greater emphasis should be placed upon basic research in our national budget.

Three phases of biological research that were greatly stimulated by the last war were certainly not initiated by the war, but they were greatly enlarged and encouraged. I have in mind the field of antibiotics, the problem of tropicalization, and biological warfare.

Certainly biological warfare has been argued about since the days of Tyndall, as the following quotation from the British Journal, "Nature", dated 1870, will illustrate: "Prof. Tyndall will have much to answer for in the results that may be expected from the spread of his 'dust and disease' theory . . . The committee on explosives, abandoning gun cotton, should collect the germs of smallpox and similar malignant disease . . . and load shells with them."

No agency is better able to finance and direct the study of problems that have a broad relation to national welfare in a modern society than is the government. After all, any scientific discovery involves three stages: (a) initiation of research and discovery of new principles; (b) development of these principles and indication of their applications; (c) bringing the resulting processes into being and utilizing them for public welfare. While the last can certainly be left to industry, or agriculture, or public health, the first two fall within the domain of government institutes. The research workers in these, together with those in universities and in various institutes, can and should be responsible for the uncovery of the further mysteries of Nature. With the ever-increasing cost of carrying out scientific research, the government institutes must and will take over a greater share for carrying out scientific research and point to the potential practical applications of the basic facts thus uncovered.

It was former Secretary Henry A. Wallace, who emphasized that: "Basic scientific research now requires a very large capital investment in laboratories, equipment, and other facilities and involves substantial operating costs. In the past these costs have been borne by corporations, the Federal Government, universities, and private foundations. The extent of the research now required far exceeds the financial resources of the universities and private foundations, and much fundamental research for which there is no immediate practical application as salable products will naturally not be undertaken by corporations. Increased Government support is necessary to make scientific and technical information generally available in the interest of equalizing opportunity for large and small business, the promotion of competition, the prevention of monopoly, and the stimulation of economic advance."

Vannevar Bush, former chief of the Office of Scientific Research and Development, is just as emphatic in recommending the establishment of a national foundation: "Progress in the war against disease depends upon a flow of new scientific knowledge. New products, new industries, and more jobs require continuous additions to knowledge of the laws of nature, and the application of that knowledge to practical purposes. Similarly, our defense against aggression demands new knowledge so that we can develop new and improved weapons. This essential, new knowledge can be obtained only through basic scientific research. Science can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world."

Government-supported institutions have done and will continue to do so at an ever-increasing rate. They will serve as one of the most important fountains of research which will continue to be the fundamental base for stimulating industry and agriculture, and lead to improvement of public health and human welfare.

The concept of a research institute, as it has been visualized by those who established this Experiment Station, has been fundamental in nature, a search for basic facts. This is well described by Samuel Johnson, who conceived of the Station as a place "where competent scientists would make a regular business of discovery". The fundamental facts thus uncovered by careful investigation soon proved to have numerous important practical applications. The agricultural institution thus became a gathering place for scientists. These scientists concentrated, not only upon the discovery of facts which might prove of practical importance in agriculture, but also upon the uncovering of fundamental principles, as determined by analysis, and upon establishing the role of the facts thus uncovered in natural processes. The fundamental concepts which served as a basis for the establishment of this institute soon proved to be the pattern for others to follow.

Institutes of this nature offer an ideal opportunity for teamwork research, which is so characteristic of modern scientific development. It

is true that the individual research worker has an important place in this and in other institutes, and he should be encouraged and supported in every way possible. But it is the results of the work of a team of investigators, the careful planning and coordination, that have yielded some of the greatest discoveries in recent years. I can best illustrate this again from the field of science that I am most familiar with at the present time, that of antibiotics. It is true that two of the classical observations in this field have been made by individual investigators, namely by Fleming, in 1929, on penicillin, and Dubos, in 1939, on tyrothricin. These were important discoveries but, without further coordinated efforts, one remained as a laboratory curiosity, and the other was not extended further and proved to have only limited practical application. It was the team of Oxford investigators that established the nature and potentialities of penicillin, and the planned comprehensive studies on antibiotics, produced by actinomycetes in our and other laboratories and in this institution as well, that yielded, in rapid succession, streptomycin, chloromycetin, aureomycin, terramycin and neomycin—all of which proved to be of inestimable value to mankind.

It is the coordination of the discoveries of the individual investigators, therefore, on the one hand, and of the team of research workers on the other, that will yield the great secrets of nature, for the benefit of man. The government institutes, as conceived originally by the fathers of this Station, offer ideal opportunities both for individual initiative and for planned teamwork. Let us hope that modern society will learn to use these discoveries for its own well-being rather than for its destruction. The subject of antibiotics, which I have used as an illustration, as it has unfolded itself only during the past decade, has proved that it can be done.

III.

ENDOWED INSTITUTES

ALEXANDER WETMORE
Secretary, Smithsonian Institution

One of the most interesting chapters in the history of American science is the story of the foundation of our first learned societies and scientific institutions. The oldest of these, as we all know, is the American Philosophical Society, founded in Philadelphia in 1743, somewhat more than a hundred years after the first colonies established themselves in North America. Explaining this long interim, Benjamin Franklin said at the time: "The first drudgery of settling new colonies, which confines the people to mere necessities, is now pretty well over and there are many in every province in circumstances that set them at ease and afford leisure to cultivate the finer arts and improve the common stock of knowledge." Even so, in that early period those Americans who had opportunity or leisure for scientific study continued for the most part to look to the Old World for guidance. And it was nearly forty years later that a similar institution, the American Academy of Arts and Sciences, was organized in Boston, and in 1780 incorporated by the Massachusetts Legislature. In Washington, the Capital City, there was nothing comparable to these Philadelphia and Boston groups before 1840. The nearest approach was the Columbian Institute for the Promotion of Arts and Sciences, which held meetings in a room in the Capitol and had the support of men such as John Quincy Adams, Henry Clay, Edward Everett and Daniel Webster. But this organization was short-lived. Though it was succeeded by a somewhat stauncher society —the National Institution for the Promotion of Science—this did not survive the Civil War.

It is no wonder then that when, in 1838, under the operation of the remarkable will of the Englishman James Smithson, the United States came into possession of half a million dollars—a large sum in that day —to "found at Washington an establishment for the increase and diffusion of knowledge among men" our Congress did not at first know what to do with it. For eight years the legislators debated the question as to what form Smithson's Institution should take. Few of them, I venture, realized that they were making history. For the Smithsonian Institution not only set a format for the endowed scientific institution that has had wide application, but for many years the Smithsonian was a principal source of substantial aid to scientific inquiry in the United States. Although Congress over the years has given the Institution the job of administering several Government bureaus, the Smithsonian, as the parent organization, with increased endowments from many sources,

has always been a private institution, under Government guardianship, as envisioned originally by an individual who sought to advance the frontiers of man's knowledge and thus to perpetuate his own name. Since those early beginnings of more than a century ago, the endowed institution has become a definite part of our society. In a broad sense it represents continuation and extension of the interest of those wealthy persons of the seventeenth and eighteenth centuries who promoted science as an individual effort, whose successors in the later years have been far-sighted and altruistic in their financial gifts in permanent endowments to promote the cultural welfare of man.

Obviously, there are many kinds of endowed institutions, of varying magnitude, purposes and designs. In our present day they range from the large foundations, such as the Rockefeller Foundation and the Carnegie Corporation, with assets running into many millions of dollars, to small museums, colleges, libraries, scholarships, chairs, and other memorial and trust funds. Big and little, they have entered into our economic and social structure in a pervasive manner that is easy to observe but difficult to evaluate fully with clarity or precision.

To provide a background for our present discussion, which will be limited on my part to the endowed research institution in America, I should like first to mention very briefly the nature and accomplishments of a few of the more outstanding endowed institutions and foundations that we have known in this country during the past two centuries; and I beg your indulgence if in so doing I refer frequently to the institution with which I have been associated for the past twenty-six years, since my closest familiarity is with its operations.

I have already mentioned the American Philosophical Society, founded by Benjamin Franklin and his fellow Philadelphians. Patterned to a large degree on the Royal Society of London, it has remained for more than 200 years one of the most distinguished bodies of scholars in the Western Hemisphere. For the greater part of this long period the society was self-supporting. It held meetings of its members for the exchange of information in all branches of learning, and built through these years a most impressive series of publications. More recently, the Society has come into possession of considerable endowment funds, mainly through the unencumbered gifts of the eminent geologist, Dr. Richard A. F. Penrose, Jr., and so has been able to expand its activities. Under this income it has held numerous symposia and conferences on current scientific and educational problems; it has extended grants in aid in many important researches of workers in other organizations; and in 1935 it began its new series of *Memoirs*. The Society since its foundation has wielded a wide influence on learning in America, an influence that continues unabated. At the present time, then, the American Philosophical Society is in part a mutual society of men organized "for promoting useful knowledge," and in part a corporation administering endowment funds, the income of which is appropriated for research and other purposes concerned with human welfare. This same evolution has taken place with many other learned societies—a change from a self-supporting association of members to an endowed institution with wider opportunities for service.

Another example is found in the American Academy of Arts and Sciences. This society too had its Benjamin Franklin—in the person of John Adams, who was its prime instigator and who served as its president for nearly a quarter of a century. In the year of its incorporation in 1780, the Academy sponsored its first research project—an expedition undertaken in collaboration with Harvard College to what is now Islesboro, Maine, to observe an eclipse of the sun. One account of this maiden effort illustrates that truism of scientific research: that frequently the by-products are of more importance than the result originally sought. "Although the Revolutionary War was still in progress," the account says, "the scientific party headed by Professor Samuel Williams of Harvard was permitted to land by the British naval authorities, but so little time remained for the astronomers to make preliminary observations on the latitude that when the eclipse took place they found themselves just outside the path of totality. This very fact, however, enabled them to discover what are commonly known to the astronomer as Baily's Beads." Except by this accident this interesting phenomenon would have remained longer unknown. The Academy now administers a variety of funds, best known of which perhaps is the Rumford Fund, established in 1796 by Count Rumford, the American-born Benjamin Thompson, who four years later was to establish the Royal Institution of London. The Rumford prize is given for discoveries on light or heat; grants may also be made from the fund for the purchase of scientific apparatus, for aids in research, and for the publication of scientific papers. The first recipient of the Rumford medal was Robert Hare, of Philadelphia, in 1839, for his invention of the compound or oxyhydrogen blowpipe; the most recent was Franz Eugen Simon for his "outstanding contribution to the attainment of low temperatures and to the study of the properties of substances at temperatures near the absolute zero". In general, it has been said that the Academy's grants "have produced results of value far in excess of what might have been expected from the small amount of money involved. Through their aid, discoveries of broad significance have resulted, which would otherwise have been indefinitely delayed." Furthermore, the Academy has a distinguished publication record. Its *Memoirs, Proceedings* and other series have been for 170 years "one of the main depositories for original scientific monographs by American men of science".

We must not forget two other great institutions—both in Philadelphia—that belong to this early period in the nineteenth century. The first of these, the Academy of Natural Sciences of Philadelphia, was established in 1812; the second, the Franklin Institute, in 1824.

Each has a special province—the Academy being concerned with the natural sciences, and the Franklin Institute with the mechanic arts and applied science. Both maintain large libraries and museums, and both have endowment funds to administer, though the Academy is supported in large part by subscriptions and membership contributions. The Franklin Institute administers the Henry W. Bartol Research Foundation, for carrying on research in the applied physical sciences, and the Fels Planetarium, both created by special gifts. The Proceedings of the Academy of Natural Sciences have been in continuous publication since 1841, while the Journal of the Franklin Institute, published since 1826, has reached its 249th volume—both truly remarkable publication records. Both of these institutions, it should be emphasized, have wielded an influence extending far outside the locality in which they happen to be situated.

In the year 1846, which our American historian Bernard De Voto has called the "year of decision" because of the number of important events in the history of our country that revolve around that date, there came into being the Smithsonian Institution. The story of how this Institution originated, through the provisions of the will of James Smithson, has often been told and need not be repeated. The Smithsonian was unique, as from its very start it was an endowed institution, differing from the learned societies already mentioned in the fact that it was not made up of an association of members but, under specific authority of the United States Congress, operated with the single purpose of utilizing Mr. Smithson's money in the way he had directed. The first Secretary of the Smithsonian, the physicist Joseph Henry, a genius in the art of organization, laid down and fought for certain precedents and principles that made the Institution something of a paragon. In a biography of Joseph Henry only recently published, Thomas Coulson, of the Franklin Institute, remarks that Joseph Henry made the Smithsonian Institution "a powerful auxiliary to scientific culture" and "the greatest influence upon American education for almost a century".

One principle enunciated by Joseph Henry was that of cooperation. He saw great possibilities for the new institution, but he realized that with its available income it could not accomplish alone all that he envisioned for it. In his report for 1854 he emphasized this point. "It is the policy of the Institution," he said, "to furnish all the means in its possession to aid scientific research, and not to hoard up its treasures or confine their use to those who may be immediately connected with the establishment, or who may be supported by its funds. *Cooperation* and not *monopoly* is the motto which indicates the spirit of the Smithsonian operations." The Institution always has endeavored to live up to this statement. It has furnished cooperation in important ways by conference and advice, through correspondence and otherwise; by furnishing materials for investigation, as a gift or loan, and for teaching purposes; by personal assistance; by direct subsidy, and by means of

publication. It has cooperated in many hundreds of scientific expeditions and explorations. In this same report of Henry's for 1854 there were listed twenty-six important explorations undertaken by the Institution during the preceding two years, including six Pacific Railroad surveys, and it was stated that "with scarcely an exception, every expedition of any magnitude has received more or less aid from the Smithsonian Institution". This record of scientific study in the field since that period has extended widely to remote portions of the earth, and still continues. In the publication field, the first memoir issued by the Institution, the now-famous volume "Ancient Monuments of the Mississippi Valley," by Squier and Davis, was a magnificent cooperative effort of a kind that has continued through the years. A very considerable portion of the papers comprising the 35 quarto volumes of the Smithsonian Contributions to Knowledge, and the 115 volumes of the Smithsonian Miscellaneous Collections are by writers not connected, or but indirectly connected, with the Institution.

I have dwelt upon this principle of cooperation because it points to a problem that faces every endowed institution—how to dispense funds and cooperation widely, and wisely, and at the same time maintain a rigid independence and full freedom of action. Here again, I believe, Joseph Henry, in his advocacy of that freedom, made a real contribution. Today, it is easy for us, who live in our democracy, to understand why we must all strive to keep our endowed institutions free, but in retrospect it is important to note that Henry, at that early date, clearly saw the necessity of keeping the institution he headed a free agent, unrestricted except by the broad limitations of the stated aims of the organization. Perhaps he was guided by the wisdom of George Washington, who advised his countrymen to "avoid entangling alliances".

Nearly two centuries ago, William Blake, thinking in terms of the creative imagination, said, "Poetry fettered fetters the human race". The same is true of science and scientific research. Science fettered retards human progress. The decline of creative science in totalitarian countries is not hard for us to visualize. The inquiring mind may reach a goal by being bound to prescribed formulae or to preconceived notions but, under such restrictions, it will never blaze a truly new trail or chart a truly new course.

Individually working in the interests of humankind, our endowed institutions have magnificent opportunity to maintain themselves unshackled by political or business loyalties, governmental conservatism, central planning, regimentation or other expediency. Dr. Vannevar Bush, in his report to President Truman in 1945, "Science the Endless Frontier", refers to our research institutions as "the well springs of knowledge and understanding". "As long," he said, "as they are vigorous and healthy and their scientists are free to pursue the truth

wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it."

The endowed institution has thus a definite obligation to recognize and encourage uncompromisingly the status of the research worker as a free agent in his approach to his problems and in the ultimate result that he may attain. This does not mean that the scientist must be a lone wolf or a prima donna, for no one knows better than he the value of unregimented cooperation or of the inspiration engendered by the association of several minds. Many of the more important results of scientific research of the present day are the result of close teamwork by research workers, directed in operation, but free in their interpretation, and in shift of approach as their problem develops. It means that the scientific worker, if he is to be truly productive, cannot have hanging over him any threat or shadow that would poison or dilute the stream of his thinking in his investigations. It means that there can be no compromise between truth and error, nor any bending of results because of compulsion imposed by social systems or ideologies.

Around this very point has revolved one of the most amazing spectacles in scientific controversy of recent years—that between the Lysenkoists and those who hold with Mendelian-Morganist genetics. It is important for us to remember the basic principles from which the totalitarian scientists have departed so disastrously. I feel that the endowed research agencies have definite responsibility in upholding these principles to the world against all odds.

It has doubtless occurred to you by now that we must differentiate two principal types of endowed institutions: (1) those that initiate and operate research programs of their own, in addition to administering endowment funds for the aid and encouragement of science, and (2) those that only administer funds for research grants and other purposes. In the first group we have, for example, in the scientific field, such organizations as the Carnegie Institution of Washington, which according to Dr. Keppel was "the first foundation to be specifically dedicated to research"; the Mellon Institute of Industrial Research, organized to conduct comprehensive investigations in the pure and applied natural sciences and to train research workers; the Smithsonian Institution; Research Corporation, which as a non-profit organization administers patents and applies the income to grants for scientific studies; the Allan Hancock Foundation, for research in marine biology; and many other agencies. In the second category—those that conduct no research programs but make awards, grants and fellowships for purposes including scientific research are the Carnegie Corporation of New York, with capital assets of over $170,000,000; the Rockefeller Foundation, $158,000,000; the Commonwealth Fund, $50,000,000; the John Simon Guggenheim Memorial Foundation, $25,000,000; the Mayo Association, $32,000,000; the Viking Fund, $3,000,000—to name but a few.[1]

[1] The figures here are from the 1948 edition of "American Foundations and Their Fields".

I list these in order to convey some idea of the scope and magnitude of the foundations, which in part represent some of the largest fortunes ever accumulated.

This support of the public interest through research is only part of the picture, for even in cultural matters we cannot live entirely through our rich friends. We must also help ourselves; and, manifestly, the largest share of the cost of education with its many related scholarly activities, of many phases of scientific investigation, and of humanitarian services, must be managed by public agencies through taxation by the state. Large-scale support of applied research by the Federal Government was a particular outgrowth of World War II, and still continues, but this will not reduce the scope of the work of private endowments for research in any degree. Where Federal funds enter the same fields, these should supplement and not attempt to replace. What has changed the picture in recent years has been the dispersal of many private fortunes, particularly through the operation of higher income and corporation taxes. Just before the financial crash in 1929, it was estimated that there were 30,000 to 40,000 millionaires in the United States. By 1948, according to one estimate, this number had dropped to 8,000. This redistribution of wealth has operated to increase the number of the small foundations, as shown by figures given in the volumes, "American Foundations and their Fields". In the first edition of this work, published in 1935, 123 foundations were reported; in the sixth edition, published two years ago, 899 in all classes were included.

It may be that we may never again have the equal of a Carnegie, a Rockefeller, or a Mellon, with their almost incredible fortunes and philanthropies, but it is safe to say that the influence and diversifications of the endowed institutions will become steadily broader. It seems probable that we always shall have the equivalent of our Pulitzer prizes, Nobel awards, Rhodes scholarships and Guggenheim fellowships, and it is likely that their benefits will be more widely disseminated. It is comforting to remember in this connection that it is not necessarily the large grant that produces the greatest results. We are told, for example, that the discovery of the vulcanization of rubber by Charles Goodyear was made possible by a hundred dollars contributed by a relative at a critical time when the experiments might otherwise have been abandoned. In the same way allotment of funds by the Smithsonian to Robert Goddard at critical times for support of his rocket studies gave return out of all proportion to their size.

All in all, the role of the foundations in our democracy represents a tremendous potential. The place they occupy can scarcely be overestimated, and they have made possible some of the most important contributions to modern science. Only a portion, of course, of the huge assets available are for scientific research, but, even so, the trustees of these foundations have in their power the opportunity and the right to

uphold our democratic ideals and to keep research free and untrammeled. And in a very real sense they are obligated to do so, an obligation for the good of all that has been recognized by the Government in making them tax-free.

Parenthetically, may I observe that my first scientific studies following my undergraduate days in the university were in one of the scientific bureaus of our federal Department of Agriculture, where I was occupied in research, which in the end result was applied in some form to the advance of the interests of the farmer. From this experience it has seemed to me constantly that the research opportunity in an agricultural experiment station, such as the one in whose honor we meet, is one of the great ones, as here it is possible to carry forward pure research on the one hand and the direct application of the practical part of this research to the benefit of agriculture on the other, to the end that there may be steady advance and progress in both. It was belief in this possibility that led to the establishment of The Connecticut Agricultural Experiment Station seventy-five years ago, and recognition of the resultant accomplishment that has brought the expansion of the agricultural experiment station program throughout our land.

To return to our endowed institutions, the future of our financial endowments is one that gives grave concern to many minds, but one for which undue pessimism should not prevail. Increased taxation on private and corporate income, imperative today because of the common necessity, has sharply curtailed gifts of funds for research and for philanthropy in general. This same taxation likewise curtails income from the usual kinds of trust fund investment. Some of the smaller groups may be partly or wholly eliminated but I believe definitely that the larger ones will continue. Increasing costs, through inflation and other factors that are steadily with us, may limit scientific production in the more expensive and elaborate laboratories and organizations to some extent, but the funds available for smaller grants to individual workers and to groups of workers will continue to produce new knowledge as they have in the past—knowledge that will apply for the good of all. New knowledge does not necessarily have to be large to be valuable.

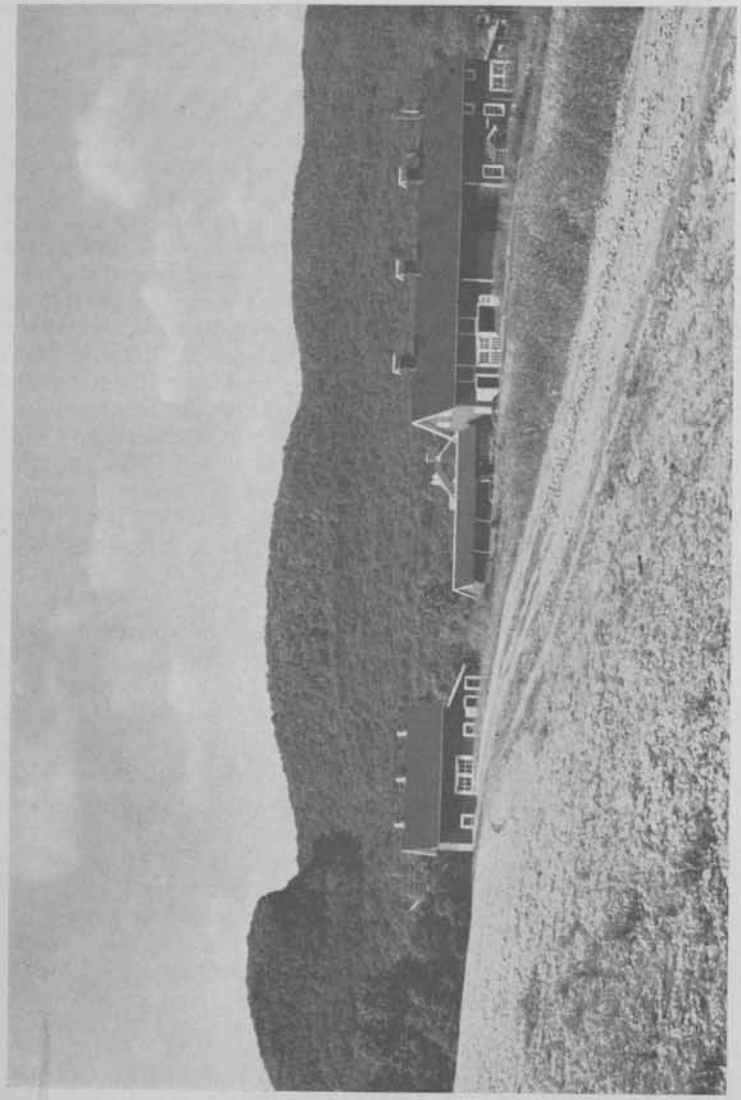
While governmental tax-raised funds may have to take over maintenance of many of the present collections of art, natural history and other cultural materials now in private hands, research of individual workers may always be subsidized, both in connection with such collections and apart from them.

I am inclined to feel that national public agencies, such as the proposed National Science Foundation, can never fill the role that the private foundations have played and are playing in our democracy. Whenever it comes to fruition, the National Science Foundation will be a very potent supplement and encouragement to the Nation's research

activities, and it will furnish much vital financial plasma to the blood stream of American science. But, if I may say so, a foundation that depends for its existence upon short-term and annually uncertain appropriations made by Congress is not a foundation in the sense of those that we are discussing nor can it be expected to fulfill the same long-time functions.

If there is one characteristic common to those American endowed institutions that have wielded the greatest influence, it is the breadth under which they operate. I believe that it is this trait that has distinguished them, and that has given them life by enabling them to keep abreast of the times. In this changing world in which we live, real security for the future is often more a dream than a reality, and we are coming to think that perhaps there is no such condition as "in perpetuity". Naturally a benefactor in giving away his money wants to be sure that it always will be used for the purposes close to his heart, but he should not be short-sighted in the restrictions with which he hems in his gift. As Fred Keppel once described the situation, "He has sometimes in his mind a beautiful picture of what he would like to accomplish, and proceeds to paint this picture in too great detail upon his deed of gift. He does not foresee the inevitable division of responsibility between the dead hand . . . and the living minds of trustees to come." It should not be hard for him to realize that he can benefit mankind most, and his name will live longer, if he believes in the integrity of trustees and leaves his gift unrestricted. On the seal of the American Philosophical Society appears the Latin motto *Nullo discrimine*. James Smithson left his fortune to establish an institution for the increase and diffusion of knowledge among men. He did not limit in any way the kind of knowledge, and as a result the Smithsonian has been able to operate for more than one hundred years along a broad front, adaptable to changing times, and to the special abilities of its staff. The Rockefeller Foundation was established simply for "the well being of mankind throughout the world". The Carnegie Institution of Washington was created to encourage "in the broadest and most liberal manner investigation, research, and discovery, and the application of knowledge to the improvement of mankind". True, always there will be many endowments made for specific purposes, but those that reflect the greatest and longest-continued honor to their founders, and that serve mankind best, are those with the fewest strings attached to them—for the good of all the people *nullo discrimine,* without distinction.

In closing, I should like to recall to your minds that terse injunction once made by Andrew Carnegie. "Find the efficient man," he said, "and enable him to do his work." Therein lies the secret of administration in successful scientific research, and therein, in the last analysis, lies the greatest opportunity for the endowed research institution and foundation. It is not so simple as it sounds.



View of the Experimental Farm at Mt. Carmel, showing the main barns, with the Sleeping Giant Mountain in the background.

IV.

UNIVERSITIES

EDMUND W. SINNOTT
Director, Sheffield Scientific School, Yale University

Among mankind's great tasks today, one of the most important and significant is that of pushing forward the frontiers of scientific research, for on its results depends in large measure the progress of civilization. This intensive search for truth about the universe and the living things which inhabit it has now far outrun the efforts of men like Franklin and Darwin, who were essentially amateurs. It is no longer the task simply of a few professors in our universities or scientists in academies. Scientific research is being undertaken from many directions and in many ways. My predecessors on this program have shown how diverse is the field of modern investigation. Laboratories supported by the state, like the one which we are here met to honor, have had a long and valuable part in it. Endowed institutes, devoted to particular fields of research, have been of great significance. The rapid growth of industrial laboratories in recent years testifies to the profound importance of science in the practical affairs of men. Despite the activity of these newer agencies, however, we cannot fail to recognize the vital contributions which our universities still make to scientific research. In them science has long been nurtured in the United States and their contributions are still of the very greatest importance. Scientific investigation in our universities is far from outmoded. It has never been so active as it is today. Universities are not only concerned with the actual conduct of research, but are the source and training ground of the host of young scientists who are so vitally necessary in carrying forward our great programs of research everywhere. These great institutions of learning are destined, I believe, to continue as the most important contributions to scientific progress in the world.

The university has a number of advantages as a center of scientific research.

Ideally it is free from subservience to others—to the government, to special interests, or to industrial requirements. It has no necessary tie to practical problems. It can enter any field of research no matter how recondite or how little promise of economic significance there may be in it. President Lowell of Harvard once said that if a university scientist wished to study the left hind leg of paleozoic cockroaches, he should be free to do so. No other agency has this complete freedom of action to explore every nook and corner of the universe without regard to where the exploration may lead. In this wide-ranging search, discoveries of the most unexpected kinds are often made. One old friend of mine studied for many years the fossil, Foraminifera, a field from which we should

expect little but the most specialized knowledge to result, but his researches, amazingly enough, proved to be of the utmost value to engineers in their search of petroleum. The scientific investigator who is free to range wherever he will is a notable exponent of what Horace Walpole called serendipity, the ability to discover new and surprising things quite different from the ones which he set out to find.

Another important advantage of university work is the possibility which it offers of guiding the next generation of investigators. Teaching is one of its important responsibilities. Truth must not only be discovered, but passed on to others who must themselves be trained to find more truth. This is not only a valuable contribution of the university to society, but is in itself an important stimulus to research. The presence of keen, inquiring young minds is always conducive to intellectual activity and is sometimes missed in those more monastic institutions where teaching is not done. Men in such places often look longingly, I think, at their university colleagues for whom this resource is so abundantly available. Our students may owe us much, but surely we owe much to them, as well. Without their continual challenge, we might well slip into the authoritarian attitude which, many think, comes very easily to professors.

A third advantage is the presence in the university of men from very different disciplines. One of our dangers in the sciences is that of too narrow specialization. We need, and perhaps especially in these days, wider contacts between ours and other great fields of human knowledge. The opportunity for this is provided in the university in higher degree than anywhere else. Aside from the pleasure and stimulus of living in such an atmosphere, men often gain indirectly much actual help in their own problems. Let us remember that Darwin got one of his greatest ideas from an economist. As a morphologist, D'Arcy Thompson was much aided by mathematicians in his studies of the geometry of organic form. The company of poets and literary men is not to be scorned, for scientists work by inspiration as well as application. More than all, as science becomes more and more complex, we need the help and company of the philosophers. To be a citizen in this community of diverse minds is thus a profound advantage which the university scientist possesses as compared with his colleagues in other institutions. He should exploit it more than he sometimes does. As a result of their situation in this favorable environment, the scientific men in our universities have been able to maintain their leadership in many fields of work and especially have made their laboratories the chief source of theoretical progress. We have long looked to our universities as great centers of germination for new ideas.

With all these advantages at their command, you may ask why it is that not all scientific work is being done in our universities. There are a number of reasons why this should not be so. Clearly, the special fields of agriculture and industry need laboratories particularly devoted

to their concerns, in which workers' efforts are focused more sharply on practical problems than is usually possible in the universities. These laboratories have certainly justified their existence and will doubtless continue to thrive. Endowed institutes also have a unique and important place to fill. All these are necessary and productive sharers in the great program of scientific research. There is need for all of them and university science welcomes their cooperation most warmly.

But we must recognize that this Eden of ours does fall somewhat short of perfection, in comparison with other scientific agencies, and that the universities must solve a number of problems which now beset them if they are to continue as leading centers of scientific research. Some of these problems are particularly important today.

First, and most obvious, is the difficulty of obtaining adequate financial support. Science costs progressively more as it becomes more specialized. The simple laboratories and home-made apparatus of past days no longer serve. Elaborate devices of many kinds are now essential if research is to be carried on successfully. We may sometimes wonder whether our investigators may not be overly prone to demand the latest in the wonderful array of new scientific gadgets, and it should be emphasized to them from time to time that it is still possible to do good work in many fields without the very newest models of microscopes and incubators. The fact remains, however, that to work efficiently, and in many fields to do any work at all, modern equipment must be available. The cost of this is mounting rapidly from year to year.

At the same time as this sharp upturn in costs is taking place, the universities maintain with increasing difficulty even their present program in the sciences. This is a matter familiar to all of you and is especially serious in universities like the one which I represent, most of whose support is derived from private funds. Rising costs and falling income, together with the breaking-up of large fortunes, heavy taxes on wealth, and the consequent absence of munificent benefactions of past years, provide one of the serious problems of university administration today. The sciences, particularly, those problem children of the university, especially feel the financial pinch because of their relatively high per capita costs. It is still not difficult to get funds for the investigations of problems which have wide appeal and for fellowships; but givers seem to feel that the basic equipment—the laboratory, the salaries of professors and the general "overhead"—ought to be provided by the universities. It is expenses of this sort which we have great difficulty in meeting. Alumni and generous givers help, of course, but more and more the universities are coming to depend on outside agencies, notably the state, directly or indirectly, for the support of their scientific work. This introduces an insidious danger, since support from tax funds may be expected to bring some measure of governmental control and the spectre of politics in science is ever with us. Even now a vast amount of government money is already flowing to our universities and on the

whole with beneficent results. Many of our greatest institutions of learning are already largely supported by state funds. If government aid is intelligently administered, as we hope it will be in the proposed National Science Foundation, there is little to fear, but the danger is always present that the most precious asset of a university, its complete freedom of intellectual activity, may be imperiled by this means. Because of the temptation to direct our investigations into channels which may lead to practical results, are of interest to givers, or for which funds can be readily obtained, we may easily be persuaded to mortgage our freedom of action. If it is truth which makes us free, freedom also makes for truth, and it should be our particular care to see that this benign circle is not broken.

Fortunately, there is little prejudice now, I think, against working on problems of practical value. In the university where I did my graduate work, there was an almost pathological fear of applied research, as something which was beneath the dignity of a university scientist. That feeling now is pretty well dissipated. All scientific work, whether fundamental or applied, is important, and the line between the two in recent years has been largely obliterated. Nevertheless, the universities do have the great advantage of not being required to look at the practical side of their results and we should be particularly careful not to sell this birthright to gain financial support. It is this problem which keeps administrators awake of nights, for the problem of university research in science cannot be finally settled until an answer is found to this basic need.

There is a second difficulty which makes many universities something less than ideal places for scientific work. The investigator, enthusiastic about his work and eager to be at it, but distracted by many other duties, often longs for the unrestricted days with which his colleagues in other institutions are blessed. He has a teaching load to carry and must do his share to help the university perform its great function of instruction. This duty in many cases, especially with our swollen student bodies and the need for economy, may become very onerous. The number of graduate students is at an all-time high level and there are many research problems to direct and dissertations to read. All this is interesting, stimulating and important, but at the same time it is vastly time-consuming.

Furthermore, in conformity with our American system of university organization, there is a huge amount of executive work which the members of our faculties, especially in the science departments, are called upon to perform. At Yale, for example, the standard equipment for a department of science calls for a chairman, a director of the laboratory, a director of graduate studies and an executive officer. The first three posts are sometimes held by one man—a killing job—but however they may be distributed, there is a lot of work to be done in running a department. This takes not only time and energy but is often a serious distraction from research. We sometimes look wistfully at our

colleagues abroad who seem to manage their universities with much less running to and fro than we seem able to do. This problem is receiving much thoughtful attention, but there is no easy answer to it.

There is a third difficulty that is not confined to university laboratories but is perhaps more evident there than elsewhere. The most precious products of scientific research are *ideas*. These are the raw materials out of which everything else is built. With all the tremendous development in science in the United States, however, it must be ruefully admitted that we have not produced our share of great new germinative ideas in recent years. In atomic research, for example, most of the fundamental theoretical progress was made either by European scientists or men who had received their training abroad. We are strong in applications, in development and engineering, but much less in the fundamental contributions of theory on which these all are based. This is a fact which should give us concern and about which our universities, particularly, have cause to worry. They have long been the chief centers of progress in scientific theory, and the most fruitful producers of ideas, since they have been so free to explore widely.

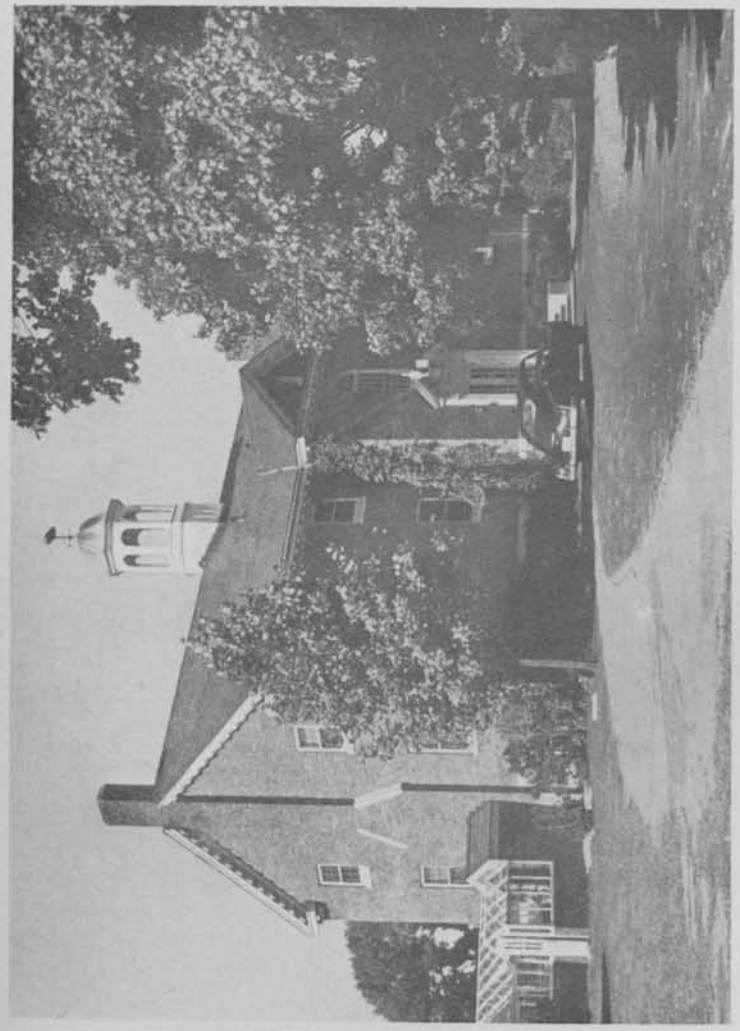
What is the reason for this failure to do our share in fundamental theory? I believe that it is because we spend too much time in collecting data and too little in thinking about them. We are in danger of being overwhelmed by a mass of undigested results. What we need are more active intellectual enzymes to enable us to digest and assimilate this material and to build it into an ordered system of knowledge. Despite the enormous progress we have made, many of the underlying problems in science are still far from solution—that of developmental organization in biology for example—and new ones are constantly arising. We need to think more about our work. We need to develop more adventurous hypotheses. One hears a great deal in these days about teamwork in science, about the need for cooperation between men in different aspects of the scientific field and about the subordination of individual research workers to the group. Certainly cooperative research is essential, but let us not forget that the ideas on which progress depends originate in the minds of individual scientists, and that what is ultimately accomplished depends in large measure on how fruitful this source proves to be.

This problem is perhaps especially conspicuous in the training of our students. A graduate student in science must turn out a good dissertation. It must present a wealth of new facts. If he is to advance in his profession, he must keep producing such pieces of work, concrete, tangible and covering many pages. We are inclined to judge him by the number of hours he puts in at the laboratory and the tables of data he turns out. If we catch him loafing or wool-gathering, we are apt to frown. Particularly if he is prey to that dangerous weakness, speculation, we are moved to take him aside in a fatherly fashion and warn him against it. We point out that the pages of scientific journals are open

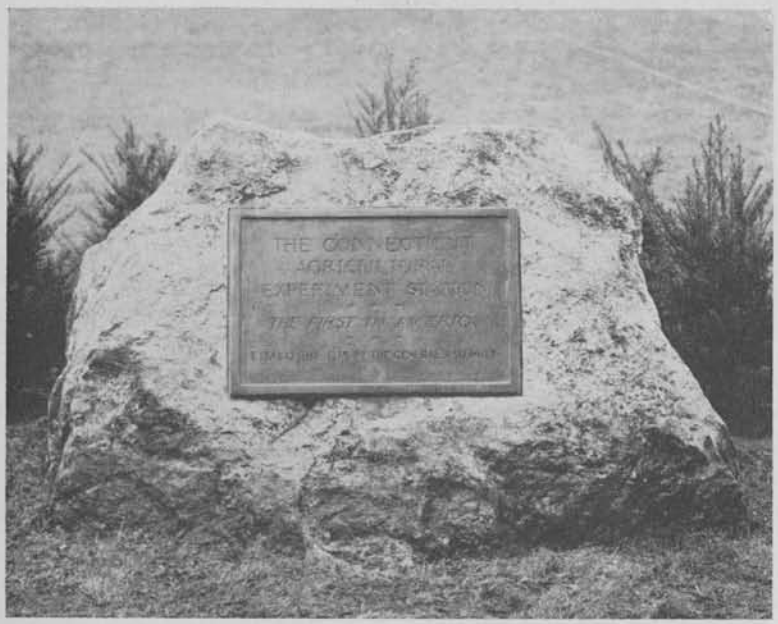
only to papers which report new facts and that mere discussions are discouraged there. This attitude of mind, I believe, too often reduces the research of our students—and sometimes of ourselves—to glorified scientific "busy" work, nothing more than additions to the huge mass of facts which have already been accumulated. We should be of greater service to our students, and ultimately to science itself, if we encouraged them to put their feet up on the table every once in a while and lose themselves in thought about their problems, to walk all around their heaps of facts and look at them from every side. We are sometimes inclined, in our enthusiastic progressiveness, to smile at our English cousins, with their leisurely weekends, their long university vacations, and their time-wasting habit of stopping work for afternoon tea in their laboratories. A little more of this leisurely, relaxed attitude would be good for us, for often those precious things, new ideas and original solutions for our problems, flash into our minds, seemingly out of nowhere, in moments of relaxation. We can prepare the ground for them, but we must lure them in, not try to drag them in by force. Scientists are much like poets, after all, and need often to loaf and invite their souls.

This sort of regimen is good, I think, for all scientists, but it is especially to be encouraged in our universities where the opportunities for profitable extracurricular work of this sort are so numerous. If we can persuade our students that all their capacities—mental and spiritual—are involved in scientific research, we shall do much for the advancement of science and the efficiency of our university work. One of the glories of The Connecticut Agricultural Experiment Station is that it has always emphasized the importance of such research.

These are some of the problems which confront the investigator in our universities and the administrators who seek to make his work successful. They are not insoluble but they will demand our earnest attention in the years to come if the American university is to retain its honored place as leader in the task of scientific research. Our presence here today is evidence of our belief in the supreme importance of this task. There is a vast deal to be done. We may well say that the harvest indeed is plenteous but the laborers are few. We shall need to devote to it a much larger share of our national income and of our resources in mind and skill if we are to gain for society from the sciences the wealth of practical rewards and of intellectual and spiritual satisfaction which they have to offer. There is no single highway to this end. All of us, whether we work in institutions like the one we honor today, or in universities, or in any other sort of organization, are embarked together on that great adventure with the universe which scientific research is. Let us hope that when the centennial of The Connecticut Agricultural Experiment Station is celebrated in 1975, it will be in a more hopeful world where the beneficent influence of science will have done still more to lead us toward that Golden Age of peace and brotherhood for which we all so eagerly yearn.



The Station's Tobacco Laboratory, located at Windsor.



Commemorative tablet presented to the Station on the occasion of its 75th anniversary by a group of Connecticut residents.

PRESENTATION OF COMMEMORATIVE TABLET

The tablet pictured at the left was presented to the Station on the occasion of its 75th Anniversary by a group of Connecticut residents headed by Edward R. Jones of Waterbury. It was placed near the main entrance to the Station by the Connecticut Development Commission, and was unveiled during the Anniversary Celebration. The tablet is fashioned of bronze and is mounted in a boulder of native Connecticut granite from the farm of Norbert Kneur of Guilford.

The presentation was made by Raymond Loring, chairman of the Connecticut Development Commission, who stated, "It is quite obvious that a very wonderful job is being done here, and that you have a great many friends who want to show in some lasting fashion their friendship and their appreciation of the fine work that is being done at the Station. This bronze plaque set in its native Connecticut boulder will be a perpetual reminder to those who visit these beautiful and fruitful grounds that here indeed is the answer to 'Why An Agricultural Experiment Station?'—Connecticut's answer, the first."

Accepting the plaque on behalf of the Station, John Lyman, vice-president of the Station Board of Control, said, "In receiving this plaque for the Station, I know that I am also receiving it for all the people of Connecticut because this Experiment Station serves all of us. I am distinctly proud, also, that there are great numbers of people in the State who wish to commemorate the great work that the Experiment Station has done for agriculture. This, as Mr. Loring says, will be a perpetual landmark, a perpetual memorial, not only of what has gone on in the past, but it will also indicate what can be done in the future."

PROGRAM FOR DELEGATES DINNER

Friday, September 29, 6:30 P.M.

New Haven Lawn Club

TOASTMASTER—JOHN LYMAN, Station Board of Control.

GREETINGS FROM:

Agricultural Research Administration, U. S. Department of Agriculture, PHILIP V. CARDON, Administrator.

Section of Experiment Stations, Association of Land-Grant Colleges and Universities, MASON H. CAMPBELL, Director, Rhode Island Agricultural Experiment Station.

Rothamsted Experimental Station (Harpenden, Hertsfordshire, England), FRANK YATES, Head, Statistical Department.

Wesleyan University, JOE WEBB PEOPLES, Professor of Geology.

University of Connecticut, ALBERT N. JORGENSEN, President.

Yale University, EDMUND W. SINNOTT, Dean, Graduate School, and Director, Sheffield Scientific School.

Industrial Research Institute, Inc., NORMAN A. SHEPARD, Chemical Director, American Cyanamid Company.

American Academy of Arts and Sciences, G. EVELYN HUTCHINSON, Professor of Zoology, Yale University.

American Association for the Advancement of Science, GEORGE A. BAITSELL, Professor of Biology, Yale University.

National Academy of Sciences, DETLEV W. BRONK, President, National Academy, and President, The Johns Hopkins University.

The Honorable CHESTER BOWLES, Governor of Connecticut and President of the Station Board of Control.

DINNER PROCEEDINGS

More than 200 official delegates, staff members and guests attended the anniversary banquet which marked the close of the Station's two-day celebration. Greetings were brought to the Station on this occasion by representatives of government, universities and scientific societies and institutions. The United States Department of Agriculture and the Association of Land-Grant Colleges and Universities, each sent a delegate to salute the first station on its 75th anniversary. The three Connecticut universities, which have been most closely associated with the Station, sent their greetings. Two of these, Wesleyan University and Yale University, housed the Station during its early days.

The three general scientific societies of national scope each named one of its members to bring greetings to the Station. The oldest experiment station in the world, the Rothamsted Station in England, greeted its American counterpart on this occasion. Science in industry was represented by the Industrial Research Institute, Inc.

John Lyman, vice-president of the Station Board of Control, welcomed the guests and acted as toastmaster. Besides introducing the scheduled speakers, Mr. Lyman introduced five persons from the floor. These were: W. L. Slate, Director Emeritus of the Connecticut Station; Mrs. Slate; Theodore S. Gold, grandson of the T. S. Gold who was a charter member of the Station's first Board of Control; Mrs. Gold, and George Haven, grand-nephew of Dr. Samuel W. Johnson, founder of the Station.

The list of delegates which follows was prepared according to our best knowledge of those actually present. However, there were several last-minute substitutions, cancellations and acceptances. We regret any errors of ommission or commission which may have occurred.

Name of Delegate	Title	Representing
ATHERTON, Raymond P.	County Agent	Litchfield County Farm Bureau
ATWOOD, Frank F.	Member	National Association of Radio Farm Directors
BACON, C. Marsden	President	Eastern States Farmers' Exchange, Inc.
BAITSELL, George A.	Member, Executive Committee	American Association for the Advancement of Science
BARR, Charles B.	Secretary-Treasurer	Connecticut Florists' Association
BIRD, Arthur C.	Secretary-Treasurer	Connecticut Nurserymen's Association
BISSONNETTE, T. Hume	Biologist	Trinity College
BLACK, Lindsay M.	Curator of Plant Pathology	Brooklyn Botanic Garden
BLAKESLEE, Albert F.	Director	Genetics Experiment Station, Smith College
BRISCOE, John D.	President	Connecticut Purebred Dairy Cattle Association
BRONK, Detlev W.	President	National Academy of Sciences
BROWNING, Harold W.	Vice-President	Rhode Island Agricultural Experiment Station
BUCKINGHAM, S. McLean	Director	Connecticut Poultry Association
CAMPBELL, Colin E.	Director, Vancide Department Laboratory	R. T. Vanderbilt Company
CAMPBELL, Mason H.	Chairman, Northeastern Section	The Experiment Station Section of the Land-Grant College Association
CARDON, Philip V.	Agricultural Research Administrator	U. S. Department of Agriculture
CHANDLER, Robert F., Jr.	President, University of New Hampshire	New Hampshire Agricultural Experiment Station
CHAPMAN, Leroy M.	County Agent	Fairfield County Farm Bureau
CHESTER, K. Starr	Supervisor, Agricultural Research	Battelle Memorial Institute

Name of Delegate	Title	Representing
CHRISTENSEN, Irving	Vice-President	Connecticut Vegetable Growers' Association
CLARK, Merritt	Vice-President (Sales)	American Seed Trade Association
COE, John P.	Vice-President and General Manager	Naugatuck Chemical Division, U. S. Rubber Company
CONNOR, Ralph A.	Vice-President	Rohm & Haas Company
CONOVER, Mrs. Woolsey S.	President	The Federated Garden Clubs of Connecticut
COULTER, Francis	President	New England Seedsmen's Association
CURME, George O., Jr.	Vice-President (Research)	Union Carbide & Carbon Corporation
DEAN, Philip F.	County Agent	Middlesex County Farm Bureau
DEDERICK, Harold	President	Connecticut Association of Soil Conservation District Supervisors
DEMEREC, Milislav	Director	Carnegie Institution of Washington
DODGE, Barnett F.	Former Fellow	Mellon Institute of Industrial Research
DYAR, George W.	President	Connecticut Pest Control Association
EDWARDS, Sidney A.	Managing Director	Connecticut Development Commission
ELLIOTT, John H.	County Agent	Tolland County Farm Bureau
FARRELL, Michael A.	Assistant Director	Pennsylvania Agricultural Experiment Station
GERSHOY, Alexander	Geneticist	Vermont Agricultural Experiment Station
GLEASON, Henry A.	Head Curator	New York Botanical Garden
GOLD, Theodore S.	Secretary	Connecticut Dairymen's Association
GREENWOOD, Douglas E.	Entomologist	Virginia Truck Experiment Station
HALCROW, Harold G.	Former Economist	Montana Agricultural Experiment Station
HALE, W. Stanley	County Agent	New London County Farm Bureau
HARDIN, Clifford M.	Director	Michigan Agricultural Experiment Station
HARRIS, William L., Jr.	County Agent	Hartford County Farm Bureau

Name of Delegate	Title	Representing
HEINICKE, Arthur J.	Director	New York State Agricultural Experiment Station
HELLER, Paul	Manager	Connecticut Artificial Breeders' Association
HEPBURN, Robert G.	Associate Director	Connecticut Agricultural Extension Service
HILL, Albert F.	Research Fellow	Harvard University Botanical Museum
HILL, G. Albert	Commissioner	Connecticut Highway Department
HOLMES, Francis O.	Associate Member	The Rockefeller Institute for Medical Research
HORSFALL, Frank, Jr.	Horticulturist	Virginia Agricultural Experiment Station
HUTCHINSON, G. Evelyn	Fellow	American Academy of Arts and Sciences
JORGENSEN, Albert N.	President	The University of Connecticut
LOWE, Yehuda	Agricultural Attache	Agricultural Research Station, Rehovot, Israel
LOWELL, James B.	Commissioner	Connecticut Department of Finance and Control
MANGELSDORF, Albert J.	Geneticist	Hawaiian Sugar Planters' Association
MARSHALL, Rush P.	Director of Research	Bartlett Tree Research Laboratory
MAYNARD, Fred C.	President	Connecticut Seed Trade Association
McNEW, George L.	Managing Director	Boyce Thompson Institute
MILES, H. C. C.	Secretary Emeritus	Connecticut Pomological Society
NORCROSS, Roy E.	County Agent	New Haven County Farm Bureau
O'KANE, Walter C.	Board Chairman	Crop Protection Institute
PAGE, Harry E.	Secretary	Connecticut State Grange
PEOPLES, Joe W.	Geologist	Wesleyan University
PETRUNKEVITCH, Alexander	President Emeritus	Connecticut Academy of Arts & Sciences
PLATT, Elliott H.	Executive Secretary	Connecticut Department of Farms and Markets
PRENTICE, Donald B.	Treasurer	The Society of Sigma Xi
RAFFERTY, Brae	President-Elect	Connecticut State Medical Society

Name of Delegate	Title	Representing
RANKIN, John S., Jr.	Naturalist	Marine Biological Laboratory, Woods Hole
ROBERTS, Frank W.	President	Connecticut State Farm Bureau Federation
RUDNICK, Dorothea	Biologist	Albertus Magnus College
RUPRECHT, Rudolph W.	Vice-Director in Charge	Florida Agricultural Experiment Station
SCARSETH, George D.	Director	American Farm Research Association
SEAVER, Stanley K.	Former Agricultural Economist	Minnesota Agricultural Experiment Station
SHEPARD, Norman A.	Chemical Director	Industrial Research Institute
SHEPARD, William C.	Secretary	Connecticut Forest & Park Association
SIEVERS, Fred J.	Director	Massachusetts Agricultural Experiment Station
SINGLETON, W. Ralph	Geneticist	Brookhaven National Laboratory
SINNOTT, Edmund W.	Director	Sheffield Scientific School, Yale University
TRULLINGER, Robert W.	Chief	Office of Experiment Stations, U. S. Department of Agriculture
WAKSMAN, Selman A.	Microbiologist	New Jersey Agricultural Experiment Station
WARNER, C. Kent	Head of Science and Mathematics Departments	New Haven State Teachers' College
WATSON, James G.	Member	American Association of Agricultural Editors
WETMORE, Alexander F.	Secretary	Smithsonian Institution
WHITHAM, George E.	County Agent	Windham County Farmers' Association
WILCOXON, Frank	Director, Insecticide and Fungicide Laboratory	American Cyanamid Company
WINTER, Floyd L.	Vice-President (Research)	Associated Seed Growers, Inc.
WOODRUFF, John B.	Secretary	Connecticut Tree Protective Association
YATES, Frank	Head Statistician	Rothamsted Experimental Station
YOUNG, Wilfred B.	Director	Storrs Agricultural Experiment Station