GENERAL SCIENCE

Science, The Third Revolution

By DR. GLENN T. SEABORG

➤ SCIENCE has entered our society and will take us on a breathtaking ascent to heights undreamed of a few decades ago. The revolution inspired by our Founding Fathers gave birth to our nation; the Industrial Revolution, inspired by man's inventive spirit, gave us a place among the nations of the world; and the Third Revolution—the Revolution of Science, inspired by our educated men and women—has made us a leader of nations.

During the last several decades, and especially the last two decades, this nation and the world have witnessed a remarkable expansion and extension of knowledge. This knowledge has been and is being transformed into the outlines of a new and revolutionary society.

We have all been part of a new tide of exploration and discovery, not limited to the dimensions of the past, but creating new dimensions of its own. Indeed, the revolutionary accomplishments of the past decade—in space—have extended man's reach far beyond this planet.

Man has progressed further in the fields of science and technology in the past several decades than in all of previous history; and the further progress in science and technology during the lifetime of today's graduate will again much more than exceed that of all times past—of all time previous to 1962.

So that all of you may appreciate the impact that this new force—this Third Revolution—has had on your lives, let me review some of the scientific advances that have occurred over the past three decades, most of them during the lifetime of today's youngest graduate.

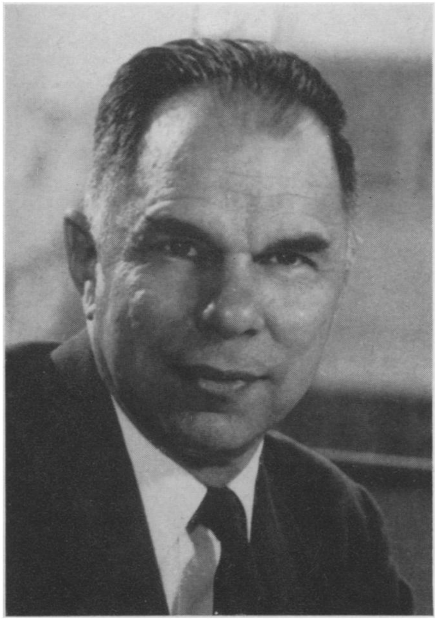
Advances in Past Three Decades

In physics, more than ninety per cent of all the elementary nuclear particles were discovered. Nuclear fission and nuclear fusion, the sources of nuclear energy, were also discovered. The major portion of our knowledge of the solid state of matter, of plasmas and other high-temperature phenomena, is the result of the efforts of the last thirty years.

In chemistry, a whole realm of plastics and other synthetic products has been developed in these three decades. The chemical processes associated with the photosynthetic cycle in plants have been largely unraveled by research in these years.

In biology, our understanding of the life process has largely resulted from the research and discoveries of workers in the past 30 years. The study of viruses and the diseases they cause, for example polio, has been an area of tremendous progress during the last decades.

Much of the impact of these scientific advances results from the technological applications that have accompanied them and with which each of us has experience in our everyday lives.



DR. GLENN T. SEABORG, Nobelist and Chairman of the Atomic Energy Commission.

For example, in electronics, the transistor, television and radar; in agriculture and gardening, insecticides, weed killers, and the improved fertilizers which permit the home gardener to have a green lawn all season long with only one application; in medicine, the sulfa drugs, penicillin, streptomycin, aureomycin, radiation diagnosis and therapy, and the many other seemingly miraculous drugs and therapeutic and surgical procedures which have been developed for the benefit of us all; in business, the myriad automatic processes, the photocopying machines, the computer, and even the vending machine that can make change of a dollar bill; in the home, color photography, hi-fi, the fabrics woven of the new miracle fibers that will not spot, stain, or wear out, and the plastic baby bottle.

I could go on for much longer than you would probably care to listen enumerating the benefits technology has provided for us during these decades.

What Future Holds

What will the future hold? This question has always challenged man. In fact, to attempt to forecast these future advances requires a certain degree of audacity, although I believe somewhat less courage than it does to speculate on the stock market.

A portion of the future is already clear. Our ventures into space are but a beginning. In the next few decades man will travel to the moon and the planets—an entirely new frontier, a new dimension, will be opened to challenge mankind.

Worldwide radio and television broadcasts from satellites in planetary orbit direct to homes everywhere will soon be a reality.

The cure of cancer, mental illnesses and other unconquered disease may become possible. The life span of the average man and woman will be increased through biological and medical advances.

New sources of power will be developed. Already the energy generated by nuclear fission appears on the verge of economic feasibility. Sometime in the future, controlled thermonuclear fusion may also become a reality, which would mean that we could use the virtually limitless water of the oceans as fuel to generate heat and electrical power.

I could continue on, conjecturing on such matters as antigravity, teleportation and telepathy. However, I am not that audacious.

There is, however, one technological advance I would wish to see occur and that is an efficient means for the storage of electrical power. The battery is a very inefficient container for the storage of considerable amounts of electrical energy.

If a super-efficient condenser could be developed, it would be possible theoretically to store in several ounces the power now contained in several thousands of pounds of conventional batteries. With this advance, the automobile with its internal combustion engine and even the proposed gas turbine would become obsolete—the clean electric motor car would come back into fashion in a new dress. Conceivably, power could be generated in large central plants and distributed in these convenient packages for mobile and remote uses.

Electrical Power in Future

Every few months each home would require only a recharged condenser to supply its electrical needs. Transmission lines might well become obsolete. Of course, I am not certain that this will occur in the next several decades—and it may never occur. But if such dreams become realities, you can readily visualize the implications.

However, life is not merely a physical experience. In any civilized society, and particularly in an advancing culture dominated by the overtones of science and technology there will be continuing and significant changes, many of which cannot now be foreseen, in the social, the economic and the political environments in which we live.

Unemployment is one of our social problems today. It may be related, to some extent, to automation and other technological advances accompanying our scientific discoveries.

However, we must not forget that, in the past, scientific advances have eventually provided many new opportunities for productive work, and that in periods of transition, when the old processes are being improved and the new opportunities developed, there must always be problems of adjustment and accommodation.

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The social effects of science extend beyond such problems. The increasing proportion of the aged in our population, the reduction of infant mortality, and other results of the accelerating advances in medical science will sharply affect our social structure.

These will give us problems of rapidly expanding population; increased problems of the aged; and concern with crowding, slums and housing. Science and technology will also give us greater leisure time through shorter periods of work. Science has provided instruments of war giving the continuing international crisis new dimensions which gravely affect our entire social structure. Revolution never follows a calm, undisturbed course. Although we have less need for physical work, we have much more need for mental work, and our need for education has increased at every level.

Much of what I have said can also be applied to the impact that science has had and will have upon our nation's economy and our economic relations with other nations.

Our country occupies only seven per cent of the world's total land area and numbers only about six per cent of the world's population—yet, in approximate proportions, it uses almost forty per cent of the world's total electrical power, drives over sixty per cent of the world's automobiles, communicates through more than half of the world's telephones, listens to and watches nearly fifty per cent of the world's radio and television sets, and reads about two-thirds of the world's supply of newsprint.

Distribute Science More Widely

If the world of the future is to be a good and happy place for human beings, the benefits of science and technology must be distributed even more widely over the earth, so that men everywhere can share in their abundance and in the hopes that they bring.

Another way to view the impact of science on our own economy is to examine this nation in its earliest years, during its first revolution. At that time we were an agrarian society, dependent upon agriculture for our economic well being. Our advancement was linked with advancement in agrarian techniques. George Washington, after whom this university is named, evidenced his awareness of this economic structure when he attempted, while President, to establish a National Board of Agriculture to improve and better our understanding of farming.

Today we are a scientific and technological society dependent on ever increasing advances in these areas for our continued prosperity and vigor. For real economic growth in our country today we do not need simply improvement in existing processes, we need new discoveries, new applications, new ideas. This is the Third Revolution. This is the beginning of a Scientific Society.

Revolutions are in essence political. The Third Revolution in science is no different. I believe the political changes resulting from science are particularly evident in our federal government.

Prior to this Third Revolution, the pace of science in government was leisurely. The first technical agency of our government was the United States Coast Survey in 1807. The first agency established by the government as a result of scientific study was the Steamboat Inspection Service in 1837. The National Bureau of Standards was not established until 1901.

In fact it was not until the Second World War that the pace really quickened. The accelerated pace was necessary since that war was in large part a war of science and technology, a war which produced one of the greatest forces of all time—the nuclear weapon.

Immediately following the war the Atomic Energy Commission and the Office of Naval Research were established. In 1950 the National Science Foundation began operations.

In the past several years, with the national realization that our hopes for maintaining a just peace depend in large part on science and technology, science has been asked to assist the government further. In the past several years the President's Special Assistant for Science and Technology, the President's Science Advisory Committee and the Federal Council for Science and Technology have been established to provide competent scientific advice to the highest policy levels of government.

Most recently the Office of Science and Technology has been created by President Kennedy to define more clearly and to formalize this structure.

In the developments leading to the present status of science in our government and in our society many studies and analyses have been conducted to determine the proper role which science and scientists should play.

Looking at the broad spectrum of science and technology it must be apparent that in today's world there is no department in an industry, no division of a commercial enterprise, no level of governmental activity which does not require scientific information, scientific advice and scientific guidance.

This is not because the scientist is possessed of some omniscience or omnipotence —it is simply because our present scientific society and our government as a viable part of that society must meet, every day, questions and problems which the scientist alone is qualified to answer.

There are few subjects which have received more study and comment in the last decade—and particularly since Sputnik— than the relationship between science and government. These studies and comments have generally been parallel, that is, they have taken similar direction.

They have recognized the importance of the relationship; they have analyzed it; in general they have expostulated but they have not expounded. This is to their credit. They have been groping to find the place of science in a developing scientific society. They have been probing to find the means for making scientific methods and knowledge an effective instrument and a constructive force in the new scientific revolution.

However, the general approach has been toward effectuating an advisory relationship between scientists on the one hand and government, as representing both a political and social entity, on the other. This is important. Scientists are asked for advice; scientists offer advice. But the permeation of science into the whole fabric of our society requires that science be utilized other than as a reference book—other than as a Noah Webster or a Dr. Spock or a Dr. Gesell.

It means that science must become a general and participating partner in government, not merely a limited or advisory partner. Men who know science and technology —whether or not they are scientists or engineers—must join in creating our laws, in forming our social order and in establishing our national policy.

I am aware that we have come a considerable way toward acquiring a scientific capability on a broad scale in our government. I was pleased early in my discussions with the members of the Joint Committee on Atomic Energy, who have the Congressional responsibility for the program of the Atomic Energy Commission, to find them conversant in the subject matter—atomic energy—and to find that some of the members had developed their own technical specialties.

I have observed this same scientific understanding in many other members of the executive and legislative branches. It arises out of necessity. The problems to be faced, the decisions to be made, the policies to be decided almost all include some complex technological questions.

Government—willing or unwilling—has evolved from an era when the rifle, with ten or so parts that an infantryman—blindfolded—could assemble and disassemble in ten minutes, was a major weapons system.

Today, one can gain the impression that a weapons system is not even considered important unless it has more than 100,000 parts, is able to destroy a city or two, and requires several hundred men for round-the-clock operations.

Science Needed for Peace

It is hardly necessary to say that this affects all of us. However, not only do we have need of science in the defense of our territory and national integrity, but we also have need of science in the arrangements for a durable and lasting peace. Disarmament with its subsidiary issues such as the nuclear test ban is, I believe, one of the most vital areas of national and international endeavor for the scientifically capable.

Basic to most of the issues of the negotiating table, including the important ones of enforcement and control, are scientific and technological considerations. Agreement must first be reached at this level if final political accord is to be achieved. The day of the rifle is gone. The day of the awesome proliferating weapon systems must, somehow, go.

We live in a present of intricate technological systems, a present which calls for capable men and women with scientific understanding to come forward and serve their country. I believe that, most importantly, we, as citizens, must do all that is possible to encourage people of scientific capability to enter government. Competent persons with scientific or technological training should assume the responsibility of running for legislative offices.

More people of scientific capability are required in the executive branch to help administer the vast technical programs on which the government, by necessity, has embarked. To assure that the government does, in fact, obtain the best people, it should, as a matter of national policy, recruit with vigor and purpose.

During the period of the establishment of our government as a government under the law and later, during the development of our national character and institutions, we drafted the lawyer into the service of the nation, not only in the judicial, but in the executive and legislative branches of our government.

We still need the lawyer, but we must extend the draft to a new class. We must conscript science and technology into this service. We can no longer afford to exempt the scientist or the engineer. We must reclassify him.

We not only can use him in our present posture, but we need him in order to bring into the law making process and into the area of the administration of government a further comprehension of the interaction of technology and scientific advances with our society. This we may be able to do once we can convince him that there is as much challenge and excitement in the laboratories of government as in the laboratories of science.

I do not say that we should emulate the Soviets who have virtually enthroned the engineer and the scientist in the seats of power so that they number the majority of the members of the Presidium, the Council of Ministers and the Party Secretariat.

But, we must bring the engineer and the scientist across the threshold and into the chambers where our national policy is created—not merely allow them to stand in the corridors where it is discussed. We can no longer afford to insulate the body politic from the contributions, influence, and impact of such a significant segment of our revolutionary scientific social order.

I must admit that in making these suggestions concerning the entrance of scientists and engineers into government I make the assumption that a sufficient number of people with this background as a starting point can also acquire a sufficient degree of proficiency, which is a necessary requirement, in the science or art of politics.

I hope that I am correct in making this assumption. The basic requirement is the combination of scientific capability, however acquired, with political capability, and this combination can be, and has been, achieved by many people with different starting points.

Let me add a word concerning planning at all levels, including the national level, for the progress of science itself.

We must insure that we have a sufficient number of scientists, and a sufficient number of engineers, whose contributions insure the practical applications of many of the discoveries of pure science. We must insure the availability of the increasing financial support required for the conduct of pure, applied, and engineering research, and especial attention to the needs of the universities and colleges is required for this purpose.

All of this must be done without impairing individual initiative, the characteristic which is so essential to formulating and solving the problems of research. We must continue to require that the results of the scientist's labors pass that severest of all tests, the judgment of his critical and qualified fellow scientists. This rule will prevent the development of pseudoscience.

Its application should guide the future progress of science itself.

Excerpted from an address at George Washington University.

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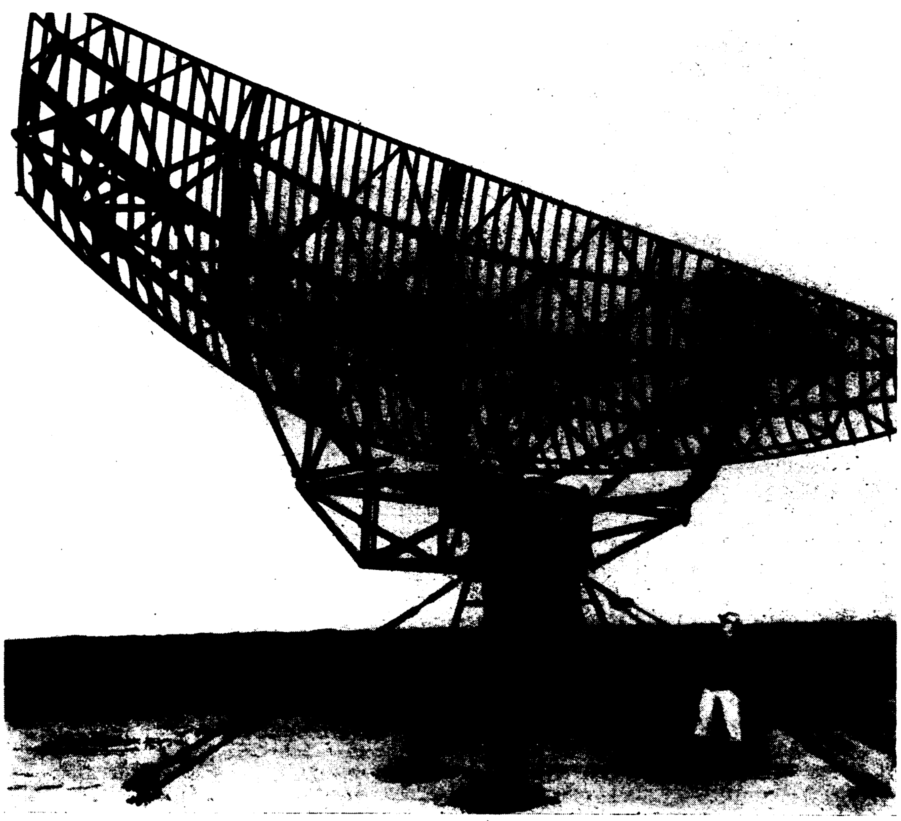

GIANT RADAR ANTENNA—The Army's largest portable, tactical antenna, the first of a series produced for the Army Signal Corps by Hazeltine Corporation, has been delivered for use in missile monitor air defense installations. Adaptable to any radar in its frequency band, it has a reflector measuring 40 by 11 feet. It can be segmented and transported by truck or flat car and set up in about four hours by a team of eight men.

VETERINARY MEDICINE

Thoroughbred Horse Gets Human Disease

➤ MUSCLE SPASMS called congenital myotonia, similar to a human disease, has now been reported for the first time in a thoroughbred horse. It is also found in goats.

Drs. Sheldon Steinberg and Stella Botelho of the University of Pennsylvania, have concluded that this muscle abnormality may occur more frequently throughout the animal kingdom than has been believed.

The symptoms included lameness, first noted at three weeks of age, which was most marked after a period of rest and decreased after activity. Treatment after 12 months has failed to arrest the symptoms, although the horse remains well otherwise.

The report appears in Science, 137:979, 1962.

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TECHNOLOGY

Airgeep Flies Without Wings or Propellers

See Front Cover

➤ AIRGEEP II, seen on this week's front cover, flies without wings or conventional propellers.

A successor to Airgeep I, first flown in May 1958, it is powered by two turbines. The airgeeps make use of the ducted propeller principle. Without wings or conventional propellers, they are a departure from most vertical take-off and landing designs. Lift is derived from two 3-bladed ducted rotors, one at the front and one at the rear of the machine. The pilot's and co-pilot's seats are in the center section between the rotors. The rotors are completely shielded on all sides, an important safety feature. It is designed to be capable of flights at altitudes of several thousand feet.

Compact design and protected rotors enable the aerial jeep to thread its way down narrow roads, between trees and other obstacles. It can be wheeled into large cargo aircraft without disassembly.

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