earlier cultures its heritage of thinking and feeling, and incorporate its inheritance into its own life. To make a democratic culture was no simple problem. It required speculation and experiment. In their magazines, the early nineteenth-century writers provided discussion that was fruitful for their generation and is enlightening to us as we try to understand the beginnings of our culture.

Ornithology in Oklahoma . . .

areas concerning which we do not now have enough information. The teaching of ornithology at our Lake Texoma Biological Station will continue and develop. A course in Birds of the World will be offered at the University. Organizations like the Tulsa Audubon Society and Cleveland County Bird Club will spring up and grow. Bird students the State over will see to it that interesting specimens which come to hand are preserved with care. *The Scissortail,* the official organ of the recently organized Oklahoma Ornithological Society will continue to bind us all together.

I have been heartened tremendously by the University's furnishing our fine bird and mammal "range" at the museum with a new tiletex floor. *Range* is a word we ornithologists use for a room in which scientific skins are kept for reference and study. Our range is large, well-lighted, and well-ventilated—the direct result of Dr. Stovall's thoughtful planning. Mr. Hoover is building us five new book-cases for my big ornithological library, not to mention dozens of new trays for the metal bird-cases.

For the Birds of the World course I plan to offer next year, many new specimens will be needed—a Kiwi from New Zealand, a Cassowary from Australia, a Frogmouth from New Guinea, a Screamer from South America, to mention only four. Alumni and friends can help us gather these specimens. Some will come from zoological parks, some from other museums, some straight from the field.

We shall have a glorious time together studying birds—preserving specimens as they come to hand, carrying on life history studies, banding birds, feeding birds in winter, seeing to it that bird habitats are preserved. Much work is to be done. Doing this work together can enrich the lives of all of us. I predict that it will.

In his dissertation for the degree of Doctor of Education, Ernest Allen Jones points out that approximately 63 percent of the students entering Oklahoma colleges and universities from 1948 to 1952 had less than average reading ability. About 21 per cent possessed adequate reading ability for study in our colleges.

The Atmosphere for Progress in Science and Technology

By BERNARD O. HESTON

In recent months there have been cries that science is being stifled by those who would insist upon secrecy, especially in connection with the atomic energy program in the United States. Those who demand that the results of many current investigations be kept secret believe, and presumably in good faith, that the security of this nation depends upon our having a body of knowledge which has not yet been acquired by other peoples. A part of this belief arises from a non-uniformity of definition, and perhaps another part from the failure to look to the past to discover the effects of this kind of isolationism.

To begin with we must agree upon a definition of science, and for the purpose of this discussion, we limit ourselves to the field which many call pure science; applied science we term technology. Thus science will mean the study of the fundamental behavior of the universe, the discovery of physical laws, and the development of hypotheses and theories which will guide our thinking. When the observable facts agree with the theories and hypotheses, we say that we understand the field under investigation. The scientist is engaged in gaining this understanding, and in the process he must acquire many new factual observations from the world about him.

Many of the factual observations of the scientist, with or without the intervention of some theory, may be put to practical use. This exploitation of science and the kind of information the scientist used, is technology. Perhaps an example or two will further distinguish between these fields of endeavor.

The geologist may examine a specimen obtained from a prospective oil well, and, if he is not busy with the production of petroleum, he will be interested in the rock as an indication of the age of the particular formation. The adjoining formations will tell him, through the application of a theory about the formation of the crust of the earth, something about the history of his sample. He may be able to estimate the climatic conditions which prevailed before or during the formation of the stone. When he has completed his examination, he will be satisfied that he knows more about the earth, and he may even be able to use new observations for an extension of theory. This is pure science at work.

The petroleum geologist, or perhaps only the driller who has no special theoretical knowledge, may examine the same specimen and recognize it as the same formation which he encountered in the past. He may even be led to predict the probable success of the venture on the basis of past experience. He is not concerned with the age of the earth, and when he finishes his examination, he expects only to obtain practical results, that is, more oil, rather than an increase in knowledge. This use of knowledge is technology.

Most recent and striking example of the difference between science and technology is in the field of atomic energy.

About the Author

Dr. Heston, whose specialty is physical chemistry, came to the University in 1942 as an Assistant Professor of Chemistry, was made an Associate Professor in 1942, and Professor in 1947. He had taught at the State Teachers College, Duluth, Minnesota, and at Oklahoma A. and M. College before joining the University faculty. A member of Phi Beta Kappa, Sigma Xi, and American Chemical Society, he is active in research as well as successful as a teacher.

In the years between 1895 and 1940 scientists were greatly concerned with the nature of atomic structure. The acquisition of knowledge about the structure of the atom was slow. New theories were proposed and these suggested the extension of experimental work. The discoveries resulting from experiment enabled the workers to modify the theories or to propose new ones. As the process continued, there was more agreement between theory and observation until a fair degree of understanding was reached.

The practical thinker, seeing the possibility of obtaining almost fabulous amounts of energy from known processes, if only they could be carried out on a large enough scale, immediately set about to find the ways and means for utilizing what was at hand. The success of this program was a triumph of technology, but it involved, so far as can be determined, no new scientific principles. It should be noted again that both the scientist and the technologist used a great deal of the same factual information in reaching the desired goal.

In the 1940's the progress in dealing with atomic structure was extraordinarily rapid; but this was made possible because a far greater store of information than ever before was made available on which to draw in evolving a satisfactory theory. The scientist finds himself in the position of a detective with an abundance of clues. The analogy is really not a bad one. The methods used by the two kinds of investigators are much alike, and they involve much the same kind of mental processes.

It is pretty generally believed, and widely taught, that scientists have a special kind of method in arriving at their startling, beneficial—and sometimes terrifying results. Upon closer inspection, however, we find that the scientific method really requires a great amount of mental trial and error. The method differs from that of the detective in that the effort usually extends over a longer time and involves the thinking of a large number of workers. In the past it has also been difficult to speed up the process, largely because the thinkers had to take time off to search out, each for himself, observable facts to use before they could advance their thinking. It is safe to say that the most rapid progress was made by men who were not burdened by the necessity of laboring for a living, and who had available all possible factual information.

On the other hand, there have been in the past a number of externally imposed deterrants to scientific progress. For a time the Church opposed free investigation and exchange of knowledge. In some countries general poverty combined with unfavorable political systems, prevented scientific work or philosophical speculation. All the energies had to be devoted to more immediately practical pursuits. At some periods wars have interferred with the free exchange of information between countries, or so disrupted life in general that no speculative thinking was possible. Science depends on freedom.

Today, we all know of some of the barriers opposing the free interchange of factual information, especially as regards the facts of nuclear chemistry and physics. It has not been the intention of the Western Powers to limit scientific development by restrictions, but rather to retard technological progress in this field in other countries as a military expedient. The fear that our supremacy in the atomic-weapon race will be overcome has led us to conceal much information that could be of no technological help to our competitors, but which might aid in the formulation of new theories or the testing of old ones. The restriction of such information applies to friends as well as enemies, and tends to limit the number of intelligent workers whose abilities can be applied to the solution of the scientific problems. Our Atomic Energy Commission apparently senses this situation and makes every effort to classify information in the light of scientific needs. In spite of this recognition of the problem, we know that more rapid progress would be made in the absence of these restrictions.

In Russia today, as well as we are able to determine from the popular press, there are local restrictions on the exchange of ideas. The reasons for these restrictions are presumably political; they are imposed for the purpose of unifying all political, scientific, and economic thought. Such a prejudicial attitude is now new but, as in the past, it impedes progress. The attitude is not necessarily peculiar to governments or religious bodies; it may be found among scientific workers as well. Some of the letters of the Russian chemist, Lomonosov, about 1750, giving his views of the nature of matter, end with the statement that he would not attempt to publish his views because no one would believe them.[1] A number of examples of the reluctance of scientists to accept foreign ideas could be cited, but in no instance has this opposition been organized. The end result has been the same, whether the opposition is by government, church, scientist, or custom.

What then is the effect of the restriction on exchange of information on the progress of technology? Usually we can show that, when factual information is denied to a region or nation, that nation will bend every effort to acquire the facts for itself, and the result will be the eventual establishment of an independent technology. This is possible because either the necessary theoretical explanation is already available, or the technological advance outstrips the theoretical. If technological advance is to be given first consideration, this can be illustrated by an example from our own economy.

With the advent of mass production of automobiles, attendant upon improvement in the internal combustion engine, it became necessary to develop fuels which would give the required performance. One of the requirements was the elimination, or suppression of knocking, and a search for chemical compounds which could be added to the fuel to suppress this kind of detonation resulted in the discovery of a number of anti-knock compounds, the most satisfactory of which was tetraethyl lead. The search was conducted empirically on a trial and error basis, and not as the result of the application of a theory of combustion. As a matter of fact, the information gathered during the search for these compounds, and in studying the conditions under which they were effective, contributed greatly to an understanding of the nature of the chemical reactions occurring during combustion. Here the technological advance came about first to fulfill a need, and the scientific development of theories and explanations followed.

The other example, where the theories were developed first, will bear two illustrations. During the First World War the United States was deprived of its source of many dyes and drugs. The basic theories of organic chemistry were known to all, but the technical developments had been largely restricted, through patent laws, to central Europe. Through concerted effort, the industries needed to supply the domestic market for these substances were established, competed successfully after the war, and expanded the manufacture of chemicals in this country to its present high level. Here the restriction of the supply of a commodity hastened the acquisition of the knowledge required for the development of a technology.

Taking as another example, the development of nuclear energy, the effect of the limitation of knowledge can be seen in the Russian success in making atomic weapons. The theory of the reaction was known generally before the outbreak of the war, and the use of the first atomic weapon demonstrated, with certainty, that the theory could be applied. It was supposed that a great number of experimental facts would have to be acquired before a nuclear

[1] Note the similarity between this statement and the Dedication which Copernicus wrote for his *De Revolutionibus coelestium libri* VI, (1543), as quoted in Professor Rader's article in the April issue of the *Quarterly*.

reaction could be carried out, but under the stress of the times, Russia has demonstrated that the necessary research program can be successful.

Without the stress of war or dire economic necessity, these remarkable advances in technology would certainly have been very slowly attained. Neither government nor industry would have felt it possible to justify the enormous expenditures of time and money, especially in view of the great risks involved, during periods of peace.

We may summarize these observations briefly. The conditions most favorable to the advancement of science, as defined in this paper, are those which allow for a free interchange of information and a free expression of ideas. The individual must also be free to spend his time in pursuit of fundamental truth, and this will require a maximum degree of security from actual want, and security from restriction externally imposed.

Technology on the other hand, makes most rapid strides when under pressure to accomplish a given task. In times of peace and security, the cost of rapid technological progress often appears too great, and what changes are made must therefore come about more slowly. Without the pressure of the First World War the chemical industry in the United States would probably have been delayed in its development for ten or twenty years. Without the present cold war, the development of the technology of atomic power might conceivably have been delayed in Russia for a long time.

What can be expected for the future in these fields? So far as can be envisaged the future will follow the same pattern as the past. The advance of science will be slow, and the new ideas will come from men who have the time to speculate, and the chance to discuss their thoughts freely with fellow scientists. And technology will progress by spurts as in the past, forging ahead under stress, and relaxing in times of peace and prosperity.

Conservation Research . . .

sub-humid areas need to be studied. Experiments in the production of quick-growing pulp wood should be considered. Waste products of the sawmills, such as sawdust, bark, and wood not suitable for lumber, could be analyzed for use in various products. These and many more problems must be solved before it can be said that Oklahoma forests are properly utilized.

For Oklahoma to continue to go forward, much research must be done in the conservation of these very important natural resources—water, soil, minerals, and forests. The conservation of all four is interrelated and the problems of all four must be solved in the relationship to each other. The conservation of water cannot be accomplished without the conservation of soils and forests. The conservation of soils is of little value unless the water is available for crops. The production of minerals is related directly to the production of the other three because the processing of the minerals, to a large extent, depends upon the water available. Thus, the future of the State of Oklahoma depends upon the conservation of not one but all of these important resources. The solution of these problems lies in intensive research. On the basis of this research a long range, co-ordinated program for the conservation of natural resources must be developed.

Area Program Initiated

In response to the pressing demand from government and private business for personnel better trained to meet the problems which arise out of the relations of the United States with other countries, the College of Arts and Sciences has established Area Study Programs, on the undergraduate level, for Latin America and for Asia. Dr. Max L. Moorhead is chairman of Advisory Committee for Latin-American Area Study; and Dr. Percy W. Buchanan, for Asiatic Area Study.