characteristic of our specific culture. If this were not so, we could not understand why certain aspects of mental life that are characteristic of the Old World should be entirely or almost entirely absent in aboriginal America. An example is the contrast between the fundamental idea of judicial procedure in Africa and America; the emphasis on oath and ordeal in the Old World, their absence in the New World.

The problems of the relation of the individual to his culture, to the society in which he lives have received too little attention. The standardized anthropological data that inform us of customary behavior, give no clue to the reaction of the individual to his culture, nor to an understanding of his influence upon it. Still, here lie the sources of a true interpretation of human behavior. It seems a vain effort to search for sociological laws disregarding what should be called social psychology, namely, the reaction of the individual to culture. They can be no more than empty formulas that can be imbued with life only by taking account of individual behavior in cultural settings.

Society embraces many individuals varying in mental character, partly on account of their biological make-up, partly due to the special social conditions under which they have grown up. Nevertheless, many of them react in similar ways, and there are numerous cases in which we can find a definite impress of culture upon the behavior of the great mass of individuals, expressed by the same mentality. Deviations from such a type result in abnormal social behavior and, although throwing light upon the iron hold of culture upon the average individual, are rather subject-matter for the study of individual psychology than of social psychology.

If we once grasp the meaning of foreign cultures in this manner, we shall also be able to see how many of our lines of behavior that we believe to be founded deep in human nature are actually expressions of our culture and subject to modification with changing culture. Not all our standards are categorically determined by our quality as human beings, but may change with changing circumstances. It is our task to discover among all the varieties of human behavior those that are common to all humanity. By a study of the universality and variety of cultures anthropology may help us to shape the future course of mankind.

CONQUEST OF THE PHYSICAL WORLD[1]

By Professor BERGEN DAVIS
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ACCORDING to the traditions of an ancient people, the progenitors of mankind, after tasting the delights of the fruit of the tree of knowledge, were commanded to "subdue the earth and have dominion over it." It is perhaps not an accident that the love of knowledge and the love of conquest are thus coupled together. It is rather a fundamental psychological association. "Knowledge is power" has become a proverb of the race.

"Subdue the earth" has had diverse expressions in fact. The career of man over the face of the globe has largely been one of destruction. The forests were destroyed. The hidden minerals, the noble and the useful metals were dug from the earth and dissipated. A later form of this ruthless destruction has been the irreversible dissipation of our stores of energy in the form of coal, oil and natural gas.

The phenomena, and the forces of nature seem to have oppressed the primitive mind with awe and fear. The savage man worshipped these awful forces as gods, while the progress of civilization may be measured in terms of the extent of the conquest and reduction of these natural forces to our uses.

The love of knowledge and the love of conquest have been expressed through our impulses. There are impulses for discovery and for adventure. The original idea of conquest and adventure was to seek new lands, to explore and subdue and often to destroy other peoples. That there may be other adventures and other conquests is an idea of recent origin. The unknown domains that the primitive man fears, the civilized man conquers. Here are new opportunities for discovery, for conquest and for adventure. This is the finest type of conquest and adventure. In the pursuit of knowledge we injure no one and in its acquisition we benefit many.

Men dream of the excitements and the adventures of exploration of unknown lands, of the ascent of a mountain or the conquests of the air. These may be thrilling adventures. Both in value and thrill they are not to be compared to the discovery of a new phenomenon or a new law of nature. The conquest of a mountain or a pole, like those other conquests "sung by the Troubadours," lose their thrill with their accomplishment. The conquests and adventures of science are inexhaustible. There are always new lands to conquer. This is the real "Endless Adventure," rather than the pursuit of a transient political life.

The allotted time for this address will not permit

[1] Address of the retiring vice-president of Section B—Physics, American Association for the Advancement of Science, Atlantic City, December, 1932.

even a partial survey of the conquest of the physical world. I must, however, allude to an early and a thrilling adventure. I refer to the conquest of the heavens. The discoveries of Tycho Brahe, Keppler and Galileo placed the ideas of Copernicus on a firm foundation. The earth and man are not the center of things. We take our proper place as humble citizens of a larger and more wonderful universe. The establishment of observation and experiment in science was also a conquest of first importance. Quantitative experiment and logical induction superseded the older and often erroneous inferences of a deductive philosophy. The results of the quantitative experiments of Galileo were given a precise and logical statement by Newton in the "Three Laws of Motion."

The nature of matter has been a continuous subject of speculation since the time of the Greeks. It has only recently become the object of experiment. The activities of the alchemists resulted in the development of the new science of chemistry as a branch of natural philosophy. An early generalization of these studies was the concept of the conservation of matter. That matter was neither created or destroyed in the processes of chemical action was established by the quantitative experiments of La Voisier. These ideas about the conservation of matter and the transmutation of the alchemists are of great interest in the light of recent events.

Closely allied with the question of the nature of matter was the nature of heat. Many philosophers at the close of the eighteenth century considered heat to be a form of matter. The American adventurer, Count Rumford, showed conclusively that the heat developed by friction depended on the mechanical effort of overcoming that friction. To Count Rumford heat was work. The further researches of Carnot, Meyer, Joule and others completed the identification of heat as a form of energy before the middle of the nineteenth century. A second great generalization was established, that of the conservation of energy.

Another major conquest of the nineteenth century was that of the nature of light and radiations in general. Here the corpuscular ideas of Newton gave way to the wave theory and experiments of Young and Fresnel. The researches of Faraday into the phenomena of electricity and magnetism led him to expect a connection between light and electricity. Later Maxwell formulated and extended these ideas into the beautiful electro-magnetic theory of light. In our very brief and partial survey we are nearing the close of the nineteenth century, but we must not leave the century without reference to the conquest of space by Heinrich Hertz. I refer to the propagation of electric waves, the sequel of which is the radio communication of the present day.

A new era has come. A new world was discovered at the end of the last century, which is being rapidly conquered and settled in the twentieth century. In introducing the conquests of modern physics, I can not refrain from quoting from an address by Lord Salisbury at the opening of the British Association for the Advancement of Science in 1888: "We stand to-day on a bright oasis of knowledge in an illimitable desert of the unknown." The twentieth century adventurers have enlarged the oasis but the desert is still without limit. The present is an age of conquest and adventure. It has been called the Elizabethan age of romance and discovery in science. The adventurer in science like those other adventurers may sail uncharted seas into the unknown. The chances of discovering new lands are great indeed.

Two venturesome explorers set forth into the unknown in the last decade of the nineteenth century. (a) The discovery by Roentgen of a new radiation from vacuum tubes operated at high voltages; (b) The discovery of the radioactivity of pitchblende by Becquerel. These were not unrelated discoveries. They opened up new realms of ideas as to the nature of matter, of electricity and of energy. Many in this room have taken part in the rapid conquests that followed these two discoveries. The younger members are familiar with it as recent history of our science. One major result was the identification of matter with electricity, whatever they may be. It was conclusively shown that electricity is not a continuum, but is composed of discrete particles of definite charge and mass. Electrical currents are but the coordinated motion of these particles, thus reviving the older ideas of Weber and Riemann. The first of these primordial particles to be isolated and studied was the electron. It was established by the direct experiments of Kaufman, that the mass of an electron was not constant but depended on its velocity. Mass was related to energy. As early as 1881 Sir J. J. Thomson had shown that an electrical charge should have mass. After the discovery of the electron this idea was more precisely developed by Lorentz. The theory of Lorentz relating mass and energy was later confirmed by the experiments of Bucherer. The theory of delayed potential of Lorentz contains not only the dependence of space coordinates on velocity, but time itself is a function of the velocity. These expressions are known to us all as the Lorentz transformation equations. These ideas were later given a more general expression by Einstein in what is now known as the special relativity theory. Both theory and experiment had shown the identity of matter and electricity. The generalization of Einstein had identified these two with a single universal entity, namely energy. This conception of the identity of mass and energy was not new with the relativity theory. A relation between the mass and energy of an electric charge had previously been derived. The expression, however, for the energy contained a geometrical factor and was not universal and independent of form.

We have already referred to that great conquest of the nineteenth century, the electro-magnetic theory of light. The production of large scale electric waves had been demonstrated by Hertz. The corresponding origin of light waves could only be surmised. The discovery of the electron illuminated what before had been dim and obscure. A closer study of radiation showed this concept of its origin to be incomplete. Here again a bold advance was made into the desert of the unknown. A new period of discovery and conquest was begun. I refer to the quantum of radiant energy discovered by Planck. Energy is no longer a continuum, it is atomistic like matter. Energy, matter, electricity are all atomistic. They are entities having discrete existence in both time and space.

New settlers rapidly filled the El Dorado discovered by those two adventurers of 1895–1896. Great realms were founded in the new lands. Great conquerors arose such as Professor and Madame Curie and Lord Rutherford. The founding of the radium "family" was a remarkable analysis and penetration into obscure and difficult experiments, such as the world has seldom seen. Now rapidly followed the nuclear atom of Rutherford and Bohr. The processes of the radiation and absorption of energy were clarified. The "jungle" of the spectra had been subdued. The Bohr theory of the atom was a splendid triumph even though we may abandon some of the concepts underlying its original structure.

We come now to the nucleus of the atom and to nuclear physics. The scattering of α-particles showed that these positively charged particles were repelled from the atomic center according to the inverse square law and that they approached within 10^{-12} centimeters of this center. A distance thousands of times less than the accepted dimensions of an atom. So Rutherford pictured the atom as a positively charged nucleus surrounded by numerous neutralizing electrons. This picture of the nucleus involves that radioactivity is a nuclear phenomena, and that radioactive transformation is a nuclear disintegration. The whole sequence of descent in the radium family was shown to be but the emission of α-particles or electrons or both from the nucleus. Matter is thus capable of self transformation. Can this process be brought about artificially? An affirmative answer was encouraged by the discovery of the isotope. In spite of fractional atomic weights the masses of atoms were found to be integer multiples of a unit, the hydrogen atom. Moreover the more precise measurements of Aston showed that there was a small change of mass in the process of atom building. Artificial transformation was first accomplished by Rutherford in 1919. The bombardment of nitrogen and aluminium by α-particles produced hydrogen nuclei (protons), moving with very great speeds. Projectiles of high energy were required to produce this transformation. Two builders of ordnance, E. O. Lawrence and Robert J. Van de Graff, have recently constructed great guns for this bombardment. The object in view being to hurl atomic projectiles with an energy as great as that of α-particles.

The nucleus of the atom had already been successfully bombarded by Rutherford, but the fortress was not completely reduced until a few months ago. I refer to the significant discovery of Cockcroft and Walton that protons having energy as small as 120,000 electron-volts could disrupt the lithium atom. More remarkable still, two α-particles were ejected having a combined energy of 16,000,000 electron-volts. Nuclear energy was set free by artificial means. To my mind this is a landmark in the conquests of physical science. It is also the beginning of an economic revolution.

NUCLEAR CHEMISTRY

In molecular chemistry we have endo-thermic and exo-thermic processes. So also in nuclear chemistry. The type of disintegration referred to was an exergic process. All processes of nuclear transformation may be considered as either endergic or exergic. Here we have the beginnings of the chemistry of the nucleus. This I believe will be the great field of physical and chemical research of the twentieth century. I wish to go more in detail into this chemistry of the future. Atoms may be classified into nuclear types: (a) nuclei of $(4n+0)$ type, (b) $(4n+1)$ type, (c) $(4n+2)$ type and (d) $(4n+3)$ type. The integers 0, 1, 2, 3 refer to the number of uncombined protons in the nucleus. In the case of the $(4n+3)$ type, the bombarding proton unites with the three free protons forming a new α-particle. This involves a decrease in mass and a corresponding liberation of energy. The process may be written $(4n+3)+H^1 \rightarrow 2$ α-particles + energy. The hydrogen isotope H^2 has recently been discovered. The isotope H^3 probably exists. With these three types of protons one may expect processes:

$$(4n+3)+H^1 \rightarrow q\,(\alpha-p)+E.$$
$$(4n+2)+H^2 \rightarrow q\,(\alpha-p)+E.$$
$$(4n+1)+H^3 \rightarrow q\,(\alpha-p)+E.$$

These types include a considerable portion of the elements. These processes are all exergic. The mass decreases and energy is liberated. Only a small initial energy is required to start the action. It is identical in type with the ordinary union of hydrogen and oxygen in which a small initial energy starts a great explosion. I append a short table of a few possible nuclear chemical processes together with the energies involved.

$4H^1 + 2e \rightarrow$ α-particle $(\alpha\text{–}p)$	$+27 \times 10^6$	electron	volts
$H^1 + H^1 + e \rightarrow (H^2)$	$+2 \times 10^6$	"	"
$H^2 + H^2 \rightarrow (\alpha - p)$	$+23 \times 10^6$	"	"
(4n + 3) type			
$Li_7 + H^1 \rightarrow 2\ (\alpha - p)$	$+14 \times 10^6$	"	"
$B_{11} + H^1 \rightarrow 3\ (\alpha - p)$	$+10 \times 10^6$	"	"
$B^{11} + H^1 \rightarrow C_{12}$	$+14 \times 10^6$	"	"
$Fl_{19} + H^1 \rightarrow O_{16} + (\alpha - p)$	$+5 \times 10^6$	"	"
$Fl_{19} + H^1 \rightarrow 5\ (\alpha - p)$	-2.8×10^6	"	"
$Fl_{19} + H^1 \rightarrow Ne$	$+7 \times 10^6$	"	"
(4n + 2) type			
$Li_6 + H^2 \rightarrow 2\ (\alpha - p)$	$+20 \times 10^6$	"	"
$B_{10} + H^2 \rightarrow 3\ (\alpha - p)$	$+18 \times 10^6$	"	"
$B_{10} + H^2 \rightarrow C_{12}$	$+21 \times 10^6$	"	"

The proton rather than the neutron is taken as a unit building block, since the mass of the neutron is not yet definitely determined.

The isotope H^3 while probably existing in nature has not yet been observed. The process $(4n + 1) + H^3$ will not be discussed. The above processes with one exception are all exergic. The possible endergic processes will not be here considered. In examining this table we observe that, as in the case of molecular chemical processes, the more stable compounds show the greater energy. There can be no doubt that the α-particle is a very stable nucleus. Next to the proton it is the best type of projectile for nuclear bombardment. The projectile is not easily disrupted by the impact.

The amount of energy available in any nuclear transformation may be taken as a measure of the nuclear chemical affinity. In molecular chemical action, where two processes are possible, that one is more probable which liberates the greater energy. From this point of view the process $(B_{11} + H^1) \rightarrow C_{12} + 14 \times 10^6$ electron volts is more probable than the alternative formation of $3(\alpha - p) + 10 \times 10^6$ electron volts. In this case one might expect the formation of C_{12}, also one should expect the energy to appear as a photon. On the other hand in the experiment of Cockcroft and Walton the emission of α-particles was actually observed. This idea that the probability of capture should depend on the free energy is confirmed by the recent results of Cockcroft and Walton. It was found that the relative probability of capture of a proton by lithium, boron and fluorine was 10,000, 4,000 and 1,350; the corresponding ranges of the α-particles observed were 8.5 cm, 3.5 cm and 2.8 cm, respectively. Successful theories of these types of nuclear processes should contain a free energy term either implicitly or explicitly.

The possible types of transformation in which no free α-particle is produced are of great interest. Such processes are illustrated by $(B_{11} + H^1) \rightarrow C_{12} + E$ and $(B_{11} + H^2) \rightarrow C_{12} + E$. If no α-particles are formed and the process occurs the energy should be emitted as gamma radiation. From the purely mechanical point of view both the energy and the momentum may be conserved. Since the mass of the photon is small it will contain the greater part of the energy. If continued experiments fail to find such radiation that fact will be of great importance in the theories of nuclear transformation.

The (nucleus + H^2) process will not be further discussed except to point out that $(Li_6 + H^2) \rightarrow 2\ (\alpha - p) + E$, $(B_{10} + H^2) \rightarrow 3\ (\alpha - p) + E$ and $(B_{10} + H^2 \rightarrow C_{12} + E$ are all probable processes since the free energy is very great.

This nuclear chemical action is not of rare occurrence. Cockcroft and Walton report that about one portion in 10^9 bombarding protons united with the lithium nucleus. The ratio of cross-section of the lithium atom to its nucleus is about 10^9. Taking into account the depth of penetration of a high speed proton the probability of capture is not exceedingly small.

The same energy laws of chemical action probably obtain here as they do in the more familiar molecular chemistry. The endergic processes require a supply of energy. This view is confirmed by such types of disintegration as observed in the bombardment of nitrogen and aluminium by α-particles. The mass change involved, while small, appears to be an increase. There is no available energy except that of the impacting α-particle. The observed energy of the emitted protons is of the same order as that of the impacting α-particles.

The great "chemical" affinity of the lithium nucleus for a proton is indicated by the following considerations. Investigation of scattering of α-particles from atoms show that they are repelled according to the inverse square law of force to a distance of approach of less than 10^{-12} centimeters. This determines the order of the dimensions of the nucleus of an atom. Experiments of this type indicate that the radius of the lithium nucleus is about 5×10^{-13} centimeters. The approaching proton is also repelled by this same law of force. The experiments of Cockcroft and Walton gave capture of a proton at an energy as small as 120,000 electron-volts. At this energy a proton can approach only to a distance of 10^{-11} centimeters from the lithium nucleus. This distance is twenty times greater than the probable radius of the nucleus. In spite of this great distance the affinity is great enough to cause capture.

The chemistry of the nineteenth century was a chemistry of atoms and molecules. It was largely a wet chemistry. The chemistry of the twentieth century will be that of the nucleus. It will be dry. The younger men may well see and take part in a remarkable revolution in physical science and in industry. Enormous stores of energy will be made available and mankind will be largely relieved from physical toil.

The methods of using this nuclear energy are not yet developed, but new discoveries will be made. The difficulties will be rapidly overcome. One might imagine the following hypothetical process: The bombardment of aluminium by α-particles gives high energy protons. The bombardment of lithium by protons gives high energy α-particles. By bombarding a mixture of aluminium and lithium with protons the future physicist may start a process similar to but much more intense than the more familiar thermite reaction. The mixture in a certain sense is an explosive mixture. It contains within itself the possibility of maintaining the action if it is once started.

The structure of the nucleus and its energy processes will become the commonplace of the newer physics. New discoveries will be made. One can even imagine the future physicist studying a divisible proton and electron as we study a divisible nucleus at the present day. It is unphilosophical to set a limit to the conquests of physical science. Man has not exhausted the secrets of nature in a few centuries. There are many things undreamed of in our philosophy.

To the younger physicist I would say it is a great thing to be young in this year 1932. The opportunities for discovery are very great indeed, much greater than for Faraday one hundred years ago.

The oasis of knowledge has been much enlarged, the desert of the unknown is still without limit.

OBITUARY

WILLIAM SYDNEY THAYER

IN the sudden death of Dr. William Sydney Thayer, at the age of sixty-eight, from a heart attack on December 10, the medical world lost an outstanding teacher and investigator—one who had been actively and successfully at work in the Johns Hopkins Hospital and Medical School for over forty years, an important contributor to the national and international prestige that those institutions enjoy.

Born in Milton, Massachusetts, on June 23, 1864, Dr. Thayer came from a distinguished family, of which Ralph Waldo Emerson and Oliver Wendell Holmes had been members. His father, James Bradley Thayer, was professor of law at Harvard, and his brother, Ezra Thayer, became dean of the Harvard Law School. In 1901, Dr. Thayer married Susan Chisolm Read, of Charleston, South Carolina. One of the great sorrows of his life was her prolonged invalidism, and her premature death in 1917. Of his immediate family only one sister, Mrs. John W. Ames, of Cambridge, Massachusetts, survives him.

In his physique and character, in his love of scholarship, and in his standards and ideals, Dr. Thayer was consonant with our ideas of the best that New England blood and training have to give. He graduated in arts at Harvard University in 1885 and received his medical degree from the Harvard Medical School in 1889. He served as interne in the Massachusetts General Hospital, engaged in postgraduate studies in Berlin and Vienna, and worked for a brief period as a general practitioner in Boston. In 1890, he joined Professor Osler's house-staff in the Johns Hopkins Hospital, acting first as "differentiating physician" for the out-patient department and, later, serving for seven years as resident physician. For many years he was professor of clinical medicine in the Johns Hopkins Medical School; in 1919 he became professor of medicine in the university and physician-in-chief to the hospital; and, in 1921, resigning the active professorship (to be succeeded by Professor Warfield T. Longcope) he continued as professor emeritus of medicine until the time of his death.

Dr. Thayer believed that internists holding university positions should not only be able practitioners and skilful teachers but should also exhibit intellectual curiosity and should engage therefore in the work of original research; throughout his career in Baltimore he set a laudable example in these several types of activity.

As an original investigator he made many important contributions to inner medicine, among which may be mentioned especially the results of his studies of the blood in leukemia (1891), in typhoid (1895), and in malaria (1893–1900) and of his researches upon the third heart sound (1908–9), upon cardiac murmurs (1901; 1919), upon the cardiovascular complications and sequels of typhoid fever (1903–4), upon chorea (1906), upon arteriosclerosis (1904), upon heartblock (1916) and upon gonococcal endocarditis and endocarditis lenta. He inspired younger men to undertake researches with him, and with some of them (G. Blumer, C. E. Brush, M. Fabyan, H. H. Hazen, J. Hewetson, J. W. Lazear, W. G. MacCallum, R. S. Morris, F. W. Peabody, B. H. Rutledge and G. H. Whipple) he made joint publications. It is interesting, too, that during his lifetime he had made