

Science and Man's Unfolding View of Himself

By ARTHUR H. COMPTON

It is a rare privilege to present the first DeGolyer lecture at the University of Oklahoma. The history of science, which is the central theme of this lecture series, is epitomized in Everette DeGolyer himself—a man whose life has been a remarkable combination of the search for knowledge and the love of adventure. An extensive student of the growth of science through the centuries, DeGolyer has seen in the historical approach an effective means of explaining what science is concerned with and how scientific thought develops. His own experience illustrates one of the salient lessons of the growth of science, that knowledge when combined with humility brings not only the power to control nature but also a life rich in human understanding.

I have chosen for my subject the manner in which the growth of science has given to man a better understanding of himself and of what he may become. Let me illustrate what I mean by recalling the story of the discovery of the moons of Jupiter. It was one of the most fruitful moments of man's history when Galileo with his new telescope first saw these satellites revolving around their central orb. Galileo was finding new facts about the world. But the greater interest of his discovery was what this new knowledge told about man himself.

Could anyone longer doubt that our earth and its moon formed a similar system, or that the earth and its companion planets revolve around the sun as Copernicus had argued? Thus man took his true place in the physical world, as a speck on a minor planet bound to one of the billions of stars of one of a myriad of galaxies. And yet in the very act of learning this new truth he found that he was a most extraordinary speck, which could penetrate secrets about the world of which it is a part, and could share its ideas with other similar specks. Thus did Galileo's advance in knowledge of the world give man a much more adequate understanding of himself than had before been possible.

The importance of science in its effect

on human life has until very recently received slight attention by historians. During the generation just past, however, the life of much of mankind has changed so markedly that some scholars at last are becoming aware that what affects our way of living has other roots than armies, and the market place, and the church.

The heart of science is not, however, in the new wonders and achievements that it makes possible. Rather, *science's prime concern is with the understanding of the world and of man.* A scientist is a person with a curiosity for reliable knowledge. Like Chaucer's Oxford scholar, "gladly would he learn and gladly teach."

It is fortunate that occasionally an historian arises who is concerned with man as a human being rather than as a unit of society. Such a man is George Sarton, who has sought diligently for a unifying principle in history. In his recent book, *Science and the New Humanism*, Sarton has pointed out that almost the only aspects of human activity which show definite and continuous growth throughout human history are those of science and technology. Here, he believes, is the central thread of the human story.

Sarton contrasts the continual development of man's activity in these fields with the relatively static situation in such basic matters as art and music. In these aesthetic arts it is difficult indeed to trace a clear advance, and what changes have occurred seem to stem largely from new possibilities that have arisen through advances in technology.

The continuing advances that man has made through the ages have been those in learning and doing, especially in methods of learning and methods of doing our tasks. As empires and civilizations have risen and fallen, each has left to its successor certain valuable new arts. The Phoenicians left their alphabet, the Greeks their democratic culture, the Romans their law and engineering, the American Indians their growing of corn. Such human assets are not lost, but are built into the growing life of each new society.

Prominent among the methods of learning that we thus inherit is the scientific method. We learn in school, and correctly, that the scientific method includes observation, forming of hypotheses, and carefully checking conclusions against the data of experience. An important aspect of the scientific method that is, however, frequently overlooked, is the continual comparing of ideas and information among all who are interested. Thus it was the interplay of Galileo's observation of Jupiter's satellites with Copernicus' theory of the solar system that gave significance to both, and stimulated the rapid growth of astronomy and physics which culminated in Newton's laws. Such exchanges of ideas were first cultivated by establishing scientific societies and academies and soon after by the publication of journals. By 1953 we find in the United States thousands of research teams so organized that each person will stimulate and supplement the thinking of every other, all making full use of the growing body of scientific knowledge flowing from every corner of the world. The result of such interchange is that our scientific knowledge is today increasing at an exponential rate. Since 1900 the science publications during each fifteen years have been roughly equal to that of all previous history.

This rapid development of science is of immense practical importance. It is one of the most significant causes of the dramatic growth of society during the past two generations. Man's phenomenal growth in the United States may be summarized in a sentence: In the first fifty years of this century our population has doubled; life-expectancy has risen from 46 to 69 years; the real earnings of each individual have increased approximately three-fold; the number of books on library shelves eight-fold; the fraction of our men and women receiving college education has become ten times as great. Other factors than the growth of science have contributed to this advance, such as the development of manufacturing procedures and techniques, a continental area of free economic exchange, a social consciousness of the importance of every person as an individual. But, without the new frontiers opened to us through such new discoveries as those of electricity, of mechanics and heat, of chemical processes, of the life of micro-organisms, of improved agricultural techniques, our American society would very probably already have reached a saturation plateau. With the current rapid growth of science, we anticipate on the contrary, a considerable period of continuing growth in numbers and well-being.

It is not my primary intention to consider today, however, the effect of the

growth of science on our economy. The importance of this implication of science is well recognized and has been widely discussed. I am concerned rather with what this growing science is doing to man's view of himself.

First, I should like to give a quick review of the history of man's development, as seen from the vantage point of science. Such account should give a basis for projecting our hopes for the future.

Second, I want to sketch man in his world setting as this science of 1953 sees him.

And, finally, now that science has become so vital to the healthy growth of society, I want to present, as I see them, the requirements that science makes of man if he is to thrive in the new world that we are entering.

I. A Long-range Perspective of Man's Development

As we endeavor to view ourselves fairly as a part of the world of nature, let us then place ourselves in perspective by taking seven-league steps backward in time.

Look first at what has happened to man during the brief years since World War II. The close of that epic struggle and the events that have happened since have left us aware in a totally new sense that mankind has a single, united destiny. Among the billions of men and women and children are many varieties of race and religion and political doctrine and forms of social and economic life; but we all depend on each other. Trouble in any part of the world affects us all. Strength and vision anywhere can be turned to the benefit of all. Our economy is a world economy, limited by the planet's resources. The thinking of every man and every group of men affects the attitudes and destiny of mankind. With radio, television, round-the-world airplanes, and atomic weapons that require vast national organizations to produce them, our thinking has of necessity become to a new degree global.

This is but one aspect of what eight short years have done to our thinking about ourselves. We must remember that every comparable period in the life of each man or woman has been filled with similar soul-stirring events. While it is true that social changes are now increasingly rapid, it is primarily because they are more remote that we do not see the active drama in the lives of each of our forebears. The same elements of new vision, bold decision, and courageous adventure in a difficult world that we are now experiencing were likewise present to them.

Let us now move backward in time by

increasing steps. The next step will be back to 1895. This is the date of the discovery of X-rays, one of the historic landmarks of science. It was during the half century from 1895 to 1945 that man learned the bounds of the universe as to its smallest and largest dimensions, learned approximately its age, found the major elemental parts of which it is made, and the sources of physical energy that keep it going. We then came first to appreciate the fact that we ourselves are an integral part of the life that surrounds us, and learned much as to the physical basis of that life. It was during this fifty-year period that the world became generally aware of the immense practical usefulness of science in giving man health and longer life, in supplying his needs, in attack and in defense against his enemies.

These great advances of the past half century were the outgrowth of the previous half millenium of modern science, that started in the fifteenth century with Leonardo, Copernicus, Columbus and, shortly afterward, with Galileo. These men and their followers were true amateurs of science, who sought to enlarge the boundaries of knowledge to the enrichment of man's understanding and to the greater appreciation of God's glory. During this five-hundred-year period lived the great geographic and scientific explorers. But they did not stop with exploration. Where possible they also reduced the infinite variety of the world to systematic law.

Another ten-fold step takes us to the fourth millenium before Christ. Here is the dawn of written history, the beginning of medical science in Egypt, and of astronomical records in Babylonia. We find arising the first evidence of social conscience, the awareness that man is inescapably his brother's keeper, culminating in the Christian concept of God as the Father of all men. During the intervening millenia we note these prototypes of all true scientists: Pythagoras, who set himself to find "of what and how the world is made in

order that we may learn a better way of life"; and Democritus, who "would rather learn the true cause of one fact than become king of the Persians." We see the growth and decline of science in Greece and Arabia, and the torch of knowledge being passed on from Arabia to Europe.

A further step of perhaps seven-fold takes us back to the first appearance of *homo sapiens*. Endowed with the same native capacities as ourselves, it required the many intervening millenia of struggle of these forebears of ours with nature and with each other to develop the tribal patterns from which civilization was to emerge.

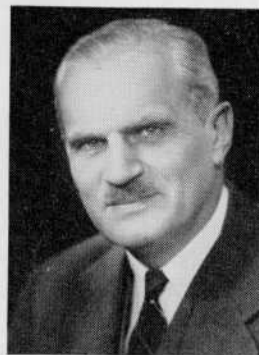
Another step, this time perhaps twenty-five fold, takes us back roughly a million years to the origin of man. As a clever animal that could talk and use tools effectively, he was fitted to survive in competition with his physically more powerful cousins.

We again step backward in time by twenty-fold, to the period when the great mammals flourished most abundantly, the elephant, the horse, the ape, the dog. Another twenty-fold step goes back through the period of the dinosaurs to the beginnings of vertebrate life. Another three-fold step, to somewhat more than a billion years ago, and we are close to the origin of simple life as shown in the record of the rocks. Thence another step backward in time of some three- to five-fold, and, as scientists now generally believe, we pass by the origin of our earth to the beginning of the universe itself as a system comparable with what we now know.

This perspective of how we have come to our present state serves to emphasize two points. The first is that what has happened to man during our lifetime has been possible only because of the long ages of development that have gone before. Just as the leaves of a great tree in the forest are this year's expression of the life that for a century has built the tree's trunk and limbs, so what has happened to mankind within our memory is merely our generation's ex-

About the Author

The University was indeed fortunate when on February 2, 1953, Dr. Arthur Holly Compton, Chancellor of Washington University, delivered in the Edgar D. Meacham Memorial Auditorium the first DeGolyer Lecture—fortunate because Dr. Everette DeGolyer, '11 ba, had made the lecture possible, and fortunate because the man who gave it is one of the most distinguished scientists and philosophers of the Western World. The Quarterly is honored to be able to publish his address.



perience of a great adventure, which has included not only the growth of science, but three centuries of American pioneering, five thousand years of the development of social responsibility of each person toward his fellows, and millions of years of ceaseless struggle by living creatures to achieve the best that nature has made possible for them.

The second point is that while the last fifty years which many of us here can remember is indeed only a thousandth of a second at the end of the long day that the world has existed, that moment has given a very substantial addition to the heritage of the future. In terms of man's awareness of his relation to the world, and in terms of the ability of living creatures to bend nature to their needs, the advance during this half century has been comparable with that during all the previous history of the earth. For its opportunity to share in these heroic contributions to man's enduring heritage, science may properly be humbly thankful.

II. Man's Place in the World of Nature

It is worthy of note that a perspective view of the history of man's origin and development such as we have just presented would not have been possible without the science of the past two generations. The archeologists' study of the dawn of civilization, the anthropologists' discoveries of the development of primitive man, the geologists' use of uranium as a clock for dating the formation of rocks, the astronomers' explorations of the depths of the universe, combined with the physicists' theories of gravitation and of matter—these are what have made this sketch possible.

To the same recent scientific studies we are indebted for the knowledge that our universe has spatial limits. The physicist now knows that distances smaller than about a million-millionth of a millimeter will never be significant, because if our well-tested theories are correct, no instrument is even theoretically possible that can measure so short a distance. The astronomer knows also that nothing more distant than about five billion light years will ever be known to us, for from such distances the signals sent by the stars vanish into nothingness. So we find that the space with which we are concerned has practical limits both small and large.

The total mass of the universe that is available to our knowledge can be roughly, but reliably, estimated as a certain number of tons. The principal parts of which it is made, the protons, neutrons, electrons, and photons are familiar to the physicists who work with such things; and to the

chemists much is known about how these parts interact to form atoms and molecules and crystals and stars and galaxies. When we recall that sixty years ago the scientists were still questioning whether atoms had physical reality, and the distances known by the astronomers were only a ten-millionth of those that are now observed, the recent advance in our understanding of our physical setting may be appreciated.

The advances in our understanding of life have likewise been far-reaching. Less than a century ago the students of biology became aware that living organisms are chemical systems comparable in structure with those classified as non-living. They learned also that through various changes, step by step, more and more differentiated types of organisms came into being, though the immense time required for these changes was not fully understood. The inertia of tradition against accepting this knowledge was, however, great, and it was not until the present half century that informed men and women have generally based their thinking on a recognition of themselves as products of nature working in its normal course.

But, in more recent years, much new about the physical nature of life has also been added. We have learned something of how the chemical processes of life occur. Though we do not fully understand how sunlight falling on leaves makes sugar from the carbon dioxide in the air, we find it possible to bring about analogous reactions in the laboratory. We have found the enzymes that induce the chemical reactions which produce starch from sugar in the body and which release muscular energy as sugar is changed to lactic acid. The control of such reactions by the chemical hormones supplied by the body has enabled us to understand our own growth. Studies of chromosomes and genes have made possible not only the better understanding of our own heritage, but have opened to us new means of developing our food supply through hybrid corn and improved animal stock.

Psychology also has added its important contributions to man's understanding of himself. Among these contributions three are prominent. First is the exploration of the manner in which the behavior of animals and man is dependent upon external and internal physical factors. Second is the remarkable role of the subconscious in shaping our attitudes and actions. The third contribution is the measurement of human intelligence. On the one hand, these intelligence studies have led to better understanding of the factors that affect intellectual capacity. On the other hand, they have enabled us more reliably to fit

men and women into their appropriate places in society.

Thus, every branch of science has contributed its significant part to our understanding of ourselves and of our relation to the world around us.

In thus sketching man as seen through the eyes of science we need to keep in mind, however, that his major human aspects have developed without reference to science. These human aspects are those related to ideas and ideals, to sentiment and passion, to sympathy and ambition, to pain and pleasure, to imagination and to human understanding. Let me call attention to two specific examples where our experience goes beyond the recognized province of science. The first is that of freedom to determine our own actions. The second is our awareness of our thoughts and feelings.

According to the science that was accepted from the seventh century down to 1920, man's every act was completely determined in advance by the motions and forces of the elemental atoms. The science of 1953 recognizes that man's actions are *not* predetermined by physical conditions. After taking into account all the physically measurable conditions imposed by the external world and the physiology of the nervous system, there still remains an area within which man's actions are in principle unpredictable. This means that in terms of physical science, while thirty years ago one saw no possible counterpart in man's actions to his feelings of free choice, now our science is consistent with possibility of such a counterpart. That is, physics now accepts the possibility of human freedom and thus of his moral responsibility, which until thirty years ago seemed irreconcilable with the causality of science.

This development is of no small significance in this day of conflict between the authoritarian and the free world. It is no accident that in communist Russia the "principle of indeterminacy," on which this change from complete physical causality depends, is rejected as inconsistent with the principles of Marxian materialism, and I am informed that my own researches on the theory of the scattering of X-rays which were partly responsible for the indeterminacy principle may not be taught as valid. Thus is emphasized the human significance of science's carefully tested finding that the freedom of man to act as he wills is consistent with physical law.

The second notable limitation of science's endeavor to describe man is its inability to give any clue as to how his awareness is related to what happens in the world of matter. Our studies of physical science

have given us no knowledge whatever of how it is that we feel and think and choose.

At an earlier stage of our knowledge it had perhaps seemed relevant that the chemical balance within our physical organism affects our thinking and our emotions. Such effects as those of caffeine and alcohol had long been known. When it was found also, for example, that one's temperament is strongly influenced by the hormones fed into the system as glandular secretions, some persons seemed to feel that the parallelism between conscious thought and physical process was becoming so close that one should be considered as the necessary counterpart of the other.

The recent experiments with so-called "thinking machines" have brought sharply to our attention the fact that considered responses to stimuli do not imply awareness.

For example, there is the automatic anti-aircraft gun control. By radar signals this device "observes" a flying plane. By suitable signals it may identify the plane as belonging to the enemy. By following its course, the control mechanism will of itself determine the plane's distance, height, speed, and position far more rapidly than is possible by human calculations. Having been adjusted to the range and caliber of the gun, the mechanism will aim the gun to take account of the motion of the plane, it will of itself judge the most favorable instant for firing, or it will refuse to fire if the plane does not come within range.

You have here the following essentials of a thinking organism: the sensory organs that respond to an external object; the nervous system that brings these signals to the central brain; the brain itself which notes and remembers what has happened, judges the appropriate response, and signals the members to react. Much more elaborate mechanical "thinking" systems are possible, and some are actually in use. It is in fact difficult to conceive of any kind of thinking process that cannot in principle be performed by such an electronic device. Previous experiences can be recorded and used to influence "judgment." Bias to represent prejudice, the phenomena of lethargy or over-activity, the response to multiple stimuli, and many other traits of the human mind can be reproduced. Even the possibility of freedom for choice can be introduced by making the ultimate action dependent, within specified limits, upon some such event as radioactive emission, the occurrence of which is unpredictable by physical law.

Does then such a device really think? Certainly it gives a considered response to the stimuli that it receives. It may well be more rapid and more reliable in its judg-

ments than the man who made the machine. But is the machine *aware* of what goes on in its mechanical brain? We have no means of knowing. Its responses are no more indication of awareness than is the falling over of a chair if I give it a blow with my hand. The "thinking" machine, like the chair, is merely responding according to well-known physical laws whose operation is wholly unrelated to the phenomenon of consciousness.

Thus, we are faced clearly with the fact that awareness, or consciousness, is in a category distinct from our objective science. It is something which each of us experiences subjectively, and hence knows more immediately than we do the external world. We can find also by experiment how our own conscious life may be affected by internal and external physical conditions. But as to how this consciousness comes to be, or how widely awareness may occur throughout the universe, science gives us little guide.

Thus, man knows himself as an observer of the world about him. He can influence that world to work, within certain limits, in accord with his own desires. With all that science has done, however, man remains separated by an impenetrable barrier from sharing any awareness that other portions of the world may have of the drama that is happening in the universe. No avenue has appeared whereby we may gain reliable knowledge from observing the world around us as to whether consciousness exists anywhere outside ourselves.

By some intuition, nevertheless, man learned a million years ago that certain sounds made by his fellows meant that they too had thoughts and feelings like his own. Since man's actions are to the best of our knowledge completely consistent with physical laws, which are themselves rigorously independent of any consideration of thought or emotion, *this understanding of the meaning of language goes beyond any purely physical explanation*. Nevertheless, the fact is that by the help of the spoken and written word, by gestures and other means, we do share our thoughts with each other.

Presumably, this understanding of language comes from a recognition of kinship, such that each expects the other's emotions to be like his own when he acts in a similar manner. This process is much more primitive than reasoning, but it goes reliably to conclusions not attainable by science, because it uses the information that comes from one's immediate awareness of his own thoughts, which are hidden from any scientific observation.

In precisely the same manner science leaves the way open for us to share the spirit of the universe, that is, to communicate with the God that the mystics declare they know. One must not, however, look to science for evidence of conscious motivation, such as love or hate, in the great powers that govern our existence and our actions. It is not in the character of science that it should reveal anything about the mind of God any more than it does about the mind of man. If any such knowledge is attainable, it likewise must presumably come through the recognition of kinship, to which the untutored mind may well be more sensitive than the mind disciplined to scientific reason. Perhaps this is the point of the injunction that if one would see God he must become meek as a little child. While a babe early senses the approval or disapproval of its mother, the sophisticated eye of science would see in the mother's actions merely the consistent working of the immutable laws of physics.

It is becoming more and more probable that, in principle at least, science will eventually account for the structure, the biological growth, and the actions of man as a part of the physical world. From what we have just seen, however, it is clear that man is not thus completely described. Left wholly out of account in such a physical description is the realm of ideas and ideals, of purpose and responsibilities, of understanding and emotion. It is such matters of the spirit that give life its human meaning. Just as these things reveal themselves to our own immediate consciousness, so we recognize them likewise as the factors that give inherent value to other persons. But of such value science remains unaware.

Thus, it is that the recent remarkable growth of science, by the very process of extending our knowledge of the physical world, has shown us more sharply its own limitations. Science shows us the framework that is the basis of our lives. It apparently is not in its character that it should open to us a knowledge of our mind and spirit. Yet we find that the full development and significance of man's spirit is consistent with all that science knows.

On describing the view of ourselves that science helps us gain, we have seen that man is a part of the world of nature, but an extraordinary part. He is aware of what is happening, he has ideas, and within certain wide limits set by laws of nature he is capable of putting his will into effect.

There is, however, another remarkable way in which science has affected man's view of himself. This is the effect of the

explosive increase of scientific and technical developments during the last few generations, to which we have referred. The possibility is now before us that, if he is sufficiently wise and determined, man can free himself in very large measure from the age-old specters of destitution and disease. Thus science, through its applications in technology and medicine, opens up to man the possibility of a fuller measure of freedom and human dignity. From time immemorial most men and women, most of the time, have suffered from hunger and have died prematurely from disease. People have considered marginal living, with its misery, as an inevitable part of life. In the United States, on the contrary, we have for three centuries enjoyed the altogether exceptional condition where at all times there has been adequate food to prevent any widespread hunger. For many generations this was largely because of our open frontier. But during the last two generations, with the geographic frontier closed, our means of living have continued to increase. Our population is now some three-hundred-fold greater than that at which the American Indians had become stabilized in the same area, and we still have no immediate concern with regard to further growth. In fact, our experience in curtailing population expansion in the hard times of the 1930 depression, combined with encouraging technical developments which promise added supplies of food and other means of living, give us confidence that in our country we can for some time ahead keep a favorable balance in the ratio of goods to population. This is merely a technical way of saying that by and large we seem, temporarily at least, to have banished the age-old specter of destitution and hunger. It is this situation that appears to be wholly unique in history. Furthermore, thanks to our medical advances, we are approaching the condition where a newborn child may reasonably expect to live in health to the age at which he will enjoy his grandchildren.

Arnold Toynbee has described this as the great event for which the first half of the twentieth century may well be remembered, that for the first time in the long story of mankind it has been found that destitution and disease are not necessary aspects of life, that the great new freedom implied by health and adequate goods for all is a reasonable goal for society. Because this new freedom is made possible by the growth of science and technology, we may properly include the aspiration to a destiny of the greater human dignity that is implied by health and well-being as a major contribution of science to man's view of himself.

III. What Science Requires of Man

But here is a lesson that mankind needs to learn. The relative freedom from destitution and disease is at present limited to the parts of the world whose culture is similar to our own, while the major developments of science are known everywhere. It thus becomes evident that the availability of scientific knowledge by itself is not enough to ensure this freedom. The very powers that science has given have so changed the conditions of life on our planet that we must ask anew what must we do if we are to thrive in the age of science?

The contrast between the improving situation in the United States and the essentially static situation in India is instructive. In India starvation is the same active threat that it has always been, and I am authoritatively informed that over the last half century the life-expectancy in that country has remained approximately constant at 25 years, as compared with the rise that we have noted in our country of from 46 to 69 years. Yet in both countries knowledge of the new advances in medicine and technology is in the hands of the responsible leaders. The proportional rate of increase of population in the two countries has been about the same. Nor can we attribute the difference to India's greater population density. Like the United States, India still has within it vast untapped natural resources.

What factors other than knowledge of science and technology are then necessary to ensure an advance in living standards? I would draw attention to two such factors that are present in the United States to an unusual degree. The first is our education, both formal and informal, for mutual understanding and widespread cooperative action. The second is the spirit of the American who is eager to do his part in making his community one in which every person can live fully.

In singling out our American education, I am not thinking only of our extensive school and college attendance, though this is of obvious value where science is important. I have in mind also the mutual understanding that comes with widespread travel and with news reports and with learning that one can earn his way by taking a job. All of these aspects of informal education help us to rely on others and thus encourage us to develop the specialties that are possible only in a co-operative society.

But to my mind it is our confidence in the value of working to make our world what we want it to be, inspired by a recognition that our own welfare is inseparable

from the welfare of our fellows, that is the distinctive source of our nation's health and prosperity. It is not that such a spirit is uniquely American, but this spirit of enterprise combined with the kind of altruism that identifies the welfare of oneself with the welfare of the community, is in fact more than ordinarily present among our people. It is this spirit also that has led us into the kind of widespread education that has enabled us more quickly and extensively to use the gifts of science.

The unusual development of this faith among our people is ascribed by historians in large measure to our nine generations of experience as pioneers. In the frontier settlement one shaped his own world and built for the next generation. There was no other way to live. The weight of tradition and the destruction from frequent wars that have too often frustrated such constructive efforts in older civilizations have had little effect in our history. Thus when a new possibility is presented by technology, our thought is at once how can this be used to improve our manner of life.

But there is a deeper basis for our desire to make life better. It is the drive of the spirit that first sent the Pilgrim fathers to our shores and which continues to be active among us. Our late eminent historian, James Truslow Adams, describes this spirit as "the American dream." "It was not a dream of high wages and motor cars merely," he wrote in his *Epic of America*. "It was a dream of a social order in which every man and every woman might grow to the greatest stature of which they are innately capable, and be recognized for what they are rather than for the fortuitous circumstances of their birth and position."

As long as such a dream represents an ideal for which Americans will work, we can be confident that we will educate ourselves and develop our science and technology as best we can toward meeting the needs of men and women. The methods for finding new knowledge are now familiar. With a firm will to live freely and fully, one can see ahead solutions not only of the problem of an increasing food supply, but also the means and the incentives for keeping the growth of our population within bounds. We see adequate strength for the defense of our freedom and for those social problems which have caused earlier civilizations to decline.

Thus we have seen how the growth of science has given us a new understanding of ourselves as a part of nature. We have seen how we can interpret our actions as a living organism in terms of physical and chemical events. We have noted, however, that natural science gives no clue as to the

mystery of our mind, and that it leaves us free to consider ourselves as morally responsible for our actions.

The thrilling discovery of the present century is that mankind may reasonably hope to free itself very largely and permanently from the curses of poverty and premature death. And for this discovery thanks are due chiefly to science. It is reasonable for us to hope for further improvement of our lot, not only as to our physical needs, but also as to our human understanding.

Such advance will not come, however, as the automatic result of advancing science. High aspiration and education guided by appreciation of the worth of one's fellows and crystallized in the will to help each other live, is necessary if the powers of science are to meet the human needs that we see ahead.

Just fifty years ago, H. G. Wells wrote with far-seeing vision:

"The past is but the beginning of a beginning, and all that is and has been is but the twilight of the dawn. . . . A day will come when beings who are now latent in our thoughts and hidden in our loins shall stand upon this earth as one stands upon a footstool, and shall laugh and reach out their hands amid the stars."

As we review the striking growth of science, we see how rapidly this vision of H. G. Wells may take on substance. It is the truth that gives power that will open to us this brave new world, and have faith that our growing science is adequate to meet the economic and social problems that lie ahead. Whether in fact the future will realize this noble vision will depend upon whether we and our fellows will accept and will earnestly commit ourselves to achieving an order in which each person can do his part and thus fully live.

Boy's Own Historian . . .

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the case with history, so long as G. A. Henty writes books for boys, and boys read them . . . that he is able to invest the dry facts of history with life, and make it attractive to the modern schoolboy, says not a little for his power as a story-teller for boys. It is questionable if history has any better means of fixing itself in the minds of youthful readers than as it is read in the pages of G. A. Henty's works.

There are few periods of world and English history not dealt with in the Henty books. A mere listing of the periods covered—Ancient, Medieval, Modern—would be a tedious and formidable task. More than sixty are devoted to English history: Caesar's Invasion and Boadicea's (Boudicca's) Insurrection, 55–62 B. C.

(50); Alfred's war with the Danes, 870–901 (20); the Norman Conquest, 1063–66 (57); the Third Crusade, 1189–94 (11); wars with Scotland, 1297–1315 (16), 1327–1333 (21); war with France, 1330–1376 (17); Wat Tyler's revolt and the Black Death, 1381 (68); the War of the Roses, 1399–1403 (71); the war with France and the Battle of Agincourt, 1415 (65); Drake's voyage round the world and the Armada, 1572–1588 (8); the Rise of the Dutch Republic and its struggle for independence, 1572–1575 (38), 1585–1604 (43); the English Civil War and the Commonwealth Period, 1642–1660 (12); the Restoration, the Great Plague and Fire of London, 1665–1666 (58); Monmouth's Rebellion, 1685 (82); the Battle of the Boyne and the sieges of Derry and Limerick, 1688–1694 (30); the War of the Spanish Succession, 1701–1710 (5), 1702–1714 (83), 1705–1713 (26); the War of the Austrian Succession and the Forty-Five, 1740–1747 (31), 1740–1763 (69); the beginnings of the Indian Empire, 1751–1760 (13); the Seven Years' War, 1755–1759 (27); the American War of Independence, 1774–1781 (18); the Siege of Gibraltar, 1779–1783 (47); the Napoleonic Wars, 1798–1815 (73, 92, 23, 4, 70, 74, 39); the wars in India with Tipoo Saib, 1799 (61), and the Mahrattas, 1816–1818 (84); the First Burmese War, 1824 (66); the First Afghan War, 1835–1842 (85); the Conquest of the Punjab, 1845–1849 (55); the Crimean War, 1854–1856 (14); the Sepoy Mutiny, 1857–1859 (7, 56, 9); the War with the Maoris in New Zealand, 1860's (44); the First Ashanti War, 1871–1874 (15, 90); the War with the Malays, 1870's (79); the Zulu and the First Boer War, 1876–1881 (19); the Second Afghan War, 1878–1880 (24); the Bombardment of Alexandria, 1882 (46); the Nile Expedition to rescue Gordon, 1884–1885 (49); the Chitral and Tirah campaigns, 1895 (90); the war with the Mahdi, 1898 (89); the Great Boer War, 1899–1902 (81, 86); the Boxer Rebellion, 1900 (91). A further listing would tax the reader's patience. Suffice it to say, the history of European countries (Sweden, Germany, France, Holland, Italy, Greece, etc.), the British Colonies, the United States, Mexico, and South America are adequately treated.

Although Henty's juvenile characters act like adult Britons of the upper middle class, they follow a pattern almost as rigid as Horatio Alger's: a boy's rise to fame and fortune. He is manly, courageous, dogged, self-educated, lucky, and ingenious in suggesting stratagems and devices to extract himself and others from tight places. He acts against a backdrop of historical events, generally the chief battles of

particular military campaigns, in which he plays a leading part. One publisher's hack reassured Victorian papas and mammas that Henty's tales "are all clean, and although some are full of exciting situations and thrilling to the last degree, they are of a high moral tone, while the English employed is of the best."

Plots tend to be monotonously similar, even if one allows for the different manners and customs so ably depicted. A single example will serve to illustrate this point. *Bonnie Prince Charlie*, one of the most popular of the series, narrates the romantic events of the Forty-Five so dear to the heart of such romance writers as Robert Louis Stevenson and John Buchan and fits their formula of flight and pursuit, daring deeds, bold stratagems, derring-do, and thrilling escapes. The hero, son of a Scotch officer in the French service, is brought up by a Glasgow Bailie. He is arrested for aiding a Jacobite agent, escapes to sea, is wrecked on the French coast, makes his way to Paris, serves with the French army at the Battle of Dettingen, kills his father's enemy in a duel, escapes to the coast, shares in the adventures of the Young Pretender in the last Jacobite Rising, and eventually settles down happily on his Scottish estate.

As we were reminded above by Beebe, the titles of the Henty books appealed to boys, not only for their contents and formats but because of their easily remembered titles and subtitles, such as *Orange and Green: A Tale of the Boyne and Limerick*, which indicates that the book is about Ireland and the military operations in that country between the Jacobite forces of James II and the English-Dutch troops of his nephew William of Orange. Many of the titles begin with the easily remembered prepositions, such as *At, By, Through, With*, and many utilize the principle of alliteration.

Henty's great popularity can be accounted for because he knew, Ezekiel-like, how to make the dry bones of history live before the birth of the chaos that seems to have engulfed the present generation of American youth, who know little of the past and seemingly would heartily concur in the hackneyed old statement, "Let the dead past bury its dead."

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