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THE CHANGING VALUES OF SCIENCE[1]

By Dr. R. C. WALLACE

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THERE is no need to elaborate the assertion that changes of emphasis are taking place in our time in the values of science. This has been a matter of perception and of observation. Men whose responsibility it is to make contributions to the advancement of their own fields of science have felt the change. Others who are not scientists have spoken about it, and have not infrequently misunderstood its meaning. It is a formidable task to endeavor to interpret the changes which are taking place, more particularly because we are in the middle of the current. We have not a position of objective independence. But it is of value to the speaker at least, whose day-by-day thinking is perforce confined to the field of educational values, to clarify in his own mind the shift in emphasis and in meaning which science, as a tool of thought, is experiencing before our eyes. It may not be out of place to take the occasion of the Hector Maiben lecture, which you have honored me with the invitation to deliver, for the presentation of such thought on this subject as I may be able to place in coherent sequence.

It is, after all, somewhat of a paradox that there should be any change of attitude in the scientific way of thinking. So much of the contribution of science in the last three centuries is a permanent readjustment of the thought of mankind and is not subject to change. The rationalism of the scholastics of the middle ages gave way under the revolt of the Renaissance, and the growing demand for facing facts. It was this demand which led to the development of modern science, and to its great victories in the exploration of nature and the harnessing of her forces for the use of man. When he finished his treatise on the "Principles of Psychol-

[1] The Maiben Lecture delivered at the meeting of the American Association for the Advancement of Science, Ottawa, June 30, 1938.

ogy," William James wrote, "I herewith forge every sentence in the teeth of irreducible and stubborn facts." James's was the scientific method. Since the time of Roger Bacon, the scientist has forged every sentence in the book of exploration "in the teeth of irreducible and stubborn facts." He has persuaded the world to adopt the same method in all departments of knowledge, no matter whether related to science or not. The historian, the sociologist, the psychologist, the theologian wrestle with stubborn and irreducible facts because the scientist has shown in his field of work that they must be faced and accounted for. There has grown up an attitude of intellectual honesty which has had a cathartic value in clearing away the unrealities which had worked themselves into the rationalism of the pre-Renaissance period.

Further, there has developed under the hand of the scientist a technique of obtaining the pertinent facts. Facts do not come of themselves. They must be sought for under controlled conditions, or under conditions which, if not controllable, are fully understood. The experimental sciences have provided the means wherewith to ascertain facts under controlled conditions. They have had their special sphere in the physical realm; but the biologist has used the experiment with amazing success in the less easily controllable field in which he operates. In the sciences which deal with man, and in social studies of all kinds, the experiment is less readily applicable, and the student is forced back on the study of the conditions under which the data accumulate. These conditions may be unplanned, but they must be known. The scientist has shown how to disentangle the significant conditions from the adventitious. He has placed facts in their setting in the flow of events.

In this whole process an intellectual habit has been created. Through the path of science we may not yet have traveled far in answer to the quest of the "why," but we have gone very far in satisfying the question as to the "how." We have acquired the habit of mind—and it has become almost intuitive—of finding out under what conditions this or that thing takes place. We assume an orderly process in nature; and we determine the order in each particular circumstance. Within the limits in which scientists work, the assumptions have been justified in a practical way by the results. Science has acquired a prestige in the modern world, not so much from its intellectual attitude, but because of the contributions which the scientist has made to the amenities of living. In the things that we eat and drink, in the clothing wherewith we cover ourselves, in our communication and our traveling, in our amusements and our recreations, we lean on the scientist at every turn. He has become indispensable. In his understanding of nature's laws and in his using of the knowledge to the satisfying of the needs and the desires of man, he has shown results which convince. He has become respectable and even respected. A practical age demands a sign which it can understand. That sign has been given with convincing iteration.

It seemed in the nature of the case inevitable that the new tool and the new method of science should give rise to a mechanistic conception of nature's processes, whether in the inanimate or in the animate sphere. Under similar conditions, similar phenomena occurred. The physicist would be prepared to go even further, for his is, from the experimental side, the most exact of the sciences. His formulation would be: Under the same conditions, the same phenomena occur. Precisely the same conditions do not occur; nor can they be made to occur by even the most skilful experimenter. But the basic conception of the uniformity of nature's processes has served the scientist so well as a working philosophy that it has been taken to be, to all intents and purposes, a fundamental truth. Without it, all experiments would cease; for results could have no meaning. And it was of purely philosophic interest whether certain conditions caused certain phenomena to occur, or whether, as Hume would have it, the relationship is simply that of time sequence. To the scientist it was enough that he could count on the sequence, and it was simpler to use the phraseology of cause and effect. Such a system, closed and complete, works as a machine. There may be an awkward question as to the winding up at the beginning; and there have been the prophets who foresee an eventual running down to a dead stop; but for our time it goes, and goes inevitably by the force within itself. Not only in the physical world is this the case. The biological processes are physical and chemical; even the mental processes in man himself have a physical and chemical background. It has seemed logical, therefore, to many biologists and psychologists that the mechanism of the physical world operates with the same rigidity and inevitability in the living processes and in man himself. The behaviorists are the legitimate offspring of the mechanists. And if in the social relationships the operation of the mechanical principle has not yet been so clearly established as in inanimate nature, there has been the feeling that this is only because the factors are less easily analyzed, and that with the development of the social sciences the principle will be found to operate with the inevitability which is displayed elsewhere. The work of classification and analysis goes on. The statistician accumulates data in the field of sociology. Measurement has invaded the preserves of the educationist. There is no realm so intangible that the scientific tool may not find a hard surface on which to operate. There is no human problem so complex, as many think, that it may not ultimately resolve itself

into the ordinary phenomena of causal conditions within the system, and the inevitable consequences of those conditions—in a word, a system working within itself in a mechanical process as rigid and unalterable as the movements of a clock under the force of its mainspring.

And yet, we have somehow felt not quite satisfied. The authority of science has been too convincing for complete conviction. It has overreached itself, and is in danger of falling on the other side. Good men suffer not infrequently from the excess of their virtues. Their goodness is too overpowering to be altogether real. In similar fashion, the underlying assumptions of the scientific method have been too complete to meet the case. They have left no room for anything else, and there is something else which the methods of science fail to elucidate. That is the reason for the reorientation and revaluation which is taking place to-day. In this readjustment the scientists are joining hands with the philosophers; for the task belongs not to science, nor to philosophy, but to science and philosophy together.

Overemphasis is something to which the mind is prone; and it is, to our way of thinking, a question of overemphasis with which we are dealing in the development and use of the scientific tool. We have been passing through a period of depression, which has given special significance to the dependence of man on his economic setting. If we were to judge from the discussions and the literature of the past eight years, we would be led to the conclusion that man is primarily concerned about, and influenced by, his economic relationships. We would be led to subscribe to the premises on which Marx erected his political philosophy. And yet we know that this is not the truth of the case. There are other, and more fundamental, springs of life and conduct than the economic. We have been under the spell of the overemphasis of a phase of the truth; and we are only gradually coming back to a sounder balance. So in the changing emphasis in the religious life, where in one age the dogmatic formulation is all-important, in another the social gospel prevails, in another the mystical approach. It seems difficult—indeed it may not be possible—to maintain through the ages an even balance. Truth seems to unfold itself by exposing the falsity of the over-statement of positions, which, within their own limits, are true.

There is a growing doubt as to the applicability of the scientific method in the study of human affairs, to the extent at least to which it has been used in the last quarter of a century. It is this doubt, as much as the recent discoveries in subatomic physics, which has raised the question that is before us this evening. It goes without saying that there is a great body of facts which can be accumulated, tested, analyzed, tabulated. These facts clarify situations otherwise vague, about which opinions are accustomed to be formed without the support of the necessary data. This process is essential; and only the trained scientist can do this work. But those among us who have to deal with some of the mental and emotional expressions of human activity have not felt assured. To take, for example, the field of education. Much has been done, and some of it of real value, in analyzing objectives and aptitudes and the specific values of this or that educational tool in developing the aptitudes which are needed for the various professions or vocations. In these investigations the scientific method and technique have been employed. The work has clarified the situation. It has given a sense of precision to an otherwise somewhat nebulous subject. But one is left with the feeling that there are values in education—and these the most important—that elude the pan of the balance. They are imponderable, but they are very real. Any one who has come under the influence of an inspiring teacher knows the things whereof I speak. They are the things which are felt, not said; and they are of the very essence of a liberal education. They are far beyond the power of analysis of the scientist, but they are understood by the scientist as a man. So too, for instance, in the progress of the study of sociology. Very much of real value has been accomplished by the detailed statistical studies which have been made in recent years. We understand better, and in a quantitative way, how people are affected in the mass by opinions and movements and habits. We are thrown back, however, on the fact that while in a general way mass movements may appear to be reduced to a quantitative basis, the individual unit is a human being of unpredictable responses and reactions; and there are values in sociology as in education which elude the precision methods of the scientist. In economics, too, the conviction grows on the layman that the discrepancies between theory and fact which have been in evidence in recent years are to be explained by the consideration that economic laws work not *in vacuo* but in and through human beings, who refuse to be treated as though they were robots working under purely mechanical forces.

Is it the case that the difficulty lies, not in the incompetence of science in this field of human affairs, but in the lack of knowledge of the complicated factors which operate in human life and thinking and conduct? Is there not so much to be explored before we can say so peremptorily that there are areas beyond the limit of scientific analysis? Will not the rapidly advancing knowledge of psychological processes change the situation? Can the scientist go forward at all unless on the hypothesis that the scientific method is applicable?

Or, on the other hand, are there values which are beyond the reach of the scientist *qua* scientist, and of which his method has no means of assessing the validity? This is the fundamental question; and we have discussed the human problem first because the question has arisen in many minds in recent years. There are scientists not a few who feel that as scientists they must go forward on the assumption that there are open fields still to be cultivated, but as men feel that there are regions, the door to which they will not be able to unlock by the key which science provides.

We shall return to this question. But what is the situation in the inorganic world, where the problems of life, ever more complicated as we ascend to the level of man, do not confuse the issue? Are there limitations here as well which have to be understood and defined; and what is the basis for establishing such limitations?

It would be incorrect to say that such limitations have been established. It would be nearer the truth to say that there are probably limitations. A quarter of a century ago a statement of even such a tentative nature might not have met with general support. The reason for the change is in the newer development of nuclear physics, where the principle of indeterminacy and the unpredictable movement of the electron around its nucleus have raised questions as to the rigidity of the physical mechanism. The reduction of any physical phenomena to a law of averages, in which the action of the individual particle, no matter how small, is not possible to predict, weakens the basis on which physical science has been built. Such a procedure may be useful in relating together the laws of the physical world, derived as statistical averages, with the laws of human behavior; but it does not strengthen the hands of the scientist who has been accustomed to work on the implicit assumption of rigid causality in the phenomena of nature.

Are we justified in basing philosophical conclusions on these newer findings in ultramolecular physics which seem to carry with them a certain air of indeterminacy? May it not be that further work will discover the factors which influence the movements which are at present unpredictable? Or must we accept the position and guide ourselves accordingly? It would seem to be dangerous to go far on the strength of data derived from the operation of non-observable phenomena. It might seem more advisable to urge caution in drawing conclusions until a closer approach has been made to the matter at issue. In the stream of literature which has poured forth on the subject in recent years, however, there has been general acceptance of the position that a new orientation is needed in our approach to the physical world, and that the scientist must guide himself accordingly. Let us examine some of the more important contributions which have been made towards an understanding of the world in this new setting.

Eddington accepts the indeterminacy which the modern findings of physics have proclaimed, and with it, as a necessary consequence, the relegating of the principle of causality to the dustheap. This is not to say, however, that it is a world of chaos with which we have to deal. Eddington does not go so far as to say that there may be a principle of volition in inanimate nature akin to that which he accepts in the realm of human consciousness. He bases his conception of the orderliness which may exist in nature on the statistical laws which hold good for nature's processes in the mass, whatever may be the capricious action of the minute individuals which make up the mass. It is the orderliness of the mortality rates of human beings, accurate for the purpose of insurance companies, but of no value to you or to me in forecasting our own span of life. But to him there is a world beyond those pointer readings which alone represent in our consciousness the expression of nature's working. The data of science are symbols of that of which we can not be conscious and which we are unable to apprehend. There is a mystical background in nature and in man which Eddington interprets, not as a scientist, but as a poet. Therein lie both the intangibility and the charm of much that he has written.

Eddington is a scientist with a philosophical outlook. Whitehead is a philosopher with a mathematical background. The approach of Whitehead is a different one to that of Eddington. Eddington's concern is to make clear the limitations under which the scientist works, and the reality of that other world, known only to our own consciousness and what we know of the consciousness of others, in which the intangible values hold sway. It is in effect a dualism, on the one hand of pointer readings which we build up into our body of scientific knowledge, on the other hand of values which come to us through other channels, but which commend themselves as enduring realities. Whitehead sees the special area in which the scientist works, but his concern is primarily to integrate this world of the scientist into the larger whole. He seeks for a representation of reality into which the inorganic and the organic world fit without distinction and without separation. To Whitehead all nature is an organism, of which that part known to science is only a part, but nevertheless an outward evidence of the inward whole. That nature is an integrated organism is an assumption which the philosopher, whose function it is to look out on truth in its most universal significance, may readily take as a premise to his thinking. It is the attitude of the poet, to whom all outward expression in nature is an indication of an inward spirit

which pervades the world, and gives it meaning. It is no easy task for the uninitiated reader to understand the way in which Whitehead's organism functions. It is less difficult to understand that in the ultimate analysis there may be a harmony in which mere arbitrariness has no part; and in Whitehead's words "to know that the system includes the harmony of logical rationality, and the harmony of esthetic achievement: to know that while the harmony of logic lies upon the universe as an iron necessity, the esthetic harmony stands before it as a living ideal moulding the general flux in its broken progress towards finer, subtler issues."

It would serve little purpose to discuss all the interpretations of the world of nature and of man which have been given to us in recent years. May I limit our attention to one other, from a man with a scientific background very similar to that of Eddington. Herbert Dingle is unsympathetic to the positions taken both by Eddington and by Whitehead. Eddington he finds to be illogical in that he has taken the position that "the only subject presented to me for study is the content of my consciousness," while he has at the same time admitted the reality of the external world on which the scientist operates. He has thus been disposed to attribute an element of the mysterious and mystical to this outside world, because it is outside the realm of consciousness. Dingle considers this to be an unnecessary consequence of inadequate premises. Whitehead's assumption, on the other hand, that there is an organism in nature which rationalizes in itself all that is perceived and all that is felt, Dingle considers to be an assumption without proof. As a scientist he feels that, while ultimately this may be found to be the case, it can not be assumed in advance. His plan is to build up, if the facts justify it, a basis of rationality in the more limited areas which are available for exploration with the limited means at our disposal, and to work outwards from this central nucleus until eventually a field theory may be developed which will rationalize the whole of nature. Einstein has gone part of the way in this direction in his field theory of gravitation. Dingle takes the position that in the ordinary world of everyday experience causality rules, and common-sense judgments are found. The scientist, however, deals with concepts, idealized from the common-sense everyday world; and in the world of concepts time has no meaning, and causality consequently has no validity. The electron is a concept, mass is a concept, light is a concept. The function of the scientist is to interpret the memory of experiences by concepts and to correlate these concepts into ever-widening wholes. Science abstracts from the world of experience. The more complete the abstraction, the less the sense of reality in the concept which is created.

I am reminded, as I ponder over the position taken by this able astrophysicist, of a conversation with a prominent member of the somewhat revolutionary group of Canadian artists, popularly known as the School of Seven. The discussion was on the representation of a tree which stood prominently in the center of a bare northern landscape. To me the tree was unreal and almost fantastic. As a lover of nature I registered my protest. It was explained to me that the function of the artist is to see an inner significance, to abstract it from the setting and to depict it by itself alone. So too, it was stated, the poet finds an inner significance, separates it from its extraneous environment and presents it as a central truth, independent and alone. Somewhat the same method, if one interprets Dingle aright, is adopted by the scientist. The concept of the electron, like that of the tree in the Canadian painting, stands isolated and unreal to the world of experience. It is a symbol of a central truth; true in essence, but symbolic when viewed from the position of the ordinary world of everyday experience.

These three interpretations of the validity of the scientific method, sketchy and incomplete though this presentation of them necessarily is, are profoundly significant. It is to be expected that there will be no unanimity in the approach to truth; and Eddington, Whitehead and Dingle are far apart in their interpretations. Man gropes for the ultimate, and groping means exploration in all directions. But they have things in common, and two of them seem to call for special emphasis in a discussion of the values of science to a modern world.

It is very evident, in the first place, that the rigidly mechanistic conception of the universe, as it appeared to an earlier generation of scientists, has lost its force to-day. It is not in the thinking of the men to whom I have referred, nor to others of similar stature who, too, have gone deeply into the subject. This change has taken place partly because scientists are not prepared to insist on the principle of causality in the face of the recent findings in nuclear physics; but mainly because they are doubtful whether the method of the scientist is adequate to determine the whole of the processes of nature, even in the purely physical realm. There are many who would feel that, when further knowledge has been gained, the mechanical principle may yet prove to be the most adequate interpretation. There are few who would take the position that it is the only interpretation of the phenomena of the inanimate and animate world.

In the second place, there is a growing tendency to treat nature as a whole and to make no separation between the inanimate and animate world. Whatever explanation will ultimately be found to be adequate must prove to be adequate for the living and non-liv-

ing alike. The mechanists endeavored to apply this principle to the whole of nature, and in so doing reduced man to an automaton. Freedom of choice disappeared in the process; and reason has rebelled against this explanation of the springs of our being. But it is felt that there must be a principle of rational operation of the world, and that man in all his activities, physical, intellectual, spiritual, will be found to fit into the plan as well as does the growing crystal. If there is not a closed system self-determining and working as does a machine, there must be a rational system, which the mind of man may yet be able to understand. The philosopher assumes that such a comprehensive system exists; the scientist feels that the proven area of rational operation is widening, and may some day include the universe in its scope.

These two positions, which seem to be representative of the thinking of our time, namely, that the mechanistic conception of the world is inadequate and that there will in all likelihood be found to be a rational basis applying to the inanimate and animate world alike—these positions have been taken because of a sense of values which has found inadequate interpretation under the old régime. Eddington has illustrated this sense of values in a memorable passage in which he describes his inner satisfaction in the contemplation of the ripples on the surface of a lake, touched by the afternoon sun; and by contrast his intellectual process in formulating the motion of the waves into a differential equation. Esthetic values seem to stand apart from the formulae of science. They must be accounted for. They must be accounted for in a wider synthesis in which science plays a fundamental part. And they must be accounted for not as an experience of human consciousness only. The glory of the afternoon sun over a lake in the northern woods, when it would seem that the very gates of heaven are rolled ajar and a fleeting glance is permitted of the eternal Presence—that glory is not in the mind of the worshipper only, and of no reality unless there is human consciousness to feel it. It is a value in nature, which goes back to a time when there was no human eye to perceive; it will be there when the procession of human beings has trod across this fleeting stage of time, and made the final bow to the audience of the stars. The quality of beauty resides in the essential fitness of things themselves, as in the mind attuned to perceive that fitness. The deeper values are universal, in and through nature, of which man is only a part. It is the great task of science to integrate these eternal values into a rational whole with the external phenomena of nature with which science has been hitherto more immediately concerned. Ultimately there can be no conflict; there can not even be a dualism. If truth has any meaning, it is that there is one truth, expressed it may be through many aspects, but blending into a unified whole. The tools adequate for the work of delving for this comprehensive truth must be shaped for the hands both of the scientist and the philosopher, for they must work together in this great quest.

In all our thinking we come back to the human sciences. It is in the realm of human activity and human aspirations that the ultimate test will be made. I have already indicated in the discussion that it is here that the gap between the findings of science and the whole truth has been felt to be greatest. It is here that the need for a clear understanding is most urgent. In the need for clearer thought as to ultimate values which we call good, whether in personal or social relationships, whether as formulated by legislation or by an inner moral law which finds no expression in words, can we advance to clearer criteria by the well-tried method which science has so successfully pursued elsewhere, or must we always be content to say, as the Earl of Listowel has recently said: "Here we turn for guidance, not to science but to the beating of our own hearts and to those great books of poetry, philosophy, and religion in which the finest of men have recorded what life could give in its highest, and happiest and most vivid moments. The sixth book of Plato's Republic, the thirteenth chapter of St. Paul's first letter to the people of Corinth, the Sermon preached by Jesus on the Mount—such brief communications as these are a better training-ground for those who would direct the affairs of nations than all the voluminous writings of Einstein, a Pavlov, or a Freud"?

In this problem of values, as McDougall has pointed out, we face the question not only and not so much of the "how" but of the "why" and "to what end." Evaluation involves purpose and direction; and it is there that the persistent question is being asked.

"O, I wad like to ken," to the beggarwife says I
"The reason o' the cause an' the wherefore o' the why
Wi' mony anither riddle brings the tear into my e'e."
"It's gey an' easy speirin," says the beggarwife to me.

The questions will up, and the human heart demands an answer. The answer is not easy. "It's gey an' easy speirin." The scientist has been concerned with the "how." He has confined himself to it. He has achieved great success in it. But he is beginning to realize that, somehow, the "how" and the "why" are inextricably bound up together, and the answer to the one involves an answer to the other. Ends and means are tied up in the same bundle of life. If he can deal with means alone as a scientist he must deal with ends as a man; but he would wish to use his ability and technique as a scientist in the whole field, and not in a part. Here is the attitude of the younger men in

the field. I quote from "Human Affairs." "Science is not a device for making self-filling fountain pens. Science unveils a new order of values; it demands another way of living. With its vast concept of being we may cast a new mould for the shaping of action. For there is an intrinsic beauty in the architecture of scientific thought, an intrinsic worth in acquiring its realistic type of thinking, a superb ethical discipline in the impersonal quality of its ends. To spread the scientific spirit in the community is a need of the first importance. We must infuse the neutrality of science into the partiality of human affairs. We must leaven the mentality of our age, still heavy with individualistic and archaic modes of thought, with the rationale of science. How else, if not by such an attitude, can the supremely urgent innovations so patiently contrived by the human sciences be made available?" And again, "We believe that the human race has only begun to unfold the infinite range of its possibilities."

There is no lack of confidence here. There is the ring of the optimism of youth, aware of the ground which has to be conquered. The nature of man requires the discipline which comes from the objectivity of science. The cravings of the human spirit have to be submitted to the corrective of the process of facing facts as they are or as they will yet be ascertained to be. Science provides a pattern of thought, to which if man would submit himself much of the shortsightedness and unwisdom of man and the structure of society which he has built up would disappear. These statements will command assent. And, if, further, the scientist, the moralist, the philosopher and the mystic can together search out the heights to which man is capable of climbing, the task of mapping out the path by which the toilsome and laborious ascent may be made is not beyond the power of science, in its wider sense, to perform.

In all this groping of science toward wider human contacts, what is the responsibility of those among us who are concerned with the education of young men and women, and with the validity of the means of education which lie to hand? Where does science now stand in the scheme of education for the needs of the world of our time and of the time of the generation that is to follow us? This is a question which has been in the background of my thinking as I have endeavored to paint the picture of the values of science as they appear to me in their changing form.

Two things impress themselves on me. The first is that the method and the attitude of science are indispensable for modern life and thought. No young men or women are equipped for life without that background, for they will live their lives in an atmosphere permeated with that outlook and that method. Without this equipment they are as passive spectators looking out on the active stream of life as it goes past, for they have not the technique to understand the significance of the processes of modern civilization. This is not to say that we are sound in all our procedure. The time has come, in my judgment, to question the value of the large amount of time which those who are not to be scientists spend in the laboratories of our modern universities. It is not improbable that more might be gained by observation of the method and the enthusiasm of the able teacher of science. But that method and that enthusiasm must in some measure be imparted to all who are to take their share in the work of our modern world.

The second consideration—and it is even more fundamental—is that this kind of education is not enough for our time. It is imperative that the young scientist should know something of the problems of the psychologist, the philosopher, the economist, the sociologist and the statesman. Not that he should be familiar with the details of those vast fields; that is not humanly possible. But it is possible, and it is necessary, that he familiarize himself with one of the realms of human relationships and feelings, in order that he may place his science in its setting for modern needs. The value and the influence of the man who works completely apart from, and without knowledge of, the deeper movements of mankind, grows less with the passing years; for he at least will play no part in that widening influence which science must exert on the solution of the problems which confront the human race. In this matter we are in grave danger. One contemplates with disquiet and apprehension the increasing stream of narrow specialists who issue from the institutions of learning into a world that is seeking for other counsel than they can give. We need the men who are imbued with the scientific spirit and who have access to the inner courts of the temple of the mind and the spirit of man. That kind of man must be cultivated in our halls of learning. Can it be that we are failing in our task?

We go forward in the faith that truth is universal, and that ever-widening areas will be mapped and explored. It is a small island from which we set out to chart that great sea. If science is to be our instrument, it must be capable of meeting heavy demands. For we will voyage into the infinite, beyond the last horizon.

'From this wave-washed mound
Unto the farthest flood-brim look with me;
Then reach on with thy thoughts till both be drowned;
Miles and miles distant though the last line be,
And though thy soul sail leagues and leagues beyond—
Still, leagues beyond those leagues there is more sea.'