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THE RESEARCH SPIRIT IN EVERYDAY LIFE OF THE AVERAGE MAN[1]

RESEARCH has been considered generally as a phase of effort quite distinctly set off from the natural course of human interest. It is my purpose to discuss the spirit or attitude of investigation as normally involved in the everyday working plans of the average person.

Of the significance of research in all fields of our endeavor the extraordinary advances and applications of science in the recent war have not left the world in doubt. For nearly half a century Germany had been known as a nation given to investigation in a great variety of little explored subjects, and governed in considerable measure in accordance with the results of such researches. The strength of German military organization, backed by scientific and economic interests welded into one powerful instrument, brought to all the Allied Powers full realization of the need for a supreme effort of intellect in many kinds of scientific and economic operation previously unknown. The result of this reaction was a stupendous contribution to application of research. Incidental failures, due to unpreparedness and to lack of organization, may not detract from the importance of what was thus produced.

No less clear is now in post-war reconstruction the evidence of need for entirely new views of old knowledge, for immediate answer to old questions not yet solved, and for quick results of investigation on problems of construction never before encountered. As had been predicted, we find ourselves to-day going forward to new plans of human organization, but more unsatisfactorily prepared for the complex situations of the new era than we

[1] Delivered as the address of the retiring president of the Pacific Division, American Association for the Advancement of Science at Seattle, Washington, June 17, 1920.

were for the more narrowly limited and clearly defined issues precipitated by sudden climax of war. Conflict such as that through which we have just passed intensified interest and brooked no delay in judgment. Reconstruction under peace conditions sets no precise time limits for its decisions. Therefore, we face to-day the settlement of great questions upon which the future of the world depends, but without that definite intention of judgment called forth by the immediate urgency of war-time crises. Our need for solving present vital problems requires a clear understanding of what the questions are and a determination of the responsibility for their solution. While we may assume that this responsibility rests more heavily upon some than it does on others, it is my purpose to call attention to the part which all thinking people have in the movement to bring these great issues to settlement.

In order that there be no misconception of the views presented, it should be clear that the interpretation of research in this discussion comprises not merely the detailed investigations of fundamental scientific principles, but with this includes all inquiry which may be included within the range of thought leading to constructive action. The mere acquisition of knowledge does not contribute unless it is carried on in such a relation that it leads ultimately to the process of building. On the other hand, construction can not go on without the process of investigation, as each new building operation involves an individual problem to be solved.

Some one has said that much of research—with the accent on the "re"—may be so called because after completion it becomes necessary with much labor to search it out again when real opportunity for use appears. Work of an investigational nature carried on with the right spirit, and with proper organization, should be planned to find its place without great loss of energy or time, or at least be located where, with other building materials, it lies at hand ready for use as required.

The research spirit represents a reaching out to understand and use all that lies about us. Its expression is as natural to a thinking mind as hunger is to stomachs. Its origin is by some compared to an awakening—in which we recognize the world of things about us but have come as yet only partially to know it. I prefer to think of it as identified with the growth tendency inherent in biological organisms, which may carry us on and on without limit, as our powers and range increase from age to age. Constructive work is inseparably a part of the living of intellectual life.

Much of misunderstanding that arises generally regarding the function and place of research relates itself to false conceptions, *first* of the limits of the broad field of knowledge, and *second* of the degree of stability in nature and in man as an outgrowth of the natural world.

An astonishingly large percentage of the human family conceives of available knowledge as comprising nearly all that may be known, and including much not worth knowing. Such views are not limited to uneducated persons, but have been found among scientific men accepting as final all present fundamental theories of the nature of matter, origin of the earth, relationship of life forms, and other equally critical interpretations of the natural universe. It has required the shock of many recent discoveries in physics, chemistry, astronomy and biology to make clear the fact that our understanding of much that is nearest to us is only imperfectly formulated; and that in the present period we can be assured of a field of the unknown, but not unknowable, about us so vast that realization to our ignorance makes us look only with humble pride upon past accomplishment. To such a field for endeavor as I have remarked for science there may be compared similar regions in the economic, governmental, and cultural subjects, toward which not only the student but the man of business and of affairs looks out with strong desire for attainment of much in knowledge that has not yet been reached. In our day the research of business on scientific lines bulks large in comparison with non-applied science, and present accom-

plishment has only stimulated the desire for further advance. Every evidence that we have indicates the wide open range for discovery of new principles and new applications of knowledge in practically every field which the intellect explores.

In an attempt to understand the need for continuous research activity, an acquaintance with the order of stability or instability in nature and in human affairs is hardly less important than a conception of the relatively narrow limits of attained knowledge. Human beings seem curiously inconsistent in that though they are stunted individually without constant growth or change, they attempt to deceive themselves into belief that an unchanging situation is the normal condition of nature. We calculate an average rainfall and expect it to rain just so many inches, be it 24 or 46 each year. We are shocked if it rains less. We see the rocks distorted and torn by countless movements dating through all past periods of earth's history, but we are surprised when a slip of a few inches disturbs the seeming present-day stability and produces an earthquake. We build highways of concrete and are astonished that they wear out. We write constitutions and expect the judgment of the men who made them to fit all times and conditions. Yet history shows us that with the law which states that nothing is completely destroyed, we must write with Pythagoras that nothing remains continuously the same. The geological book—the greatest historical document of all the ages—gives us as one of its truths the fact that in the known hundred or more million year record of life, nothing has remained in constant form; that the rule has been not only continuous change but also continuous advance of the highest level. Through vast periods man has himself been subject to changes like those that have been expressed in other living types; and the habit of nature so set forth seems to indicate that with the earth in continuous state of modification we may expect life and man to keep for the future a rate of growth not less rapid than that of past ages. Assured of the validity of these principles, we can be certain that as a race and as individuals we shall be almost continuously under the necessity of meeting adjustment and readjustment to new conditions. We have to face not merely the question of new knowledge which research should secure for the use of the moment, but with this we must have understanding which will guide and support us in the continuous movement incidental and evolutional which must be looked upon as the natural order.

With realization of the unattained limits of knowledge, and with the conception of continuously operating growth and readjustment to which we as individuals and as groups are subject, there comes to every person an understanding of the necessity for continuously operating constructive work. The giving of such a view as has been suggested is in my interpretation a necessary part of the broad function of education.

Education should not only give the wider and deeper view of the structure of knowledge, but with this it should furnish an acquaintance with the methods by which knowledge is obtained and applied. By one classification, educational work may be given five great purposes: (1) To determine our individual capacity for knowledge, and adaptability to special subjects; (2) acquisition of facts; (3) learning quality of judgment and organization of materials; (4) developing power to construct or create; (5) forming of character and development of altruistic motives. Education often concentrates itself on the acquisition of knowledge or of facts organized and unorganized, neglecting in considerable measure questions of capacity, training of judgment, constructive ability, and the development of character. Not without significance is an illustration in a recent publication representing a student with his arms piled full of books marked "knowledge," but unable to accept the volume of "wisdom" or judgment offered to him.

The third and fourth of the five points mentioned in the classification of educational aims, namely, judgment and creative ability, are in a large measure representative of re-

search. Though based upon the accumulation of facts, the critical significance of research lies in the quality of judgment and organization leading to constructive use, with the ultimate goal of application or service. One of the greatest contributions that education of the future can make is to place the emphasis in training on a broader view of organization of knowledge, on the ability to judge and construct, and on the desire for service. Not until such an understanding of the function of educational training comes into general acceptance, can we expect the average man to be brought into full participation or interest in the spirit and opportunity of the constructive work of the world required from day to day.

It is, I believe, also a responsibility of the educator to bring about a better understanding of the relation between the two great ideals of *construction* and of *service* which are fundamental to the philosophy of right living. Two groups of persons who contribute greatly to advance the comfort and happiness of mankind are, those who produce the new ideas upon which we build from age to age, and those who give themselves to public service in the larger sense. There is in my judgment a close and necessary connection between these two types of relations to the community. Research should lead to construction and is not complete unless the results are available for general use; while public service rarely attains the purpose for which it is initiated unless it is distinctly constructive.

I have spoken up to this time of the broader view of research, and of its more general relation to great problems with which we are confronted. In considering specifically the connection of this phase of thought with the life of the average man, we should look more particularly to the practical value of constructive work in contacts which may be considered representative of everyday life.

Research or constructive work is often divided into two types, one concerning fundamental principles without regard to their immediate application; the other, sometimes designated as research of application, representing especially the investigation of methods by which principles already known are put to human use.

The first type of investigation has been advanced especially in institutions concerned particularly with scientific and educational problems. Much fundamental investigation has, however, been conducted by engineering and governmental laboratories established specifically for the purpose of contributing to clearly determined needs. Through acquaintance with any one of many occupations such as agriculture, engineering, or business, the average person is sooner or later intimately in contact with some phase of this type of research.

Research of application reaches its highest expression in the great engineering laboratories of corporations recognizing the possibility of drawing from the field of investigation uses of scientific laws or principles, which may make possible great saving or higher efficiency in the conduct of their business. Enterprises organized for legitimate gain do not always make increased income by increased profit percentage, but often by increase in volume of business, introduction of new materials, or utilization of new ideas. Volume of business may mean increase of plant. The use of new materials often means a practical reorganization of plant and increased expenditure. Introduction of new ideas may mean increased efficiency, increased profit, and, with the exception of purchase of patents, may not require continued increase of expenditure.

Research of application finds general use in the problems of everyday business and everyday life, in which we are forced to make decisions which lie between following rule of thumb methods and the possibility of making a special judgment for every situation which confronts us. It is the difference between the attitude of the oculist or optician who has just so many possible standard types of cases into which all eye troubles can and must fit, and the other man who, under normal circumstances, considers each eye as different from every other and judges it specifically, accord-

ing to the fundamental laws of physics basic to his subject. It is the difference between the type of housewife who makes all pies in California according to the rules used by her grandmother in Maine, regardless of the character of the flour, or the kind of fruit; and the other housewife who, according to the materials involved and the end to be attained, judges through experience and experiment the combinations most acceptable.

The average man of intelligence comes to recognize in the course of his thinking that he lives in a world which we understand only imperfectly. At every turn he encounters the limits of his own knowledge and of our total accumulated store. In every kind of business or occupation he moves among those concerned with attack upon problems which are new in the general as well as in the individual sense. In some small part he is called upon to help in the solving of these questions. He is also expected to know how to secure information on problems which he needs to solve. In a still larger way he must understand the movement toward solution of economic and governmental question, in order that as a citizen he may exercise his privilege of giving intelligent support to those whose special work it is to investigate these matters and to pass judgment upon them.

It is a part of the duty of the average man to know the difference between pernicious questioning and constructive thinking; to judge what things of the established order should be left alone and which should now be changed. He must be a conservative, standing for stability, and yet recognize the constitutional evanescence of all things natural and human, and stand for progressive movements at critical times.

The average man must learn to know and value the contribution of the specialist or expert in constructive work, and call into his service men representing fields other than his own particular province. The habit of requesting properly organized investigation must be developed and put into operation in directions which show promise of leading to results of importance to the community interests.

The average man will do his research mainly in the field of application, rather than in studies of fundamental principles, but he will find the pleasures of constructive work outweighing in realization all other types of enjoyment. He will discover here a continuing interest which leads on with undiminished attraction and brings renewal of life stimulus.

As opposed to the life of constructive type, we may visualize the conservatism of habit in those individuals who fit themselves into the treadmill cycle of custom. Their individuality wears down to nothing, and they become only cogs in a machine of which neither the structure nor the purpose is seen. On the other hand, the constructive life means not alone continuous growth and unending youth, but it offers as well the largest opportunity for enjoyment of service. It furnishes the basis for that reaffirmation of individuality which both in science and in human service has been characterized as being born again. One who constructs and accomplishes sees new life. Those who follow blindly and without individual vision are sometimes known as of the practical type, and not infrequently pride themselves on refusing to accept the new which may be good and perpetuating in their life work the errors of their grandfathers, which the grandfathers would not thus have carried on.

Research and advancement of knowledge in the future depend not alone upon expressions of individual genius, nor upon opportunity for concentrated investigation in limited fields. The intelligent use of results of constructive work by the people as a whole, a general understanding of the methods by which this information has been obtained, and a knowledge of the means necessary to support research are also indispensable. Great advances of the future are not dependent upon having every man do everything as an expert, but they will rest upon a wide appreciation of the importance of constructive thought, of organized knowledge, and of the need for continuous advance of knowledge.

Education will play a large part in the support of research through giving, even in

elementary courses, the proper view of knowledge and an understanding of the means by which it grows. Nothing would probably go farther toward bringing us to a satisfactory view of our present situation than a course of instruction on that which we do not know, but which might by investigation become known. With this there should go a presentation of evidence as to the methods by which constructive work could bring this information and apply it.

A great responsibility for realization of the possibilities in education rests upon those scientific organizations which have given themselves especially to the problems of constructive thought. Through the scientific institutions which we represent, it is our duty to make clear the function of education to train in judgment and construction rather than to encourage merely the amassing of facts. A responsibility rests upon us to see also that the results of our own investigations are not buried more deeply than were the materials upon which they have been based. New ideas should be clearly recognized, fully stated, and placed where the applying engineer may find the data which he requires to meet human needs. We have again a duty, so to organize our work that other investigators and applyers may not only know the results, but that they may cooperate with us to mutual benefit.

There is no doubt that properly organized and coordinated efforts of science and education may increase greatly the present opportunity of the average man for constructive activity, making his life more useful and happier. The average man of the future will of necessity live his life largely in a routine based upon customs of the prevailing social order. He will give himself to action governed by established rules formulated from experience; but always and increasingly in his individual affairs, as in his relation to the community, he will find his largest measure of satisfaction in the building type of effort originating through his own thinking. As the product of the life work of each individual accumulates, the evidence of true individuality will become more clear, until there emerges from the chrysalis stage of mere physical and mental separateness the newborn personality of one who in creating an idea has given to himself the right of eternal individual recognition as an intentional participant in human progress.

As the problems of community organization become more clearly visualized, the importance of the research or constructive spirit in the average man will increase, and the future of democracy depends in a measure upon the possibility of securing for each capable person an opportunity to obtain the wider view of the greater problems, to learn dependence upon those who know and are true, and with all this to make contribution in an unselfish spirit. Unless these objects are realized we are doomed to revolve without progress through endless cycles of misunderstanding and conflict.

Education with its varying emphasis on the fundamental truths of science, philosophy, human relations and religion is our principal safeguard. Our definite guarantees of progress are found in the lessons of history, taken with the present wide expression of individual responsibility for judgment in the critical affairs of citizenship.

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DOCTORATES CONFERRED IN THE SCIENCES BY AMERICAN UNIVERSITIES IN 1920

A compilation of the doctorates conferred by American universities has been made for each year from 1898 to 1916, and the data published in Science annually through 1915 and in *School and Society* for 1916. Dr. Burg, who compiled the last annual statistics, severed his university connection in 1917 and the compilation was turned over to someone else who for various reasons was unable to complete the work. No statistics, therefore, are available for 1917–18 and 1918–19, but the compilation has been resumed for the academic year 1919–20 in so far as the doctorates conferred in the sciences are con-