SCIENCE

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RESEARCH[1]

THE university is the natural home for research. The development of research institutes, except of those that have been built up around a great genius, and during the period of the active life of such a man, is apt, in the long run, to be more of a menace than help to the work of investigation. In a way the establishment of these institutes is a measure of university inefficiency. They mean that the universities have failed to rise to their full possibilities as centers of mental activity.

Research institutes lack the current of successive generations of students from which to pick out the right minds and to draw new blood. They do not feel the internal heave and struggle, the pressure that comes from association with the great turbulent mental forces that accompany youth. There is too much pressure for evident results, too much discipline of research minds to achieve a big effect. Just at the period when those who have the proper training and ability and the love for investigation that must go with success in discovering new things, many of the workers in research institutes and departments are compelled to work on the problems of some one else. This is valuable and satisfactory up to a certain point, but beyond that it means sterilization of the best that is in the men; it means putting aside their own projects, perhaps permanently. It is a serious thing for any one full of expanding ideas to be made a "scientific bootblack."

The university, if manned as it should

[1] Address before the Society of Sigma Xi at Stanford University, May 8, 1916.

be, is the ideal place for the development of fundamental research as contrasted with the more showy kind. If the tendency to forced stimulation of mediocre men, who have persistence and the leisure that may come from fellowships and scholarships, can be minimized, the universities can and eventually will become the seat of the greatest ferment, working out toward new discoveries.

Our whole concept of education has changed. It is now one of fact and not opinion. The "theological period" of assertion has largely gone by. There is no common source of information, no palladium such as the Bible is to religion, in modern science. What Agassiz says has no final value except to those who know his record, his trained mental processes, his method of arriving at pronouncements. We ask for foundations; we want to be able to see affirmation built up stone by stone; or we want to be able to work backwards and tear down the separate blocks, testing each and finding out thereby the real quality of the structure of assertions and theories formed by them. Allegiance to truth, as far as we can understand or discover the truth, is the main concern of the scientific worker of to-day. He knows that he must get into harmony with facts if his work is to be effective, to endure. Along with this appreciation of truth there has been a striking development of the conscience of the expert, who can only be partisan to the truth. The rescue of the so-called "expert" from his present unsavory position seems likly to follow the great advance in knowledge which has come from careful "fact study." We owe much of this very desirable change to the important body of information which has been brought together by those engaged in what we sometimes rather glibly call "research."

Research means a point of view, a type of mind, a healthy curiosity. It results in a welling up of inspiration. Our senses become blunt, our edges dulled to the usual, the old, the stereotyped. They keep acute to the new, the unexpected, the obscure, the intangible, the will-o'-the-wisp. For the interpretation of a subject to advanced students, only the mind alert in research, curious for the new, can be of the best service. Without that open point of view the solidification that usually begins in the early thirties of life soon becomes petrifaction. A noble mind has found its limits and will gradually wear off all its new contacts and beat its life out, leaving only the revolution of the treadmill to furnish evidence of activity. Freshened by contact with the new, the yet unexplained, the human intellect expands throughout life, becoming, through its constantly increasing store of fact and experience, more and more serviceable. Particularly is this true where the judgment has been developed through guiding others along the old paths and starting them off with compass and necessary equipment along the new paths which lead out to the maze and appealing mystery of the unknown.

The college or university teacher who fails to take a part in research in some form or another prunes himself of those branches that give promise of the best future fruit. There are many ways in which the research point of view may be maintained. It does not necessarily mean published work. It may be most serviceable to the teacher and yet show only in fresh thoughts, new stimulation to the student to think for himself, to investigate. It may be concerned largely with improvement in the presentation of subjects before classes. The man who devotes much of his time to research and experimental work and yet drags out the well-thumbed notes of bygone lectures to hammer at his classes is far from having the

research mind we need in the teacher. Such a man is of less value than the instructor who studies his subject but makes no pretense to so-called "productive work."

The research mind keeps up to date in its correlations and brings the inspiration of the best and newest into each teaching day. Sometimes one feels that the external drive towards research by university sentiment leads to many puny efforts and to abortive results. Perhaps, however, even though the result to science is small, the effect upon the individual is salutary. The greatest sport the world knows is the search for the absolutely new in any line. One need only sense the joy once to feel its lure.

I recall when working in Ehrlich's laboratory in Frankfurt his pleasure in each of the new chemical substances formed by him. He would make a new combination and show it to those working near him, even insist upon putting it into their hands to hold for a moment, saying: "Sehen Sie mal, jemand hat, es nie vorher gesehen; es ist ganz neu." Think of the satisfaction, the sport: "No one has ever seen it before; it is absolutely new." Who that could would not try a round in such a game? The successful players in it are those who have builded strong in mind and body—who have climbed to the upper heights, obscured by the mists, where the game is played. Each group of workers pushes the altitude upwards, broadens and solidifies the base, turns peaks into plateaus. The chosen few scale the lofty, unexplored spurs; the many join in filling in the gaps, opening up the intervening spaces, and making the secure level ground. We can not all be scouts; most of us must make up the rank and file of the army; some of us can only play the part of quartermasters.

The attitude of the university towards research should be a sane one. At times waves of research hysteria have swept over university circles and the sense of proportion has been lost. The number of published pages has seemed to be the standard of scholarship rather than the character of the work done. One has often seen research notes elaborated into articles; articles subsequently enlarged to monographs, and monographs padded out into books. The essential thing, however, is the discovered fact, the reasoning leading up to and away from the new fixed point. There is no common standard possible in this work nor in research in general; but the university can insist that the instruction offered by its research workers shall show that fresh and stimulating point of view, and that enthusiasm, that go with the growing mind that is abreast of the best thought in its subject. Under these conditions research will play that large part in the life of the university faculty which it should play, and students and teachers will make progress in their chosen fields.

Immortality is a theme upon which human thought has exhausted itself without absolute and universal conviction because it takes the human mind beyond its depth at the first long stride forward. But there is one phase of immortality about which we can all be assured. The mind of to-day can through the minds of to-morrow project itself into immortality. Ideas and ideals travel through generations of minds to eternity. It will ever be the inspiration of the teacher that to him in particular comes this great opportunity to be a part of the future, by moulding and guiding and training the minds of the present.

The man who discovers some new arrangement of forces, some new fact in regard to chromosomes, some fresh chemical combination, the cause of an obscure disease, has thereby become immortal, for his effort has added something which, if true, can not be lost to the human race. What

happier form of immortality than this—to have added something to the world's store of fact and of law!

Many then are the inspirations of research, and many the satisfactions of the teacher and the investigator. If we keep our view point clear, recognize the many ways in which new facts and new thoughts are garnered, avoid the spirit of pride and intolerance—we can be assured that from our university faculties there will come a spirit of research and of helpfulness that will act as a powerful factor in moving civilization onward and we hope upward.

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CONTRIBUTIONS OF THE UNITED STATES COAST AND GEODETIC SURVEY TO GEODESY[1]

In the earlier days of the Coast Survey, whose centennial is now being commemorated, the geodetic function, as such, was little in evidence. It was then simply an aid in carrying on the work outlined in the Act of 1807, which provided for a survey of the coasts of the United States, in order to provide accurate charts of every part of the coast and adjacent waters.

Upon the reorganization of the Survey in 1843, the cornerstone was laid for that fine system of geodetic works which the Survey has at present. In this reorganization two very prominent features, from a geodetic standpoint, are to be noted. The first is the man who was the dominant figure in the board of reorganization, and the second is the principles he advocated. Probably no other man has had the influence upon the geodetic operations of the Survey as had Superintendent F. R. Hassler, and probably no one thing has been of such importance to these operations as the scientific methods proposed by him. To him belongs the credit that to-day the operations of the Survey are bound together by a trigonometric survey with long lines, and executed by the most accurate instruments, and the most refined methods, rather than being correlated by purely astronomical observations. Due to his far-sightedness, the best of foundations was thus laid for geodetic operations, and from this time geodesy became an important part of the Survey's work.

A further impetus was given to the work when, shortly after the close of the Civil War, Congress authorized a geodetic connection between the Atlantic and Pacific coasts of the United States. The result of this was the great transcontinental arc of triangulation along the 39th parallel of latitude, one of the most famous arcs in the history of geodesy, and one which has helped to place the United States in the front rank of the nations carrying on geodetic operations. One of the immediate results was the recognition of the geodetic function as an important part of the Coast Survey's work, and in 1879 the Survey's title officially became "The Coast and Geodetic Survey."

THE TRANSCONTINENTAL ARC

The great triangulation system along the 39th parallel was probably the greatest single contribution to the world's geodesy that had been made by any one country. It marks an epoch in the scientific history of the United States and in that of the world. The results of the work are most important and far-reaching to geodesy, geography, geology, and the other earth sciences.

It is the longest arc of a parallel ever undertaken by a single nation, being more than 48° of longitude between its extremities, or about one-eighth of the earth's circuit, and is more than half the length of the combined arcs (measured by various

[1] Address given at the celebration of the centennial of the U. S. Coast and Geodetic Survey.