

ent civilizations that existed in this country—an idea that unfortunately the writers of earlier times did not give us.

At the same time, we must not forget to study the cultural strata to see if there be in some place some means of arriving at a classification or chronological order in which the civilizations followed one another, a history that we have not been able to establish up to this day. All these propositions will require the cooperation of the young who will learn and will in turn become our teachers; who will continue our work, disregarding and boldly setting aside the doubts and hesitations of the old, and who will not fear to open new paths and with youthful vigor bring to a happy end what we have only been able to begin.

EDUARD SELER

THE PLACE OF RESEARCH IN UNDER-GRADUATE SCHOOLS¹

THE aim of this academy is the encouragement of research along scientific lines by establishing and maintaining intercourse among those engaged therein, thus stimulating them by a consciousness of companionship in productive intellectual activity. In a small society, embracing in its scope all the sciences, one does not expect in these days of specialization to find others engaged in just the same field of investigation as himself; it is through inspiration rather than information that the investigator profits by these meetings.

It is now hardly necessary to emphasize, even to the non-scientific public, the importance of scientific research; to it mankind owes in a large measure not only his material prosperity, comforts and conveniences, which is sufficiently obvious, but, what is even more important, his intellectual freedom. The changes that have taken place within the last century in our

¹Address of the president of the Indiana Academy of Science, November 25, 1910.

physical environment, with the innumerable applications of science to useful purposes, are no more profound than our intellectual advance and the growing pervasiveness of the scientific spirit in all lines of thought and endeavor for human betterment, physical, social and moral. Our increasingly extensive and effective philanthropies, our giant strides in sanitary administration, and the tottering barriers between the sects of Christendom, are very tangible evidences of the spirit that is not satisfied with precedent or authority, but craves certainty as to the facts, and reasonable explanations for them, as well as the application of all knowledge to the uses of man.

The membership of this academy happily includes scientific workers in many fields. Some apply the results of research to the needs of the state in developing its resources and protecting its citizens against the injuries inflicted by ignorance and fraud; others make science the servant of industry and commerce; others, again, are active in applying it to the preserving and restoring of the health of our bodies. A large part of our membership, however, is made up of those whose chief occupation is teaching.

While it has not always been the case, it is probably true at present that the most valuable contributions to human knowledge are made by those engaged in this profession of teaching. This is not surprising, for the nature of his calling demands that the teacher to be effective must ever continue to be a student, and the thorough study of any subject reveals the limits of our knowledge in that field and tempts the man of active intellect to the task of extending those boundaries; there is surely no keener pleasure than the learning by one's own search some truth, however inconspicuous, not previously known.

Not only does teaching tend to stimulate research, it also gives it balance by preventing the too exclusive attention to the comparatively narrow field under intensive cultivation; the necessity of presenting well-ordered information covering the broader subject, and the oral statement of original theories and conclusions, must have a broadening and clarifying influence on the intellectual activity of the investigator.

As teaching is a help to research, still more is research a vitalizer of teaching, particularly of the teaching appropriate for graduate students; indeed, the work of research is at least as important as that of instruction where advanced students are concerned, and the university should be a source of new knowledge, where those desiring to devote themselves to the same high quest may be stimulated by the example and companionship of productive scholars.

The leading European nations have apparently realized more clearly than we the value of scientific research, and have provided more adequate rewards and more favorable environment for the investigator, with the result that the ratio of intellectual to material prosperity is higher there than here. Within the past generation, however, we have become more awake to these matters, and have determined in our strenuous way to make research "hum." The awakening has unquestionably been beneficial on the whole, but we have, it seems to me, failed to grasp certain fundamental distinctions between the needs of graduate and of undergraduate students; the hum of research has been allowed to drown the cries of the injured in many an undergraduate school, where teaching is sacrificed to research, and where too early specialization is encouraged and even forced upon the student.

We are not as yet in this country producing our proper share of scholars of the first rank. The reasons for this are many, including hasty preparation, premature specialization, insufficient rewards, and unfavorable environment.

As to preparation, those of us who contemplate academic careers are usually unwilling to invest sufficient capital of time and money; we expect to complete our scholastic education, if uninterrupted, at about twenty-five years of age and then enter upon an active career in which there is little time or opportunity for research or even very serious or intensive study, for the sake of the immediate pecuniary reward; in Europe, several more years are spent in subordinate positions as investigators, on a semi-independent basis both scholastically and financially. The European makes a larger investment and reaps a larger ultimate reward, not only in money, but still more in the consideration accorded to intellectual eminence.

Concerning too early specialization and its shallow results, I shall speak later; let it suffice here to say that, for example, he is a poor chemist who is only a chemist.

The rewards at present offered for pure scientific work in this country are insufficient to attract the most vigorous, capable and ambitious men; not only, nor chiefly, are the financial returns here less than in Europe in spite of our higher cost of living, but the public respect for intellectual distinction is far inferior in this country, on account of our commercialism and our acceptance of wealth as our standard evidence of merit.

The environment, too, is less favorable to the highest scientific work in that the numbers of those engaged therein are so few, and the national characteristic of haste rather than thoroughness pervades our activity. The value of real scientific

attainment is still but dimly recognized by the industrial world; chemists are employed like clerks, without graduate training, and work like day-laborers, but for less pay, at routine analysis, with neither the training nor the opportunity to attack the larger problems in a fundamental scientific way. Such chemists are not on the same plane as the higher chemists in the German manufacturing industries, who have supervision of the works as well as the laboratories. One result of this primitive lack of demand for highly trained men is the small number pursuing research in our universities, so that even our best qualified professors have a mere handful of research students, and many of these can be induced to continue their higher education only by fellowships sufficient to pay their living expenses; if such aids were discontinued the numbers of our graduate students would be even less favorably impressive than at present, though in time the larger investment of those remaining would show in the larger salaries that would have to be paid to the men more difficult to find. Leading German professors attract large numbers of well-trained students, making possible their remarkable productiveness.

The keener competition in all walks of life in Europe has some advantages—only the thoroughly trained can hope for success, hence their desire for the most complete preparation. We consider ourselves fortunate in being protected against foreign competition, and in being able in consequence to make an equally good living with less effort; but are we really to be congratulated on our lower intellectual standard of living and on our dependence upon imported thought and intellectual products?

Another result of the limited scale on which scientific investigation is being con-

ducted, and our “high standard of living,” is that it is not worth while for manufacturers here to supply refined or unusual scientific material; if an American investigator needs, for instance, a special chemical, he must wait two or three months for its importation, while his European colleague could obtain the same in as many days or even hours, or, if manufactured here, two or three times the foreign price must be paid. The American artisan is more highly paid than his European brother, but not so the more eminent intellectual worker. Does this mean that we are not civilized enough to appreciate any but material products?

Naturally the realization of the value of intellectual things is found first among those engaged in the work of education, and our larger and better endowed colleges have within the last half century shown their appreciation of productive scholarship and developed graduate schools to compare more favorably with the European universities, so that it is no longer necessary for our students to go abroad for the inspiration of working with men who are extending the boundaries of human knowledge. Once started, the fascination of research insures its continuance as long as a favorable environment exists.

The institutions that have been able by their large means to adequately maintain graduate departments have been so amply rewarded by their enhanced prestige, that many others, without sufficient means, have attempted to do the same thing; the result has been impaired undergraduate instruction with a more or less successful imitation of graduate work.

A graduate school should recognize as its most important possession the productive scholarship of its faculty, making the institution a center of new knowledge, and all other matters should be arranged with

a view to encourage and stimulate scientific investigation. A very moderate amount of class instruction and other duties should be demanded of the members of the faculty, and students should be sufficiently mature and earnest to work without compulsion and with little direction under the guidance and inspiration of the men who are doing real original work.

The case of the undergraduate school is fundamentally different. I believe that the prominence given to research in many undergraduate schools is a positive injury to the student; his instructors are chosen on account of their ability or promise as investigators instead of their qualifications as teachers, and even the student himself is encouraged or forced to undertake so-called research with entirely inadequate training, both as regards breadth and depth. The undergraduate years should be employed in acquiring a well-balanced knowledge of the fundamentals of the student's specialty, and an acquaintance with the elements of many allied subjects, together with a working grasp of such tools as modern languages, to make professional literature accessible at first hand, mathematics, for the mental training and grasp of the quantitative and statistical treatment of all studies, and every undergraduate student should give such attention to history, literature, and economics as to make him an intelligent citizen and man of culture.

Only when this has been in a measure accomplished—and in looking back to our own college days we realize that a mere beginning had been made when we graduated—is the student in a position to profitably undertake research with a proper appreciation of what he is doing and how to do it, so that it is really research for him and he is not merely a pair of hands under the direction of another's brain.

The effectiveness of a scientific investigator is generally proportional to the thoroughness of his preparation; too many attempt to discover new truths before they have grasped those already discovered by others.

In many institutions one of the requirements for graduation is called a thesis, and such a tradition is difficult to dislodge, but I think the name is unfortunately pretentious and is apt to mislead the student into thinking himself more advanced than the facts justify; it savors of the same spirit that induces the high school to ape the college in so many ways, in its pernicious fraternities and even in having a "baccalaureate" service—doubtless to celebrate the fact that the boys about to graduate are still unmarried; such unwholesome symptoms are usually most conspicuous in institutions with the least merit. The preparation of an undergraduate thesis may be a valuable item in the course if it is not so administered as to waste the student's time, narrow his mind and swell his head. I believe its most valuable feature is its compelling him to go to original sources for information, namely, library work. Too many students graduate without this experience and with a knowledge of books limited to the prescribed texts employed in the course. To choose a subject of real interest to the student and of suitably narrow scope, and to find out by systematic search in the scientific journals all that is known about it, and then to write an essay in which the information is carefully arranged and well presented, is a task well worth the performance.

It is entirely laudable for every institution to aim at ever higher goals; not, however, by raising the entrance requirements beyond the reach of its natural constituent, even at the dictation of some self-appointed board demanding uniformity under diverse conditions, and not by

changing the object of its training—there would not be necessarily any gain to the community at large should a school of pharmacy gradually become a theological seminary or even a medical college; a school of pharmacy is just as necessary as either of the others.

It is perfectly natural for any teacher or group of teachers to aspire to more advanced grades of work, but this should not be undertaken unless the more elementary and fundamental work is adequately cared for.

We are suffering from too much ambition of this kind; too many trade schools attempt to be colleges, and too many colleges attempt to be universities, at the expense of their efficiency in their original equally important field. Let us imagine that every grade school gradually introduced more and more work of the high school, that every high school gradually became a college, and that every college gave more and more of its energies to graduate students! Or let us imagine that every institution giving grammar school instruction attempted also to provide training through the high school, college and university curriculum! What a ridiculous and inefficient educational system must result. Roughly speaking, for every thousand grade schools we need about a hundred high schools, ten colleges and technical schools, and one graduate university.

Fortunately, there is a supervision that prevents the transformation of grade schools into high schools, and separates the work of the two as soon as numbers of pupils justify the step; it is a pity that there is no authority with power to insure similar efficiency on the part of undergraduate and graduate colleges and universities.

We are failing to appreciate the distinction between undergraduate and graduate

work. In most ways there is little more in common between these than between that of the high school and of the college, and the university is injured in the attempt to make it a small part of a large college. Efforts have been made in this country to have universities unhampered by undergraduate departments; unfortunately, however, the country has declared itself not yet ready for such a logical and much-to-be-desired arrangement.

The chief function of the undergraduate school is to give instruction in such a way as to insure mental development. For those few who are to proceed to graduate work, the soundness, breadth and depth of the foundation will largely determine the safety and usefulness of the superstructure of specialization to be erected later. The first qualification for membership in the teaching staff of an undergraduate school should be teaching ability together with a thorough knowledge of the subject to be taught.

This teaching ability is largely a natural gift, and if of a high order is not common. Let us recognize it, use it, and reward it as an asset of the highest value. It can not be created by the study of pedagogy any more than logical thinking by the study of logic; it is founded on the intuition of sympathy. Teaching is the keenest pleasure to some, the hardest drudgery to others; the student readily distinguishes the two. I would not, however, imply that even the best teacher can work effectively with the undergraduate who struggles to escape education or who is unwilling to make any effort for it because his interests are now intellectual; such students have no proper place in an institution of higher learning, and we expend much too large a part of our energy in forcing such material through to graduation. The fashionableness of going to college is by no means an unmixed blessing. Why does not some en-

terprising individual start a college with luxurious dormitories and means of recreation and dissipation, where work shall be optional and house-parties continuous? Enormous fees could be charged, professional athletes employed, a suitable degree conferred after four years, and the working colleges protected from young men not desiring to be educated.

The chief function of an undergraduate institution is instruction, and its faculty should be chosen with this in view. Every such teacher, however, to attain his highest efficiency, should engage in some kind of research, that is, getting new information at first hand. This can not fail to have a vitalizing effect on his teaching, keeping clear the distinction between fact and theory, and maintaining his instruction abreast of the times.

There is questioning of the value of much that is published as scientific research, and it is easy to criticize the spirit that piles up undigested data or adds to the number of chemical compounds for the sake of having something to publish; it is impossible to say, however, that any such information is and will continue to be valueless. I am less interested in discrediting such work because it now receives higher recognition from the undiscriminating in the educational world than it deserves, than I am in asking for recognition for a kind of labor, just as truly research, that now receives too scant credit from the public and from those responsible for the distribution of rewards to college teachers. I refer to what may be called pedagogical research—the labor involved in improving and constantly rejuvenating the instructional work. Any course that remains unchanged for many years is probably in need of repairs, but desirable changes usually involve much labor on the part of the instructor. The teacher whose

heart is in his teaching and who carries the usual overload of duties is likely to be kept busy at just such work, and have no time left for the more conventional kinds of research; but his students will profit by his labors. The administrative officer who directly or indirectly puts pressure upon a college teacher to neglect his teaching is seriously injuring the college; yet this is by no means uncommon, intentionally or otherwise.

Research, of whatever kind, is largely a matter of inspiration, and can not be forced; as profitably might a poet be urged to become a painter as a scholar be pressed to undertake investigations foreign to his inspiration. Left to himself, the investigator will do what he is most interested in and therefore likely to do most fruitfully; to attempt to force a teacher whose instincts are for pedagogical research to other kinds of investigation is likely to spoil a good teacher and make a mediocre investigator. The method of forcing commonly practised is the indirect but very effectual one of recognition of published research by promotion and increased remuneration, while devotion to teaching and pedagogical research receive no such rewards.

Let us recall our own undergraduate experiences. Did we not in many cases get most stimulation and make most progress under teachers unknown in the professional journals? It is to be expected, indeed, that the teacher whose chief pride and interest are in his teaching, and whose chief reward is the advancement of his students, should be of more real value to those students than the investigator whose hours of reflection are devoted to the problems of his research, and to whom the instruction of classes is incidental, if not, as in many cases, an unwelcome interruption. Gifts of an equally high order for instruction

and for investigation are not usually found in the same individual; let each give his main effort to what he can do best; let the investigator work with mature students and the teacher with the immature, and let the distributors of rewards make no invidious distinctions in the recognition of the two equally necessary and meritorious services.

It is eminently desirable that a teacher should be also an investigator; in every faculty, however, some members have more pronounced ability than others in this direction, and it is proper that such should receive special consideration as to other demands upon their time and attention in order to enhance their productiveness by favorable conditions. To the others, whose bent is less marked in the direction of research, should be assigned the duties of administration and the committee work, with, if necessary, the high school commencement addresses. Neither should the more general business of the college be regarded as of any less value or importance than research, or less worthy of reward. To be sure, it has not the same advertising value, but an institution of learning should be above adopting the motto "quick returns and small profits." The most enduring good accrues to the students, and therefore to the college, from inspired teaching and wise and careful administration.

It is certainly the part of wisdom to provide as favorable conditions as circumstances will permit for the encouragement of research. Several factors more or less obvious enter into this favorable environment and influence the productiveness of the investigator, but the real determining factor is in the man himself; he must have ideas, enthusiasm and industry; he may even be a crank; he must have an accurate memory to retain the results of extensive

reading, and as much as any one can profit by good health, to withstand the strain of concentrated and continuous effort; he must be absolutely honest with himself and the professional world. If he has the necessary qualities it is very unfortunate if his circumstances do not permit their most fruitful activity; if he has not, let him serve his institution in other ways for which he is better fitted—ways of equal importance. Few men can spend several hours daily with classes, several more in administrative work, one or two more in committees, and have any vitality left either for research or professional growth.

The greatest need of most successful college teachers is more time to think. The evil effects of the prevalent rush become apparent only very slowly—in the course of years—in a gradually failing effectiveness for lack of mental nourishment. No one can use a few minutes now and then, snatched from the more urgent duties of the moment, to do or even think real research; ideas do not come on demand, interruptions are often fatal to inspiration, experimental work often must be continuous to lead to results; investigation that is worth while is not a routine operation to be started and stopped by a gong; there must be mental growth as a background. It would probably be economical in the long run if the real teacher-investigator could be assured of uninterrupted privacy for half of every day.

In addition to time for thought, reading, experimentation and writing, the teacher of science needs space and material equipment. There is a temptation to spend money most freely in ways that lead to the most tangible results, and would-be benefactors may cause serious embarrassment by providing buildings without equipment or endowment; blessed be the liberal contributors to the "gen-

eral fund," meaning equipment and, most important of all, competent men.

In the providing of suitable buildings with limited means, circumstances must decide how much can be devoted to what may be called luxuries and quality as against necessities and quantity; it is certainly desirable to have buildings as beautiful as possible, but not at the expense of adequate size and equipment.

Books are too often a crying need; they cost so much and they show so little; and yet without them research is impossible. The most serious lack is usually that of complete files of the scientific journals, which can *never* be purchased on a non-accumulating allowance of a hundred dollars a year. The value of the library habit to the student can hardly be over-estimated, but to develop this plenty of books and an attractive place for reading them are almost indispensable. How welcome to the business manager of many a college in straitened circumstances would be the professor who "did not read books but wrote them."

Turning now to the question of assistance, from the purely business standpoint, a man should not be required to do what a cheaper man can do as well; the problem, however, is by no means solved by so stating it. The profitable use of assistants is a far from simple matter; their duties should be so assigned and supervised that their time may be spent to the advantage of the department and also to their own obvious profit. The men available have usually recently graduated and should realize that the salary is not the chief reward for their services, but that the time spent as an assistant in a well-conducted department is valuable as a period of education and necessarily precedes any more advanced position in the college or university world. The assistant should welcome

all such experience, even if some drudgery is included, as gives him an insight into the teaching of his subject and the management of departmental business, such as the handling and ordering of supplies, the administration of classes, and the keeping of systematic records. To really review and extend his knowledge of the fundamentals of his subject so as to meet the needs of students entitled to his help is no slight task, but the assistant should use his utmost efforts towards progress in more advanced study and in research if his preparation is adequate. The assistant who shows the right qualities will not long fail to receive recognition and promotion; in the teacher's profession "everything comes to him as can wait" as far as he has the qualifications. Given the natural ability, industry and personality, thorough preparation will compel success; an assistant's position in a large and efficient department in association with successful men is better preparation for ultimate success in college or university work than the better paid positions in high schools open to men of equal training.

Those having charge of assistants should see to it that there is opportunity and encouragement for proper growth. It is through such assistants that the older teachers may hope to accomplish research, in doing which both are equally benefited. It is, however, something of a deception to call such assistants' positions "fellowships" if the duties of the department occupy any considerable part of the time.

It is certainly desirable that the more experienced teacher should delegate to assistants such of his work as can be properly done by them; it is very undesirable that he should cease to have direct and constant contact with the work of students; the direction and development of courses should remain actually in his

hands and the work of assistants be under constant scrutiny. When it becomes impossible for a course to continue actually under the direct management of a senior instructor it should be placed in charge of a qualified associate whose responsibility will be the incentive for his best work; the plan followed in some universities of having courses nominally in the hands of those for whom it is impossible to actually direct the work, which is really done by junior men, is essentially unfair to the latter, in withholding from them the credit to which they are entitled, not conducive to the best results in that it fails to provide the incentive for devoted effort on the part of those actually planning and administering the work, and an imposition on the college and the public, who believe the courses to be really administered by the more widely known teacher. Many a student has been disappointed in finding that he has little or no contact with the man advertised as having the work in charge.

In growing institutions it is the usual experience of the teacher that other duties encroach more and more upon his instruction and research, the latter being first sacrificed. Some of these are indispensable, such as the keeping of accurate records of students' work, and as institution and department grow there is some unavoidable increase in the machinery for handling students; the red tape and machinery should be recognized as a necessary evil—a means not an end—and kept at a minimum; if the choice were imposed between good teaching with no records and good records with no teaching, the election would be simple. There may be a conflict of opinion on this subject, however, between the engineer of the beautiful machine and the poor laborer whose energies are consumed in feeding it with reports.

I believe that we devote too large a part of our attention to the lazy and incompetent, to the detriment of the more energetic and able students, on account of the struggle for the prestige accorded to numbers, which we may also charge with the use of colleges as lounging places for the sport and the intellectual dead-beat. It is surely unfortunate if a teacher has to spend his time in keeping elaborate records of and forcing the loafers instead of stimulating and satisfying the gifted.

The question of salary has an intimate bearing upon the efficiency of college teachers, and it is generally admitted that they are underpaid. The cost of living varies so widely in different college towns that a salary adequate in one would be entirely insufficient in another, so that it is impossible to name a suitable salary. As a general principle, however, it may be accepted that the remuneration should be enough to attract men of energy and ability and make possible their best work. It is not desirable that teachers should vie with the commercial classes in display or in expensive amusements, and men of intellectual strength would not wish to; it is proper that they should receive enough to permit comfort without anxiety, membership in scientific societies and the opportunity to attend their meetings, books and other professional tools, and also travel, society, and the enjoyment of music and art, for the sake of their own broad development and consequent influence in society as well as with their students. The man who never sees anything but his home and his place of business is certain to be narrow. Many young men ruin their professional prospects by marrying on a very small income even before their education is complete; it is no evidence of a lack of sentiment for a man to postpone marriage until he is in a position to properly main-

tain a family. Further, it is surely the cause or the result of second-rate qualifications as a college teacher to attempt to carry on another business with no bearing upon his professional pursuits for the sake of the increased income. Scarcely less valuable is the semi-professional routine of tutoring, commercial analysis, and even the preparation of uninspired text-books, for the same reason. These things do not give the best preparation for and naturally do not lead to the highest university positions, though they do bring immediate financial reward; better far devote the time to some research if there is any in the teacher, and qualify for advancement in the college or university world. In education as in business, both the teacher and the institution may expect to get what has been paid for; if the teacher gives less than his best efforts he may look for less than a full reward, and the institution that seeks bargains in teachers will probably get something cheap—and nasty; if first-rate results are to be achieved the price of first-rate ability must be paid, allowing for a long and expensive preparation.

The bearing of this upon the question of research is evident; to cultivate the vitality of the intellect it must be free—free from anxieties as to the necessities of life, free to proceed in broad and deep channels, with all the incentives of intercourse with things intellectual and esthetic.

The story is told of a college teacher, who was conspicuous at prayer meetings, that it was his custom in closing a lengthy petition covering a large amount of detail to say, "And now, O Lord, to recapitulate," and so on.

Permit me, then, in conclusion to summarize the points I have tried to present. In undergraduate schools research has a very important place as a stimulator and vitalizer of the teaching; it is, however, a

secondary calling and should not be allowed to interfere with the main function of the undergraduate teacher, namely, instruction. The selection of men for such positions should be based primarily on their qualifications as teachers, and research should not be undertaken until a broad and deep foundation has been laid. The value of research, however, makes it most important that men capable of doing it should be helped in their efforts by the most favorable environment possible.

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A PLEA FOR ORGANIZED RESEARCH IN THE TROPICS

As science progresses we begin to look for new fields of research, for an increased sphere of investigation, for a greater and more varied amount of facts upon which to base our generalizations and our conclusions. As modern development generally becomes more pronounced we begin to reach out for opportunities in new regions, in those parts of the world where civilization has not yet gained a final foothold. To-day the tropical countries are still comparatively unknown, forming a terra incognita which contains many secrets for the explorer, many problems to be solved by the scientist, many riches to be gathered by the pioneers, always ready to exploit the resources of new regions.

With the striking diversity in their natural productions, their variety of geological structure, and their extreme conditions of climate, the tropics offer, in most branches of natural science, exceptional opportunities and wide fields for investigation and research.

Scientific research in the tropics has been carried on in a more or less perfunctory manner. Tropical research generally has not been conducted in a really scientific way. There is no organized and systematic investigation of tropical conditions, with the exception of a few years' work in this direction in Java and the Philippines.