SCIENCE

FRIDAY, SEPTEMBER 2, 1887.

THE ADMIRABLE APPOINTMENT by the President of Mr. G. Brown Goode as Commissioner of Fish and Fisheries was announced this week. It meets at once the requirements of an exacting office and the exceptional provisions of the law creating it. Professor Goode was intimately acquainted with the methods of Commissioner Baird, whose scientific zeal and knowledge he shared, and his experience and attainments in practical fish culture and in the science of ichthyology make him easily first among those whose qualifications the President has been called upon to consider. But the fact that the President has been able to select from among the civil officers of the Government a known scientist, acquainted with the habits of food fishes, to serve in this important office without extra compensation, does not remove the absurdity of this special law. If Mr. Goode should die to-morrow there is absolutely no civil officer of the United States qualified, under the terms of the act, to take his place. The special law was passed when fish culture was in its infancy. Congress was willing to risk the experiment, provided it was intrusted to Professor Baird, and framed the law accordingly. The present provisions of the law have been outgrown. It is an absurdity to have a Fish Commissioner receiving not as Commissioner but as Assistant Secretary of the Smithsonian a salary of $300 a month, and appointing and controlling a Deputy Fish Commissioner at a salary of $416 a month. Nor is there any reason why the Fish Commissioner should not be paid a salary commensurate with the importance of his office, and be exempted from discharging the duties of two offices with the pay of one. These matters can be appropriately considered when the Senate is called upon to confirm the new Fish Commissioner.

IN WRITING of examinations a few weeks since, we mentioned the fact that we proposed to return to the same subject later. It gives us pleasure this week to present to our readers the views of Gen. Thomas J. Morgan of the Rhode Island State Normal School, Prof. W. H. Payne of the University of Michigan, Supt. Thomas M. Balliet of Reading, Penn., and Dr. B. A. Hinsdale of Cleveland, on the function and conduct of examinations. Too many of those who are engaged in the profession of teaching look upon the periodically recurring examination as supernaturally ordained, and therefore not to be altered or questioned. For such persons, and for their pupils, an examination is a dreary routine to be dreaded. It is to be looked forward to for months, and 'crammed' for with assiduity and perseverance. It is this aspect of examinations which is specially to be criticised and combated. The proper place and scope of examinations in any educational system must be determined and understood. They must work in harmony with enlightened instruction, and not project a foreign and inharmonious element into it. We trust that the present symposium will exercise a good influence toward this end.

THE QUESTION OF A SYSTEM of improved public roads is one so closely related to every material interest of the State as to place it properly among the most important questions of public economy. The science of road making and maintaining, though neither difficult nor abstruse, is nevertheless based on principles so well established and so unvarying in their operation, as to render their thorough comprehension an essential to success in securing and maintaining public roads, at once efficient and economical, whatever the administrative system under which they are constructed. In other countries the superintendence of public highways is recognized as an important and responsible duty, and is usually assigned to specially-trained, expert government engineers, while in the United States, where the greater mileage makes the economy, if not the efficiency, of roads even more important than abroad, the States depend for this responsible service on private citizens locally and temporarily appointed to the duty, without having provided for them the technical instruction and training so essential to success under any system. In view of this state of affairs we take pleasure in recording a move on the part of the Engineering Department of Vanderbilt University, which, under due restrictions, provides for the proper instruction, free of charge, of those who may wish to know enough engineering to make them the better road-builders.

ORIGINAL RESEARCH IN THE AMERICAN COLLEGE.

OUR American colleges, with the exception of a few of the larger institutions, are unfortunately not places of original research. It has hardly seemed to have entered into the American idea of education that a college, besides being a place of instruction, should be the place for the origin of new knowledge. Of late years, however, the influence of German universities, and of some of the larger colleges in this country, has been creating the conviction that original research in some form is necessary for the life of our higher educational institutions. There are thus numerous indications that the future is to see our colleges more the home of new learning than they have been in the past. But while we are beginning to realize how greatly it is for the interest of our colleges that research should be carried on within their walls, the prospects are, that, until a complete change takes place in our system, such research will be confined to the instructors and graduates, and will not be shared in by the undergraduate student. With a few exceptional cases we find the attention of the undergraduate confined to routine work, and it is only after graduation that he is allowed to specialize so far as to take up original investigation. Now, while this is due partly to lack of facilities and opportunities, partly to lack of requisite knowledge on the part of the instructor to direct such work, partly to the difficulty of selecting work which a young student can do, and partly to the universal disinclination to make new moves, it is at the same time largely due to a more worthy reason than any of these. There are many instructors in our colleges, who have every facility for such work, who think it not wise to encourage it, even though it would make the personal work of teaching a much more congenial one. It lies outside the scope of our college course. While, then, we may hope to see a time in the not distant future when our colleges shall be places of research, it is very doubtful whether this research will ever be shared in by the undergraduate, except in isolated cases.

The reason for this lies in the peculiarly American idea of the scope of and necessity for what we call a liberal education, and not in any failure to recognize the value of research. The value of research as a means of education in stimulating the student is fully appreciated. It tends to counteract many evil tendencies of our college-work. Routine courses in science as ordinarily pursued are apt to become monotonous and tedious to the student, soon degenerating into mechanical work. With the experiments detailed for him in his text-book or laboratory directions, their results cease to interest him, and a careless habit is almost sure to be fostered. His thought is hardly stimulated at all, but is rather curbed by the feeling that he is going over a path which hundreds have followed before, and that consequently his discovering any thing new is an impossibility. It is indeed surprising to see what little thought is required, on the part of the student, to go through some of our routine science courses. He learns the text-book, mechanically

performs the experiments, and notes results, but the amount of personal thought which is stimulated is sometimes infinitesimal. Now, since the design of our college course is to make the thinking man, it is plain that something is needed to offset these tendencies, and some of our educators would find this something in original research. That a bit of research will counteract these evils in large measure is certain enough. When the student is engaged in solving some new problem, the whole aspect of his study is changed. It is no longer tedious and dull, but interesting and full of life. A new world of thought is opened, and scientific methods of thought and work become engendered. Travelling a new road, the student is ever on the watch for new facts and thoughts. Carelessness and mechanical labor are no longer possible, for he soon discovers that his success depends upon the amount of care and thought that he puts into his work. In short, original research soon does away with the school-boy, and makes the student in its best sense.

But while the value of this method of study is apparent, it by no means follows that such a course is best for our college student. Most American instructors believe at present that the evils resulting from such a course would more than counterbalance its advantages: for it is plain enough that a course founded upon research will tend to make specialists, and nothing else; and this is not the design of our colleges. The American college is quite naturally compared with the German universities; but the comparison is an utterly false one, for the aim of the two is entirely different. The German university student is studying a special course, for a special purpose, and is usually looking forward to government employment. The government appoints ministers, doctors, lawyers, teachers; and eighty per cent of the university graduates obtain such employment after passing a rigid State examination. It is this examination and government employment which serve as the inspiration of the student. The German Government has decided that a high education shall be the means of entrance into the upper circles of society. For a German who is not born noble, there is only one way of gaining an association with the upper classes, and that is by a university education and government employment. With such an inspiration, Germany could hardly help developing a high grade of education and early specialization. Considered in the light of education alone, her system has certainly been the most successful ever instituted. But in this country the conditions are very different, and such an educational system is both impossible and undesirable. Our government has set no premium on education, nor are our professional men at all dependent upon the government for success. They are dependent directly upon the people, and therefore upon a hundred unforeseen possibilities. There are other ways of improving one's condition and rising in the estimation of society than by becoming professional men, for many other paths of life are equally respected. We have no educated aristocracy, for we believe there are other good things besides learning. Our colleges have therefore a broad function to perform in meeting these conditions. They desire, not to make specialists, but to train men. They do not desire to make ministers or doctors or lawyers. This is left to professional schools, which therefore compare more nearly with the German university. The college course is one which we think a student should have before beginning a special training, believing that such preparation will result in making better professional men, better business men, and, above all, better citizens. It is the general training of lower schools broadened and expanded. German university education tends to unfit men for any course of life outside their specialties, and Germany is becoming alarmed over the increasing class of educated men who cannot obtain government employment, and are fit for nothing else. The same is true of our professional schools and advanced courses in higher universities; for they, too, fit men for narrow courses in life. But the college tries to put men in a position where they are better fitted for any path in life, from farmer to statesman. The professional school tries to make the scholar; the college, to make the man. That our plan of education is not adapted to the production of the largest number of gifted scholars may be very true; but that it is best adapted to the needs and demands of our system of society and government is the firm belief of most American educators.

Now, if we recognize this as a worthy aim of our colleges, we shall understand why original research is not encouraged on the part of undergraduates. We hear a constant demand in this country for a liberal education. It is for this that our students go to college, for this that the course is planned. It is planned to occupy four full years, with little time left for outside work. Fortunately, however, this idea has not been strong enough to oppose successfully the introduction of the elective system, for this freedom of choice has fought its way into all colleges. Our education has been vastly improved by allowing the student the privilege of devoting his energies toward a line of studies congenial to him. This system of greater freedom is yearly widening its scope, and it is of course impossible to tell where it will end; but there is no reason for thinking it likely to go beyond a broad freedom in electives. To take another step, and introduce the earlier and narrower specialization which would result from the encouragement of original research, would be to abandon completely our belief in the value of a liberal education; for the investigator becomes the specialist from the start. His attention is withdrawn from other subjects, and, with the American's hurry to do something, he is almost sure to neglect completely all lines of learning except his own. We do not want our colleges to develop classes of men who are good for nothing outside of one line. For the general student, then, narrow specialization is always injurious. Still further than this do our colleges go, insisting that even more should the student who aims at a special line of work be cautioned against taking it up too quickly. The only time that he will ever get for acquiring knowledge of other departments of knowledge is during his college course; for, as soon as he takes up his own, he will pursue it with an eagerness which will hide all else. To begin to specialize early seems at first sight a gain in time; but it is in reality an irreparable loss, for it is beginning to build without laying a sufficient foundation. To make the best sort of a scholar requires more than an exhaustive knowledge of one thing: it requires a broad knowledge of thought. It is quite common, therefore, to find our professors recommending their own students to keep outside of their specialties as long as possible. Practically, too, is it important, for our educational positions demand it. Our institutions are not yet highly enough differentiated to offer work for very narrow specialists. We have many colleges and broad departments. They want teachers in biology, and not in entomology; teachers of physics, and not of electricity. In short, the demand in the country to-day is almost everywhere for broadly educated men, and not for the narrow students which are the inevitable result of early attention to original research. The general training the colleges must give, all special training being reserved for the professional schools and the universities. If our colleges fill this demand, they will continue to exert a powerful influence; but, if they cease to do so, the American college will disappear, and its place will be supplied by professional schools and universities. To convert our colleges into universities is impossible, since our students have had no thorough training to start with, which corresponds to the German gymnasium. In attempting to avoid the old plan of rigid courses, and by electives introduce more freedom for the student, our colleges have vastly improved our system of education. Whether or not this idea has been carried to excess is still a matter of dispute, as can be seen by comparing the views of the representatives of our two leading colleges, Harvard and Yale. But the opinion would be almost unanimous that a system which enables the student to so devote himself to one subject that all others are lost sight of, belongs not to the American college: it belongs to the university or the professional school. At all events, our colleges at present are planned to give the student a liberal education, and not a special training; and for this purpose routine courses, and not original investigations, are adopted.

Even with our elective systems in vogue, there are, as we have seen, two equally undesirable extremes. On the one hand, routine courses tend to degenerate into mechanical work and monotony, curb original thought, and generate carelessness. This is the most common fault of our American colleges. On the other hand, original research on the part of the young student encourages too early specialization, and thus defeats the plan of a liberal education. This is not as common in this country. But neither extreme is necessary; for a medium course is possible, which shall in a measure avoid the evils of both extremes, and give the advantages of both

systems. Such a course we must regard as the most promising one for the future.

Doubtless we shall always meet with undergraduate students who are engaged in original research, perhaps in the future more frequently than at present; for there are certainly instances where such a method of instruction is best. It may be in the case of a student whose habits of carelessness require some measure for correction, or whose utter dependence upon teacher or text-book requires vigorous offset. It may be the student whose general ability is manifest, but whose interest in study has never been awakened: to him a problem of research may prove a lifelong blessing in rousing his slumbering energies. It may be the student who has determined to pursue some special line of scientific work, requiring no general learning, as that of an analytical chemist, or that of some of the government scientific staff: about all that can be said in this case is, the quicker one begins his work, the better. It may be the student whose general faithfulness elsewhere makes it evident that he may take up special work in his own chosen line without detriment to his general education; or it may be in other cases, where there seems to be a particular reason for it. But at most these instances will be few in number, and such work cannot apply to the bulk of students who take science courses in our colleges. For this larger class some sort of routine class-work is necessary; and the question arises whether it is not possible to so arrange it as to avoid the evils which have been and still are too largely attendant thereto. That this is possible is proved by the fact that it is already done in many places.

The methods of conducting the ordinary routine science courses in our colleges at the present time are extremely varied, ranging all the way from simple text-book recitations to plans which involve a large amount of independent work on the part of each student. Experience seems to warrant the statement that the nearer such work approaches the nature of original investigation for each student, the more successful it is in arousing his interest and stimulating his thought. But how is it possible to combine both plans? In many places in this country we find the adoption of plans adapted for this purpose, and implying the minimum amount of what we have called routine work. In the first place, text-books are cast aside, except as books of reference or as serving to give details. The student is thus made to look directly to his instructor for information. This system of lecturing or talking has been borrowed from Germany, where it is the only method of instruction, and is capable of yielding the most excellent or the most evil results, according to the faculty of the lecturer. Where it is simply repeating verbally to the class the substance of some text-book, as is sometimes done, it is much worse than giving the text-book to the student to learn. But where the lecturer's wide knowledge of his subject enables him to collect material from numerous sources, and he is able skilfully to arrange it in such a way as to lead the student from one principle to another, it will give more true knowledge than any text-book. The chief reason is its flexibility; but an equally important consideration is that it enables the lecturer to introduce inferences and conclusions, in the midst of the course, where they belong as drawn from the facts. He can pass from fact to inference, from inference to theory, at will; and he is not obliged to crowd all the principles of his science into an introduction to the course, where they will not be understood, or at the end of the course, when they have lost their interest, one of which unfortunate plans is considered necessary in all text-books. To be sure, we find good students not uncommonly objecting to lectures. This is largely because they are anxious for something to learn; for such work they have been taught to do. They find it difficult, however, to comprehend the meaning of a course which uses details only for their significance, and aims at principles of science rather than detailed information. They know how to learn a lesson, for this they have been taught; but they do not know how to think. In a large class in physiology, scarcely one failed to give the names of the microscopic layers of the retina, though not asked for them and distinctly told that they were of little importance to remember. But quite a number utterly failed to comprehend the significance of the eye as an optical instrument. The former was something to learn; the latter, something to think out. Of course, all students cannot be made to think; but, while it is impossible always to correct this error of learning simply by rote, it is certain that the lecture system, when wisely conducted, tends to correct it, while text-books tend to foster it. It is very seldom that an instructor who has once tried the lecture system gives it up, except for matters of detail. It helps to avoid old ruts, and insures the instructor that for a time, at least, the students are thinking vigorously, a fact of which he can never be sure with the use of text-books. It is one of the important means of bringing the student in contact with science itself rather than with second-hand learning.

Our science courses are now almost universally accompanied by a certain amount of practical laboratory-work, and here it is possible to enforce a great amount of independent observation and thought. Text-books, except in the form of a library of reference, can, if desired, be completely eliminated. A series of experiments following a course laid down in a text-book is of about the same value as experiments performed before the class, and not very much more; for, with the details and results given him, the student usually is concerned only in performing the experiment successfully, and not in thinking of its significance. But under the direct supervision of a wise instructor, each person's laboratory-work can be so planned as to force him to draw conclusions, and make his own discoveries. He may be told little or much, as the case may require, but always just enough to set him on the track of seeing more for himself. His experiments may be modified to suit emergencies. Numerous minor problems may be set for his solution, for which he has no answer, nor can find one except by studying the experiments, or as his instructor may be inclined to assist him.

An illustration or two may serve to make this more intelligible. A student studying biology is given a fish's skull to examine, with the aid of the instructor's directions, or some book of reference. After thoroughly mastering this, he is given in succession the skull of a frog, an alligator, a turtle, a bird, and a series of mammals' skulls, beginning with the opossum and ending with man. These he compares, in turn, with the fish's skull and with each other, using no books, but simply studying the skulls, with here and there a hint from the instructor, as it may seem desirable. Such a comparison can be completed with sufficient accuracy in a few days, and proves invariably of interest to the student. By the time it is completed, not only has he gained a good idea of the vertebrate skull in such a way as to remember it, but he has discovered for himself the spirit of comparative morphology in such a way that it can never escape him. Or, again, he may be given a book or a lecture describing a lobster, and given for dissection, not a lobster, but a crab; or he may be given a few simple animals, and asked to arrange them in what he would regard as natural groups. These illustrations I have taken from the department with which I am most familiar, but there is no difficulty in applying the same plan anywhere. There is an endless variety of such work, which shall compel the student to combine thought with the mechanical work of the laboratory. Nor does this plan prove as slow as it would at first sight appear. Perhaps it is slow at first, but the rapidity increases with every advance. Work can be constantly varied from one subject to another so as to conduct the student over the whole ground desired. It can be varied with the individual; and, if there be occasional lectures accompanying the practical work, there is no difficulty in covering all the ground necessary.

Such a course is simply the 'object method' adapted to a larger scale, and it has many advantages. It trains the observation, develops carefulness, stimulates original thought. It gives the student the elements of science, but in such a way that they mean more to him than when obtained by any easier plan. It gives him the satisfaction of feeling that he is accomplishing something on his own part, but does not so distract his attention as to injure his work elsewhere. It fits in with the requirements of a general course, and at the same time offers some of the advantages of the German system of independence on the part of the student. It is the best sort of science for the general student, for it gives him not only facts and principles, but some understanding of scientific methods of thought and observation, which is more valuable than the facts. It is the best method for the student who is to make the science his specialty; for, while introducing him to the elements, it familiarizes him with the spirit of scientific investigation, and shows him that nature is the text-book from which he is to learn.

It is plain enough that there are serious practical difficulties in the way of such courses. The chief one is in the amount of time required from the instructor for their successful management. It not only requires that the instructor should have a complete acquaintance with his subject, but requires a constant personal supervision and thought, constant variations with different students, and requires that each instructor should plan his own course. A text-book is impossible, for it defeats its own end; or, if one instructor should write a book for his own class, it would be useless for others. Indeed, it is hardly possible to have any definite course; the aim being that each student should be brought in contact with the principles of nature as best suits his own ability, and not that the class as a whole should go over a regular course. Such work is by far the most difficult sort of teaching; and with the present small faculties of many of our colleges, and the inadequate training of many of the professors, it is practically impossible. But happily the faculties are growing larger, and more and more attention is being paid to selecting instructors fitted for their departments by previous training. Fewer hours of recitation-work are demanded, and more time is left to our instructors for thought and personal teaching. In many places can be seen a constant growth of this personal contact of instructor and student, and as fast as it grows we see the routine work of classes replaced by the work of students as individuals.

Along this line, then, we may look for the future development of sciences in the American college. We may hope for an increase in the amount of original investigation; but this must come chiefly from the instructors and graduate students, and it will then serve as an inspiration to the college. We may look for larger laboratories, more apparatus, and greater facilities for practical work on the part of large classes of students; but this will be insufficient unless we see at the same time an increase in the corps of instructors. Our boards of instructors should be large enough to make possible some personal supervision of the students, so that the individual will not become swallowed up in the mass, and large enough to allow to the instructors some time for research, by which means alone they can keep apace with the times. The great demand of higher education in this country is, therefore, not for more colleges or more buildings, but for more money devoted to instruction.

H. W. CONN.

THE FUNCTION AND CONDUCT OF EXAMINATIONS.

THE professors of a German university do not assign the student lessons, or require him to hear lectures. When the time comes to grant or refuse him the degree, their sole sources of information as to his fitness to receive it are, the thesis that he hands in, and the examination to which he is subjected. As respects time, this is a system of unlimited election. That it develops splendid qualities in the student; that it is very grateful to young men who love freedom and hate task-work; and that, together with the other features of the German system, it produces scholars eminent in every branch of scholarship, — are well-known facts. In a German university, stated work is at a minimum, and the examination at a maximum, as a test of proficiency.

At the opposite end of the scale are the primary schools, in the strictest sense of that term. Here no election of work or time can be allowed beyond what extra-school conditions call for. 'Cutting' is absolutely inadmissible. The teacher cannot wait until the end of the term or month, or even day, to discover what the pupil knows: he must prescribe work every day, and, at the beginning, every hour, and then see that the work is done. This is a maximum of lesson, and a minimum of examination.

So far, all is plain and easy. But the moment that we enter the grades of school-work lying between these extremes, we meet a wide difference of opinion, and encounter serious practical difficulties. Here Germany has nothing to teach us. The method of the primary school is then continued to the end of the gymnasium course, when the student plunges at once into the fullest university liberty. The proper end is, rather, progressively to lift the pupil above the task-work level, to give him freedom, and to make him self-reliant. Two opposite tendencies are now very observable in the United States: —

1. A considerable number of colleges are allowing a limited election of time. This means, if a proper regimen is maintained, less dependence upon the daily recitation, and more dependence upon the examination.

2. In the intermediate public-school grades there is a diminishing dependence upon the examination, and an increasing dependence upon the daily work, particularly when the time comes to make the promotions: in fact, this tendency is declaring itself all along the public-school line.

These tendencies are both good; something of the freedom and enthusiasm of the university is finding its way into the college; and there is a manifest slackening of the high public-school tension of a few years ago, that was brought about by the abuse of examinations. Good results may be expected from both these movements.

The adjustment of requirement and election, of stated lessons and examinations, above the primary grades and below the college, or possibly the university, is a problem that every teacher and superintendent will be called upon to solve anew. The elements will vary, and no formula can be given. The solution in a given case will depend upon the facts that condition the home, the school, and even the individual pupil. It is often urged against examinations that they promote cramming. Teachers who have to solve this problem will do well to remember that they also tend to prevent cramming. Pupils cram for the daily recitation as well as for the examination; and as the daily recitation tends to check cramming for the one purpose, so the examination tends to check it for the other purpose.

B. A. HINSDALE.

I AM asked to write a very brief article on the function and conduct of examinations. By examinations is meant a formal set of questions answered in writing. Among the useful purposes which can be subserved by such tests are the following: —

1. They may serve as a stimulus or incentive to study. Students who know that at some period of their work they will be required to give written answers to questions based on the work done are likely to be more attentive, industrious, and interested in their work.

2. They encourage thoroughness. Those who prepare for an oral recitation may depend upon chance, or artifice, or favoritism, to help them through; but a searching examination, calling for exact written statements, is another matter, and demands better preparation.

3. They afford an opportunity, in some instances, for a review of the whole subject passed over during the term.

4. They are often valuable as an exercise in English composition, calling as they do for clear, concise, comprehensive statements.

5. They are a revelation to the pupils of their own ability and attainments, as well as of their weakness and defects.

6. They call for concentration of mind, sustained mental effort, and a ready use of one's resources, which is a valuable educational discipline.

7. They reveal to the teacher the results of his teaching, the failure or success of his methods, and thus afford an opportunity of modifying his work when necessary.

8. The tabulated results of a series of examinations, extending through several months or years, indicate with considerable certainty the student's trend of mind, habits of study, and scholarly development. These results are specially valuable to parents in deciding what is best for their children.

9. The results are helpful to superintendents and others in forming an opinion of the progress of the pupils, and the work of the teacher.

10. They give to school-work a kind of dignity, increase the student's self-respect, and impart to the teacher's mind a judicial habit, freeing him from the great tendency to judge of his pupils by sentimental regard rather than by a critical judgment.

With these ends in view, how shall the examinations be conducted?

1. They should be an ordinary, and not an extraordinary, part of school machinery. If they are held only at the close of a term, or at the conclusion of a study, the students should be prepared for them by the character of the daily recitation, and by occasional