Cuvier emphasized the importance of the study of examples illustrating the four types of Cuvier and the students had in turn a radiate, a mollusk, an articulate and a vertebrate to dissect and study. He not only lectured on these subjects but gave to the school a course of brilliant lectures on the glacial theory. At this point I must emphasize the fact that Agassiz was a wonderful teacher. The charm of his manner and his speech, rich as Apollo's lute, as Governor Banks said at the dedication of the museum, with its slight foreign accent, enabled him to talk on radiates, for example, to a lot of hard-headed Massachusetts farmers at the General Court and secure appropriations of thousands of dollars for his museum at Cambridge. He strongly opposed Darwin's views, but few realized the leading cause which probably animated his strenuous opposition. In 1859 Longman published a separate volume of Agassiz entitled "An Essay on Classification," which had formed the introductory chapter to his "Contributions to the Natural History of the United States." In this essay he had insisted that classification was natural, that the various categories of classification—branch, class, order, family, genus and species were as distinctly created as the individual. Simultaneously with the appearance of this valuable essay appeared Darwin's immortal work on the "Origin of Species," in which it was shown that classification was artificial, not natural, that categories of structure were the results of slow and diverging modification—in other words, that natural selection and not special creation was the cause of all this diversity of animal life. De Candolle, the illustrious French botanist, when he became acquainted with Darwin's view remarked "That it was not a theory, nor an hypothesis, but the explanation of a necessary fact, to deny which would be to deny that a round stone would not roll down hill farther and faster than a flat one." However, Agassiz's essay with the unhesitating endorsement of the views of Von Baer unwittingly supplied the strongest material for Darwin's views and led Agassiz's students, one after the other, to embrace them.

Among the various accounts that were published about the Agassiz School at Penikese was one by David Starr Jordan in *The Popular Science Monthly,* 1892, Vol. XL. In this article, Dr. Jordan gives extracts from a journal which he kept when a student at Penikese, wherein he had recorded sentiments and expressions of Agassiz given in his lectures and comments to his class.

The distinguishing feature of the Anderson School of Natural History lies in the fact that it was the first one of its kind organized in the United States and furthermore that this initial experiment was under the direction of the greatest teacher of natural history in the world. Other schools of a similar nature under the auspices of colleges and universities sprang up in various parts of the country. I do not know the chronological sequence of these summer schools of natural history, but, if I mistake not, the Salem Summer School came next, in 1876. Among the teachers of this school were three who had been associated with Agassiz at Penikese—Packard, Putnam and the present writer. Of all the summer schools in the country the Marine Biological Laboratory easily comes first in the number of its instructors, buildings and equipment, and superadded to this foundation its proximity to the United States Fish Commission gives it unparalleled advantages over all other schools of this nature.

EDWARD S. MORSE

PHYSICS AS A CAREER[1]

IT is said of the famous Clerk Maxwell that throughout childhood he continually asked the questions, "What's the go of that? What does it do?" Vague answers did not satisfy him but aroused the more distinct demand, "But what's the *particular* go of it?" Maxwell had the opportunity of devoting a life to the answering of this question, many times repeated, and of rendering such service to mankind that he will be forever highly honored among those known for their important contributions to the field of physics. Do the incipient Maxwells of to-day have in America a similar opportunity? They do, but there is danger that this fact is either unknown to them or not known sufficiently early in life.

A boy does not know of a physicist in his community and the stories of achievement in physics which he may read refer to very distant realities. Moreover, so far as he is aware, physics is not a profession. As he surveys his known opportunities for a life-work, engineering may be the only profession that seems to have an interest in the "particular go" of things. The purpose of this article is to present briefly and with directness the opportunities in physics in our country to-day. It is assumed that, given the possibility of earning a livelihood, one will choose the career which most nearly satisfies his intellectual requirements. Since the aptitude for physics is usually distinct, a comparison of the profession of physics with others is thus unnecessary. The follow-

[1] This is one of a series of articles which are being published in SCIENCE and in *The Scientific Monthly* describing to young men and women in American colleges and universities who contemplate entering upon a professional scientific career the opportunities in various lines of scientific work. This series has been prepared at the suggestion of the Division of Educational Relations of the National Research Council.

ing statement is intended merely to give one who is already interested an assurance that there is an opportunity for the physicist which is limited only by his ability.

The chief avenues open to physicists are found in education, in industry and in government service. What is the prospect of a permanent demand for physicists in these fields? The number of teachers required for our colleges and universities has grown with the rapidly increasing number of students. From educators we learn that the demand for an increase in educational facilities is not occasioned by a temporary interest, but by a realization of the value of education and by a response accentuated through the adjustment of our educational institutions to the more obvious needs of the people. The growth of our educational institutions is therefore certain to continue to be rapid. The industries, particularly those interested in electricity, have grown with tremendous rapidity and have simultaneously expanded their research and development laboratories. The experience gained has demonstrated the constant necessity of improvement of products, of cheapness and of service. It is therefore reasonable to expect a continual increase in the facilities of these laboratories and in the number of physicists employed. The government laboratories have grown with similar rapidity. Thus, in every line of activity of the physicist there is an indication of a permanent demand. The profession of physics is established. A physicist may be a teacher only, he may combine teaching and research, he may devote himself to investigation, to development or to a combination of the two, or he may become an administrator in industry.

Teaching

Every college student is aware of the compensation in the life of a professor. He is not handsomely rewarded in money, but he lives simply. His family may be deprived of very expensive pleasures, but his children have opportunities for the development of brain and character that can scarcely be measured in terms of money. The real teacher enjoys thoroughly the opportunity of aiding in the development of the young that come into his classroom. He has a vision of helpfulness and of the indefinite extension of his influence through others. It is frequently the teacher in the college, perhaps an investigator in only a small way, who has the best opportunity to assist young men in finding the professions to which they are best adapted. Also, he is responsible in part for the important contributions to physics made by his former students. This is a part of his compensation.

Teaching and Research

In the large educational institutions the teacher is an investigator who may select for study whatever field he chooses. He receives no demands from his superiors for results that are of immediate practical importance. He is free to choose for investigation any problem that catches his interest and fires his imagination. His intellectual opportunities are without limiting boundaries, and his attainments are determined solely by his ability. Yet he has the satisfaction of serving also through his teaching, his contributions and his students who subsequently become productive physicists.

Research, Including Development

Upon industrial as well as purely scientific research depends the future development in the products of industry. So active has been the development of electrical applications that the opportunities for research physicists have increased rapidly. The example set by large industries in the employment of these physicists is being followed by others. In 1921, there were forty or more such laboratories employing physicists. The nature of the need of research may be illustrated by reference to the art of telephony. As perfect as the art is to-day, the increase in the congestion of business in our great centers and the demand for long distance communication, both telephone and telegraph, have necessitated improvements in transmission undreamed of a few decades ago. Yesterday, conversation between New York to San Francisco was a wonderful achievement. To-day it is common-place. The research laboratories have solved the problems in physics involved and the development engineers have adapted the solutions to practical service. But the research laboratories are interested not only in the problems pressing for immediate solution, but they must, so far as possible, foresee the demands of the future. While the research physicist in an industrial laboratory does not enjoy entire freedom in research, yet the desired applicability of his results supplies a challenge to his best powers and his success gives keen satisfaction. One must not gain the idea that the research laboratories are demanding merely experimental physicists. They employ also mathematical physicists who never experiment. In fact, it is appropriate here to say that every physicist must be a theorist. The subject has become so involved that he must usually depend upon mathematical reasoning to determine the plan and method of his experiments.

Government Service

The Bureau of Standards is now the greatest laboratory of standardization and allied research in the world. Its physicists are employed for the most part in testing for the various industries and educational institutions of the country. But, at the same time, physicists have there been enabled to make some of the most distinguished of the recent contributions of America to physics. Other bureaus, for example, the Weather Bureau, also employ physicists.

ADMINISTRATION IN INDUSTRY

More and more is recognized the value of a scientific or technical training for men in administrative positions in industry. Some of these are in connection with research only, but others are in the business organization itself.

THE FINANCIAL COMPENSATION

If this brief article were to discuss the attractiveness of physics as a career, it would present the intellectual appeal as the most and the financial appeal as the least important. But it is assumed that the reader is already more or less aware of the nature of the various compensations enjoyed but needs especially to be informed as to the amount of salary that, at the present time, may be expected by an established physicist. In the colleges of recognized standing, the minimum salary of a professor for the college year of nine months is approximately $2,500. A few receive $2,000 or less; many receive more than $3,000. Of course, the scale of living in the community is as important a consideration as the salary itself; yet it is impracticable to introduce living costs into this presentation. In the large universities of the country, a similar position pays from $4,000 to $6,000, with exceptional higher salaries. In government service the salaries are practically the same as in education. In industry the highly trained physicist, if successful, may anticipate at the end of five or six years a salary of $5,000 or $6,000. There is no upper limit in industry for men either in research or in administration.

ABILITY

The desirable innate ability of a prospective physicist is not definitely known in detail and its measurement is even less certain. Comments thereon must hence be somewhat general. The special requirements for a successful teacher, a research worker, a development engineer and an executive in industry need not be described, as many of the differences are apparent to the student. But it is well to remark that a career in physics demands not only rigorous thinking but also that type of persistence and patience which is required in any worth-while endeavor. Of course, there is always a chance of an accidental scientific discovery of importance, but it is very much smaller than is commonly believed. It is a matter of interest that no physics research laboratory, industrial, governmental or educational, is organized to encourage especially accidental discoveries. Real contributions may arise through accident, but progress in research is usually by a procedure based upon deductions obtained through analysis. Moreover, the purely experimental physicist is vanishing with the increased complexity of the field, and a student who can not use mathematical methods will find therein an increased difficulty in attaining leadership in investigation in the years ahead. An aptitude for analysis, a noticeable mathematical ability, a deep interest in the "particular go of things" and a courage comparable to that in any profession are essential for the highest success.

PREPARATION

The preparation required depends upon the nature of the position. There is a demand for those with a college degree as well as for those who have pursued graduate work and have received the M.A., M.S. or the Ph.D. degree. Research and development require clearness of thought, a knowledge of the field and a confidence that comes through experience in intellectual effort. It is obvious that graduate study will develop these qualities and hence will increase the physicist's value. In education, most college and university positions demand the Ph.D. degree, though a number of minor colleges do not insist upon a preparation beyond the Master's degree. In industry the difference in preparation is recognized at the outset by a difference in salary. But it is in the long run that training shows its value. It may be said that the more ambitious a physicist the more concerned he should be to secure the best educational preparation possible. The nature of this preparation may be inferred from an earlier comment. The theories upon which researches are based are usually mathematical and the student who wishes the best chance for advancement in his career must emphasize mathematics as well as physics. If one is especially fond of mathematics he may well aspire to become a mathematical physicist. In such a case the mathematical training possible in the requirements for a Ph.D. in physics is not sufficient. There are a number of adequately equipped graduate departments of physics in this country and young men of ability will find available graduate appointments carrying stipends, but which involve no return in service, and graduate assistantships which give an opportunity for self-support. The former is to be preferred, for the combination of teaching and study found in the latter requires a longer period of preparation. The way to the top is not short and an ambitious young man needs to save all the time possible.

In general it is fair to say that high attainment as a physicist is difficult. It is in this difficulty, however, that the challenge and ultimately the joy in success rest. If one goes into business to make money he will seek, if possible, an unlimited opportunity. If one enters upon an intellectual career he desires the opportunity to achieve the highest success of which he is mentally capable. He wishes to be limited by nothing save his own ability and industry. A physicist has just this opportunity. He need not wait for business to grow or clients to appear. He can study and contribute to the most important and fundamental problems in physics of the day. He can, if his researches are published, attain without difficulty nation-wide recognition for what he has accomplished. As a consequence he can not avoid chances of advancement appropriate to his ability. His light is upon a hill and can not be hid.

The purpose of this paper is to present to interested students facts without persuasive enthusiasm, and hence to attract to physics as a career only those whose ability and intellectual ambitions can turn a plain statement of facts into an appeal.

GEORGE WALTER STEWART
UNIVERSITY OF IOWA

A COURSE IN GENERAL SCIENCE

IT may be reasonably conjectured that at every university in the United States the elementary courses in science are overcrowded. Complaints take various forms: Instructors have no time for research; students can not be interested or even taken care of; weak but industrious students fail in large numbers.

Under the circumstances it might well seem that a possible remedy for the situation has been overlooked. Have we not made the teaching of the individual sciences too much of a fetich? Can not something be said for the giving of a course in general science?

Objections in quantity come to mind. But most of them reduce to one of three points. No instructor knows enough to teach a worthwhile course in science in all its major branches. If such a person were found, the chief values of science teaching would be lost in what would necessarily be a lecture course. In any event, one more "snap" would be added to a curriculum which at least theoretically opposes easy courses.

Yet one may doubt whether, if there were a demand for lecturers on general science, supply would not follow. The writer has found a considerable number of students drifting through non-scientific "majors," yet taking for diversion a creditable quantity of differing sciences. Certainly these students could not teach any one science, even in an institution of reputable high school grade. Very often they are only mildly attracted by the experimental side of the sciences. So much may be granted. But, incidentally, they are usually far more interesting talkers and writers than us professed and lettered scientists; they might develop into very effective teachers of general science, if there were any inducement.

Doubtless the first set of such teachers, if not those of a later date, would make gross errors. It is too early to pretend to know what should be included in a course in general science. Possibly it might have running through it the basic idea of explaining evolution in its many forms from the Rutherfordian theory of radioactivity to the development of man from *Pithecanthropus*. But suppose the worst. Suppose a man who taught general science, and who knew nothing to speak of about electrons and explained valence with utter disregard of the newer chemistry; who gave his students in astronomy and geology La Place instead of Moulton and Barrell; who did not know that the thallophytes are a very miscellaneous group of plants, lumped together because none of them are bryophytes, pteridophytes or spermatophytes; who—but finish the heinous list for yourself, if you are a physicist, biologist, etc. Under our present system there seem to be some *Sigma Ksis* who discourse well on benzene rings and think chromosomes are plants; who can bound every ore deposit in America and blithely call whales fishes. Isn't it possible we have out-Huxleyed Huxley in our desire to flee from Greek and Latin? Which is worse: To have, as we do have, groups of young scientists who are really only organic-chemists or statistical geneticists or other ists, or to have scientists with a trifle less of specialties and an ABC knowledge of the fields of their fellows?

Besides, the confessedly inferior knowledge of this hypothetical teacher of general science is meant only for that vast group of students who can be attracted to science as a study of the laws of astronomy, chemistry, physics, but who revolt from the laboratory notebook and the minutiae of topographic maps. One great benefit of the suggested course would be the freeing of the enthusiastic laboratory teacher from the incubus of indifferent students—though there is hope that a stimulating approach to modern "organized knowledge" would lead some of the indifferent to further purposeful experimental work. Just as the true laboratory teacher would be relieved and perhaps even be enabled to do research, so would the student genuinely interested in science from the outset find himself among a small group of congenials who would eschew the general course and elect, these chemistry, those botany, etc. Surely, too, since the present courses in elementary this or that could then move far more rapidly, the chemist could find time for botany, the economic geologist time for biology, the mineralogist time for astronomy.

One may doubt, moreover, whether "the chief values of science" would be any more lost than at present.