SCIENCE

VOL. LXIII APRIL 23, 1926 No. 1634

CONTENTS

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 8, 1879.

QUA VADIMUS?[1]

The task of an investigator requires for its success the toughness of a soldier, the temper of a saint and the training of a scholar.—*Humphry Davy.*

The philosopher should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biassed by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary subject. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature.—*Michael Faraday.*

FROM the orb which daily throws its golden rays upon this university,[2] came on November 14, 1925, the announcement of an anonymous gift to Cornell, the income of which is to be used for the "benefit and advancement of teaching and research in chemistry. The gift was made to enable the University to carry out a plan formulated by Professor L. M. Dennis, Head of the Department of Chemistry. Distinguished men of this and other countries in chemistry and allied fields of science were to be invited to spend one or two semesters at Cornell delivering lectures, conducting research, and generally collaborating with the Department while in residence here."

Some days later there followed the announcement, "Dutch chemist accepts offer to teach here." Let me assure you that I feel very much honored by your kindness in choosing me as the first incumbent and that I fully realize the duties laid upon me by your doing so. I sincerely hope that this establishment of the new "non-resident lectureship" may, as the years go on, bring the results that were in the mind of the anonymous benefactor when he made this generous gift to Cornell.

When, for about a quarter of a century, a man has, day after day, devoted himself to university instruction, has seen numerous generations enter the Temple of Minerva, and has seen them leave her sanctum decked with the doctor's hood, when he has passed those years in unbroken and intimate intercourse with his pupils, it is obvious that he is perfectly well acquainted with the difficulties which many of them have met on their way.

[1] Introductory public lecture delivered by Professor Ernst Cohen, first incumbent of the non-resident lectureship in chemistry recently established at Cornell University.

[2] *The Cornell Daily Sun.*

Qua vadimus? Which way shall we go? How are we to arrange our studies? This is the question which year after year many new students ask themselves when they enter the gate of the university, and not only themselves, but also their older colleagues, or the professors to whose guidance they are going to entrust themselves, for in most cases it appears that they themselves are unable to answer this question satisfactorily.

How could it be otherwise? For do they not take a road totally different from the one they have trod up to this time? Are not the requirements totally different now that they are no longer under rigid scholastic restraint? Is it any wonder that they are in the position of the medical practitioner who standing at a sick bed is often confronted with the problems of solving an equation with thirty unknown quantities? The demands which society will make of the beginner in the execution of his scientific profession are such that only he can hope to satisfy them, who knows how to use in the most practical way the time allotted to him for study and for scientific development. Means to attend this end—lectures, practical class-work, books, colloquia, students' lectures, excursions—are not wanting in these days; on the contrary, there is rather "embarras de choix," but the difficulty for the future scientist is to choose rightly, at the proper moment, and after the choice, he must solve the question: "In what way can I make the most practical use of the means that are presented to me?"

Let us pass in review the whole machinery of instruction and indicate the importance and meaning of every part, while at the same time we answer the question how to make the best use of these parts. And let us bear in mind that the student's "Lehr und Wanderjahre" should make him not only a scholar, but especially a "man."

"Die Vorlesungen sind eine unangenehme Unterbrechung der Ferien!" ("The lectures are an unpleasant interruption of the holidays!") is a well-known complaint uttered by professor and student alike, but let us not forget that these are at least of *some* use. Purposely I say "of some use," for experience teaches that the student is apt to overrate the significance of lectures. Enter the lecture room when the students, eager for knowledge, are assembled there, and you will conclude from the continual scratching of pens, which indicates that the words of the professor are perpetuated on paper, that "taking down verbatim" is considered to be a highly important part of the curriculum. Times have changed: seventy-five years ago the renowned Dutch author, Kneppelhout, published his "College Life," a book well worth reading even now, in which with caustic irony he divides the professors into *two* classes: the dictating professors, and the teaching. He berates the former roundly, because they compel the young man of twenty to keep up with the erratic rate of the glib lips, without allowing him time to let his brains catch their line of thought: nowadays it is the student who seems to attach such an immense importance to taking down the words he manages to catch. The more experienced student wonders if short notes worked out as soon as possible after the lecture would not answer the purpose much better, with the simultaneous use of text-books to which he is so often referred.

Would not this lead to a great saving of time? By this method he would avoid the one-sidedness which is a common error of the student in taking the professor's exposition as the only correct and the only possible one. In this way the student easily escapes the rock of "jurare in verba magistri," which is so dangerous especially to the beginner. Moreover, the use of good books when working out what he has heard in the lecture room offers the great advantage that the student gets a better insight into the real value and the significance of a lecture in general.

The subjects are discussed from the professor's subjective point of view as regards the importance which ought to be attached to certain special parts of the science he teaches. Thus it may happen that more attention is paid to subjects to which the professor has especially devoted his energies than to others, no less important, which are farther removed from his special field of investigation. The text-book will draw the student's attention to the existence and importance of such subjects, perhaps acquaint him with problems which captivate him more strongly than those of which he heard in the lectures. And in this way he enters, as it were imperceptibly, the domain of independent study, the study which distinguishes the university from the schools he has just left.

I hear one of you object: "Yes, all this is very fine, but in the examination we are required to know all that has been treated in the lectures." Then my reply is: "Undoubtedly there are lectures, especially those given to freshmen in which the elements of a certain science are presented, and it is absolutely necessary for every one who wishes to go deeper into this science to be well acquainted with all that is treated in the lectures. But this is true of a few courses only. It is absolutely untrue for advanced students and for these a deeper insight into, and a broader view of the matter is of the greatest importance. No reasonable teacher will ever insist that his pupils pay most attention to those parts of science which he has treated exhaustively in a course of lectures. The purport of these lectures is to fix the student's attention on important points, to acquaint him with the literature which has been published on

that particular subject, to point out the way in which certain problems may be studied in connection with the present advance of learning, and, in the last instance, all this is intended not only to make him acquainted with those problems and the way of solving them, but especially to awaken his love for the study of other topics which have not been treated, and so to fit him for the solution of new problems. I am sure that you will agree with me when I say that this end can not be attained by mastering only that which is taken down in the lecture room. I can give you a striking example. When studying thermodynamics, many students, I may say most, are satisfied with studying the derivation of the numerous relations which the lecture teaches them. When they have to apply the formulas thus derived, we are immediately aware that they are not able to do so, especially in the computation of concrete cases. Only by continual practice in the solving of problems is it possible to get a clear understanding of the subject.

But again I hear the objection that this method of study would take up too much time; that those who wish to complete their university course within a reasonable period have not sufficient leisure for such practice. Allow me to set your mind at ease on this point. The man who takes up his studies in this way saves a lot of time. The thorough method is far superior to the superficial. It is true that at first the beginner will think that he makes little headway, but this impression is entirely wrong and soon disappears. The numerous, disheartening repetitions which are the lot of those who are less conscientious are eliminated in this way. The Italian proverb obtains here also: Che va piano, va longano, e va lontano (Who goes slowly, goes a long way and goes far).

Practical class-work, if judiciously ordered, forms a pleasant and powerful help to stimulate the studies at the writing-desk which, especially at first, are more or less monotonous. Many generations of students have experienced this since Justus von Liebig insisted on practical class-work as an inherent part of chemical study. He put this idea in practice at his celebrated laboratory at Giessen. As early as 1683, Johann Moritz Hoffmann, professor of medicine at Altorf, expressed the same idea. And to-day we may make Pasteur's words our own: "Les laboratoires sont les temples de l'avenir, de la richesse et du bien-être; c'est là que l'humanité grandit, se fortifie et devient meilleure." (The laboratories are the temples of the future, of wealth and well-being; there mankind grows, gains strength and progresses.)

I just now used the phrase, "if judiciously ordered." This is true for the teacher who must make the best choice out of the heap of material that lies ready to hand, as well as for the students as regards the manner in which they make use of the opportunities which are offered them.

In connection with the high educational value which a correct method of practical class-work possesses, I will enlarge on this point for a moment. "Ce n'est pas assez de savoir les principes; il faut savoir manipuler." (It is not sufficient to know the principles: manipulation must also be mastered.) No less a person than Michael Faraday took those words for his motto when he published his first manual of practical chemistry, "Chemical Manipulation," being instructions to students in chemistry on the methods of performing experiments of demonstration or of research with accuracy and success. For many decades the great importance and the deep significance of this "savoir manipuler" has been recognized all over the civilized world, and to-day this principle is everywhere introduced in our teaching of the non-mathematical sciences. Therefore, it may appear to be unnecessary to point out once more that for the prospective natural philosopher it is of the utmost importance to apply himself, heart and soul, to this branch of his studies. Yet experience has taught me that, especially at the beginning, most students do not realize this obvious truth. Furthermore, whoever thinks that a working day of eight hours will be sufficient for him to attain his purpose, let him desist from the study of the exact sciences and choose a sphere of activity in which the number of working hours is regulated by law.

Every chemist must be skilled in recognizing and detecting the substances which he handles every day, that is, in qualitative analysis, and it stands to reason that he must also be thoroughly familiar with the methods which acquaint him with the quantitative composition of those substances. Whatever career he will follow afterwards, he must have mastered the A, B, C of these methods. It seems commonplace to enlarge on these points, but my excuse is that more than once I have met students who were strangely deficient in their knowledge of analysis. I willingly admit that there is a certain monotony in making oneself familiar with these manipulations, that for many it is "making the best of a bad job," but it is an absolute necessity.

Then we should not forget that performing analytical operations offers an excellent opportunity of training oneself in keen observation, in accuracy, and, last but not least, in economizing time. He who is able to perform a number of analyses simultaneously and to divide his time in the most practical and economical way, acquires qualities which are of great use to him in future years in every branch of study. He learns to make the most of his time. We can not enter into further particulars about this

point, but I wish to call attention to a serious mistake which is very common and which often leads to a highly undesirable waste of time and material. Many students, after a quantitative measurement, put off the calculation of the results until after a second experiment. Now this is most unwise, for often the calculation shows that some error has been made, and if this error had been known to the student before the second experiment had been carried out, he would have been warned in time to avoid the rock on which his first experiment had stranded. For the serious worker, "manipuler" has another great advantage—it compels him to bear continually in mind the principles on which his work is based, and to recall and put into practice that which he has heard in the lecture room or read in his books. This advantage, however, is only for him who does not work mechanically, or does not blindly follow the manuals he uses in the laboratory, without verifying the laws they teach.

The memorable words of Clemens Winkler should be engraved over the entrance of every chemical laboratory, and not only there, but also on the mind of every student of chemistry:

> Die wirklich erfolgreiche Durchführung anorganisch-chemischer (I add: organischer und physikalisch-chemischer) Arbeiten ist aber nur demjenigen möglich, der nicht allein theoretischer Chemiker, sondern auch vollendeter Analytiker ist, und zwar nicht nur ein praktisch angelernter mechanischer Arbeiter, sondern ein denkender, gestaltender Künstler, vor dem jede der durchgeführten Operationen in theoretischer Klarheit liegt, dem die Stöchiometrie in Fleisch und Blut übergegangen ist und der bei allem, was er tut, von ästhetischem, dem Sinne für Ordnung und Sauberkeit, vor allem aber vom Streben nach Wahrheit geleitet wird.

That is in plain English:

> Successful inorganic-chemical [I add, organic and physico-chemical] investigations can only be carried out by such men as are not only theoretical chemists, but also perfect analysts, not only artisans with practical routine training, but thinking, plastic artists who have a deep insight into the theory of their experiments, who have stoichiometry at the tips of their fingers, who are always led by an aesthetic spirit for order and cleanliness, but above all by a desire for truth.

But too often the student feels inclined to complete the course which has been set him in the shortest time possible, without realizing that the way in which he completes his task must be considered of the greatest importance as regards his further attainments. He often shows little desire to repeat an unsuccessful experiment and does not appear interested in trying to better his results. And more than once we hear from those who wish to explain their lack of perseverance this excuse: "I prefer the theoretical side of chemistry to the practical."

The inclination to withdraw from experimental work in favor of speculative philosophy, to the great detriment of the scientific faculty, is especially noticeable in those students who early in their university career take up the study of philosophy. If the teacher of chemistry succeeds in convincing them that they are on the wrong road, and that a continuation of their scientific studies will give them equally great gratification, such episodes, when after a shorter or longer time the difficulties are vanquished, generally result in the student esteeming himself fortunate that he succeeded in checking his speculative inclinations at the proper time.

On the strength of these experiences I venture to warn against a premature study of speculative philosophy. If the natural philosopher, when he has won his way in scientific fields, feels inclined to enter the domain of speculative philosophy, he still may find an opportunity of following Mephisto's advice:

> Mein teurer Freund, ich rat' Euch drum
> Zuerst Kollegium Logikum
> Da wird der Geist Euch wohl dressiert,
> In spanische Stiefeln eingeschürt,
> Dass er bedächtiger fortan
> Hinschleiche die Gedankenbahn,
> Und nicht etwa die Kreuz und Quer
> Irrlichteliere hin und her.

Which runs in the English translation:

> For this I counsel my young friend
> A course of logic to attend;
> Thus will your mind, well-trained and high,
> In Spanish boots stalk pompously!
> With solemn look and crippled pace,
> The beaten road of thought will trace:
> Nor here and there, through paths oblique,
> In devious wanderings idly strike.

Then his critical judgment will enable him to turn to good advantage all that can benefit him in his further study in mathematical sciences.

Another possible error, of a totally different nature, is that he who devotes himself to practical laboratory work may have no eye for anything but his own experiments. The fact that in a laboratory a number of neophytes and more advanced students are at work together, on different, often totally divergent experiments, gives all of them an opportunity of paying attention not only to their own work, but also to the work of their fellow-students, of seeing and hearing what others do and of profiting by the mistakes and failures of their neighbors. It is a great advantage for the students if varied kinds of experiments are carried out in the same laboratory; the tendency now-

adays in some university laboratories to restrict the investigations to a narrow field is therefore not to be recommended.

No one can deny that the path of the prospective natural philosopher is beset with difficulties, or that he will meet with numerous reverses. But difficulties have their use; they stimulate the desire to overcome them. Thus the study of exact sciences exercises a beneficial influence on the formation of character in those who apply themselves to it with untiring zeal. The difficulties which the student must conquer steel his patience, and develop his perseverance, and his self-reliance, and when at last he has attained his end, he enjoys the peculiar satisfaction which indemnifies the genuine investigator for the most difficult labor and the greatest exertions. An advantage that can hardly be estimated at its true value is that such endeavors develop the sense of truth in a man. Has not the Swedish pastmaster in chemistry, Berzelius, declared: "Der erste und grösste Ruhm eines Forschers besteht in seiner Wahrhaftigkeit und Gewissenhaftigkeit; gegen diese gehalten, verschwinden alle wissenschaftlichen Verdienste." (The first and greatest glory of an investigator is his truthfulness and conscientiousness; all his scientific attainments are eclipsed by these qualities.)

You see, ladies and gentlemen, that a natural philosopher must have no mean qualifications if he wishes properly to perform the work he has undertaken. There are more and other qualities he must possess if he wishes to escape disappointments, but I can not enter into further details here. If you wish to go deeper into this subject, I refer you to the "Consolations in Travel or the Last Days of a Philosopher," by Humphry Davy, written down about a hundred years ago in his journey through Europe, and I advise you to read the fifth dialogue, which contains truths no less pregnant in 1926 than when they were set forth by the great British chemist.

We now turn to the third group of aids to the student, books of study. I think first of all of the question, "What text-book shall I use?" For the beginner I can recommend the use of one special text-book, so that the student gets acquainted with the elements of the science to be studied. But he should, as soon as possible, pass to the study of special subjects in special books. The choice is unlimited; the enormous increase of literature all over the world requires different subjects to be treated in monographs. Very often the scientist is obliged to turn to books written in some foreign language. This is, however, a great advantage to the student whose knowledge of foreign languages is generally below par, for it obliges him to go deeper into the study of these languages, and by using these books he develops greater linguistic proficiency.

The man who, later on, wishes to make the results of his researches known to a greater number of readers should be thoroughly conversant with one or more foreign languages. But in whatever language the text-books the student uses may be written, he should first of all learn to read with accuracy. The great majority, and experience has shown this very clearly, have had insufficient training in their earlier schooling. From what precedes, it follows that a library, however small it may be at first, is a "conditio sine qua non" for the earnest student. But inquiries on this point have taught me that the length of the bookshelves of most students can not be reckoned by meters, but by decimeters at most. If the student can not consult his own library, serious study is handicapped, for many reasons, one of which is loss of time if he has to borrow the books he needs.

The man who possesses a library of his own will have a better opportunity of studying chapters which for the moment are of no immediate use to him, and in this way he enlarges his views and his knowledge. I can not insist too much on the necessity of the student forming a library at his earliest convenience. He will never rue the money he spends on it. In this library he should find a place for books which treat of the history of science, as well as for those which I should like to call the "belles lettres" of science.

"Historische Studien gehören sehr wesentlich mit zur wissenschaftlichen Erziehung." (Historical studies are part and parcel of a scientific education.) Ernst Mach, with many others, has not only drawn attention to this fact, but, suiting the action to the word, has left us many an essay which bears witness to the truth of this statement. The man who studies the history of science will get a better insight into the problems that are nowadays a center of interest, nay he will also be convinced that:

> . . . es ist ein gross Ergötzen,
> Sich in den Geist der Zeiten zu versetzen,
> Zu schauen, wie vor uns ein weiser Mann gedacht.
>
> (. . . 'tis delightful to transfuse yourself
> Into the spirit of the ages past;
> To see how wise men thought in olden time.)

And when he reads the biographies of those "wise men" in which are described the ways in which knowledge was obtained, and in which the obstacles are shown which had to be conquered, he will learn to think humbly of himself and not overrate his own accomplishments. A large number of chemical and physical works are at his disposal in which great men, such as Ampère, Arago, Berthelot, Biot, Chevreul, Davy, Faraday, von Hofmann, Justus von Liebig, Edmund O. von Lippmann, Ernst Mach, Victor Meyer, Ramsay, Schönbein, Tyndall, to mention but a

few, have treated subjects, in or even outside the pale of the science they studied, in essays which excel in beauty of form and depth of thought and grip the attention of the reader by the striking way in which they confirm François Arago's words:

La culture des sciences fortifie l'intelligence sans détremper les ressorts de l 'âme, sans émousser la sensibilité, sans attiédir aucune des bonnes qualités dont la nature a déposé le germe dans le coeur humain. (The pursuit of science strengthens the intelligence, without weakening the energy, without blunting the sensitiveness, without chilling any of the good qualities the germ of which has been placed in the human heart by nature.)

Great importance must be attached to the colloquia and student-lectures. The intention of the former is to encourage the advanced student to take cognizance of the latest results of science, and give him an opportunity to state his own views on the subjects which have more particularly drawn his attention. Thus he is obliged to acquaint himself at the same time with what was previously accomplished in this direction. If the prospective investigator wishes to be conversant with the progress of science, if he wants to know what problems are of actual importance, he must read one or more of the numerous periodicals which will inform him on this point and in which, at the same time, he can follow the evolution of science in cognate or more distant domains. The cardinal point of such studies is the fact that the student gets acquainted with the literature, that he learns to find his way in it, that he gains information about problems of which hitherto he was quite ignorant. In his later life he will often be required to find his way in a field of science where, up to that moment, he had never set foot. To prepare him for such contingencies is the first aim of the colloquia. The reading of his short paper trains him in logical formulation of ideas which continual practice only can give. This is of great profit to the man who chooses a scholastic profession, but no less to the manager of some industry who comes into contact with many persons of varying intellectual faculties to whom he must explain his ideas.

The student-lectures too aim at the development of the same qualities. Here the student is required to give his audience an insight, either into an up-to-date problem of which he has made a special study or into some problem of earlier times. The preparation of such an essay, the reading of which according to the well-tried prescription by Faraday should never take longer than one hour, acquaints the prospective lecturer with the literature of his subject. Let him never forget to consult "in originali" the books which refer him to the subject-matter in hand, neither when he prepares his paper for the student-lecture, nor when later on he publishes his investigations. He should never trust abstracts made by others, for many an investigation has been rendered totally worthless from the very outset because the author, a victim to indolence, had disregarded this precept. In the student-lectures, as well as in the colloquia, every one derives profit, not only from his own essay, but also from those of his fellow students, while the discussion on the subject widens their minds.

The first aim of the man who chooses the university as the place where he prepares for later life should be to get an all-round training in the science which he wishes to study. He does not always know what path he will choose when the gates of the university shall close behind him. Is he going to follow a scholastic profession, or a technical, or will he devote himself to a life of purely scientific study? It often happens that some predilection reveals itself during his stay at the university, and that in those years a fitness for some special career manifests itself. The great thing therefore is that his university course should be such as to allow him to defer for a time definite choice as to his subsequent career.

When we take all this into consideration, it would be very convenient if the university curriculum contained another item, *viz.*, excursions. By visiting and viewing certain chemical works the student gets a notion of the value of the applications of science. I say a notion, for he must not overrate the value of such excursions. From their very nature they can give him only a very vague idea of different industries. Their complicated nature, the short time which can be allowed for such visits, the secrecy which envelops, and very rightly, the plants visited, make a deep study of the matter an impossibility, even if the student has prepared himself by reading up books on the subject. It is of course a totally different matter if the prospective doctor chemiae can become acquainted with an industry by working in a plant for some time; a stay at a laboratory where special investigations are carried out (I have in mind the laboratories at some factories, as well as government agricultural stations and the like) can form an important element in his scientific training insofar as in such surroundings quick and accurate work is necessary. I need not point out that excursions as well as a prolonged stay at some factory can be of use to the more advanced student only.

Traveling during the university course in his native country would have many drawbacks, but when once the student has obtained his degree he must be enabled (at any rate the more talented) to go on an educational tour. Even if a prolonged stay in a foreign country should have no other effect than that the young doctor acquired fluency in the language of this country, the allowance granted would be well spent. For him who has eyes to see and ears to hear, the

advantages of an eduactional tour abroad are of incalculable value for his whole life. He is stimulated by the study of new methods of investigation, by coming into contact with younger men of another nationality whose ideas and sentiments are different from his. New relations and new friendships are contracted, perhaps for life. The man who has gone through such a period himself never gets tired of dwelling on the advantages and the pleasant memories he has kept of that time. And when he returns to his own country, after a stay in some centers of learning, he recognizes the truth of the old adage: "As many languages a man speaks, so many times he is a man." The plan which I have sketched here will be of benefit to our "itinerant" students, but no less to the laboratories they visit. Great is the influence which "outsiders" can exercise on the work in a laboratory. Their presence is an excellent remedy against the "humdrum routine" of the students and the "fads" of the professor.

When the student has taken his first degree, he enters upon the most instructive period of his studies, that is, if he wishes to conclude his college life with a doctor's degree. Up to this moment the examinations, though conducted in a very liberal and fair spirit, have exercised a certain constraint upon the study of the prospective doctor. Now, however, he can give his whole mind to a subject of his own choosing. This stimulates his energy, his perseverance; he is obliged to study the literature which bears upon his subject, and when at last he has completed his research, he must put his results into readable shape and work them up into a logical sequence, and all this is excellent training in the art of putting his thoughts to paper in a lucid and accurate form.

Let no one imagine that the course which I have sketched leads to the moulding of a scientist who satisfies every requirement of science or society. This is by no means the case. Remember that in the first part of this discourse I pointed out that the "Lehr- und Wanderjahre" of the student should make him not only a scholar, but also a man. I hope that I have made it clear that the way which leads to the forming of a scholar possesses more than one factor which can also play an important part in the forming of a man. The importance of other factors, however, should not be undervalued.

> Es bildet ein Talent sich in der Stille,
> Sich ein Charakter in dem Strom der Welt!

(A man of talent is formed in seclusion, a man of character in the whirlpool of life.)

The man who devotes himself exclusively to study, who keeps aloof from an environment such as only the university can give, who does not try to set his knowledge and gifts on a broader foundation by an intercourse with "all sorts and conditions of men," who does not try to give form and tone to his character, is wanting to himself and to society. Only by mixing with the different sets at the university does he find opportunity to exchange thoughts with fellow students whose intellectual horizon is quite different from his own: only thus will he guard against those qualities of self-consciousness and one-sidedness which can but harm him in later life.

Is it not a distressing sign of want of culture when, among students who already have spent some years at the university and have passed examinations there, some are found who do not know what the Nobel prize is, or who do not know even the names of those of their countrymen who have made themselves a great name in the science which these students have chosen for their own study? There is no better place for the prospective natural philosopher to learn that his subject embraces but a very small part of human knowledge than among the fellow-students of different faculties, and so he will be prevented from becoming overwise in his own conceit. In associations and debating clubs he finds another and perhaps a better opportunity of putting his thoughts lucidly and concisely into words. The discussions with others whose conceptions and opinions differ from his train him in self-command. Here is the arena where he prepares himself for life's struggles which await him after his college years. Here he finds an opportunity to develop the qualities which, together with his scientific attainments, will have such a great influence on his future happiness.

As early as the middle of the last century the Dutch author, Kneppelhout, whom I mentioned at the beginning of my discourse, justly made sport of the man who in later years should write a pompous and learned, and necessarily Latin work: "De methodo studendi optimo" (On the best Method of Studying). It has not been my purpose to give you such a manual, for I am of the same opinion as the author of "College-Life." There is no hard and fast rule which tells you how to become clever. There are more ways to the wood than one; in our case the special qualities of the individual are of the greatest importance in the choice of the way. It has been my aim to point out to you some paths which lead to the same goal. The paths differ from one another, but every one is free to take the road he likes best. But whatever path you follow, try to remember that it is always a steep mountain-road, the ascent of which is difficult, and that you will reach the top only if you exert yourself to the utmost. In so doing you will fulfil the hopes expressed by Andrew D. White, first president

of this university, carved on the granite gateway presented by him to Cornell:

So enter that daily thou mayest become more learned and thoughtful,
So depart that daily thou mayest become more useful to thy country and to mankind.

ERNST COHEN

CORNELL UNIVERSITY

SO-CALLED VOLCANIC EARTHQUAKES[1]

IN considering the crustal mechanism that shakes the surface of the earth geologists seem to have adopted a convention or fashion, backed by honored names like Dana, Geikie and Suess, that relegates volcanic causes to the background. Volcanism to many teachers does not connote magma and substratum, but rather volcanoes and explosions. On the other hand, geanticlines and geosynclines, quite apart from anticlinoria and synclinoria in stratigraphic series, are drawn around the earth in long belts through every possible geologic structure and topographic obstruction under the magic of the word "tectonic." I have not found a single text defining the word "tectonic." Frankly, I do not know what it means. We are told that it is derived from a word meaning "roof." A roof is a structure protecting a void within. Tectonics involves "folding" into "forelands" whole strips of the earth's surface containing everything from gneiss to till and from granite to flowing lava, and from mountain ranges to a quarter of a continent. I am not mathematician enough to appreciate the geometry of folding a surface. If I might venture appositely to coin an equivalent word "volcanics," current texts would give the student to understand that volcanics involves explosion of steam mostly along ocean shorelines. Tambora and Krakatoa are the types; the earthquakes there are tiny and due to underground gases, and they are shallow and diminish a short distance away.

Modern volcanology is not in sympathy with these ideas. "Volcanic earthquakes" have no more meaning than "tectonic" ones. The volcano is not the seat of volcanism. The volcano is the least part of the process the volcanologist is interested in. The explosion is the part least volcanic of the very small part of volcanism that the volcano represents. I am speaking volumetrically.

What modern volcanology is interested in primarily is the under heat and the juvenile gas of the earth crust, the identity of that crust, thermal phenomena of geophysics wherever found and wherever measurable, kinetic phenomena of all sorts which can be considered fundamentally thermal, and measurable gradations athwart the land and vertically downward (and also athwart that seventy-two per cent. of the surface called sea-bottom), which will lead by quantitative measurement to sound and reasonable theory concerning magmatic intrusion in progress to-day. This and this only is the reason for studying active volcanoes, in order to find gradations away from them in measurable process. The processes measurable are primarily heat evolution, juvenile chemistry, seismicity, visible magmatic emission, gravity and terrestrial electric fields. All sorts of devices are possible by way of method. The science is essentially experimental because untouched. Seismology and geodesy have provided solid ground for belief in a crust and in a more mobile substratum. The geology of igneous rocks undeniably exhibits them everywhere in depth.

The earth's crust and the under stratum of magma are necessary for the concept of isostasy. Bowie, Sandberg and others have come to the conception of thermal isostasy. The crust is in balance. The disturbance of balance may arrive below by intrusion or cooling, or above by erosion and accumulation of sediment. The balance is a fact. Volcanology must measure the disturbances, assisted by all the other branches of geophysics. If the balance is a fact, and magma is a fact, and crust is a fact, and magma moves at volcanoes, and the crust moves as proved geodetically within decades and seismometrically within hours, there seems no possible doubt of the fact that magma moves at places where volcanoes have long since been buried and replaced by intrusion, or even where volcanoes of modern type have never existed. These motions just as much concern volcanology as volcano movements.

Gradations of volcanicity across country are exactly what are found and cited by the authorities as being non-volcanic. In Montessus de Ballore's "Geologie Sismologique" of 1924, page 225, the diminution of seismicity from north to south in Chile with increase of volcanic eruption in that direction is cited as proving that the earthquakes are "non volcanic." And in time the increase of earthquakes when volcanoes become quiet proves that earthquakes are "non-volcanic." No reasoning could possibly seem more fallacious to one who thinks of volcanism as dominantly intrusive.

If one examines the facts of these gradations in the world, the more one is impressed by both time and place evidence, that as crust thickens over magma and outflow of lava disappears, the seismic centers become

[1] Paper presented before the American Association at Kansas City, December 29, 1925, as part of a symposium on earthquakes.