the theories during his lifetime. In such cases subsequent observations made through many years by others will find the phenomena confirming the principles. The truths announced by men of insight are often not accepted by slower men until this later observational work is done. Many cases could be cited illustrating these statements. Darwin, in 1860, knew that life had existed that would fill in the great gaps in the very imperfect paleontological record. Since 1860 all the greater gaps have been filled by discovered fossils. Mendeleeff, when he saw the law of the periodic arrangement of the elements, *knew* that elements exist which would fill the gaps; but it took many years of work by many men to find a part of them; and during the past few years a half dozen or more of the vacant places have been occupied. Each geologist, each scientist, now as in the past, is just as right as he should be. The scientific seers will ever go far in advance and guide others, even as did the spiritual seers of old.

The scope of these observations doubtless extends beyond geology. Much of what has been said is true of knowledge as a whole, not restricted to one subject. But I shall have accomplished my purpose if what I have said be true of geology; for if my conclusions be well founded, they furnish the basis upon which courses leading to degrees in professional geology should be laid out, and to methods of good geological work in the field and in the office.

THE EXAMINATION AND THE EXAMINEE IN ELEMENTARY SCIENCE.

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The average examinee considers examinations as an ordeal which he must pass in order to obtain a certain certificate. He looks upon the examiner as a man whom he must try to convince of his knowledge of the subject, and if he can do this without excessive study, so much the better. No doubt, the examiner has largely himself to blame if the examinee can pass the examination

without a reasonable amount of study. The examination should not be of the kind that can be crammed for, but should require thoughtful application on the part of the student. It must not be of such a character that a candidate having accumulated a number of undigested facts without any knowledge of their relationships may be able to present a good appearance. If definitions are asked for, care should be taken to ascertain that the definitions mean something to the examinee as well as to the examiner. The words may be exact, the idea expressed may be perfectly correct, and yet the candidate may have no more conception of what is meant than if he had committed to memory a list of words taken from an unknown language. For instance, the statement of Avogadro's law, that equal volumes of different gases under the same conditions of temperature and pressure contain equal numbers of molecules, may be given correctly, and yet the candidate might be entirely at sea if asked what volume of hydrogen would contain five million million of molecules, provided that under the same conditions of temperature and pressure one litre of nitrogen contains a million million of molecules.

Not that I consider the memorizing of definitions useless. The strengthening of the memory has some value, but I think that storing the mind with gems of literature is preferable to accumulating a stock of definitions. Definitions, accurately and exactly learned, may doubtless be of use in later life when their meaning is understood, and in this respect the learning of a definition is better than the learning of a series of words in a dictionary or of a page in a table of logarithms. I refer to the learning of definitions without understanding their meaning. The learning of a definition, when the value of each clause and word is appreciated, is quite a different matter and is, in the highest degree, education.

The pupil beginning the study of science should realize from the very first the necessity of accuracy and exactness. He should learn that his knowledge, while necessarily limited, should be definite and distinct. A hazy idea of principles and facts is most unsatisfactory. The term *science* denotes *knowledge*, and knowledge should be exact and not of a general and indistinct kind. General knowledge has been wittily described as definite and dense

ignorance, and it must be admitted that many examination papers exhibit on the part of the examinees a great deal of general knowledge.

Accuracy of observation is one of the essentials of any scientific training, and any training is to that extent scientific in which accuracy of observation is insisted upon. If leaves are being examined, their shape should be accurately observed, the character of their margin, the texture, the surface, and other peculiarities, so that the pupil will realize that he *knows* something about the leaves he has studied. If flowers are examined, their peculiarities should be noted, and whatever object is looked at, the observation should be accurate so far as it goes. An examination paper can test such accuracy of observation. Taking an illustration from elementary chemistry instead of botany, such a question as the following may be asked, "What did you see when a piece of sodium was placed upon water?" The answer might involve the fact that sodium takes a globular form and moves about on the surface of the water; it might be that a yellow flame was seen; but that hydrogen was produced by the action of sodium on water, or that caustic soda was produced is not a thing visible in the experiment suggested. It is very important for the pupil to distinguish between what he sees and what he infers, and, still more important, to distinguish between what he sees and what *somebody else* infers. Unfortunately, most of our science students learn too much of what somebody else has inferred, usually without a knowledge of the facts from which the inference is drawn, and this inference, which we call a theory, is considered the fundamental fact and the things observed are supposed to hang upon it rather than it upon them. Such a theory is the atomic theory. Examinees in elementary chemistry, when asked to describe a chemical phenomenon, are all too apt to describe it in terms of atoms and molecules, and in such wise to show plainly that their knowledge is of the general kind mentioned above.

It is not uncommon to relegate memory to a very subordinate place in the study of science. We are told that what is required is that the pupil should understand principles, not remember facts. But the concrete is the best introduction to the abstract

and principles are best arrived at through facts, are best illustrated by facts, and are most definitely remembered in connection with facts. It is true that it is more important to train a child to investigate for himself than to give him the result of others' investigation, but the time is too short for him to investigate all he should know. It is in most sciences as it is in geography. The most complete and vivid knowledge of geography is to be got by travel, provided the traveler knows how to observe. But most people have to be content with a knowledge of other countries got at second hand. So in science; in many instances we must rest content with getting our facts second hand, and to get a clear view of the subject and to obtain a firm grasp of the principles, facts must be fixed in the mind. Hence, in an examination paper some questions involving an exercise of memory are not out of place. The examiner should be very careful in setting questions of this kind. The questions asked should not be out of the way ones. They should not in any sense be catch questions; they should be of the kind that any candidate in that grade of examination should know. For instance, in chemistry any pupil ought to learn how hydrogen is prepared or carbon dioxide, or hydrochloric acid, and the properties of these substances, and a question on matters similar to these is well suited to an elementary paper.

The case of carbon dioxide illustrates what I have said above about taking some facts in science second hand. It would not be easy for the pupil to perform an experiment to show that for a given amount of carbon, carbon dioxide contains twice as much oxygen as carbon monoxide; but he should know the fact. Unfortunately, when he does learn the fact, he does not realize that the fact has primarily been learned by experiment, but is liable to talk about atoms and molecules in such a way as to indicate that he considers carbon monoxide and dioxide as specially created by a kind Providence to illustrate the law of multiple proportions. Examinations have a very important function in stimulating the examinee to fix in his mind a number of facts. The student goes over and over his work with the view of making sure that he can tell a straightforward tale to the examiner, and in

doing so finds that the facts gain a definiteness in his own mind which they formerly did not possess.

An examination should not consist entirely of questions of fact. It should be such as to test the examinee's knowledge of underlying principles, and the relation that facts bear to each other. It would be well if some facts that the examinee is not likely to have met could be given and an explanation of them required, care being, of course, taken that the explanation depends upon principles that should be known.

Any little turn of a question that will put the matter in a different light from the ordinary is useful, and the examinee should try to get such a grasp of the fundamental ideas that he will not be caught unawares. There should not be too many questions of this character, for the examinee should not meet too much that is strange, but, on the other hand, the examinee should not have acquired so superficial knowledge of the subject as to be nonplussed by a change in form of question. There are not a few examinees in chemistry who could tell how carbon dioxide and chlorine are made, but would think they were asked something out of the way if requested to give the action of hydrochloric acid on marble and on manganese dioxide.

The science student should endeavor to cultivate accuracy of observation, exactness in the knowledge of facts, a clear insight into the relationship between kindred facts, and an appreciation of the principles involved; the examination should be of such a kind as to determine whether the candidate has made this endeavor and how far he has been successful, and should stimulate the examinee to strive in the best manner for the attainment of a thorough understanding of the work gone over, and for such a mental training as will be of permanent value in future life.—*The School Journal*.