

ceeds to the unknown ; the second starts with what we call the principles of the science ; announces laws and includes the facts under them : declares the unknown and applies it to the known. The first demands faith, the second criticism. Of the two, the latter is the easier, and the former by far the better. But the latter is seen in most text-books, and is the method on which many unscientific people ground their disposal of science. What this former method is, and why it is the better, will be seen by the following remarks.

In the first place, then, *knowledge must precede science* : for science is nothing else but systematized experience and knowledge. In its extreme applications this principle is obvious enough : it would be absurd to teach boys classification from minerals, or the power of experimental science by an investigation into the organic bases. A certain broad array of facts must pre-exist before scientific methods can be applied. (1) This order cannot be reversed. And this is illustrated by the profound analogy that exists between the growth of scientific knowledge in an individual and in the world. Generation after generation of facts ; and then there sprang up in the world the uncontrollable desire to ascertain the sequences in nature, and to penetrate to the deep-lying principles of natural philosophy. And the same desire is based in the individual on the same kind of experience. Where there is wide knowledge of facts, science of some kind is sure to spring up. After centuries of experience the *Philosophiæ naturalis principia* were published.

And, secondly, this knowledge must be homogeneous with pre-existing knowledge. It is of no use to supply purely foreign facts ; they must be such as the learner already knows something of, or be so similar in kind that his knowledge of them is equally secure : such that he can piece them in with his own fragmentary but widening experience. It is to his existing knowledge, and to that alone, you must dig down to get a sure foundation. And the facts of your science must reach continuously down, and rest securely thereon. Hence the master's business is to take up the knowledge that already exists ; to systematize and arrange it ; to give it extension here, and accuracy there ; to connect scraps of knowledge that seemed isolated ; to point out where progress is stopped by ignorance of facts ; and to show how to remedy the ignorance. Rapidly knowledge crystallizes round a solid nucleus : and anything the master gives that is suited to the existing knowledge is absorbed and assimilated into the growing mass : and if he is unwise and impatient enough (as I have been scores of times) to say something which is to him perhaps a truth most vivid and suggestive, but for which his boys are unripe, he will see them, if they are really well trained, reject it as the cock despised the diamond among the barley (and the cock was quite right), or still worse, less wise than the cock, swallow it whole as a dead and choking formula.

On these grounds then, in addition to other obvious ones, Botany and Experimental Physics claim to be the standard subjects for scientific teaching at schools. In both there pre-exists some solid and familiar knowledge. Both can so be taught as to make the learner advance from the known to the unknown—from his observations and experiments to his generalisations and laws, and ascend by continuous steps from induction to induction, and never once feel that he is carried away by a stream of words, and is reasoning about words rather than things. The logical processes they involve are admirable and complete illustrations of universal logic, and yet are not too difficult. These considerations mark the inferiority, in this respect, of Geology and Physiology, in which the doctrines must far outrun the facts

at a boy's command, and which require so much knowledge before the doctrines can be seen to be well founded. And these considerations exclude Chemistry, as an elementary subject at least, since there is so little pre-existing knowledge in the learner's mind on which the foundations can be laid. On all grounds the teaching of chemistry should follow that of Experimental Physics. To this point, however, I shall have again occasion to refer.

Unless this method of investigation is followed, the teaching of science may degenerate, with an amazing rapidity, into cramming. To be crammed is to have words and formulæ given before the ideas and laws are realized. Geology and Chemistry are frightfully crammable. But Botany and Experimental Physics are by no means so easy to cram. What they might become with bad text-books and a bad teacher I cannot, indeed, say ; but it is a very important consideration. For it is possible to teach even Botany and Experimental Physics with exquisite perverseness, so as to deprive them of all their singular advantages as subjects for elementary training in science. It is possible to compel the learning the names of the parts of a flower before the condition of existence of a name, viz. that it is seen to be wanted, is fulfilled : to cumber the learner with a terminology that is unspeakably repulsive when given too soon ; given before the induction which justifies the name has been gone through ; to give the principles of classification before a sufficient acquaintance with species has called out the ideas of resemblance and difference, and has shown the necessity of classification ; to give theories of typical form when it seems a wild and grotesque romance ; to teach, in fact, by the method of authority. And this may be done by truly scientific men, fully believing that this is the true and only method. Witness Adrien de Jussieu's "*Botanique*."

The true method is assuredly to begin by widening for your boys the basis of facts, and instantly to note uniformities of a low order, and let them hazard a few generalizations. The boys will far outrun their master. Their tendency to make the generalizations of the most astounding kind is both amusing and instructive ; it constantly reminds me of the ancient Greek Philosophy ; it is the proof that there is both the power to be trained, and a need of training. A theory is necessary to observation. Make them verify, and expurgate, and prune, and, if need be, reject their theories by a constant appeal to facts ; sympathise with them in their search for truth, and so search for more facts and more accurate observation ; and thus the crystal pyramid of their science grows, its base ever widening, its summit ever rising.

(To be continued.)

Prize Essay on Teaching Elementary Geography.

(Continued.)

First Lesson.—The picture before you is a map of the whole world. The reason it is in two parts is : the earth is round and we can see but one half of a round ball at a time. This half, (pointing to the map,) is a drawing of one view of the round world, then we turn it, as it were, to see the other half, and draw it out too.

The half to the right is called the Eastern Hemisphere, the other the Western Hemisphere. The map shows us how the land and water are spread over the surface of the globe, and the shapes they are of. The coloured parts are the land and the parts without colour the water. It is quite evident that much more of the surface of the globe is covered with water than with land. The printed words across the map are the names by which different parts of the land and water are known. The names in the largest print are those of the continents and oceans. Europe, Asia, Africa, and America are the continents. The first three are together and are called the Old World ; America is by itself and is called the new world ; called new, because not much known till some years ago.

(1) This truth has been entirely lost sight of in teaching elementary geometry. The extreme repulsiveness of Euclid to almost every boy is a complete proof, if indeed other proofs were wanting, that the ordinary methods of studying geometry in use at preparatory and public schools are wholly erroneous. To this I can do no more than allude here, as being my conviction after considerable experience,—a conviction which has overcome every possible prejudice to the contrary. It is much to be hoped that before long the teaching of practical geometry will precede the teaching of the science of geometry.