of five classes. No science work (at present) is done in the preparatory school, but all boys in the upper school do some. With the lowest class the subjects are physical geography, and in the summer, botany.

The two reasons why science should be taught in schools are (to quote from Mr. Wilson) that it "is the best teacher of accurate, acute, and exhaustive observation of what is," and that "of all processes of reasoning it stands alone as the exhaustive illustration." And the teaching of physical geography and botany I regard as fulfilling the first of these purposes. We enjoy unusual advantages for the study of these two subjects in the nature of the surrounding country. We are upon the millstone grit, but only a few hundred yards from the great Craven Fault, where the mountain limestone is elevated some 800 feet above the grit into the Giggleswick Scar.

At the distance of a few miles we have the limestone and Yoredale rocks resting unconformably upon the vertical Silurian rocks. Traces of glacial action are numerous—the new line from Settle to Carlisle cuts through moraines, where scratched pebbles may be picked up by the dozen. Erratic blocks are scattered thickly over the whole country. At hand we have the Victoria Cave, and the remains it has yielded are preserved in the school museum, and we are within an afternoon's ramble of the summits of Ingleborough and Penyghent, and of Clapham Cave, and numerous others. We are equally well off in the matter of botany; a radius of six miles round the school probably includes a greater variety of plants than any equal area in England.

Supposing a boy to enter the upper school at the age of twelve, he would perhaps remain in the class for a year, and at the age of thirteen would enter upon the *systematic* study of science; and his first subject would be chemistry, which he would attack at once *practically*. Four hours a week are given in this class to the study of chemistry—a practical lesson of two hours and two oral lessons of an hour each. In the class of perhaps twenty-five, all the boys are making the same experiments at the same time, and the work consists mainly in the study of the properties of the salts of particular metals. The boys are led to infer for themselves from their own experiments the solubility or insolubility of the salts of the metals in water, acids, &c., and from that to advance to simple analysis. No text-book is used.

In the oral lessons we advance very slowly; one term suffices probably to get through not more than oxygen, hydrogen, and water, and perhaps to begin air. It seems to me that a boy learns much more by understanding thoroughly the experimental evidence that nine pounds of water contain eight pounds of oxygen, than in learning the "mode of preparation and properties" of the oxides of nitrogen and a dozen other substances. In the next class in which the average age is perhaps fourteen to fifteen, we get through nitrogen, carbon, chlorine, bromine, iodine, fluorine, and perhaps sulphur, practical work being continued at the same rate as before. In the second class we have two hours a week for chemistry, two hours for practical work, and two hours for physics. In physics we take the various branches in succession, and get through the subjects of Balfour Stewart's "Physics" in about two years, which is the time many boys remain in the class, the ages being fifteen to seventeen. In the first class we have eight hours a week. The subjects we are taking at present are:—Inorganic and Organic Chemistry, two hours; Analysis, two hours; Electricity and Magnetism, two hours; Astronomy, two hours.

We shall shortly be able, in consequence of the extension of the buildings, to add some practical work in physics. But this will be only for the highest class.

Will you allow me, in conclusion, to quote some of the conclusions of the British Association Committee on Scientific Education in Schools, which appear to me to be still as important as when they were first written. The Committee included Mr. Farrar, Prof. Huxley, Prof. Tyndall, and Mr. Wilson:—

"There is an important distinction between scientific *information* and scientific training; in other words, between general literary acquaintance with scientific facts, and the knowledge of methods that may be gained by studying the facts at first hand under the guidance of a competent teacher." Both of these are valuable; it is very desirable, for example, that boys should have some general information about the ordinary phenomena of nature, such as the simple facts of astronomy, of geology, of physical geography, and of elementary physiology. On the other hand, the scientific habit of mind, which is the principal benefit resulting from scientific training, and which is of incalculable value, whatever be the pursuits of after-life, can better be attained by a thorough knowledge of the facts and principles of one science than by a general acquaintance with what has been said and written about many.

"The subjects we recommend for scientific *information* should comprehend a general description of the solar system, of the form and physical geography of the earth, and of such natural phenomena as tides, currents, winds, and the causes that influence climate, of the broad facts of geology, of elementary natural history with especial reference to the useful plants and animals. And for scientific *training* we are decidedly of opinion that the subjects which have paramount claims are experimental physics, elementary chemistry, and botany. The science of experimental physics deals with subjects which come within the range of every boy's experience. It embraces the phenomena and laws of light, heat, sound, electricity, and magnetism, the elements of mechanics, and the mechanical properties of liquids and gases. The thorough knowledge of these subjects includes the practical mastery of the apparatus employed in their investigation. The study of experimental physics involves the observation and colligation of facts, and the discovery and application of principles. It is both inductive and deductive. It exercises the attention and the memory, but makes both of them subservient to an intellectual discipline higher than either. The teacher can so present his facts as to make them suggest the principles which underlie them and which once in possession of the principle, the learner may be stimulated to deduce from it results which lie beyond the bounds of his experience. The subsequent verification of his deduction by experiment never fails to excite his interest and awaken his delight.

"Chemistry is remarkable for the comprehensive character of the training which it affords. Not only does it exercise the memory and the reasoning powers, but it also teaches the student to gather by his own experiments and observations the facts upon which to reason.

"Of the value of the elementary teaching in chemistry (at Rugby) there can be only one opinion. It is felt to be a new era in a boy's mental progress when he has realised the laws that regulate chemical combination and sees traces of order among the seeming endless variety. But the number of boys who get real hold of chemistry *from lectures alone* is small, as might be expected from the nature of the subject." W. MARSHALL WATTS

Giggleswick, April 15

We teachers must keep clear in our minds the two sides of the question: the relative educational value of the subject to be taught, and the age or capacity of the pupil. We may roughly classify sciences into those which cultivate the observing, and those which benefit the reasoning powers, though of course all sciences do both to some extent. Of the former, the only one which should be adopted systematically, in my opinion, is botany. Zoology cannot be as practically taught, though the *habits* of all kinds of animals afford infinite opportunity for training the observing powers of pupils in the country; which should be judiciously directed by the teacher so as to render the observations continuous and systematic as far as they go; they should be always duly recorded, dated, and correctly described. But the encouragement of making collections must be done cautiously, as boys are too prone to be thoughtlessly cruel. Of course information on animals may be given informally. With regard to botany nearly twenty years' experience of teaching boys and girls of all ages and of nearly all classes, has convinced me that it may be commenced as soon as one likes. The plan pursued by my father at Hitcham (of which an account will be found in the *Leisure Hour* for 1862, p. 676) clearly proved the advantage to be derived by village school children, and I can corroborate it by my own attempts in another village; for there was a marked increase in the general intelligence, to say nothing of botany giving the children an amusing and instructive employment in the fields instead of their idling in the street—a fact noticed and strongly approved of by their parents. This subject, whatever may be the objections to others, *can* be taught to almost infants.

With regard to electricity, magnetism, and the elements of chemistry, beyond the last of these, I have no experience, but should fancy that the manipulation required would be unattainable before the ages of eleven or twelve, and the abstract nature of force would scarcely commend itself to the understanding before that age.

Physical geography, however, is another subject which, although affording less scope for the observing powers as botany, is by no means absolutely wanting in this respect. I cannot say that my "young boys [were] more (or less) attentive, active-minded, diligent when they [were] doing arithmetic than when they [were] at a lesson on physical geography." One principle I would insist upon is to appeal to the eye, as well as or rather more than the imagination, of young people. Hence in teaching this science, where no direct observation of the facts is possible (as of glaciers, in Warwickshire), my plan was to procure abundant and good illustrations, while the chief facts connected with their motions and formations would be illustrated by diagrams on the black board. Yet the effects of river and atmospheric action may be actually seen, often to a considerable extent, everywhere; and marine action having been learnt and understood at school, has been eagerly looked for when a visit to the sea-side was forthcoming. Here, however, not only facts should be taught, but their causes, or forces in action which have produced them, and the study will then never be dry. Physical geography has its value in realising in the pupil's mind the true nature of sequences between cause and effect, and he thus begins to grasp the fundamental principle of philosophy or "continuity" of action. I have found boys of eight thoroughly able to appreciate the elements of the subject; of course by adapting the facts and reasoning to their capacities.

Physical geography, being simply "modern geology," should invariably precede geology, which above all subjects cultivates inductive reasoning, and I have found boys from about twelve well able to grasp the main facts and reasonings. If they happen to be near any fossiliferous strata or where a variety of rock specimens may be procured, the encouragement to collect as many as possible should be given at any preceding age, for the most fascinating pursuit in science is undoubtedly collecting. (I have to this day crag shells collected at the age of eight, when I was first initiated into geological mysteries.) Collecting, however, is of course only the preliminary stage, and one's scientific lore must not be allowed to rest there.

Before twelve I agree with Mr. Wilson that practical chemistry should not begin for reasons already mentioned. But, however, Mr. Wilson says, "Science should be introduced into a school, beginning at the top and going downwards gradually to a point which will be indicated by experience," surely this is inverting a fundamental principle of education, and we may ask why should science be thus singled out? Why not begin at the top with Latin and arithmetic, and work downwards? Science, however, has its "elements" and its "advanced" stages like everything else. The soundest method seems to me to select the science for each age or capacity of pupils, and for the teacher himself to adapt the branch selected to them. Let him begin with botany—with children of the age of six, if he pleases—and by using the schedule he will find it almost self-adapting to the child's powers, as I have more fully explained elsewhere (see a paper "On the Practical Teaching of Natural Science in Schools," *Educational Times*, March 1, 1876). Physical geography might come next with pupils from eight to twelve, then the experimental sciences or geology from twelve upwards. The observing of the habits of animals might go along with any other science as an out-door instructive amusement, and be limited to no age.

Mr. Wilson talks of the difficulty of a "bored and weary schoolmaster teaching science informally." Passing by the fact that if he be bored and weary, it is largely due to his own want of interest in teaching or in engaging that of his pupils; I would maintain just the opposite opinion, that assuming a teacher to be such, informal teaching in natural history has a wonderful invigorating effect and re-awakens the attention which may have become dull by monotony. Thus I have often found during a lesson in Latin, *e.g.*, Virgil's "Georgics," passages to be constantly occurring when "collateral science" can be invoked. And what is a proof of its value is, that it becomes suggestive to the pupils themselves, so that I have been obliged to check the superabundance of questions lest a Latin lesson should resolve itself into one on natural history.

Beyond such informal teaching as this I would never encourage it as a principle for teachers solely to act upon, with young children, though, of course there need be no restrictions in giving it them; but if science is to be *taught* at all—and all such informal methods are not really teaching—let it be thorough as far as it goes, lest it should lapse into a slipshod informality. It is the charm of the schedule system of botany that it demands close and accurate observation in the dissections, and the writing compels accuracy in the result as well as impresses the facts firmly upon the memory. Mr. Wilson is doubtless right in laying stress upon the necessity of securing abundance of capable teachers, which will probably ever be one of the chief difficulties to contend against.

GEORGE HENSLOW

NOTES

M. LEVERRIER has sent to M. Waddington, the French Minister of Public Instruction, a proposal for the immediate construction of the great refractor for the Paris Observatory, which is to be finished in two years and five months. A tender has been sent to M. Leverrier by M. Eichens, the constructor of the great reflector, for that purpose; M. Leverrier proposes the acceptance of M. Eichens' offer.

M. LEVERRIER has been appointed president of the Scientific Committee of the Assemblée des Sociétés Savantes, which is to be held at the Sorbonne next week.

AN Academy of Science has been established at Kansas City, Mo., United States, with appropriate sections for geology, zoology, botany, local history, numismatics, &c. One of the chief objects of the association is to form a museum of specimens which will represent the minerals and fossils, and the fauna and flora of Missouri, Kansas, and the territories.

FROM a communication received by the Scottish Meteorological Society from their observer at Stykkisholm, Iceland, dated