

It is the custom, at all of our best technical schools, to require a thesis for graduation. This thesis should always be based on careful experimental work continued for some months. It should, if possible, contain some real addition to the world's knowledge. The student cannot be expected to select, independently, a suitable topic. Indeed, where the higher degree of Doctor of Philosophy is concerned, students rarely select their own subjects. The wish of the students as to the nature of the topic should, however, be consulted. Subjects pertaining to industrial chemistry are especially appropriate, but topics pertaining to the pure science are not to be excluded, and indeed are often to be preferred because of the broader and deeper insight which they give to the student. Every technical school should hold before itself not only the purpose of giving to its students a sound preparation for industrial pursuits, but it should also contribute constantly to the increase of knowledge in those fields with which it has to deal. The reflex influence of such ideals on the instruction given is of the greatest possible importance.

The second phase of our question pertains to the accessory studies which the chemist should have. There seems to be a very prevalent notion that a chemist needs very little mathematics. With the rapid development of physical chemistry and the application of that branch of chemistry to technical problems which is soon to come, if not already here, such a view is no longer tenable. Every chemist, and indeed every one dealing with physical science, should have, at least, a knowledge of the calculus. In physics, a thorough knowledge of fundamental principles should be given and especial attention should be devoted to the subject of electricity. The methods used by engineers in testing structural materials should be acquired by ac-

tual use of the instruments employed for the purpose. Free-hand and mechanical drawing are almost necessary and some work in machine design is very desirable. In language, a reading knowledge of German and French should be acquired and the knowledge should be practically used in connection with current chemical journals. Except for lack of time I should advocate some work in biology. But, while there are fields in industrial chemistry where some knowledge of biology is absolutely essential, and while all chemists should know something in a general way about bacteriology, room can scarcely be found for these subjects without displacing something of more vital importance. In conclusion, I would say that the accessory subjects, especially, should not be slighted by the student. If he becomes a chemist he will certainly learn a very great deal about chemistry after he leaves school, but much of this other knowledge he is far less likely to acquire afterwards, and very much of it he will find practically useful if it is at his command.

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SCIENTIFIC BOOKS.

Plane and Solid Geometry. By ARTHUR SCHULTZE, Ph.D., and F. L. SEVENOAK, A.M., M.D. The Macmillan Company, New York.

The results of geometrical teaching in England are rather disappointing, if we are to judge by the reports and criticisms that have appeared in educational journals and scientific reviews. The blame is laid entirely on the system adopted, which is Euclidean pure and simple, and from which the universities and other examining bodies are unwilling to depart. It is good to be conservative; but it is also easy to overdo it. "Surtout pas trop de zèle" was Talleyrand's famous injunction. It applies as well to conservatism in pedagogics as it does to conservatism in politics. Euclid's text was excellent in his

day and for his purposes, and continued so for many a century.

The educational wants of our age are far more numerous, pressing and diverse than when the Greek geometer taught in the schools of Alexandria 2,300 years ago. We must remember, too, that it was before admiring throngs of men that he unfolded book after book of his 'Elements,' men who were attracted round his cathedra more by the knowledge that he had to impart than by the mental training to be derived from his teaching. The geometrical truths that Euclid discussed before his mature scholars have to be placed to-day before the undeveloped minds of mere tyros and placed before them as only one of the many elements of their daily pabulum.*

The necessities of our times call for less verbosity, prolixity and iteration than we find in Simson's rendering of Euclid, which is the orthodox text in English schools modified somewhat by Todhunter, Hamblin Smith, Mrs. Sophia Bryant and others. The whole presentation of the subject is decidedly hard and

* Here are the latest from *Nature* of January 16, 1902: "Mr. W. C. Fletcher, headmaster of Liverpool Institute, says that 'six years' experience in teaching geometry has led him to believe that Euclid is a great hindrance to ninety-nine boys out of every hundred in training and knowledge. A great deal of damage is done by insistence, not only upon the particular method, but on the particular order of Euclid" (p. 262).

A letter signed by mathematical teachers in the great public schools of England such as Eton, Harrow, Rugby and Winchester contains the following momentous acknowledgments: "It may be felt convenient to retain Euclid; but perhaps the amount to be memorized might be curtailed by omitting all propositions except such as may serve for landmarks. We can well dispense with many propositions in the first book. The second book, or whatever part of it we may think essential, should be postponed till it is needed for Book III., 35. The third book is easy and interesting; but Euclid proves several propositions whose truth is obvious to all but the most unintellectual. The fourth book is a collection of pleasant problems for geometrical drawing; and in many cases, the proofs are tedious and uninteresting. No one teaches Book V." (p. 258).

deterrent. Think of Book II. and especially Book V., also Books XI. and XII., and try to realize the hardship, the worry and vexation of spirit they have caused! A different sequence of propositions is needed, as well as shorter demonstrations and modern methods. When we want to cross a stream, we do not go up one bank to its source and down the other; but avail ourselves of a bridge, a ferry or an electric launch if handy.

Nor is prolixity the only salient fault of Euclid's 'Elements'; it lacks suggestiveness and fails to adequately stimulate the inventive faculty of the student. It leaves him but too often unable to think out a simple matter for himself, to originate a plan of attack or even to act on a hint. He can appreciate a neat solution to a rider; he is receptive, but not creative enough; a good consumer but poor producer.

On the other hand, we have found boys very different who had worked out their Davies or Robinson or other simplifier or improver of Legendre's great work. They had a clearer apprehension of the meaning of geometrical truths and firmer grasp of them. They usually showed marked readiness in applying their knowledge, in extending conclusions, detecting flaws and attacking problems. There was a resourcefulness and a vigor about their ways that bespoke the benefit which they derived from the subject. It was less a task imposed upon them than a congenial study. Here, then, we have the full realization of the twofold end of all undergraduate study, viz., culture and utility; or, to put it otherwise, the awakening of the faculties and the acquisition of knowledge.

Euclid might well say to Ptolemy that there was no royal road to geometry; but all the same, such a work as the 'Plane and Solid Geometry' of Dr. Sevenoak and Dr. Schultze will go far toward smoothing the way for the young geometer and inspiring him with a liking for the subject. The letterpress and figures leave nothing to be desired; the demonstrations are well spaced, short and suggestive. The arrangement of the propositions follows a logical and pedagogical order, and the exercises, which form an integral part of

the work, bear evidence of having been selected for the purpose of gradually and systematically leading the student to do some independent thinking and original work. From every point of view this elementary work on 'Plane and Solid Geometry' is a commendable text-book.

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Zoology: An Elementary Text-book. By A. E. SHIPLEY, M.A., and E. W. MACBRIDE, M.A. (Cantab.), D.Sc. (Lond.). New York, The Macmillan Company. 1901.

This is a neatly gotten up general zoology of xxii and 632 pages, with 349 text figures. The text is divided into 23 chapters, of which the first is an introduction of 12 pages briefly reviewing the properties of living things and defining a number of general terms and phrases. The remaining pages are apportioned in order as follows: Protozoa 27, Cœlenterata 29, Porifera 7, Introduction to the Cœlomata 6, Annelida 28, Arthropoda 87, Mollusca 39, Echinodermata 40, Brachiopoda 6, Polyzoa 5, Chaetognatha 4, Hemichordata (*Balanoglossus*) 5, Cephalochordata (*Amphioxus*) 14, Urochordata (Tunicates) 9, Craniata 259, Platyhelminthes 21, Nemertinea 5, Rotifera 8, Nematoda 6, Index 16.

Putting aside likes and dislikes, one must admit that this is a pretty fair distribution. We cannot, however, see what is gained by considering the Cœlenterata before the Porifera, and the Flatworms, Roundworms, Nemertean and Rotifers after the Mammals. Logical and natural sequence of generalizations is not without distinct value and interest, and from this point of view such an apparently insignificant matter of detail as intervening the Cœlenterata, or any other group, between the Protozoa and Porifera becomes important.

On the whole, the treatment of the phyla is good. In each group of animals some more or less representative form is described in considerable detail, and other forms of interesting habits or having a bearing upon some principle or generalization are noted. The systematic tables avoid the shoals of details and briefly characterize only the phyla, classes,

subclasses, orders and suborders. Under the final division of the group considered one to three genera are named as examples. The book being an English one, we are not surprised to see American forms somewhat slighted. The nomenclature is not always the most modern, but that is a matter of such minor importance in an elementary text that it may be overlooked. In some respects the authors have not always lived up to the excellent principles laid down in the preface. With them we believe technical terms and phrases should, so far as practicable, be elucidated in connection with the first presentation of forms illustrating them. We naturally expect to find radial symmetry noted in connection with the Cœlenterata, but it is first mentioned on page 80 in the introduction to the Cœlomata. As a rule the principle is lived up to in good shape. The very limited space given to embryology and physiology is in our opinion a real defect. It would have been better to make room for more of this by cutting out portions of the general accounts. We also believe that taking up a phylum by beginning with a consecutive account of some form as a type is the proper plan for an elementary text-book. In this respect the treatment of the Arthropoda, which is comparative, is inferior to that of the Annelida and other phyla.

To write a good text-book on zoology is no easy task, and to write one acceptable to every one is an impossibility. The most that should be expected of a text-book is positive and continuous assistance to teacher and pupil. Successful teaching lies with the teacher and not in the text-book.

The book before us is well gotten up. The typographical work is good, the figures as a rule are clear and the page is clean and inviting. While in some respects it still leaves room for improvement, we consider it one of the best and most worthy of recent elementary text-books on zoology.

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Gustav Theodor Fechner. Rede zur Feier seines hundertjährigen Geburtstages gehalten von Wilhelm Wundt. Leipzig, Engelmann. 1901.