which this movement will have when once it is in complete operation. It is a comparatively easy matter now for the colleges to take care of this short-course work and a considerable amount of secondary work, because the number of students so far have been comparatively limited in each state. But as we approach the time when we are to have half a million students in agriculture in secondary schools it is going to be a very different proposition. In the near future the colleges will have all they can do to take care of the students in regular college courses in agriculture. The special agricultural schools will fill a great need by attracting the more mature students who would not go to the ordinary high schools, and the ordinary high schools will have plenty of agricultural students of proper high-school age.

As I said, I believe the standard courses in these special agricultural schools should not be narrowly vocational, but should conform, in a general way, to the general standard for the high-school system in the state, and they should be organized so as to connect them definitely with the general educational system of the state. To do this it will probably be found necessary in the case of schools that have shortened the school year to twenty-four weeks of six days each, instead of thirty-six weeks of five days each, to add another year to the standard course, making it five years instead of four. But it would be desirable that besides the standard courses which would prepare the student for college or for life, as the case might be, such schools should have shorter courses more purely vocational.

SCIENTIFIC BOOKS

Experimentelle Untersuchungen über Atomgewichte. Von Theodore William Richards und seinen Mitarbeitern. Berlin, 1909.

In this fine octavo of 890 pages, Professor Richards has brought together, in German translation, the many papers upon atomic weights which, during the past twenty-two years, have been published by him and his collaborators. These researches are already well known to all chemists who are interested in the accurate determination of these fundamental constants, and the results obtained have received very general acceptance. Their collective publication, however, is highly suggestive, and deserves a careful review.

The first of these researches, that upon the atomic weight of oxygen, was carried on by the late Professor J. P. Cooke, with the cooperation of his then student, Richards. The latter began his independent work with a revision of the atomic weight of copper, which was followed by papers upon barium and strontium. Afterwards, Professor Richards had the assistance of his advanced students, and with their aid the atomic weights of zinc, magnesium, nickel, cobalt, iron, uranium, calcium, cæsium, sodium, chlorine, potassium, nitrogen, sulphur and silver have been redetermined, and apparently with the greatest possible accuracy. There is no reasonable doubt that the work done has been a great advance upon all previous investigations of similar purport; but as Professor Richards would himself admit, it is neither final nor absolute. Our knowledge of physical constants is obtained by what may be called a method of successive approximations; but absolute accuracy is unattainable. The researches now before us represent, in all probability, the closest approximations to the truth as yet reached, but that statement does not imply the impossibility of future improvement. Such improvements are likely to be small, however, and to affect only the minor decimals.

In reviewing the work so far done, one can not help noting the steady advance in experimental technique. The later determinations appear to be of a much higher order than the earlier ones. Indeed, several of the papers in the volume are devoted to improvements in manipulation, or to the exposure of constant errors against which the investigator must be always on his guard. The bottling apparatus in which materials are prepared for weighing, and the nephelometer by which mere traces of precipitates are recognized, represent improvements in apparatus. The purification of

materials is elaborately studied; the errors due to occlusions of gases by metallic oxides, and of water by crystallized salts, are pointed out; and by attention to minutiæ of this kind the accuracy of the determinations has been greatly increased.

In general, with a few exceptions, Professor Richards has confined himself to one group of methods, namely, the analysis, by known processes, of metallic chlorides and bromides. These, in nearly all instances, involve a knowledge of the atomic weight of silver, through which the atomic weights of the other elements are referred to that of the standard, oxygen. That is, ratios are determined, from which, with reference to silver as the experimental standard, the other atomic weights are computed. At first, the secondary standard $Ag = 107.93$, established by Stas, was accepted; latterly, however, it has been shown by several authorities that $Ag = 107.88$ is nearer the truth, and that the true value may even be slightly lower. This change produces corresponding changes in the other atomic weights; a condition of affairs which is not altogether satisfactory. In most cases each atomic weight determined by Richards is a function of the atomic weights of silver, chlorine and bromine, and these have been, in effect, three variables. Theoretically they are constants, but the values found for them have varied, and the variations are far reaching in their effects. The great exactness of Richards's work is in the measurement of definite ratios, which, once established, form the basis upon which our knowledge of the atomic weights must stand. As the variations in the reference values diminish, the accuracy of our deductions will increase.

From one point of view it is well that the Harvard chemists should have devoted themselves, not exclusively, but in great part, to one group of methods. Those methods have been perfected, their sources of error have probably been reduced to a minimum, and the measurements made with their aid leave little to be desired. Considered more broadly, however, it is desirable that other, radically different methods should be developed with equal thoroughness. Not until that has been done, not until closely agreeing determinations of atomic weights have been made by several distinct reactions and processes, can we regard these constants as sharply established. Work of this sort, especially with reference to the more fundamental atomic weights, is now going on in several laboratories, among which may be mentioned that of Guye, at Geneva. Within the next ten years our knowledge of the atomic weights is likely to be greatly increased. Meanwhile, the work of Richards and his colleagues must be assigned preeminence.

F. W. CLARKE

Elemente der Exakten Erblichkeitslehre. By W. JOHANNSEN. Deutsch wesentlich erweiterte Ausgabe in fünfundzwanzig Vorlesungen. Jena, G. Fischer. Pp. vi + 515. Gebunden, 10 Marks.

The epoch in evolutionary study opened by deVries's "Mutationstheorie" had been one not only of experimentation, but also, fortunately enough, of thoroughgoing analysis. We had analysis of evolution in sufficient amount, even *ad nauseam,* in the latter part of the last century; but the newer speculations are based on novel, experimentally acquired facts, and the marvel of it is that they bear little resemblance to the conventional and orthodox teachings which we accepted almost without question a decade or two ago. It is to the shame of biological science that it must be acknowledged that it was long contented to accept these speculations as fundamental principles without testing them experimentally. But all that is now happily by and the era of framing hypotheses for the purpose only of testing them is well launched.

Of the old ideas, those grouped about variation have undergone, perhaps, the completest analysis. And they needed it too, for if one thing is clearer than another, it is that Darwin and his followers did not analyze the phenomena of variation satisfactorily. It is almost pathetic to see in his letters and books how he fails to distinguish the fundamental differences between fluctuating non-inherit-