variations, theory of functions, elliptic functions, geometry and trigonometry, analytic geometry of plane and space, differential geometry, probabilities, calculus of errors, quaternions and vector analysis. Under each of these and other topics is a brief summary of the subject, often containing items that are not elsewhere so easily found.

Mechanics and Physics cover a wide range: Lagrange's equations, spherical harmonics, graphical statics, work and energy, hydrodynamics, elasticity, heat, sound, light, electric units, laws and measurements, electromagnetism, induction, hysteresis, Maxwell's theory, etc. Numerous tables accompany the text.

In arrangement and style the "Taschenbuch" reminds one of Pascal's "Repertorium of Higher Mathematics." It is, however, only about one third as large, and in mathematical content only one ninth. All references have been excluded under the heavy compression. But every mathematician and physicist will find it a useful book to have about, for it will often save searching through a library for an elusive item.

F. N. Cole

Vergleichende Anatomie der Wirbeltiere. Dr. Robert Wiedersheim. Seventh edition. Pp. 936, 476 figures, one plate. Jena, Gustav Fischer. 1909.

The rapid growth of this book, which now contains nearly a thousand pages and costs between five and six dollars, has transformed it from a text-book into a reference work. As such it will without doubt be as indispensable as in previous editions. It retains, however, much the same character as before.

It is pleasing to an American to note the large recognition of American work, but one regrets that in one or more instances the facts are recorded in footnotes only.

The text is brought up to date by the addition of new material on almost every page and certain sections are essentially rewritten, as for example, the discussion of the lymphatic system, which is more than twice as large as before. The chapter upon the skull has grown the most owing to a large degree to the introduction of more figures of chondrocrania. The section upon myology ought, it seems to the writer, to have received more attention than it has had. The subsection upon the electrical organs certainly ought to have been rewritten so as to embody recent discoveries. The sections upon the central nervous system, sense organs and the respiratory system have expanded about equally. The discussion of the peripheral nervous system is but slightly longer, but it has been largely rewritten and is greatly improved.

The sixty new figures are well chosen. A considerable number of illustrations which have appeared in several editions could well be dispensed with, and the printing of many of the old figures in colors has added little if at all to the usefulness or beauty of the book.

The bibliography has been thoroughly revised, a very large number of new titles have been added, and, owing to the omission of many of the older or less important titles, there has been only a small increase in size.

This edition can be heartily commended.

Leonard W. Williams

Lectures on the Experimental Psychology of the Thought-Processes. By Edward Bradford Titchener. New York, The Macmillan Company. 1909. Pp. xi + 318.

In these lectures, originally delivered at the University of Illinois in the spring of 1909, and now published with an appendix containing valuable notes and references, Professor Titchener presents a résumé and criticism of a much-debated recent development in experimental psychology—an attempt to extend the experimental method to the processes of thinking. The extended series of articles which are chiefly considered—though contributions by other psychologists receive due notice—have emanated from the pupils and colleagues of Professor Külpe at Würzburg. The principal names are Marbe, Watt, Ach, Messer and Bühler, and the dates run from 1901 to 1908. Many other writers, whose work or views bear on the problem, are considered in the notes or in the two introductory lectures.

The early experimental psychologists considered the higher intellectual processes too

complex for experimental control, and it is of interest to discover whether this early judgment is now superseded, and whether, quite apart from results, a method has been devised for experimenting on thought. The method now suggested is certainly direct and obvious. The person whose mental processes are to be observed is given a problem to solve; in some experiments the problem has been of the easiest, in others it has demanded careful attention; but in all cases it has been such that a solution could be reached in a few seconds, at the end of which time the thinker is required to describe what had passed through his mind in the process of solution. It is essential to the method that the same general sort of problem be set many times in succession, and that the preliminary consciousness intervening between the signal "Ready!" and the propounding of the particular problem should be described, as well as the consciousness transpiring between the propounding of the problem and the attainment of the solution. Whatever else may be said of the method, it has at least produced a large mass of data regarding matters which had previously been the subject of only casual observation. The method has been sharply criticized by no less an authority than Wundt, on the ground that it does not fulfil the essential requirement of experimental observation. In a proper experiment, as Wundt says, the observer knows beforehand exactly where his attention must be directed; the field of observation is narrowed, and the observation is consequently more minute and accurate than in ordinary circumstances. In this new work, however, the observer, who is also the person experimented on, does not know beforehand exactly what he has to observe, and, besides, must devote his attention first of all to the solution of his problem, and only secondarily to the observations which are desired. With this line of criticism, which is evidently the old, familiar objection to introspection in general, our author seems not to agree. He regards the work so far done as a promising beginning, except that too much has been attempted at once, and that some of the experimenters have been contented with observations on what the thought was about, instead of insisting on a description of the thought as a mere conscious fact.

As to the results of this work, one at least has been gained, and is freely admitted by Professor Titchener. It will be remembered that the problems set in any one series were of one general nature, which was understood beforehand. The thinker becomes adjusted to this general task, as is shown by the fact that the propounding of the particular problem is usually followed promptly by a course of thought leading to or towards the solution, to the exclusion of numerous other associations which might otherwise be recalled by the words, etc., used in putting the problem. The preliminary adjustment limits or directs the play of association. Yet, usually, no consciousness of the nature of the task can be detected in the interval between the setting of the particular problem and the reaching of the solution. What consciousness there is of the nature of the task comes in the preliminary period, after the ready-signal; and, even here, as the series of similar problems progresses and the task becomes familiar, the consciousness of it tends to be reduced, and finally to disappear, though the adjustment to the task is all the time improving. This result is valuable both as illustrating the relation of consciousness to mental function, and as indicating a dynamic factor in thought. In both respects, the result is not entirely new, having been foreshadowed, in another field, by conclusions of some of the early students of reaction times (Exner, Cattell, Lange); but it has now received a much wider extension.

Another curious result is the frequent occurrence, in these experiments, of states of mind in which one is clearly aware of the task in hand, or of the solution, or of some other fact, but is unable to detect any image or sensation, or anything which can be described except as the "thought of" so and so, or the "knowledge that" so and so. Some of the experimenters, particularly Bühler and the present reviewer, have been content to regard this description adequate, and to conclude that such "thoughts" were elements of

consciousness, irreducible to complexes of sensations and images, and of a kind hitherto unrecognized by most psychologists. Our author disbelieves altogether in the elementary character of such thoughts; he emphasizes the crudeness of the methods employed, and believes that more refined study will probably reveal vestiges of images and sensations of bodily attitudes, as components of what has been called imageless or non-sensorial thought.

In addition to its main purpose, the book is valuable as throwing a clearer light than any of his previous writings on the author's guiding principles in psychologizing.

R. S. Woodworth

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Some Suggestions for the Study of Comets[1]

Comets are, probably, the most mysterious of all celestial objects. Whence they come; whither they go, when they leave forever; where they gather fresh material, if they do, and how; their mechanical structure; the forces that commonly bind them together; the other forces that sometimes tear them apart; the origin of the curious knots, twists and streaks in their tails; and why it is that they are self-luminous, are among the things concerning comets we should like to know, but which, at present, no physicist and no astronomer can tell us.

It is but natural therefore that the return and near approach of Halley's comet should arouse unusual interest and activity in the study of these strange objects, for it is bringing us a rare chance, especially if, as seems likely, the earth should pass through its tail, of learning much that we would like to know in regard to comets and their accompanying phenomena. But to make such a study most efficient it is necessary to consider what phenomena may possibly be expected, and how they can be observed.

These form two distinct groups, namely: (1) celestial, astrophysical in the main; (2) terrestrial, chiefly meteorological. Among the former are:

(*a*) *Gross Appearances.*—This includes all distinctive markings, such as bright patches; streaks, both straight and twisted; number, direction and shape of tails; time and manner of beginning and ending of tails; and any other such phenomenon as may present itself to the observer. A photographic record, as nearly as practicable continuous, should be taken of these phenomena for future study, but it would be well to supplement the photographs by numerous eye observations.

Any one expecting to do work of this nature, and there are many observatories adequately equipped for it, would do well to consult Professor E. E. Barnard, of the Yerkes Observatory, either directly or through his papers on comets.

(*b*) *Spectrum.*—Visual and photographic analysis of the light should be applied to the comet in detail—to the jets and envelopes in and about the head, to the streaks in the tail and to all portions bright enough to yield results.

Such a program, while of decided value, can not profitably be undertaken except by those observatories especially well equipped for this sort of work.

(*c*) *Polarization.*—It is known that the light of comets is polarized to some extent, from which it is inferred that a part of their luminosity is due to reflected sunlight, but this phenomenon needs further examination, and, in particular, separation from sky polarization. It would be well to compare the polarization of that part of the comet where a right angle exists between the directions from it to the sun and the earth, respectively, with the polarization of other portions. If the particles of the comet are small in size, compared with the cube of an average wave-length of light, then, as Rayleigh has shown, there will be

[1] This paper was prepared at the request of the comet committee of the Astronomical and Astrophysical Society of America for inclusion in its circular respecting observations of Halley's comet. Through causes for which its author is in no way responsible it did not reach its destination in time to be so used and the committee now seeks to give it publicity through the pages of Science and such other journals as may choose to reproduce it.