enabled to follow the erratic variations of the former instruments through all the changes of pressure to which they were subjected in the course of his travels. Armed with this experience, on his return to London, he undertook a series of systematic experiments, not only with the instruments that he had used on the Andes, but also with a large number furnished for the purpose chiefly by Messrs. Hicks and Casella. These were subjected to conditions which reproduced as nearly as possible those experienced on the journey, and their behaviour was noted under all the varying circumstances. The results of these experiments were that all aneroids, when brought under a low pressure, continue falling for four or five weeks, and in some cases longer; that the amount of the total fall varies greatly with different instruments; and that, in general, two-thirds of the fall takes place in the first week. Mr. Whymper says: "I have seen the index error of an aneroid grow to as much as four inches; in several instances there have been alterations of more than an inch, and in numerous instances there have been alterations from scarcely appreciable errors to + or − errors of two or four tenths of an inch." On the other hand, aneroids that have been kept for some weeks at a low pressure, when restored to the full pressure of the atmosphere, take many weeks to regain their condition of equilibrium; and when they have attained this final condition, their readings are sometimes higher, sometimes lower, than their original values at the same pressure. The greater part of the recovery takes place in the first week, and a considerable part in the course of the first day.

Notwithstanding this sluggishness of action, Mr. Whymper finds that the aneroid may be usefully employed for measuring differences of altitude when all the readings are taken within a short interval of time; the shorter the better, so that the data compared are only the first effects of the changes of pressure; and this equally whether the base station is at a high or low level. He gives an instance of this in his determination of the depth of the great ravine of Guallabamba, north of Quito, at the top of which his mercurial barometer read 21·692 inches, and the two aneroids that he carried with him gave readings respectively 0·552 and 0·752 inch too low. But when the three instruments were next read, two and a half hours later, at the bottom of the ravine, the mercurial barometer indicated a rise of 2·237 inches, and both the aneroids a rise of 2·260 inch, involving an error of only 1 per cent. In this instance, the difference of elevation as shown by the aneroids was vitiated by a very small error, but the absolute heights above sea-level as obtained from their readings would involve errors of more than 600 and 800 feet respectively.

That this was no accidental result was subsequently confirmed by an experiment on twenty-two aneroids (all having large but very varied errors). After these had been kept a week at a pressure of 21·692 inches (of the manometer), they were gradually restored in the course of two and a half hours to a pressure of 23·929 inches; and, with a single exception, the rise of the aneroid readings ranged between 2·130 and 2·360 inches, the mean of the whole being 2·218 inches.

As the general result of his experience, Mr. Whymper concludes that all aneroids lose on the mercurial barometer when subjected to diminished pressure, and that the loss is the greater the greater the reduction of pressure; that when diminished pressure is maintained continuously, the loss commonly continues to augment during several weeks, but in a constantly diminishing ratio; that when pressure commences to be restored, the aneroid endeavours to recover the previous loss, and some gain more than they have lost; but the recovery is gradual, and usually extends over a greater length of time than the period during which the diminished pressure has been experieneed; finally, that the index errors of aneroids are never constant, so that apparently no process of verification can be trusted to yield corrections for permanent application, even though time be made a factor of the correction formula.

It was no part of Mr. Whymper's purpose to go deeper into the matter, and to ascertain wherein lay the source of the irregular action of his instruments. But it is evident that this must be known before we can look for any important improvement in the construction of the aneroid. In all probability it lies in the varying elasticity of the thin corrugated disk that forms the cover of the exhausted chamber, the alternate rings of which are thrown into a state of strain and stress in the process of exhaustion, and which strain and stress are varied with every change of the external pressure. Perhaps some clue to the cause may be found in the results of Mr. Herbert Tomlinson's experiments on the elasticity of metallic wires after deformation by tension or torsion,[1] since he found that, after such treatment, the metal takes a considerable time to recover its normal elasticity. It is, indeed, by no means certain that such changes of pressure as were dealt with by Mr. Whymper are sufficient to produce deformation, but the aneroid affords a very delicate measure of any change of elasticity in the corrugated disk, and there is so much resemblance in the results of Mr. Whymper's and Mr. Tomlinson's experiments as to make it at least not unlikely that there is a community of cause.

Meanwhile, travellers must bear in mind that unless the aneroid can be frequently verified by comparison with a mercurial barometer, its indications can be trusted only for such small differences of elevation as can be measured within an interval of a very few hours. A rough verification can, indeed, be obtained with the boiling-point thermometer, as is recommended by the authors of "Hints to Travellers," and this will at least enable them to avoid large and accumulated errors. A fair idea of the degree of accuracy that may be expected of this latter instrument in practice, is afforded by Dr. Scully's simultaneous observations of the mercurial barometer and the boiling-point thermometer in his journey over the Karakoram from Leh to Yarkand, which will be found in vol. i. of the "Indian Meteorological Memoirs." H. F. B.

WALLER'S HUMAN PHYSIOLOGY.

An Introduction to Human Physiology. By Augustus D. Waller, M.D. (London: Longmans, Green, and Co., 1891.)

IN these days, when the cult of the examination fetish is in the ascendant, and we are rapidly approaching the condition of the unchanging students of Confucius,

[1] Phil. Trans. 1883.

it is natural that the first question a student asks about a new book on physiology should be, "Is it the book for the College?" or the M.B., or whatever may be the examination most in vogue at his school. And this question is typical of the effect of examinations for evil, of their tendency to make men read exclusively up (or down) to the requirements of the examiners, disregarding the fact that the elementary physiology and anatomy they learn are to furnish their only weapons with which to attack the, for them, far weightier problems of pathology and treatment in their medical and surgical aspects.

On the other hand, it is a consolation to think that a good text-book must extend its beneficial influence to examinations as well as examinees, and thus improve the physiological teaching, not only by providing a trustworthy book of reference for the students, but also by putting a stop to cramming for examinations, which now forms so large a part of the teaching at London schools; for so surely as examinations improve will cramming assimilate itself to the proper teaching, and so become a work of supererogation.

I may say at the outset that Dr. Waller's book falls into the latter category, and is really the best recent work in the English language on human physiology. It presents a complete elementary account of the present state of the science, and is especially distinguished from the text-book most in vogue at the present time by its objectivity. Without loading his text with references and names, Waller retains personal interest in his work, and quotes original experiments sufficiently to attract the attention of the reader, and to give him (so far as is possible in a text-book), a real knowledge of the subject, and opportunity to discriminate between the diverse views with which the science is burdened.

I mean, no reader is compelled to accept the facts he learns here on the *ipse dixit* of the author. The facts are presented plainly enough, and their significance discussed, but the student can, if he has the habit of thought, weigh the evidence for himself, and perhaps come to a different conclusion from the author.

If we may be allowed to alter the context of a sentence of the preface, giving references and original experiments is useful "because it helps to correct that credulous bias or primitive 'suggestibility' which is a physiological property of the human brain, and only too apt to be fostered by unmitigated bookwork."

Dr. Waller follows the time-honoured division of the subject into vegetative and animal physiology; the latter, which includes the nervous system and its instruments, occupying half the entire work (270 pages).

Some might consider this too much space to be devoted to this part of the subject in a book intended primarily for, and certain to be used chiefly by, medical students. But one must consider that no other department of physiology can be so immediately applied to clinical work as that treating of the nervous system. In fact, a third year's man, who has learnt this well, requires merely a little book knowledge to recognize the most recondite forms of nervous disease, which would hopelessly elude the diagnostic powers of many an older practitioner, less versed in the latest advancements of neurological science.

In the eye wards, too, an exact knowledge of the working of the normal eye is absolutely essential, and one often hears oculists complain that they have to teach students the physiology of the normal eye before they can start on their own proper subject; and this is partly owing to the fact that these subjects are perhaps the hardest part of physiology, and partly because the student comes to them at the end of the session, and is tempted to treat them as coming last also in importance. This, however, he will be unable to do if he takes the work before us for his text-book.

The second part is treated evidently *con amore*, and is an excellent account of this branch of physiology. The introductory chapter on "The General Plan of the Nervous System" (which occupies only ten pages) is especially to be commended for its lucid brevity, the outcome of a masterly grasp of the subject.

This chapter is followed in order by the physiology (1) of the peripheral organs, muscle and nerve; (2) of the sense-organs, eye, ear, &c.; (3) of the central organs, spinal cord, spinal bulb, and brain.

The section on muscle is prefaced with a short account of the chief instruments used in electrical experiments on muscle and nerve, and of Ohm's law.

The fulness with which nervous physiology is treated will make the work very acceptable to general readers, and especially to those who wish to acquire a physiological standpoint from which to attack the problems of psychology.

The first part of the work—"The Phenomena of Nutrition"—treats adequately of the subjects of the blood and circulation, respiration, nutrition, excretion, and animal heat, but does not quite reach the high standard of excellence of the second part.

In a second edition one would like to see the questions of coagulation and of the origin of urea treated a little more fully and precisely. Its value, too, as a text-book would be much improved if the headings at the beginning of each chapter were also incorporated in the text, or put at the side of the page so as to arrest the reader's attention.

The whole work shows evidence of careful revision, and is marvellously free from mistakes or printers' errors. On p. 103, in describing the effect of the interrupted current on the ventricle, it should be mentioned that the frog's ventricle is meant, and not the mammalian.

In conclusion, I may mention that the work is furnished with a useful bibliography (confessedly incomplete) and a good index. E. H. STARLING.

OUR BOOK SHELF.

Bulletin of the New York Mathematical Society. Vol. I. Nos. 2, 3. (New York: 1891, November, December.)

NO. 2 opens with an article by Truman H. Safford founded upon three volumes of the "Catalog der Astronomischen Gesellschaft" (vols. iii., iv., xxiv., Leipzig, 1890), in which a sketch of the modes of observation since Bradley's time is given, and the excellence of the plan formulated by Argelander upheld. Prof. M. Merriman discusses the problem in least squares,—"to determine, by the method of least squares, the most probable values of a and b in the formula $y = ax + b$ when the observed values of both y and x are liable to error." An account is then given of a new Italian mathematical journal (*Rivista di Matematica*), edited by G. Peano, the cha