mental facts appear nearly inexplicable in the actual state of this theory; nevertheless, if we had only the "Réflexions" to guide us, we should have to regard him as an adherent of the caloric hypothesis. Carnot died of cholera in 1832, and some forty years elapsed before the publication of his note-book showed how his views had changed since 1824. We have only space for one extract.

"On peut donc poser en thèse générale que la puissance motrice est en quantité invariable dans la nature, qu'elle n'est jamais, à proprement parler, ni produite, ni détruite. A la vérité, elle change de forme, c'est-à-dire qu'elle produit tantôt un genre de mouvement, tantôt un autre; mais elle n'est jamais anéantie."

Then follows an estimate of the number of units of heat required for "la production d'une unité de puissance motrice"! One cannot help wondering what might have happened if he had lived a few years longer, or if his views had not remained so long hidden.

As it is, the subsequent development of thermodynamics has not been the work of one person or of one country. The chapters in which Prof. Mach traces its growth, are amongst the most interesting in the book. One of his titles—"Das Mayer-Joule'sche Princip"—recalls a controversy the echoes of which have not yet died away, and indicates his position with reference to it. That position is one which many of our countrymen will not willingly accept; any more than they would accept the statement made on p. 261—"Im Grunde ist der Weg, auf dem Joule zu seiner Entdeckung gelangt, sehr ähnlich demjenigen Mayer's." But it would be unfair to allow such brief quotations to lead to the inference that the author is unfair or influenced by national bias. On the same page he draws attention to the soundness of Joule's scientific method; points out that he never befogged himself with metaphysical considerations; and that his theories were always based upon or controlled by experiment. Nor can we justly apportion the credit due to Mayer without considering the circumstances under which he thought and wrote, or without realising how imperfect (see his correspondence with Bauer and Griesinger) was his knowledge of physics. In the technical skill, the clearness and completeness of Helmholtz's paper "Ueber die Erhaltung der Kraft," we have a complete contrast to Mayer's writings. After an account of the progress which thermodynamics owes to the researches of Clausius and Lord Kelvin, we have the following comparison of the manner in which they presented their investigations to the world.

"In his exposition, Thomson is always quite frank and straightforward in dealing with the difficulties which meet him, the course that he strikes out is always the shortest and simplest, his methods are perfectly clear, and the motives which guide him in his investigations are visible to every one. In Clausius's exposition, there is always a touch of ceremony and reserve. Often one scarcely knows whether Clausius is more concerned to make a statement or to suppress it. The principles of the subject, instead of being deduced from simple experiences, are built up on specially assumed fundamental propositions; these look as though they were more reliable, but do not really offer any greater security than the experiences which might have replaced them. He has, too, a predilection for creating new names and ideas, which are not always necessary. But none of these personal and unessential peculiarities can mar the respect which we feel for Clausius's work."

Further chapters are devoted to the principal propositions in thermodynamics, the absolute scale of temperature, the principle of energy, and the relation between physical and chemical progress.

Up to this point we have nothing but praise for Prof. Mach's treatise: it will do much to revive interest in a subject which has suffered temporary eclipse by the larger developments in recent times of electrical science. The style is clear and forcible, and a due sense of proportion is shown in the arrangement of the subject-matter. We admire his mathematical skill, his critical insight, and the fairness with which he endeavours to apportion praise. The student will find him a trustworthy guide, and the teacher will recognise the frankness of a colleague who knows where the difficulties are and does not slur them over.

To some the remainder of the book will be of equal interest, as it undoubtedly is original, and after the author's own heart. But the reader who has bargained only for a historical and critical exposition of the principles of heat and thermodynamics, may be excused for feeling that he has been betrayed. For in the last twelve chapters Prof. Mach takes the bit between his teeth, and roams at will over the domains of scientific thought, philosophy, psychology, the theory of cognition, language, aesthetics, metaphysics and mysticism. To say that there is a "manifest solution of continuity" between these and what precedes, would be incorrect; but the choice and arrangement of subjects is somewhat kaleidoscopic and bewildering. In the absence of any index, reference is difficult (though here we may be confusing cause and effect). When we want to refer to an ingenious suggestion for inducing sparrows to progress by running instead of hopping, we find it in a footnote to a chapter on "Die Sprache"; while an interesting observation on the suckling and weaning of children finds place in a footnote to a chapter on "Der Begriff." This term (*Begriff*) is defined in a previous chapter on "Die Vergleichung als wissenschaftliches Princip," in which the author also discusses the question, *Was ist eine theoretische Idee?* Perhaps the most highly variegated chapter is that on "Der Sinn für das Wunderbare."

The proofs of the book have not been carefully read. There are misprints in the German text, and still more in the English quotations and references. The diagrams are numerous and clear, but the half-dozen full-page illustrations are not a great success. Joule is represented by a coarse reproduction of Jeens' engraving. The portrait of Clausius seems to be the best. That of Lord Kelvin is the worst; at any rate, it is as bad as it well could be.

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CELL-STRUCTURE AND REPRODUCTION.

The Cell in Development and Inheritance. By Edmund B. Wilson, Ph.D., Professor of Invertebrate Zoology, Columbia University. (Columbia University Biological Series IV.) Pp. xvi. 371. (New York: The Macmillan Company. London: Macmillan and Co., Ltd., 1896.)

ORIGINALLY produced as the substance of a series of lectures of a popular character upon the problems of individual development and inheritance, the book

which Prof. Wilson has given us has taken a form which, while it can hardly longer be described as "popular," will be admitted by the more strictly scientific audience, to which it is now better adapted, to be in the highest degree fascinating. The advances which cellular biology has made, and is making at the present moment, can only be described as "leaps and bounds," and to no part of the study of the cell will this apply with greater force than to that dealing with cell-propagation. A question which seemed to our fathers, and for the matter of that to some of ourselves not so very many years ago, as of the simplest nature and capable of being described in half a dozen lines, can no longer be adequately dealt with except in a volume devoted exclusively to it, and by men who make its study the business of their lives. And although works in other languages upon the subject, such as those of O. Hertwig and Henneguy, are available for the student, it is none the less a matter for congratulation that Prof. Wilson has given us in our own speech a work which is second to none in the clear and comprehensive manner in which the facts of cell-structure and division are set forth, and the masterly way in which the principal theories which have been founded upon these facts are stated and criticised. Not the least striking feature of the book is the lavish way in which it is illustrated—a prime necessity in a work of this kind if it is to be easily read and understood. At the same time it is clear that the illustrations are carefully selected in each case with the object of presenting either a special fact or idea. And although, as might be expected from his position as a zoologist, Prof. Wilson has for the most part relied upon material furnished by the animal kingdom in illustration of his subject, he has not hesitated when occasion has offered to draw upon the important series of observations which have accumulated of late years in vegetable cytology.

The subjects dealt with are, in the first place, the general structure of the cell, the phenomena of cell-division, the special structure of germ-cells (ova and spermatozoa), together with the parts played by the several cell-structures in the process of fertilisation, the formation of germ-cells and reduction of their chromosomes. These subjects occupy some two-thirds of the entire book. Much of the remaining third is occupied by an interesting discussion on the nature and probable function or meaning of the several organised constituents of the cell; including, besides the nucleus and its various parts, the centrosome and the so-called archoplasmic structures, *i.e.* the asters and spindle and attraction-spheres. Their chemical relations and their physiological relations to one another are next passed in review, and, lastly, the most abstruse part of the subject—that, namely, which concerns the relation of cell-division to development and inheritance—is dealt with. The able manner in which Prof. Wilson has succeeded in overcoming the difficulty of presenting the various modern theories of inheritance, which are associated with the names of His, Nägeli, Darwin, Roux, de Vries, Weismann and Hertwig, in a comparatively limited space, and with admirable clearness, can only be appreciated by those who have followed the long and apparently interminable manner in which these theories have, like the Pharaoh's serpents which were popular some years

ago gradually extended their voluminous coils from a small and apparently inert mass of material, until a theory is ultimately evolved, which, in Prof. Wilson's language, "demands for the orderly distribution of the elements of the germ-plasm a pre-arrayed system of forces of absolutely inconceivable complexity." "What lies beyond our reach at present, as Driesch has very ably urged, is to explain the orderly rhythm of development—the coordinating power that guides development to its predestined end." "The same difficulty confronts us under any theory we can frame." "The controversy between preformation and epigenesis has now arrived at a stage when it has little meaning apart from the general problem of physical causality. What we know is that a specific kind of living substance, derived from the parent, tends to run through a specific cycle of changes during which it transforms itself into a body like that of which it formed a part." "But, despite all our theories, we no more know how the properties of the idioplasm involve the properties of the adult body than we know how the properties of hydrogen and oxygen involve those of water." "We cannot close our eyes to two facts: first, that we are utterly ignorant of the manner in which the idioplasm of the germ-cell can so respond to the play of physical forces upon it as to call forth an adaptive variation; and second, that the study of the cell has on the whole seemed to widen rather than to narrow the enormous gap that separates even the lowest forms of life from the inorganic world." A statement of fact which we must all have recognised, although few of us ever venture to assert it so boldly as Prof. Wilson has here done.

A characteristic feature of the book is a glossary in which obsolete terms are distinguished from those still in use, and in which also are mentioned the name of the author first using the word, and the date of its employment. This and a sufficiently comprehensive, but not too voluminous, bibliography will greatly add to the general usefulness of this admirable work.

E. A. SCHÄFER.

PRACTICAL PHYSICS.

An Intermediate Course of Practical Physics. By Arthur Schuster, Ph.D., F.R.S., Langworthy Professor of Physics, &c., Owens College, Manchester, and Charles H. Lees, D.Sc., Senior Assistant Lecturer and Demonstrator in Physics in the Owens College, Manchester. Pp. xv + 248. (London: Macmillan and Co., Ltd. New York: The Macmillan Co., 1896.)

ALL who are engaged in the teaching of physics, and all who are interested in scientific education, will take up this "Intermediate Course" with the certainty of finding much in it that is helpful and suggestive, and they will not be disappointed. It fills a distinct place of its own, between the elementary text-books of practical physics and the more advanced manuals. To some, the fact that it has been primarily written with a view to a particular examination, may be a stumbling-block; but, on close examination, there will be found in it nothing that can be fairly considered as "cram." The authors are fortunate in having had the very best help in drawing it up, namely, the criticism of successive generations of