the moon about the earth undergoes no permanent alteration, introduced a considerable error in the coefficient of m^4 in the expression for the true longitude. Correcting the whole of the coefficients in the expansion as far as m^7 , Adams assigned a value to the secular acceleration that has not been sensibly disturbed by any subsequent investigation. This value is $5''\cdot7$, a quantity only about one-half of that assigned by Laplace, or of that which seemed to be demanded by observation. The minuteness of the quantity sought affords a good illustration of the powers of analysis. The acceleration of the moon's motion implies, of course, an approach to the earth, but the amount is less than one inch per annum, and this minute quantity is determined by theory to within about one-thousandth part of its true amount.

Such an investigation as this last, exhibits the patient examination which Adams was prepared to give to a term, the value of which has been frequently under review by methods that have long been pursued. It shows a confident reliance upon the accuracy of his judgment, the completeness of his work, and a refusal to be led by authority. But some later papers on the general method of treating the lunar theory will be better appreciated, as showing, perhaps, greater originality, and illustrating the application of the results of more modern mathematical inquiry to obtain greater accuracy with less expenditure of labour. It is curious to notice that but for a lucky accident, this peculiar method of treating the lunar motion, and which is likely to be much developed in the future, would not have been published by Adams himself. In 1877, Mr. Hill published his inquiry into the motion of the moon's perigee, in which is sought an absolutely accurate value of that part of c (the ratio of the synodic to the anomalistic months) which depends upon m alone. This is the historic problem that Clairaut successfully solved by adding the term depending upon m^3 , and thus supplying a confirmation of the Newtonian theory when it was most needed. Delaunay has since determined the numerical value of the series as far as m^9 , and possibly human patience could get little further by this process. Mr. Hill had recourse to quite a different method, which, as applied, gives the same accuracy that would be attained by carrying the series to m^{27} . The sight of this paper by Mr. Hill, seems to have reminded Prof. Adams that some ten years previously he had been at work on similar lines in order to arrive at an accurate value of g , which is related to the motion of the node in the same way that c is to the perigee. The differential equation which determines z , the moon's coordinate perpendicular to the ecliptic, is

$$\frac{d^2z}{dt^2} + \left(\frac{\mu}{r^3} + \frac{\mu'}{r_1^3}\right)z = 0.$$

Prof. Adams puts

$$\frac{\mu}{r^3} + \frac{\mu'}{r_1^3} = (n - n')^2 l^2 + 2q_1 \cos 2(n - n')t + 2q_2 \cos 4(n - n')t + 2q_3 \cos 6(n - n')t + \&c.,$$

and on solving this equation was led to the form that Mr. Hill had employed in his work. For Mr. Hill had made the general equations of motion depend upon a single differential equation having the form

$$\frac{d^2w}{d\tau^2} + \Theta w = 0,$$

where τ denotes the mean angular distance between the sun and moon, and Θ can be developed in a periodic series of the form

$$\Theta_0 + \Theta_1 \cos 2\tau + \Theta_2 \cos 4\tau + \&c.,$$

leading to the same infinite determinant in both cases. This is developed in a series of powers and products of small quantities, the coefficient of each term being given in a finite form. The similarity of method pursued independently by the two mathematicians, and the greater accuracy obtainable with less labour, seem to point to a new departure in the method of treating the lunar theory. Prof. Adams has indicated what appears to him the most advantageous method of treating this problem.

We can but barely mention one other of Adams's investigations, the discussion of the orbit of the November meteors. It is well known that the late Prof. Newton left undecided the periodic time in which the meteors revolved about the sun, indicating, however, the method which might lead to the settlement of the question by the discussion of the observed amount of secular perturbation of the node. By a method given by Gauss in his "Determinatio Attractionis," it is shown how to determine the attraction of an elliptic ring, such as the meteors form, on a point in any given position. By dividing the orbit of the meteors into a number of small portions, and summing up the changes corresponding to these portions, Adams found the total secular changes of the elements produced in each of the five possible periods that Prof. Newton showed might be assigned as the meteoric path. With only one of these periods, that of about thirty-three years, was it possible for the node to advance in the manner required by the several historical accounts of the meteoric display. With a thirty-three years' period, and with no other, the longitude of the node is increased $20'$ by the action of Jupiter, $7'$ by that of Saturn, and $1'$ by Uranus, thus $28'$ in all, giving a mean annual motion of $52''$, agreeing with the observed motion, and thus satisfactorily settling the periodic time in which the November meteors revolve.

Several other papers possess great interest, and evidence among other things much painstaking arithmetic. Such is the calculation of thirty-one of Bernoulli's numbers, and the computation of the Eulerian constant to 263 places of decimals. These may have been the occupation of his leisure moments. The reputation of Adams will ever rest upon the determination of the inverse perturbations of Uranus, the work on the lunar theory, and his inquiry into the period of the November meteors.

A CYCLOPÆDIA OF BIOLOGICAL THEORY.

Les Théories sur l'Hérédité et les grands problèmes de la Biologie générale. Par Yves Delages, Professeur à la Sorbonne. Pp. xiv + 878. (Paris: Reinwald, 1895.)

PROFESSOR DELAGES has produced in this large volume of 880 pp. royal octavo, a valuable exposition and critical discussion of the modern theories bearing upon the great problems of biology. The work is remarkable for the ability with which so vast a variety of theories and observations are epitomised and considered. Whilst the author does not profess to give

more than an outline of the chief doctrines concerned, it is the fact that there is no treatise in English or German which contains so useful a review of biological theory. Written as it is, with a patriotic motive—namely, that of inducing the rising generation of French zoologists to occupy themselves with the general theories (such as those of Darwin, Wallace, Weismann, Spencer, Naegeli, and others) which have, as he justly states, received far more attention in this country and in Germany than in France—the book should prove of very great value also to English students. This is sufficient excuse for now drawing attention to Prof. Delages' volume, although it was published more than a year and a half ago. So far as I am aware, it is not so widely known in this country as it should be on account of its comprehensive and thoroughly interesting character.

It is true that the preface to his work has caused some disagreement among the Professor's own colleagues. M. Delages in severe terms expresses his disapproval of the old school of zoological and botanical studies. He points out (and I think justly) that whilst French men of science have taken a leading part in the development of biological doctrine and methods of study during the century, yet that there has been during the past twenty years in France a tendency to "une fausse direction des recherches biologiques." For works or memoirs of importance bearing upon the great problems of general biology, there are, says M. Delages, for every one written in French, three in English and ten in German. He attributes this to the fact that French students have not had their attention sufficiently directed to these great problems. Accordingly, by a very remarkable effort, he has produced the present work which shall (and in my opinion does) serve as a cyclopædia of biological theory, by aid of which the French student may be introduced to this hitherto neglected field, and led to study for himself original authorities. In fact Professor Delages has, first of all by diligent study, corrected for himself what he regards as the defect in the current education of a French zoologist, and then has embodied his valuable abstracts and critical notes in the volume which he offers to the young men who come after him.

In spite of the fact that there are others in France who have recognised, as does M. Delages, the importance of modern theories in biology as stimulating and directly producing new observations, and thus building up the fabric of biological science, yet, on the whole, I am convinced that M. Delages is right, and that such a book as his was needed and will be very fruitful in France. It is so good a book that it will be of great service also in England.

It is true that M. Delages seems to have forgotten for a moment, in speaking of the growth of histological technique as foreign to France, that Ranvier, of the Collège de France, is one of the most original and fertile discoverers in this field at present living. It is also true that his colleague, Prof. Alfred Giard, who is surrounded by an enthusiastic band of disciples, has for many years taken actually the same attitude as that adopted by Prof. Delages, and has proclaimed the importance of the new theories, and insisted, not only by precept, but by example, on the necessity of carrying on observation and experiment in zoology in order to test

hypothesis, and to determine the truth or error of current theory, rather than let them take the form of exact but meaningless record of facts, pointing to no general conclusion. None the less, it seems to me that Prof. Delages' contention is true, and that, in spite of brilliant exceptions, biological science has too often followed a false direction in France (and no doubt in England also), owing to an ignoring of the great search-lights of theory which happen to have originated outside France. The tendency to which Prof. Delages alludes was sufficiently obvious to those who were able to watch, as many still alive did, the reception of Darwin's theory of the origin of species by natural selection in France, on the one hand, and in Germany on the other. There can be no doubt that the publication of M. Delages' book is evidence of the fact that what may be called "modern biological theories" are now receiving due attention in France, and that the brilliant originality and independence of thought, as well as honesty and ingenuity of observation which characterise French men of science, will more and more be directed to the solution of those great problems which occupy the attention of the biological world at large.

A brief sketch of the contents of Prof. Delages' book is all that the space of this article permits me to give. It is divided into four parts: Part i. The Facts; Part ii. Special Theories; Part iii. General Theories; Part iv. The Theory of Actual Causes. Under Part i. are treated (1) *The Cell*: its constitution, its physiology, its reproduction; an admirable *résumé* in ninety pages of the recent work, both on karyokinesis and the physiology of protoplasm. (2) *The Individual*: regeneration, grafting, generation, ontogeny, alternation of generations, sex and secondary sexual characters, latent characters, teratogeny, correlation, death and continuity of life, the germ-plasma. (3) *The Race*: heredity, variation, the formation of species. Under Part ii. we find statements of the following theories. (1) Speculative theories as to the structure of protoplasm and the cause of its movements, viz. the theories of Berthelot, of Verworn, of Quincke, and of Butschli; (2) theories of cell-division; (3) theories of regeneration; (4) of polar globules; (5) of sexual generation; (6) of the ontogenetic process; (7) of the parallelism of ontogeny and phylogeny; (8) of the origin of sex; (9) of teratogeny; (10) of death and of germ-plasma; (11) of heredity; (12) of the transmission of acquired characters; (13) of latent characters; (14) of telegony; (15) of hybridity; (16) of variation; (17) of the formation of species.

Under Part iii. we have statements and brief, but trenchant, criticism of the theories of "animism," "evolutionism" (spermatists and ovists), and "micromerism." Under the last term are included and considered the views of Buffon, Béchamp, H. Spencer, Haacke, Dolbear, Erlsberg, Haeckel, His, Cope, Orr and Maulia, and many others, including that of "ancestral plasmas" (Weismann), pangenesis (Darwin), stirpes (Galton), whilst "organicism" is the term applied to the theory of Descartes and to the auto-determination of Roux.

In the fourth and last Part are given "Idées de l'auteur," a retrospect and review of much of what has been already treated at greater length, with the definite introduction of the author's own conclusions. By this method of division

of his work, Prof. Delages has very successfully made clear to his reader the facts under consideration, the theories which have been advanced in relation to those facts, and finally his own judgment as to what is sound and permanent and what erroneous in current theories; whilst those theoretical views which are novel, and here put forward for the first time by himself, are kept distinct. A bibliographical index, of eighteen closely-printed pages, completes the work; and with regard to this long and useful list of books and memoirs, I may say that the impression given to a reader of M. Delages' book is that he has not merely cited the titles of this large mass of literature, but has actually performed the heavy task of reading and critically estimating each work thus catalogued.

It is, of course, inevitable that such a task as that undertaken by the author should not be accomplished without some omissions and some mistakes; but it is no little merit to have performed such a task conscientiously, as it has here been performed. The criticisms advanced by M. Delages may not always be those which commend themselves to another biologist; his own theoretical views, though always philosophical and worthy of full attention, may not be necessarily acceptable in every case. Yet the value of the work is not lessened by such considerations. He is no dogmatist, and candidly declares that the theories, which he for the present accepts, are open to correction and replacement with the progress of knowledge. The worthy and useful object of the book is, in short, not to impose a set of theories on the reader's mind, but to interest him in the theoretical aspects of biological phenomena, and to assist him, as far as may be, in arriving at theoretical conceptions which may guide his investigations, if he be a naturalist, or furnish him with a key to the more popular discussions of biological problems, should he be merely a philosopher, or even "un homme curieux des choses de la science." It is a book which should be read and closely studied by every young biologist. The full and comprehensive treatment of the subject has resulted in what must appear a formidable volume equivalent to some three or four modern manuals; yet the reading of it will be found to entail but little effort, on account of the lucidity of the author's method and the unflagging interest which he himself evinces in the successive sections of his work. It is, after all, a distinct pleasure to see English and German theories formulated in the clear logical phrases of the French language.

E. RAY LANKESTER.

COMPARATIVE MYTHOLOGY.

Contributions to the Science of Mythology. By F. Max Müller. Vol. i. Pp. xxxvi + 426. Vol. ii. Pp. ix + 427-864. (London: Longmans, 1897.)

IT has for some time past been tolerably well known by many that Prof. Max Müller was working at a treatise on comparative mythology, and with others we have been anxiously awaiting the appearance of the "last word" on the subject by the eminent Oxford professor. General interest in the matter has, moreover, been excited to a more than usual extent by the comments made upon the last edition of "Chips from a

German Workshop" by writers for the press and others, for all felt that the veteran expounder of dead and gone beliefs would rise in his might and rend certain of his critics who boldly stated that he stood alone, and was the only defender of a set of dying and dead theories. It seems that Prof. Max Müller hesitated for some time before he decided to publish the 864 octavo pages which form his present work, for he had almost made up his mind that he had arrived at a time of life when rest is more pleasant than work, and at a stage in his work where it was wise to stop and let the younger men carry it on in his place. Every reader of the volumes before us will be glad that the taunts of his enemies stung Prof. Max Müller into action; for, as he says, he had all along intended that his last work on comparative mythology should contain in a comprehensive form what he had hitherto written, and what he still wished to say, and he intended it to be the logical ending of a system of works which he had planned several years ago. On Language, Religion, and Thought he has already written learnedly and charmingly, and now that we have the volumes on the fourth subject, viz. Comparative Mythology, the system which Prof. Max Müller has elaborated is before us in its entirety. Those who seek for polemics or hostile observations upon critics and their rival theories will be disappointed in the perusal of this last section of the work, for he confines himself chiefly to re-stating his views and theories, and it is pretty clear that he has made up his mind to differ from his critics on fundamental principles and methods.

Prof. Max Müller quotes many great names in support of his views, and the general reader will find it very difficult to make up his mind which school he is to follow—the linguistic or the anthropological. The anthropological school holds that mythology is, on the whole, the narrative of the various grades through which the human race has advanced slowly towards what we call civilisation, and it proves many of its statements by drawing comparisons between the beliefs, manners and customs, and habits of savages which still exist on the earth, and those of the nations which have long since passed away.

Prof. Max Müller holds that mythology is the result of a period of moral decay, and a falling away from high moral and spiritual views; we must admit that our sympathies lie with the anthropological school, and we heartily wish that Prof. Max Müller had seriously set to work to classify and arrange the arguments which have been brought in line against him, and also that he had disproved many of the statements and facts alleged against his views. Some, too, will complain that little notice has been taken by him of the writings of men who, though they be his adversaries, are held in esteem by many thoughtful and intelligent people. With the details of the minor differences between the schools we have nothing to do, for, after all, they are only interesting to the experts themselves; we hear that Mr. Lang is about to write a refutation of the most recent expression of Prof. Max Müller's views, and we may be tolerably certain that the *minutiae* of the subject will not be passed over.

It is but just to call attention to the great learning and skill with which Prof. Max Müller has arranged his