might well fancy that the basalts marked by two birds lay upon, and were newer than, the granophyre marked with four. Let us all take warning thereby.

But it is time to leave this perilous ground, and come to matters on which there can scarcely be difference of opinion. If it were desired to direct a student to a paper from which he could gather a clear and comprehensive view of the manifold forms under which volcanic products present themselves, not treated in the abstract but brought home to him by concrete examples, none could be found better fitted for the purpose than the memoir before us. And if a beginner would learn a lesson of the way in which a geologist goes to work when he wishes to unravel and interpret a complex group of geological documents, he will here find both precept and example. A point or two may be specially noticed. The enormous area which is seamed across by dykes, presumably of the same date, enables us to realize the importance of underground volcanic action, which is necessarily hidden from view in the case of volcanoes now in activity. I first learned this lesson while traversing a similar district, fully three times as large as that treated of by Dr. Geikie, in South Africa In connection with the striking parallelism of a large number of the dykes, reference is fittingly made to the classical paper of Mr. Hopkins, which he used so pathetically to complain had proved of interest neither to geologists nor mathematicians. But the mention of this paper again makes me lapse into criticism. When I first, many years ago, made acquaintance with Mr. Hopkins's investigations, two of his conclusions struck me as on the face of them so improbable physically, that, though I felt the presumption of the notion, I could not help suspecting some hitch in his analysis. One such oversight, so obvious that I can now hardly believe it to have been made by so first-rate a mathematician, I then detected. The other I have no doubt will reveal itself to careful inquiry. But from a hasty reperusal of the paper I do not think that either of these slips, supposing both to exist, affects the conclusions appealed to by Dr. Geikie; and the agreement, as far as they are concerned, between theory and observation is as complete as can be. The skill with which Dr. Geikie uses his pencil to bring out the geological features of a landscape is well known: that his right hand has not lost its cunning will be evident from the two illustrations here reproduced (Figs. 2 and 3).

Reference has been repeatedly made to the proofs of enormous denudation since Tertiary times which the volcanic rocks we are dealing with furnish in lavish abundance; it has not been so often noticed that denudation has during the same interval made its effects felt on harder and more intractable rocks. But dykes furnish proof of this in a way which I believe has not been made the subject of comment. "The evidence of this denudation," says our author, "is singularly striking in such districts as that of Loch Lomond, where the difference of level between the outcrops of the dykes on the crest of the ridges and the bottom of the valley exceeds 3000 feet. It is quite obvious that, had the deep hollow of Loch Lomond lain, as it now does, in the pathway of these dykes, the molten rock, instead of ascending to the summits of the hills, would have burst out on the floor of the valley. We are therefore forced to admit that a deep glen and lake basin have in great measure been hollowed out since the time of the dyke." A point this in favour of the "gutter-theory."

A. H. GREEN.

THE THEORY OF PLANETARY MOTION.[1]

IN the work the title of which is printed below, Dr. Otto Dziobek seeks to develop the theory of the motion of bodies subject to attraction according to Newton's law. The author, in his preface, draws attention to the objectionable practice of the majority of writers of the present day, of treating the subject so briefly that many students scarcely get beyond Kepler's laws in their knowledge of the theory of the solar system. He has therefore prepared a work which is intended not only as an introduction to the study of this branch of astronomy but especially for those desiring an acquaintance with the higher productions of the masters in this science.

The book is divided into three sections. The first begins with the assumption of Newton's law, and then treats of the motion of two bodies about their centre of gravity, giving the usual deductions relating to the motion of the centre of gravity, to the projections upon the three co-ordinate planes of the areas swept out by the radius-vector in a given time, and to the form of the orbit described. In determining Gauss's constant of attraction, k, the author says that the unit of length is the major axis of the earth's orbit (he doubtless means semi-axis, though the statement is repeated on the same page, and a like oversight occurs on pp. 11 and 16); and then with 1 : 354710 as the earth's mass and 365·2563835 mean solar days as the length of the sidereal year, k is found = 0·017209895. This is the value found by Gauss, and given in his "Theoria Motus." This constant has been incorporated in many tables, and any change in its value would be attended with considerable inconvenience. But since the time of Gauss more accurate values of the earth's mass and of the length of the sidereal year have been found, and consequently a more accurate value of k may be deduced. To avoid this inconvenience, the above value of k is retained, and with the new values of the earth's mass and the length of the sidereal year the unit of length is determined. This unit of length is slightly greater than the earth's mean distance from the sun, but differs from it by less than a unit of the eighth decimal.

A collection of formulæ giving the relations between the radius-vector, the mean, eccentric, and true anomalies, as in Gauss's "Theoria Motus," is added, together with the usual expansions in series of these quantities. The expressions for the expansion of the eccentric anomaly and of the radius-vector by means of Bessel's functions are also added.

We next come to the general treatment of the problem of the motion of any number of bodies projected in any manner in space, and subjected only to their mutual attractions. Here, considering n bodies, we have the usual deductions relating to the invariable plane of the system, and to the sum of the products of the mass of each body into the area described by its radius-vector. The author then proceeds to simplify the case by discussing the motion when $n = 3$, and thus the case of the celebrated problem of the three bodies. Of this the usual outline is given, together with certain special cases of the problem, the lines of the investigations of Lagrange and of Jacobi being chiefly followed. A brief historical outline of the problem, and of the chief investigations thereon from the time of Lagrange up to almost the present day, closes the first section of the work.

The second section of the book treats of the general properties of the integrals introduced in the consideration of the problem of n bodies. The investigations of Poisson and Lagrange are discussed, and the development by these writers of formulæ for the elements of the elliptic orbit of a planet is given. And here, on p. 98, we again note the oversight before referred to, viz. that of putting a = the major axis of the orbit instead of the semi-major axis. Of course such a proceeding if it were carried on throughout would have no effect upon the developments which are obtained, except on their symmetry, but the author, after mentioning that the quantity a represents the major axis, immediately proceeds to use the quantity with its usual signification, viz. the semi-major axis. The oversight occurs again on p. 112, and again in discussing the canonical constants for the elliptic motion of a planet, and again

[1] "Die mathematischen Theorien der Planeten-bewegungen." By Dr. Otto Dziobek. (Leipzig: Johann Ambrosius Barth, 1888.)

in the investigations relating to the partial differential equation of Hamilton and Jacobi, where the author deduces Lambert's important theorem concerning the relations between the time of describing an arc of the orbit, the chord of the arc, the bounding radii of the sector, and the major axis. This last-mentioned theorem for the special case of the parabola was first discovered by Euler, a point on which the late Prof. Oppolzer used to insist; the extension of the theorem for any value of the eccentricity of the orbit being due to Lambert. A short historical sketch of the matter contained in this section, referring chiefly to the labours of Lagrange, Hamilton, and Jacobi, concludes this portion of the subject, and we come to the third section of the book.

This last section of the work treats of the theory of general perturbations. Here, of course, Lagrange's theory of the variation of constants plays an important part, and we have that part fully dwelt upon by the author. The development of the disturbing function is given, and here and there a simplification in the symbols might, we think, with advantage be introduced. In the expansion of $(r_1^2 - 2r_1r_2\cos\theta + r_2^2)^{-\frac{s}{2}}$ we have given the simple expression for half the coefficient of $\cos m\theta$ in terms of Gauss's hypergeometric series, viz.—

$$r_1^{-s}\,\frac{s(s+2)(s+4)\dots(s+2m-2)}{2m\,.\,m!}\,\alpha^m F\left(\frac{s}{2},\frac{s}{2}+m,m+1,\alpha^2\right)$$

The secular and periodic changes in the elements of the orbit receive the usual treatment, the stability of the solar system is discussed, and also the influence upon the results of terms in the higher powers of the eccentricity and inclination.

A few pages are also devoted to a point which writers are accustomed to say never occurs in the solar system—viz. commensurability of the mean motions of two planets. The importance of the subject treated in this section induces the author to extend the limits of the historical sketch with which he has concluded the two previous sections, and to give a little more fully the history of the important theory of perturbations; and he adds, in conclusion, that the best proof of the truth of Newton's law is in the discovery of the cause "of the observed irregularities in the motion of Uranus," a cause suspected by Bouvard and by Bessel, and a problem which death prevented the latter from undertaking, but which was "von zwei anderen Astronomen Leverrier und Adams gelöst." Speaking of the latter, the author remarks that "er seine Resultate einige Monate früher dem Astronomen Airy mittheilte"; the want of a "Durchmusterung," however, placed the optical discovery of Neptune in the hands of Dr. Galle.

At the end of the book are given a few small tables chiefly Leverrier's elements of the orbits of the major planets, except for Uranus and Neptune, Newcomb's more correct values of these quantities being adopted.

We note a few misprints. On p. 5, at the bottom, referring to the rotation of the axes, "$+x$ nach $+z$" should obviously read "$+y$ nach $+z$." On p. 11, for k_2 read k^2. On p. 45, in differentiating V, a homogeneous function of degree -1, the factor z of $\frac{dV}{dz}$ is omitted. On p. 46 it might be mentioned that $M = \Sigma m$. In the copy before us, pp. 225 to 240 are omitted, and pp. 273 to 288 have been bound in their place.

Regarding the whole book, we may say that there is much that may be found in any ordinary text-book on the subject. But the author has endeavoured to do more than give a mere sketch, as writers of the present day usually do, leaving the reader to search the pages of *Crelle's Journal*, the *Comptes rendus*, or some similar publication, for important papers connected with the subject. Where these have appeared useful, they have been introduced in a modified form if necessary; and where such papers are interesting, but beyond the scope of the present work, full references are given—a practice much to be commended. The author expresses a hope that he will be able to deal later with the theory of the rotation of bodies about their centres of gravity, the figure of the earth, &c., and with the theory of the tides; and we wish him the success which the present work augurs.

R. B.

NOTES.

DR. ALFRED R. WALLACE has in the press a new work on Darwinism, which aims at establishing the theory of natural selection on a firmer basis, and also deals with the various supplementary theories which have been put forth since the publication of the sixth edition of the "Origin of Species." The book will be published early next year by Messrs. Macmillan and Co.

PROF. GIARD'S first lecture at the Sorbonne is published in the *Revue Scientifique* (December 1). It was delivered before a large audience, and many hundreds of persons had to be content to stay at the door. The Thursday lectures of M. Giard are devoted to an historical sketch of embryology in its relation to the theory of evolution. The Saturday lectures are devoted to embryological phenomena, considered generally.

ON the 19th inst. a monument of the astronomer Leverrier is to be unveiled by the French Minister of Public Instruction, in the Cour d'Honneur of the Paris Observatory. The likeness of Leverrier is said to be very striking. The statue of Arago is finished, and has been sent to the foundry. It will be situated close to the Observatory Gardens, but is not to be put in its place until after the Exhibition.

THE well-known botanist, Dr. C. J. de Maximowicz, writing from St. Petersburg to Kew about Prjevalsky, whose last book we review to-day, says:—"Yes, poor Prjevalsky is dead, and I mourn for him like a brother. He was a splendid character and a highly gifted man. He died with his Expedition fitted out and ready to start. Under these circumstances, the Russian Geographical Society intends to appoint, as head of the Expedition, Colonel Pentsow, a good topographer, who has already twice been in Northern Mongolia. Lieutenant Roborofski, Prjevalsky's associate, and a very capable officer and good collector, who did the botanical work during the two last journeys, is to go also. The plan is to remain the same, perhaps with the exception of Lhassa and the investigation of Northern Tibet. But the Society will appoint this time a geologist, which it is indeed high time to do."

WE learn that the Hon. John Collier has just completed a portrait of Dr. A. W. Williamson, For. Sec. R.S. This portrait, which is to commemorate the thirty-eight years of Dr. Williamson's professorial work at University College, will be presented to the College by Sir Henry Roscoe, on behalf of the subscribers, on Wednesday, December 12, at 4.30 p.m. The subscribers to this portrait will give a dinner to Dr. Williamson on the same evening at the Freemasons' Tavern.

LAST Saturday, a very large meeting, convened by the Council of the Teachers' Guild of Great Britain and Ireland, was held at the rooms of the Society of Arts, Adelphi, to consider a subject which is likely soon to attract much serious attention—the organization of secondary education. The Guild numbers among its Presidents some of the most eminent authorities on higher education, as Heads of Colleges, Professors of the English, Scotch, and Irish Universities, the President of the Royal Academy, Prof. Huxley, and Mr. Mundella. Sir Philip Magnus, who presided, said that at present no public body was responsible for the secondary education of the country. There was no