One may even abandon hope of and desire for the equalization of intellect and still keep the essence of Professor Ward's optimism. For every one of the desirable consequences of the equalization of intellect may be gained as well, if not better, by the same amount of effort and wisdom directed toward its *increase*. Space is lacking for me to defend this somewhat rash amendment, which the author would probably repudiate.

EDWARD L. THORNDIKE.
TEACHERS COLLEGE, COLUMBIA UNIVERSITY.

Geometrische Kristallographie. By ERNST SOMMERFELDT, Privatdocent an der Universität. Tübingen. Pp. vi + 139, 31 plates and 69 text figures. Leipzig, W. Engelmann. 1906.

This is a book intended for advanced students of crystallography, written from the standpoint of the mathematician. Specifically limiting himself to the purely geometrical properties of crystal solids, the author develops his theme from the definitions of symmetry and in the first chapters defines the thirty-two recognized classes of crystals distinguished by varying grades of symmetry. These groups are variously classified and admirably illustrated by the plates which give for each of the classes the possible crystal forms and show very graphically the relations between them. In the following chapters the mathematical relations existing between the faces of the crystal are deduced and the fundamental crystallographic laws are stated. The mathematical processes, particularly vector analysis and the properties of determinants, which are chiefly involved are made the subject of a special chapter and their treatment is stated by the author to be original and to have an interest quite aside from the application to the problems of this work.

To the student actually engaged in the measurement and study of crystals the book offers little of practical interest except in the presentation of formulæ for the transformation of indices and axes which are here developed in very general form.

CHARLES PALACHE.

SCIENTIFIC JOURNALS AND ARTICLES.

THE contents of the *American Journal of Science* for September are as follows:

R. A. DALY: 'Abyssal Igneous Injection as a Causal Condition and as an Effect of Mountain-building.'

W. E. FORD: 'Some Interesting Beryl Crystals and their Associations.'

F. E. WRIGHT: 'Schistosity by Crystallization: A Qualitative Proof.'

M. R. CAMPBELL: 'Fractured Bowlders in Conglomerate.'

E. L. FURLONG: 'Exploration of Samwel Cave.'

T. L. WATSON: 'Occurrences of Unakite in a New Locality in Virginia.'

E. H. SELLARDS: 'Types of Permian Insects.'

R. H. ASHLEY: 'Analysis of Dithionic Acid and the Dithionates.'

The American Journal of Anatomy, Vol. V., No. 4, September 1, 1906, contains the following articles:

R. B. BEAN: 'Some Racial Peculiarities of the Negro Brain.' (With 8 tables, 16 figures and 12 charts.)

F. P. MALL: 'On Ossification Centers in Human Embryos.' (With 6 tables and 6 figures.)

J. L. BREMER: 'Description of a 4 mm. Human Embryo.' (With 16 figures.)

CHARLES R. STOCKARD: 'The Development of the Mouth and Gills in Bdellostoma.' (With 36 figures.)

THE July number of the *Journal of Mathematics* contains the following articles:

EDWARD KASNER: 'The Geometry of Differential Elements of the Second Order with respect to the Group of all Point Transformations.'

F. J. B. CORDEIRO: 'Gyroscopes and Cyclones.'

W. A. MANNING: 'On the Primitive Groups of Class Ten.'

VIRGIL SNYDER: 'On Certain Unicursal Twisted Curves.'

HENRY LIVINGSTON COAR: 'Functions of Three Real Independent Variables.'

DISCUSSION AND CORRESPONDENCE.

THE NATURE AND ORIGIN OF VOLCANIC HEAT.

IN SCIENCE for August 10 Dr. Elihu Thomson gives a theory of volcanic energy which he correctly describes as an extension of the ideas of Mallet. Having been recently much occupied with the theory of volcanoes in con-

nection with the larger problem of the cause of earthquakes, the formation of mountains and other phenomena connected with the physics of the earth, the discussion of Dr. Thomson has interested me, but I find it difficult to believe that either Mallet's original view or this ingeniously modified form of it is well founded. Dr. Thomson says: "A truly solid interior seems to be demanded by the accepted great rigidity of the body of the earth * * *." This view is very frequently expressed, but in my recent paper, 'Researches on the Rigidity of the Heavenly Bodies,' published in the *Astronomische Nachrichten,* No. 4104, July 10, 1906, it seems to be proved clearly and directly that the rigidity of the earth is not inconsistent with a fluid interior. And in another paper, not yet published, I think I have proved conclusively that a fluid substratum underlies the earth's crust. Accordingly, although I am an astronomer, and have shown in the paper above cited that the rigidity of the earth exceeds that of steel, and perhaps closely approaches that of nickel steel used in armor plate, it seems to me that geologists have adopted a mistaken course in conceding the solidity of the earth demanded by astronomers, for two reasons: (1) Rigidity does not really disprove internal fluidity; (2) the geological evidence of the existence of a fluid substratum is overwhelming, and this latter result is confirmed by my unpublished investigation on the cause of earthquakes.

In my paper on the rigidity of the heavenly bodies, above cited, the argument respecting the internal state of the earth is expressed as follows:

> It is, perhaps, worth pointing out that as a molten earth, in which the density follows Laplace's law, would have a mean rigidity of its layers equal to that of wrought iron, the hypothetical liquid interior would be much less easily deformed by tidal forces than has been generally supposed; so that reaction upon the enclosing crust probably would not be very conspicuous. The amount of this reaction would depend essentially upon the difference between the rigidity of nickel steel and of wrought iron, which is about one fourth of the rigidity of the whole earth as now constituted. Even if one supposed the interior of the earth to be liquid, the pressure to which it is subjected is so great that the tidal surgings of the nucleus, tending to deform the crust, would be comparatively ineffective; and if the crust of solid rock like granite be moderately thick, it is doubtful if the yielding would be sufficient to reduce sensibly the theoretical height of the fortnightly tides of the ocean. Accordingly it appears probable that the argument drawn from the tides against the fluidity of the earth's nucleus may in reality be somewhat less conclusive than the most eminent mathematicians have supposed. But from the accordance between the value of the earth's rigidity obtained from the theory of gravity with those found by Darwin from observations of the fortnightly tides, and by Hough from the prolongation of the Eulerian period for the variation of latitude, it seems impossible to escape the conclusion that the rigidity of our globe as now encrusted probably approaches that of nickel steel.
>
> It is scarcely necessary to add that the traditional theory long held by geologists that the earth's interior is a mass of mobile liquid in which currents still persist (cf. Fisher's 'Physics of the Earth's Crust,' second edition, pp. 246, 305, *et seq.*) when viewed from the gravitational standpoint is, therefore, found to be inadmissible. The great effective rigidity or viscosity of the matter within the earth makes any supposed motion of the imprisoned fluid quite inconceivable.

Thus, on the one hand, I have shown by strict mathematical reasoning from recognized data admitting of little dispute or uncertainty, that the rigidity is not inconsistent with internal fluidity, while on the other, I have made it clear that the free circulation of currents within the fluid nucleus would be impossible, owing to the rigidity depending on pressure. In fact the matter within the globe, as Arrhenius has also pointed out, may well be gaseous, simply condensed by pressure till it has an average rigidity exceeding that of steel. There are forces, however, which may produce motion just under the crust, which give rise to earthquakes.

Dr. Thomson's view that 'the flexures taking place in the earth's crust or in the outer portion of its mass may bring to bear upon deep-seated and, perhaps, already heated solid rock masses a sufficient pressure to cause them to readjust their positions,' and thus give rise to volcanic action, is in accordance

with many modern speculations on the cause of earthquakes, which ascribe these tremors to the slipping of rocks. My unpublished inquiry indicates that the true cause is very different. I regret that I am not yet able to give the chain of reasoning by which this result is established, but I may say that it is shown that one common cause underlies earthquakes, volcanoes, formation of mountains and islands, the elevation of plateaus, the feeble attractions of mountains noticed in geodetic operations, and the formation of great sea waves which frequently accompany violent earthquakes. All these phenomena are proved to be intimately connected, and I have shown that they depend upon a single cause, and that the earth's crust is underlaid by a fluid substratum in which the forces arise that disturb the crust.

It is nearly always assumed that changes in the earth's crust are due to secular cooling, but is that really so? When the truth comes to be known, I think it will be found that we have all been working on a false premise; a misleading hypothesis. In *Astronomische Nachrichten,* 4104, I have shown that rigidity prevents circulation, and, therefore, secular cooling would be confined almost entirely to the surface layers. Fisher and others have shown that the shrinkage due to the cooling of the crust is quite inadequate to account for the mountain folds observed upon the earth, which my researches show to depend on an entirely different cause.

Dr. Thomson is quite right in pronouncing against radium as a cause of volcanic action. The Hon. R. J. Strutt, of Cambridge, has shown that radium is very abundant in the rocks of the earth's crust, such as granite. If, therefore, we imagine radium to be the source of volcanic outbreaks, we should expect abundant eruptions to occur in all countries underlaid with granite—the United States, Europe, Asia, Africa, Australia, Brazil—which is contrary to observation. The well-known distribution of volcanoes invalidates the radium theory completely.

The Hon. R. J. Strutt, from his radium investigations, concludes that the internal temperature of the moon exceeds that of the earth. The observed low temperature of the lunar surface, however, contradicts this hypothesis, and thus we must be very cautious about ascribing too much to radium. The best experimental evidence available is that radium is a temporary form of matter, the energy of which must be renewed from other sources at intervals of 20,000 years, and thus it may play only an inappreciable part in the physics of the universe. So far, there is no evidence that it is an important cosmical agency.

The great forces which have most profoundly modified the world will be found to be familiar ones, which are overlooked mainly because they are so simple and so near at hand.

T. J. J. SEE.

U. S. NAVAL OBSERVATORY,
MARE ISLAND, CALIFORNIA,
August 16, 1906.

THE NATURE OF EVOLUTION.

ON returning from Central America I find Dr. E. A. Ortmann's paper in SCIENCE of April 27 under the heading 'Dr. O. F. Cook's Conception of Evolution.' Lest the use of this label deceive any possible patrons of the genuine preparation, it may be desirable to point out that the most important ingredients have been omitted, so that the peculiar virtues of my evolutionary eye-water are entirely lost!

To suppose that progress in evolutionary knowledge can be made by the arbitrary limitation and redefinition of terms would imply, of course, a very shallow and merely metaphysical apprehension of the concrete data of the subject. Nevertheless, conceptions of evolution have to be communicated through the medium of language, and language has to be explicit if it is to convey definitely outlined ideas. When there is a practical reason for doing so, a term may be used in a special sense, subject only to the obvious desirability that linguistic changes, whether of new words or of modified meanings, be kept down to the lowest possible limits which will serve the purposes of clear exposition for the subject in hand.