

general systems of *Sets*, *Matrices*, or *Algebras*; and without much further knowledge I should not attempt to write in any detail about such subjects. I may, however, call attention to the facts which follow; for they appear to be decisive of the question now raised. Cauchy (*Comptes Rendus*, 10/1/53) claimed *quaternions* as a special case of his "clefs algébriques." Grassmann, in turn, (*Comptes Rendus*, 17/4/54; and *Crelle*, 49) declared Cauchy's methods to be precisely those of the *Ausdehnungslehre*. But Hamilton (*Lectures*, Pref. p. (64), foot-note) says of the clefs algébriques (and therefore, on Grassmann's own showing, of the methods of the *Ausdehnungslehre*) that they are "included in that theory of SETS in algebra announced by me in 1835 of which SETS I have always considered the QUATERNIONS to be merely a particular CASE."

But all this has nothing to do with Quaternions, regarded as a calculus "uniquely adapted to Euclidian space." Grassmann lived to have his fling at them, but (so far as I know) he ventured on no claim to priority. Hamilton, on the other hand, even after reading the first *Ausdehnungslehre*, did claim priority and was never answered. He quoted, and commented upon, the very passage (of the *Preface* to that work) my allusion to which is censured by Prof. Gibbs. [*Lectures*, Pref. p. (62), foot-note.] I still think, and it would seem that Hamilton also thought, that it was solely because Grassmann had not realized the conception of the quaternion, whether as Ba or as Ba^{-1} , that he felt those difficulties (as to angles in space) which he says he had not had leisure to overcome. I have not seen the original work, but I have consulted what professes to be a *verbatim* reprint, produced under the author's supervision. [*Die Ausdehnungslehre von 1844, oder die lineale Ausdehnungslehre, &c. Zweite, im Text unveränderte Auflage, Leipzig, 1878.*] Prof. Gibbs' citations from my article give a very incomplete and one-sided representation of the few remarks I felt it necessary and sufficient to make about Grassmann. I need not quote them here, as anyone interested in the matter can readily consult the article.

In regard to *Matrices*, I do not think I have ever claimed anything for Hamilton beyond the *separable* ϕ , and the symbolic cubic (or biquadratic, as the case may be) with its linear factors; and these I still assert to be exclusively his. My own work in this direction has been confined to Hamilton's ϕ , with its square-root, its applications to stress and strain, &c.

As to the general history, of which (as I have said above) I claim no exact or extensive knowledge, Cayley and Sylvester will, no doubt, defend themselves if they see fit. It would be at once ridiculous and impertinent on my part were I to take up the cudgels in their behalf. P. G. TAIT.

The Spinning Ring.

I CANNOT suppose that the mathematicians are all in error; but venture modestly to ask what are the assumed conditions under which a girdle round the earth at the equator would be subject to strain. If the surface of our globe at the equator were continuous and level land, about 30,000,000 of persons—more than 1000 to a mile—standing at equal distances and joining hands, would form a girdle without any strain, or the girdle might be formed of separate pieces of wire placed end to end in close contact, which, if afterwards soldered, would form a girdle, without strain.

Then, it is stated, in *NATURE*, vol. xliii. p. 514, that a wire girdle supported on poles, if "relieved from gravitation," but acted upon by a (greatly augmented) "centrifugal force equal to the cable's weight"—that is, by an equal force acting in the opposite direction—would be subjected to a 20 fold strain. Why?

REGINALD COURTENAY.

4 Serjeants' Inn, Fleet Street, April 30.

BISHOP COURTENAY'S questions may perhaps be clearly answered as follows. The centrifugal force of a free spinning hoop has to be balanced by its peripheral tension; but this, having a large tangential and a small radial component, acts at a disadvantage, and may have to be very big to balance even a moderate centrifugal force. The larger the hoop the more marked is the magnitude of the tangential component as compared with the radial or effective component; so that a hoop 8000 miles in diameter could not rotate even once a day without tearing itself asunder.

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An actual girdle round the earth is not dependent on peripheral tension for balancing its centrifugal force, since it is subject to an overpowering centripetal force due to the earth's gravitation.

The statement made by Mr. Herschel on p. 514, vol. xliii., involved not a 20-fold stress but a 20-fold speed, which means a 400-fold stress.

OLIVER J. LODGE.

The Use of Startling Colours and Noises.

LAST January a friend showed me a smew (*Mergus albellus*) shot on the Dee, near Chester, the crop of which he had found to be full of young flat-fish. He called attention to the dazzling whiteness of the bird's breast, and suggested that it must frighten the fish, and so be a disadvantage to it. A little consideration showed that the effect would be precisely the reverse. As long as the flat-fish remains at rest, its colouring assimilates so closely to the sand on which it lies, and with which it partly covers itself, that it would not be easily seen by the smew. But if, startled by the white object flashing down on it from above, it moves, it is seen at once, and of course captured. Anybody who has ever collected small insects, such as beetles, will admit the truth of this at once.

The same effect is probably produced by the hooting or screaming of owls when hunting at night. A mouse, which would be invisible even to the sharp eyes of an owl when motionless, would be seen at once if startled into motion by the sudden "shout" of the bird, whose noiseless flight had brought it unperceived into close proximity.

Perhaps these suggestions may serve to explain other apparent difficulties in the way of natural selection.

The brown owl hoots throughout the winter here, so that it cannot be a sexual call.

ALFRED O. WALKER.

Nantyglyn, Colwyn Bay, May 25.

The Formation of Language.

I PERCEIVE that my note on the evolution of speech in the case of one of my children has excited some interest and called out communications both to myself and to you; but I must trespass again on your kindness to explain that what I considered noteworthy in that case was not the invention of words, which is not of rare occurrence, but the, to me, far more important phenomenon of the evolution of the habit of speech through the three stages, so distinctly marked in this case—of simulation, the faculty we share with the monkey, and which does not imply the possession of the idea; of invention of symbols, which indicates the birth of the power of conception, and perhaps the formation of what Max Müller calls "concepts," and the perception by the young mind of a community of interest and intelligence; and, finally, the faculty of learning from others ideas already formed, or what must be considered the germ of science: and it was the clear demarcation of the three states which interested me more than the mere invention of words. And this interest is the greater as the case appears to illustrate a law that the development of the individual follows the lines of the universal, so that the child but repeats, in a very much abbreviated sequence, what humanity had gone through as a whole. My purpose in bringing the case before your readers was rather to invite the repetitions of my observations with a view to the establishing of the law, than to publish an isolated phenomenon.

W. J. STILLMAN.

Rome, May 8.

Cordylophora lacustris.

IT will be interesting to zoologists to know that Prof. Weldon recently found very large quantities of *Cordylophora lacustris* on submerged roots and stems in the Rivers Ant, about Ludham Bridge, and Thurne, at Heigham Bridges, Norfolk. From my own knowledge, I can say that it is very generally met with throughout the whole system of rivers and broads in connection with the Bure. At the places spoken of, a fresh-water tide of from 6 to 18 inches is felt. I think I am safe in saying that a salt tide has but once been known so high up these rivers.

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