rotational movement of the whole system (that is, of the head) currents of liquid in a direction opposite to that in which the head is turned. The amount of the flow in each canal depends upon the plane in which the head is turned and upon the rate of the rotation. There are perfectly fixed relations between the rotational movement of the head and the currents in the inclosed liquid; if these currents can be perceived they will give us an exact account of the rotational movement of the head. We may regard, as possible organs for the perception of the currents, the so-called 'auditory hairs' which project at right angles inwards from a widened and flattened part of the canal; they are thus placed so as to be most sensitive to currents in the canal, and are on the other hand connected to nerves, of which they form the end-organs.

"To turn these facts to account in the sense of Goltz's theory we must assume that every flow of the endolymph, perceived by the ampullary nerves, produces a sensation of rotation of the head in the plane of the canal in which the flow takes place, and in a direction opposite to it, but that the perceptions of the six ampullæ of the two labyrinths combine to form a joint sensation. . . . .

"Our assumption has a necessary consequence. If the rotation of the head (of course along with the body) is kept up, the initial backward flow of the endolymph will be destroyed by friction against the walls. If the head then suddenly stops, the endolymph must, in virtue of its inertia, flow on in the sense of the rotation of the head; a sensation will therefore be produced of rotation of the head and body in a direction opposed to that of the previous rotation."

In this view the endolymph is held to lag behind the rotational movement of the head when this movement begins;—when the movement has continued at a uniform rate for some time, the endolymph is constrained, by fluid friction, to take part in the movement of the head, and if then the rotation of the head stops, the endolymph moves on. We have, thus, two ways in which a relative motion can occur between the endolymph and the walls of the cavity containing it:—1. When the head begins to move—here the walls leave the fluid behind. 2. When the head stops—here the fluid flows on. In both cases the sensation of rotation is felt. In the first this sensation corresponds to a real rotation, in the second it does not, but in both it corresponds to a real acceleration (positive or negative) of rotation, using the word acceleration in its technical kinematical sense.

Mach's view differs from Breuer's in this, that while Breuer assumes an actual flow of endolymph through the canals, Mach believes that the very narrow bore of the canals will preclude such a flow—the friction being so great that the most abrupt rotational movement of the head will not produce sufficient difference of pressure to cause an actual current. Instead of a current there will be produced a change of pressure in the ampulla, which would produce a current were the canal wider, and this change of pressure may be sufficient to act on the hair-cells, and irritate the ends of the nerves.

In Brown's statement of the theory, not the endolymph only, but the whole liquid and soft contents of the bony canals are supposed to lag behind the movement of the head, and in his first paper he suggested that there might be a relative motion between the bony and the membranous canals. This view, founded on the statement to be found in various anatomical text-books, that the membranous canals float nearly loose in the bony canals, is scarcely tenable when we know that the former are somewhat firmly attached at one side to the periosteum.

Another important point in which Brown's statement of the theory differs from that of Mach and from that of Breuer, lies in his regarding the two labyrinths as forming one organ, all the six canals of which are required to form a true conception of the rotatory motion of the head.

The doctrine of specific nervous action, now we believe generally accepted by physiologists, implies that while greater or less stimulation of an end-organ produces difference of sensation, a variety in the *mode* of stimulation cannot be perceived. Flow through the ampulla from the utricle to the canal on the one one hand, and from the canal to the utricle on the other, must produce a precisely similar sensation if the hairs of the hair-cells are equally moved. We must therefore look further for an explanation of our power of distinguishing between rotation in the one sense and rotation in the other sense about the same axis.

Mach was at first inclined to suppose that in each ampulla there are two sets of nerves each sensible to rotation in one sense only. He now adopts the explanation proposed by Brown, who based it upon the fact established by careful measurements in a considerable number of animals, that the *six* canals are sensibly parallel two and two. Thus the two horizontal canals are in the same plane, while the superior canal of one side is in a plane nearly parallel to that of the posterior canal of the other side. Further, in each of these three pairs (right and left horizontal, right superior and left posterior, right posterior and left superior), the two canals are so placed that when rotation takes place about the axis to which they are perpendicular, one of the two canals moves with its ampulla preceding the canal, so that the flow, or tendency to flow, is from ampulla to canal, while in the other the ampulla follows the canal and the flow, or tendency to flow, is from canal to ampulla. If, then, we suppose that flow from ampulla to canal—or, adopting Mach's view as stated above, *increase* of pressure in the ampulla—alone stimulates the hair-cells, while no effect is produced by flow in the opposite direction—or by *diminution* of pressure in the ampulla—we have in the six canals a mechanical system capable of giving us an accurate notion of the axis about which rotation of the head takes place, and of the sense of the rotation. To this explanation Dr. de Cyon objects that it assumes two organs, the superior canal of one side, and the posterior canal of the other side, which are not anatomically fellows, to be physiologically fellows. To this it is sufficient to answer that the motions which these two organs are supposed to perceive are produced by altogether different muscles. Let us take the case of the right superior and left posterior canal—the former is sensitive to rotation in one sense about an axis approximately passing through the left eye and the right mastoid process, a motion produced by muscles on the right side of the front of the neck, while the latter canal is sensitive to exactly the contrary motion about the same axis, and this motion is produced by muscles on the left side of the back of the neck. It is surely unreasonable to expect anatomical relations to exist between the organs perceiving two motions which do not exist between those producing them.

ALEX. CRUM BROWN

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

WE have already referred to the mathematical courses for session 1878-9 in Johns Hopkins University, Baltimore. The following is the detailed programme:—I. Prof. Sylvester will lecture on (*a*) determinants, (*b*) modern algebra, (*c*) theory of numbers. II. Dr. Story will lecture on (*a*) higher plane curves, (*b*) solid analytic geometry, (*c*) quaternions, (*d*) elliptic functions. III. Mr. Craig will lecture on hydrodynamics. IV. Lectures will be given by appointed instructors on (*a*) differential equations, (*b*) analytic mechanics, (*c*) conic sections, (*d*) theory of equations, (*e*) differential and integral calculus. V. Mathematical Seminarium:—A Mathematical Seminarium is conducted under the guidance of the Professor and Dr. Story; it comprises all the instructors and students of mathematics in the university. At its monthly meetings, besides occasional papers, such topics as may from time to time suggest themselves in the course of reading to the students or instructors, or may otherwise be of general interest to persons pursuing mathematical studies, are made the subject of free oral discussion. VI. Scientific Association:—The Scientific Association of the Johns Hopkins University meets once a month for the discussion of subjects of general scientific interest. At these meetings an opportunity is afforded for communicating abstracts of recent mathematical progress, as well as the results of individual research. VII. Mathematical Journal:—"The American Journal of Mathematics" is published quarterly in the City of Baltimore, under the auspices of the Johns Hopkins University, and affords an efficient medium of intercourse between members of the university engaged in original investigation, and a wide circle of mathematicians in America and in Europe. VIII. All the mathematical journals published at home and abroad are taken in by the university. At the Peabody Library complete sets of "Crelle's Journal" and the most important scientific transactions are also accessible. The university library and reading rooms are open daily from 9 A.M. to 10 P.M.

THE Calendar of the Yorkshire College for its fifth session, 1878-9, forms a volume of 140 pages. The college has now day classes in the following subjects:—Mathematics, experimental

physics, chemistry, geology and mining, coal mining, biology, engineering, classical literature and history, modern literature and history, modern languages, oriental languages, and textile industries, and evening classes in all the above except experimental physics.

In reference to the question of help for lectures to the scientific societies of English public schools, a correspondent sends a Harrow list as a suggestion to other schools. He believes that all the hon. members who are masters shown in the list have delivered addresses to the society; the rule always was to invite the most eminent among the strangers who gave lectures to become hon. members. Hence several well-known names connected with literature or science are among the latter.

The Working Men's College, which was founded by the late Frederick Maurice, in 1854 (and which naturally sustained a heavy loss by his lamented death in 1872), with a praiseworthy desire to extend its usefulness, has arranged for a series of general and popular lectures, which are intended to be perfectly free, not only to Students of the College, but also to the general public. With this view the Council has managed to secure the aid of such men as Professors Corfield and Lowne, Dr. Casson and Mr. Frederick Harrison, all of whom take part in these lectures between this and Christmas. This attempt to render the public uses of the College much more prominent than heretofore will not, as it appears, in any way interfere with its ordinary and recognised functions, and will not in any degree impede its class teaching, which has always been of the highest character. Various courses of scientific lectures by Mr. Dunman and Mr. Owen are announced.

SCIENTIFIC SERIALS

Journal of the Cincinnati Society of Natural History, July. Vol. i., No. 2.—This number gives earnest that good work is meant by the members. Its contents are chiefly interesting to palæontologists, who will find in it a list of lower silurian fossils of the Cincinnati group, by Messrs. J. Mickleborough and A. G. Wetherby, together with descriptions of many new forms found in these strata, by Messrs. Ulrich and Miller.

Reale Istituto Lombardo di Scienze è Lettere, Rendiconti, vol. xi. fasc. xiii.—We note the following papers in this number:—Causes and circumstances influencing hereditary transmission in animals (continued); Participation of the nervous system in the phenomenon of fecundation, by Signor Lemoigne.—Anæsthesia and anæsthetics in mediæval surgery, by Prof. Corradi.—Influence of water on the spinning of the cod of the silk-worm, and on the quantity and quality of the silk, by Prof. Gabba and S. Textor.—On some facts relating to saccharification of amides in the digestive process, by Dr. Solera.

Journal of the Franklin Institute, August.—This number opens with a discussion, by Mr. Isherwood, of some instructive experiments on the expansion of steam in the steam-engine.—A new method of grinding glass specula is described by Prof. Elihu Thomson, the principle of it being the fact that when two equal discs of glass or other material are ground together, one above the other, the under one always becomes convex, while the upper one becomes concave, and by making the strokes of the upper disc wide and sweeping, this change of form may be greatly accelerated.—Dr. Morton gives an account of the singing telephone as made at the Stevens Institute of Technology.—A new method of reduction for diffraction spectra observations is communicated by Dr. Rosenberg.—The problem of perforated pipes, as applied to "sprinklers" (a pipe system lately introduced into cotton-mills for preventing the spread of fires), is investigated by Mr. Frizell.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, September 30.—M. Fizeau in the chair.—The following papers were read:—Formation of an astronomical museum at the Observatory of Paris, by M. Mouchez. This is to include portraits of astronomers and *savants*, a collection of medals, drawings and photographs of celestial objects and phenomena, ancient instruments, &c.—Experimental facts showing that abundant sudoral secretions are not necessarily connected with excessive activity of cutaneous circulation, by M. Vulpian. In a dying cat, *e.g.*, when the heart's action is much weakened, and the digital parts are bloodless, the sweat exudes freely from these parts.—Remarks on the phonograph and the telephone, by M. Bouillaud.—Determination of the exact number of irreducible co-variants of the binary cubo-biquadratic system, by Prof. Sylvester.—Industrial utilisation of solar heat, by M. Mouchot. This describes experiments made during the Exhibition. *Inter alia*, he set in action, on September 2, a solar receiver with mirror having an aperture of about twenty square metres. It had, at the focus, an iron boiler weighing, with accessories, 200 kilogrammes, and having a capacity of 100 litres (30 for the steam chamber and 70 for the liquid). In half-an-hour the 70 litres were raised to boiling, and the manometer soon registered 6 atm. pressure. On September 22, with slightly veiled sun, he got 6·2 atm., and worked, under a pressure of 3 atm., a Tangye pump raising 1,500 to 1,800 litres of water hourly to the height of 2 m. With a clear sky on the 29th ult. 7 atm. was reached.—Discovery of a small planet at the observatory of Ann-Arbor, by Mr. Watson.—On intra-mercurial planets, by M. Gaillot.—On molecular attraction in its relations to the temperature of bodies, by M. Levy. To know all the isothermal and all the adiabatic lines of a body, and so to be able to study it completely, it is necessary and sufficient to know *two* of its isothermal lines and *only one* of its adiabatic lines.—On losses of charge produced in the outflow of a liquid when the section of the flow undergoes a sudden increase, by M. Boussinesq.—On the rotary power of quartz and its variation with the temperature, by M. Joubert. The angular coefficient of the curve of variation increases at first pretty rapidly up to 300°. From this to 840° (the boiling point of cadmium) it is nearly constant and the curve nearly a straight line with point of inflexion about 500°. Beyond 840° and up to 1,500°, the rotatory power increases only with extreme slowness. With a quartz of 46·172 mm., giving a rotation of 1,000° at zero, the increase from 300° to 900° is twelve minutes per degree. With a quartz of only 11 mm. the increase would still be three minutes per degree. Thus quartz makes an extremely sensitive thermometer, with the essential condition of comparability.—Phonic wheel for regularisation of the synchronism of motions, by M. Lacour. An iron-toothed wheel turns with its teeth very near an electro-magnet which is caused to exert periodic attraction by means of a vibrating diapason.—On the presence of isopropylic, normal butylic, and secondary amylic alcohols in the oils and alcohols of potatoes, by M. Rabuteau.

CONTENTS