If the solid is melted it is called a fluid, and is commonly supposed to be unable to withstand a shearing stress. This is due to the following circumstance: Let us press down A. If B did not move, then B would have to follow A, if it were not that in a fluid the atoms no longer oscillate about a fixed point, but change their positions relatively to one another. The atom B moves at ordinary temperatures at a velocity of somewhere near 100,000 centimetres per second. The distance between any two atoms is somewhere in the neighborhood of 1/100,000,000th of a cm. Consequently in the 1/1,000,000,000,000,000th of a second, the atom B will have passed without the radius of attraction of A. Consequently we see that for any forces which are impressed in a greater time than $10^{-13}$ second, the fluid will have no rigidity. But if the force is applied in less time, we have no reason for supposing that the fluid will not resist shearing, or that a water tuning fork could not be constructed at the centre of the earth. For, if we accept the electrostatic theory of cohesion, the force which A exerts on B when A is pulled down travels at the rate of more than $10^{10}$ c. m. per second. As B will have to move say $10^{-8}$ c. m. to get out of the way of the pull from A, we see that if an impulse is given in less than $10^{-18}$th of a second, B will be pulled down, and the fluid will resist a shear. And it is this force which acts to join the atoms together which gives rise to the phenomenon of surface tension. Consequently we see that if the ether has rigidity, whether it be a solid or a fluid, it must have surface tension.

Let us take the case of two bubbles of air in water. There is a surface tension at the junction of the air and water, and it may be shown that the effect of this is to bring the two bubbles together. A similar result would follow if the two bubbles had their places taken by two drops of water hotter than the rest of the water. Or if the drops were made up of a number of concentric shells, the density of each shell being greater than that of the shell next inside it, the equivalent of such a shell would be produced by sticking the prongs of two tuning forks into the water, for at those places where the velocity of a prong was greatest the density of the water in unit volume would be least, and the forks would be attracted. So if we suppose the atom to be, say, a Thomson vortex ring, and that this vortex ring, in virtue of its rotation, renders the ether next it less dense, or less rigid, it would attract any other atom similarly constituted in the same manner as we know two atoms do. And this attraction would be always the same in quantity, no matter what the temperature or surroundings, so long as the atom was the same, *i. e.*, its weight would be constant. And if another atom produced a different degree of density or rigidity near it, its weight would be different and constant.

Thus we see that if the ether has inertia (or some "counter motive force" opposes its motion), then matter must have inertia, and if the ether has rigidity, and atoms produce a difference in the cohesion of the ether near them, then all atoms will attract each other in proportion to the change they produce in the rigidity of the ether near them.

There are two experiments which seem at first sight to contradict Fizeau's experiment. First, the fact that a rotating disc of matter has no effect on a magnetic needle placed at its centre. Second, the fact that light suffers no retardation or acceleration when passed along the lines of force between two plates at different potentials, and placed in an electrolytic bath.

The first is readily explained when we consider that when the disc is rotating it is carrying with it ether as a whole, *i. e.*, equal quantities of positive and negative electricities, or is equivalent to two currents of equal strength flowing in opposite directions, and consequently can produce no effect outside of the body. Or, to use Prof. J. J. Thomson's symbolism, the ends of the Faraday lines are both within the body, and do not pass outside, whereas in Professor Rowland's experiment the Faraday lines have one terminal on the disc, and the other outside. The two cases are not similar.

The second case, that of the electrolytic bath. In this the ether does not move as a whole, there is merely a shearing of plus and minus electricities past each other, and the algebraic sum of the velocities of the components of the ether is therefore zero. Or, the ether does not move, so far as any possible effect on light is concerned.

## THE "GLACIAL PERIOD" PROVED AS A NECESSARY CONSEQUENCE OF THE EARTH'S MOVEMENTS.

BY MAJOR GENERAL J. C. COWELL, WINDSOR CASTLE, ENGLAND.

FROM the increasing interest that is manifested in all that relates to the glacial period, and the discovery, by General Drayson, of the Second Rotation of the Earth, it will be of value to those who are studying the geological evidences of the ice ages, to devote some time to the ascertained facts proving the Second Rotation as compared with the accepted theories, since these appear to supply all the conditions necessary for the explanation of the glacial phenomena, at regular intervals; and it is with the object of rendering the subject clear to them that the following remarks are offered to the readers of *Science*.

It has hitherto been stated by Herschel and other writers of his day, that the movement of the Earth, which caused the precession of the equinoxes and solstices, and the changes in Polar distance, and Right Ascension of the Stars, is "a conical movement of the Earth's axis round the pole of the Pole of the Ecliptic as a centre."

Drayson claims that this definition is vague, if not misleading, even as regards that part which speaks of a conical movement of the axis. He claims that it is the two half axes that trace cones, the apex of these cones being at the centre of gravity of the Earth.

He also claims that this conical movement of the two half axes is the mere mechanical result of a Second Rotation of the Earth, just as the conical motion every twenty-four hours, of all lines from the Earth's centre to points at the Earth's surface, is the result of the daily rotation of the Earth.

An examination of the annual changes in Right Ascension of every Star in the Heavens (see pages 163 to 219 in "Untrodden Ground in Astronomy and Geology") proves that a second rotation is the *only* movement which will explain the recorded changes in the Right Ascension of Stars. Hence, instead of some vague and undefined movement of the Earth occurring whilst the axis has what has been called "a conical motion," the detail movements of each point on the Earth's surface are accurately defined by the second rotation. Secondly, the Earth's axis traces *a circle* round the Pole of the Ecliptic *as a centre*, keeping constantly at the same distance of 23° 28′ from it, wrote Herschel and others.

In the face of the fact that the obliquity (*i. e.*, the angular distance between these poles) decreases about 47″ per century, the above statement is obviously erroneous.

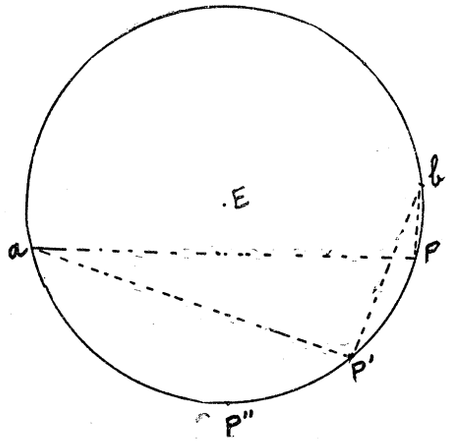
As an escape from this error it has been asserted by some that the Pole of the Heavens moves about 20″ annually at right angles to the arc joining the Pole of the Heavens with the Pole of the Ecliptic, but as the latter

Pole was supposed to move it was imagined that the course of the Pole of the Heavens was not a true circle.

Now, as it has been proved that the movement of the earth which causes the Pole of the Heavens to move, is a second rotation, it follows, as a geometrical law, that, as long as the Pole of this second rotation remains fixed, the course of the Pole of the Heavens must trace a circle, and no other curve than that of a circle. It has also been asserted that the Pole of the Heavens does trace a circle in the Heavens, but not round the Pole of the Ecliptic as a centre, this centre being *somewhere* very close to the Pole of the Ecliptic, but the exact position of this centre was unknown.

Hence, it is evident that the true curve traced by the Pole of the Heavens, or the true radius of the circle traced by the Pole of the Heavens has, during the past three hundred years, been undefined and unknown.

The confusion in one branch of astronomy which has prevailed in consequence will become evident by an examination of the following diagram:




E is the centre of the circle of which bPa is the circumference, b, P and a being three points on the circumference.

Suppose the angle bPa to be 95°. If the point P be moved to P′ then it is a geometrical law that the angle bP′a will also be 95°. Also if the point P be moved to P″ then bP″a will be 95°.

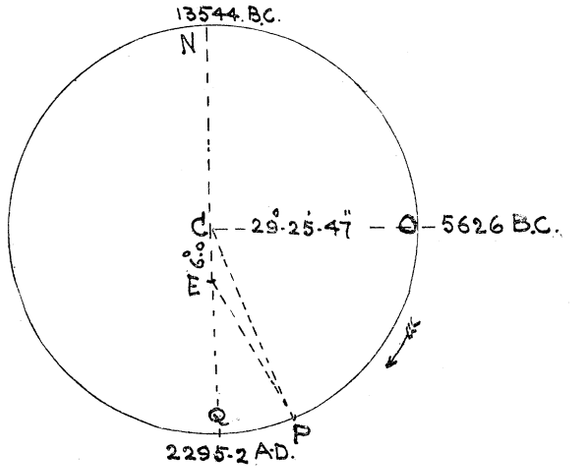
We can now apply this law to Astronomy. Suppose A and B to be two stars, and P the Pole of the Heavens, at any date, the stars being believed to be on the circumference of the circle traced by the Pole. Suppose the stars A and B to differ in Right Ascension exactly 95°. Then, as the Pole moved round the circumference to P′, the two stars A and B would always differ 95° in Right Ascension.

If repeated observations showed that the difference in Right Ascension between the stars A and B did not remain constant at 95°, but varied slightly from year to year, then these stars would be assigned "*a proper motion*" *in Right Ascension*, whereas the real cause of the difference in Right Ascension of these two stars, not being a constant quantity, may be due to the fact that the radius of the circle which the Pole describes is not that which it has been imagined to describe, and the two stars were not, in consequence, on the circumference of the circle. Some stars, on the other hand, are known to have a proper motion. During very many years it was asserted that the Pole of the Heavens traced a circle round the Pole of the Ecliptic *as a centre*, and on this erroneous assumption the theory of the proper motions of the stars was based. (See pages 126 to 130 in "Untrodden Ground in Astronomy and Geology.") Many earnest, hard-working men have employed their time in making out lists of the supposed proper motions of stars, and pages of astronomical societies' volumes have been filled with these lists. Medals have been given for this work, but what is their value?

To assert that any star has a "proper motion" in Right Ascension, in consequence of the Right Ascension varying, whilst the true course which the Pole of the Heavens traces has been unknown; and the exact manner in which each zenith is affected, has not even been considered yet, is very remarkable. But during the last hundred years astronomers have copied each others' proceedings, without apparently perceiving that to define the true circle traced by the Pole of the Heavens was the first important problem to be solved; and until this problem was solved any assertions relative to the proper motion of the stars were valueless.

Instead of the Pole of the Heavens tracing a circle round the Pole of the Ecliptic as a centre, and keeping constantly 23° 28′ from it, recorded observations prove that the Pole is carried by the Second Rotation round a circle, the radius of which is 29° 25′ 47″, the whole circle being completed in a period of 31,682 years, the Pole of Second Rotation being 6° from the Pole of the Ecliptic, and so situated that at the date 2295.2 A.D. the Pole of the Heavens, the Pole of the Ecliptic, and the Pole of Second Rotation will be on the same great circle of the sphere.

The following diagram indicates the course of the Pole of the Heavens during one entire Second Rotation of the earth:




The circle represents the course traced by the Pole of the Heavens, in consequence of the Second Rotation. At the date 13544 B. C. the Pole was at N, at 5626 B. C. it was at O, and at 2295.2 it will be at Q.

The distance of the Pole of the Heavens as it moves round this circle from C, the Pole of Second Rotation, is a constant quantity, viz.: 29° 25′ 47″. E, the Pole of the Ecliptic, is 6° from C. Hence, when the Pole of the Heavens was at N, it was distant from E 29° 25′ 47″ + 6° = 35° 25′ 47″.

The rate of the Second Rotation, as indicated by the length of arc over which the Pole is carried in a given time, is 40.9″ annually. Hence, we can easily calculate at what part of the circle the Pole was, or will be at, for any date. For example, at what date was the Pole at a point in the circle 90° from Q? 90° = 324000″, and these seconds divided by 40.9″ gives 7,921 years from the date 2295 A. D., that is, 5626 B. C. We now have an important triangle to deal with, viz.: the triangle ECP. We have EC = 6° (a constant) and CP = 29° 25′ 47″, another constant; when, then, we find the value of the angle

ECP (+2295–date in number of years) ×40.9″=the angle ECP at date given, we can calculate the value of the side PE, which is the distance of the Pole of the Heavens from the Pole of the Ecliptic, and is consequently the measure of the obliquity, and of the Arctic Circles, and Tropics on Earth at the date when the Pole was at P.

The method of calculating the distance PE, which is the value of the Obliquity, is very simple, and is given in detail at page 74 in "Untrodden Ground of Astronomy and Geology" (two sides and the included angle). By this calculation the Obliquity for the 1st of January, 1800, is found to be 23° 27′ 55.3″, and for the 1st January, 1850, 23° 27′ 30.9″, showing a difference of 24.4″ for fifty years during the first half of the present century. But, between 1800 and 1900, calculation gives a difference of 46.5″ (see page 75 of the same work). In Article 640 of "Outlines of Astronomy," by Herschel, is the following: "Meanwhile, there is no doubt that the plane of the Ecliptic does actually vary by the action of the Planets; the amount of this variation is about 48″ per century." This statement shows how entirely the true cause of the decrease of the obliquity was overlooked. It was positively stated that the Pole of the Heavens kept a constant distance of 23° 28′ from the Pole of the Ecliptic. If it did keep at this constant distance, then no amount of change, even of many degrees, *in the plane of the Ecliptic*, would produce even 1″ change in the obliquity, which would always remain 23° 28′.

That the Polar distance of a star can be calculated for 100 years or more, and from one observation only, is proved by numerous examples given from page 52 to 63 in "Untrodden Ground in Astronomy and Geology."

An examination of the last diagram given in this paper shows that the course of the Pole of the Heavens during one Second Rotation caused it to vary its distance from the Pole of the Ecliptic as much as 12°, and hence at the date 13544 B. C. the Arctic Circle and Tropics extended 12° more than at present, thus causing those vast changes referred to by geologists as "the Glacial Period," and giving the dates for the commencement, duration and termination of this period, which agree with the latest discoveries of geologists.

The Second Rotation gives accuracy of detail and a complete explanation of recorded facts, whilst by its aid calculations can be made which have hitherto been considered impossible. "A Conical Movement of the Earth's Axis round the Pole of the Ecleptic, as a centre, omits *all* details, and leaves recorded facts without any clear explanation. First, then, we have for a "conical movement of the earsh's axis" a second rotation of the earth, which *causes* a conical motion of the two half axes, and shows how the zenith of each locality on earth is affected by this movement. Second, for the Pole of the Heavens tracing a circle round the Pole of the Ecliptic as a centre, at a constant distance of 23° 28′, we have this centre 6° from the Pole of the Ecliptic, and 29° 25′ 47″ from the Pole of the Heavens, with the results explained above.

The following are some of the errors which have been, and still are, promulgated in consequence of the true movements of the earth being misunderstood by many persons :

First: On many celestial globes and star maps a circle is drawn round the Pole of the Ecliptic *as a centre*, and on these, near the circle, is written, "Circle described by the Pole of the Celestial Sphere in 25,868 years." This error is due to two oversights. First, although it was admitted that the two Poles decreased their distance from each other about 47″ per century at the present time, and had decreased their distance during all time of which we have any records, yet they always kept 23° 28′ apart. The second error was that, because the annual amount of the precession (about 1800 A. D.) was 50.1″, this rate was constant for all time, whereas, for a uniform movement of the Pole, the annual amount of the precession varied *with the distance apart of the two Poles.*

Second: It having been assumed by theorists that the Plane of the Ecliptic could not vary from a mean position more than 1° 21′, it has been asserted that the Obliquity could not vary more than 1° 21′. This error was promulgated in consequence of the true circle traced by the Pole of the Heavens not having been known. No matter how much *the plane* of the Ecliptic varied from a mean position, there could be no variation in the Obliquity, if the Pole of the Heavens was, as asserted, kept always 23° 28′ from the Pole of the Ecliptic.

The cause of the decrease in the Obliquity of *about* 47″ per century, its present rate, is not due to any change in the plane of the Ecliptic, but is due to the fact that the centre of the circle which the Pole describes is 6° from the Pole of the Ecliptic, instead of being coincident with it.

Third: It has been asserted that because the decrease in the Obliquity, or angular distance, between the two Poles was about 48″ per century, therefore in 10,000 years the decrease would be 4,800″=1° 20′ only.

Such a statement indicates a want of knowledge as to the *cause* of the decrease, and a forgetfulness of the geometrical law that a curve cannot decrease its distance from a point at a uniform rate.

An examination of the last diagram shows that a variation of 12° will occur in about 15000.

Fourth: It has been asserted that the Arctic Climate, which reached to about 54° Latitude during the Glacial Period cannot possibly be accounted for by astronomy. Because, "There is none amongst the slight variations of the Earth's movements which, even with the aid of any extension of time, however indefinitely great, could alter the present angle of the Earth's axis as it lies to the plane of the Earth's orbit. This angle, which is about 23°, is firmly fixed by that apparently essential property of matter—Inertia." It is singular that such a statement shou'd have been made, for the Earth's axis is not inclined to its orbit at about 23°, but at about 66° 33′, and it varies this angle at about 47″ per century at the present rate of the Earth's gyration, so it cannot be firmly fixed.

Fifth: The changes produced on various meridians and zeniths by the Second Rotation, are most important, but, notwithstanding this, have been hitherto entirely overlooked. In every observatory the Polar distance of a star is deduced from its observed meridian zenith distance, and its Right Ascension from its Meridian Transit. But, that the zeniths and meridians of two localities, differing in latitude, were differently affected by the so-called "conical motion of the axis," has been entirely disregarded.

Sixth: The standard measure of time is also affected by the Second Rotation, and a siderial day is at present a vague quantity, only imperfectly defined by the statement that it is the interval which elapses between two successive transits of the same star ; because this interval varies for nearly every star. *The only uniform standard of time* is the interval between two successive transits of the Pole of Second Rotation (see chapter 13 in "Untrodden Ground in Astronomy and Geology"). The statement made by Sir John Herschel in a foot note at the end of "Outlines of Astronomy" "that 3m. 3.68s. of purely imaginary time was inserted between 1833 and 1834 in order to correct

errors, and that the whole subject of time had fallen into confusion," is the result of an incorrect standard of time having been used, and still being used.

Seventh: By the present accepted *theories*, it is not known whether the annual rate of decrease in the obliquity (which is the same thing as a decrease in the distance of the Pole of the Heavens from the Pole of the Ecliptic) has a decreasing or increasing rate. It is now, and has been during many years taken as a constant quantity of 0.476″ annually, which is geometrically as unsound, as though it were stated that the Polar distance of a star decreased each year at a uniform rate. It is not known how long this decrease in the obliquity will continue, or when it will become an increase. It has continued during 1800 years at least, but when it commenced is not known. What the obliquity was 5,000 years ago, and what it will be 5,000 years hence, is not known; because the true course traced by the Pole of the Heavens relative to the Pole of the Ecliptic has not been known.

The Second Rotation supplies all these details, and proves their accuracy, by the agreement of calculation with recorded observations. The detail movements of every zenith are given by the Second Rotation, whereas hitherto all zeniths seem to have been imagined to be similarly affected by the so-called "Conical Motion of the Earth's axis." It is impossible to conceive more convincing proof of the truth of Drayson's discovery. The Second Rotation of the Earth merely gives accuracy of detail where hitherto there has been vagueness and imperfect definition.

The various statements that have been confidently put forward regarding the impossibility of any great change having occurred in the Arctic Circles and Tropics, is due to the fact that the true course of the Pole of the Heavens relative to the Pole of the Ecliptic has hitherto been unknown. Such statements, however, having been accepted as if they were statements of fact, without full enquiry, have induced some writers to put forward extraordinary theories incapable of being proved, to account for an Arctic climate having descended to about 54° latitude within comparatively modern times.

Considering that the true course of the Pole had never been accurately defined until the Second Rotation was made known, it appears strange that so many forms of vague speculation should be seriously discussed as a possible cause of the glacial epoch, whilst the fact that the centre of the circle which the Pole describes is proved to be 6° from the Pole of the Ecliptic, has been overlooked, or considered quite impossible.

More especially is this neglect remarkable because twenty-five years ago the dates for the duration and termination of the Glacial Period were accurately given by Drayson in consequence of a knowledge of this beautiful movement, and when scarcely a geologist believed that the dates were anything but erroneous; and now what do we see? Geologists substantiating by evidences which none can doubt, the absolute accuracy of his observations and calculations.

It is to be expected, after such results, that astronomers will define, in unmistakable terms, the true course of the Pole of the Heavens relative to the Pole of the Ecliptic. The definitions of the past will not and cannot satisfy, and a consideration of the following questions ought not to be beneath the notice of any one, because until the matter is solved conclusions as to the proper motion of stars, the changes of latitude of observatories, and even the variation in eccentricity of the Earth's orbit, are assumptions only, based upon unsound foundations.

1. Is the true course of the Pole a circle round the Pole of the Ecliptic as a centre, keeping constantly at 23° 28′ from it as stated by Herschel and other writers?

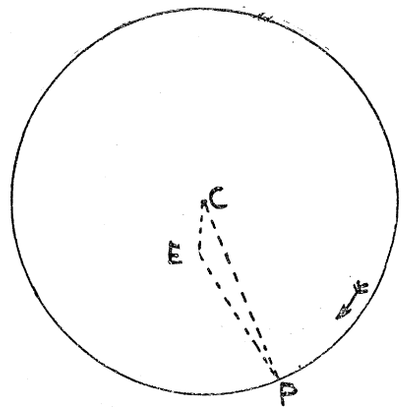
2. Is it an irregular curve always moving at right angles to the arc joining the Pole of the Heavens to a movable Pole of the Ecliptic?

3. Or, is it a circle round an undefined point, which is supposed to be the mean position of a movable Pole of the Ecliptic? If so, where is the point?

It is probable that the facts of the Second Rotation have not been carefully examined, as it appears that some individuals hold the opinion that it is merely a vague theory opposed to well established facts in astronomy. The very reverse is, however, really the case, and the following are some amongst many problems which can be solved by a knowledge of the Second Rotation of the Earth.

Such problems cannot be solved by those persons who are unacquainted with it.

Problem 1.—Calculate the mean obliquity of the Ecliptic for any date, say the 1st of January, 1873, without reference to the observed obliquity at any previous date, and without reference to the annual rate of decrease found by observation.



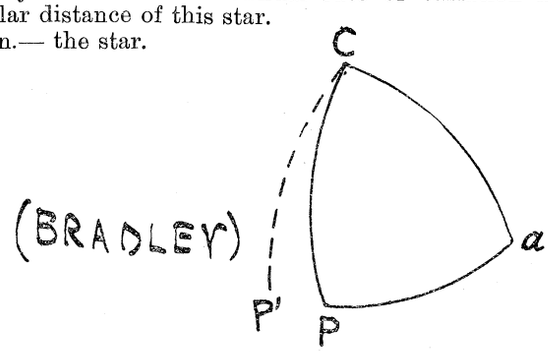

Where EC=6°–CP=29° 25′ 47″, and the angle ECP for date 1st January, 1873, is found thus:

(2295.2–1873)×40.9″=4° 47′ 47.9″ = angle ECP on the 1st January, 1873.

On calculating the value of the side PE, which is the obliquity, this value is found to be 23° 27′ 20.2″, and it is recorded in the Nautical Almanac, 1873=23° 27′ 20.88″.

Problem 2.—In Bradley's catalogue of stars for 1st January, 1755, the mean north Polar distance of Alpha Draconis was given as 24° 26′ 47.4″. This star is 26° 37′ 3″ from C, the pole of Second Rotation. Calculate the mean North Polar distance of this star for any other date, say 1st January, 1850, and 1st January, 1890, without any reference to the annual rate of variation in North Polar distance of this star.

Solution.— the star.




From a knowledge of the Second Rotation:

The side PC=29° 25′ 47″.

The side Ca=26° 37′ 3″.

From Bradley's Record Pa=24° 26′ 47.4″ on the 1st January, 1755.

Having the three sides of the spherical triangle ℓ Ca, the angle at C can be calculated, and it proves to be 53° 15′ 26″ for the 1st January, 1755.

Owing to the Second Rotation the Pole P is carried round C as a centre, at the annual rate of 40.9″. Between 1755 and 1850 there are 95 years, which multiplied by 40.9″=1° 4′ 45 5″ for the increase of the angle at C, which becomes 54° 20′ 11.5″ for 1850, when the Pole has reached P′.

We then have P′C=29° 25′ 47″ Ca=26° 37′ 3″ and the included angle P′Ca=54° 20′ 11.5″ to calculate P′a.

By calculation P′a=24° 54′ 21.2″ and found by observation, 24° 54′ 21.4″.

For 1st January, 1890, the angle C becomes 54° 47′ 27.5″ and by calculation, as before, P′a=25° 5′ 55″, and by the Nautical Almanac 1890, 1 January=25° 5′ 54.8″.

Hence the polar distance can be calculated for 135 years to within one second; and, considering the uncertainty of refraction, it is probable that the calculation is more correct than observation.

Such a result speaks for itself, and may well excite admiration of General Drayson's perseverance during many years of tedious calculation, until his labors have at last been rewarded by the splendid discovery of the radius of the circle described by the Pole of the Heavens, and the centre of that circle.

Had Newton with his marvellous intellect known, as we do *now*, that an almost tropical climate existed in what are now Arctic regions, and an Arctic one as low as 54° of latitude; that the axis of the earth varied its inclination to the plane of the Ecliptic; and that vast elevations and depressions had occurred upon the surface of the Globe causing its centre of gravity to vary its position by the consequences of these movements, as in transferring enormous quantities of the waters of the sea from one locality to another; who can doubt that he would have discovered the manner in which the Pole of the Heavens would have moved in obedience to the law of gyration? And with such catalogues as we now possess, he might have achieved the same results as have been obtained by Drayson in discovering, as he has done, the details of the Second Rotation. At all events he would certainly have attributed the Precession of the Equinoxes to the true cause of this, and not to the assumed joint action of the sun and moon on the protuberant Equatorial Zone.

## A SEGREGATION OF FRESH-WATER FISHES.

BY THEODORE GILL, M. D., PH. D., WASHINGTON, D. C.

One of the most remarkable facts in zoögeography is the segregation of the greater part of fresh-water fishes represented by the ostariophysal orders, that is, the families *Characinidae, Cyprinidae, Siluridae* and their subdivisions. These are all genetically related, and must have developed from a common stock early accommodated to the fresh water and subsequently differentiated into many families and a host of genera with many hundreds of species. The few marine representatives of that host are the *Ariinae*, or *Tachisurinae*, and the *Plotosidae*, and these must have diverged from primitive fresh-water types.

Another case of segregation of a widely distinct series of families has never been recognized, and attention should be directed to it. It is that of the haplomous fishes.

The *Haplomi* are teleocephalous fishes with a pneumatic duct and abdominal ventrals, and were considered by Prof. Cope to be an order of physostomous fishes, including *Esocidae, Umbridae, Cyprinodontidae* and *Hypsaeidae*. These are evidently related to each other, although not very closely, and are mostly fresh-water forms. There are two other families which have hitherto found no satisfactory resting place which I am disposed to associate with the typical haplomes—*Percopsidae* and *Aphredoderidae*.

If the six families thus associated are really genetically related, we would have another series of families segregated as a fresh-water group, and which must have been long established. The only one of these six families with marine representatives is *Cypronodontidae*, and this seems to be the most generalized and most nearly related to the Synentognathous fishes, on one hand, and the Perciform, on the other. Whether the salt-water Cyprinodontids are the descendents of primitive salt-water fishes or have reverted to the sea in later times, is now an open question. This I do not propose to discuss at present, reserving it for future consideration, as well as numerous collateral questions which may suggest themselves. My only object at present is to draw attention to the zoögeographical fact mentioned and the morphological problem involved.

It is noteworthy that all the families enumerated are represented in the United States, and half of them (*Hypaeidœ*, or *Amblyopsidae, Percopidae* and *Aphredoderidae*) are found nowhere else. The *Esocidae* and *Umbridae* are represented in Europe as well as America. The *Cyprinodontidae*, or *Poeciliidae*, are generally distributed. All the families are remarkably well defined. Finally, it may be suggested that the unwonted position of the anus (jugular or thoracic) of two (*Amblyopsidae* and *Aphredoderidae*) is possibly more than a mere coincidence, and may be an inheritance from common ancestors.

## BIOLOGICAL INVESTIGATION IN BOTANY.

BY J. CHRISTIAN BAY, BACTERIOLOGIST OF THE IOWA STATE BOARD OF HEALTH, AMES, IOWA.

A couple of smaller notes on the biological question, as far as botany is concerned, were published by me in this journal. To the first of these, What is biology? this little note is to be regarded as an appendix. My first paper contained, originally, a number of notes on the modern methods of biological investigation in botany; I kept them back in order that they should not be misunderstood.

A short time ago I received Professor N. Wille's inauguration speech in taking the chair of botany at Christiania, Norway. Professor Wille has said, in a few words, what I wished to say on the occasion above referred to. Therefore, I shall quote him:

"The so-called plant-biology is a child of the Darwinian theory of selection. It should be called, more correctly, *oecology*. This branch of investigation should embrace, as nearly as possible, the science of all life-phenomena of plants, *minus* physiology: in other words, oecology is the science of the mutual relationship between the plant and the surrounding nature, when this relationship does not rest upon physical and chemical causes.

"Oecology has still retained many reminiscences from the teleological conception of earlier days, when nature as a whole was thought of as created for the sake of being principally of use to, or a plaything for, the human race. Plant oecologists, or as they like to call themselves, plant biologists, have the idea that everything must be useful or developed in a certain way in order to be of use for certain purposes.

"We shall give an example of one of the typical representatives of this line of study. He placed an ant on the leaf of *Sonchus*, and found that the ant tore the cuticula, so that the milk juice from the leaf came out. The resin