

guished from other beetles in having the forepart of the head prolonged into a long and slender snout, in the end of which the mouth opening and the small horny jaws are placed. This snout (which in the Bruchians is folded over on the chest) they make use of not only in feeding, but in boring holes, into which they afterward drop their eggs. The history of many American species is imperfectly known, if we are to credit a recent French periodical; however, our American "Pea-bug" (Fig. 7), which has now spread over Europe, has become an active collaborer of the "Death Watches" in boring holes through the pages of European books, to deposit the eggs that produce the destructive larvæ. According to Kirby and Spence, a minute beetle, to which they give no common name, but merely a scientific one (*Hypothemus eruditus*) out of all proportion to the size of the insect, is often found burrowing in considerable numbers in the bindings of books and doing much damage.

The larva of the common "Tabby Moth" (*Aglossa pinguis*, Fig. 8) will often establish itself upon the binding of a book, and spinning a robe, cover it over with its own excrement, thus doing the volume no little injury. Dr. Packard states, on the authority of Prof. A. E. Verrill, that the larva of another species (*Aglossa cupreatis*, Fig. 9) does great damage to the old leather bound volumes in the library of Yale

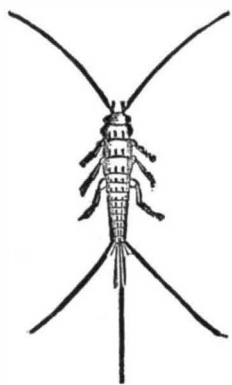


FIG. 10. SUGAR LOUSE.
(*Lepisma*.) (Enlarged.)

College, by eating out great patches and galleries in the leather covers, and also, in some cases, some of the glue and pasteboard.

Perhaps the most destructive of insects are the white ants of the tropics, which devour everything except glass and metals that comes in their way. Humboldt states that in equinoctial America, where these and other destructive insects abound, it is rare to find books or papers that go back more than fifty or sixty years. Fortunately, these little animals have never as yet emigrated from their native shores. Kirby and Spence state that a little insect belonging to that microscopic family, the *Acarini*, or "Mites," eats the paste that fastens the paper to the bindings of books, and so loosens it. The name of this insect is *Cheyletus eruditus*, or, as we might translate it, the "Erudite Mite." In the almost limitless class of insects there is one small but interesting family in particular, containing minute, wingless forms, which seem to connect the true winged insects with the Myriapods. These agile creatures, called "Bristle-tails," have a long flattened body, with metallic scales, in form somewhat like those of butterflies; and these scales are a favorite

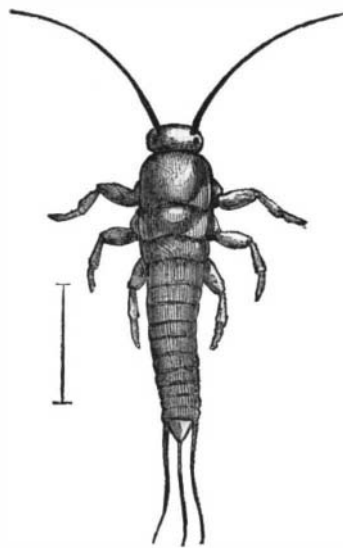


FIG. 11. BRAZILIAN TRAÇA.
(Magnified.)

object with all microscopists as "tests." One species, the "Sugar Louse" (*Lepisma saccharinum*), is very common in almost every house, where it eats holes in silks and silken tapestry, and devours the paste and eats holes in the leaves of books. It has a spindle-shaped body (Fig. 10), covered with silvery scales, the sides of the abdomen being furnished with a series of appendages, or false feet, and the tail provided with three bristles pointing outward. Judging from an engraving and description, merely, of the insect, we should say that the Brazilian "Traça" (Fig. 11) was closely related to our *Lepisma*. The eminent French philologist, Villosion, who was sent by his government to Venice in 1778, in order to search the library of St. Mark for unpublished Greek manuscripts, and who subsequently traveled several years in Greece and the Archipelago, mourns, in his work entitled *Fragments sur la Grèce*, over the fact that he found the libraries in the monasteries at Salonica, Scio, Santorini, Naxos, and even at Constantinople falling literally into dust through the ravages of insects. But however great be the voracity of the insects that have devoured so many precious volumes in the country of Homer, it can scarcely equal, judging from the accounts that we have of it, that of the minute "Traças" above mentioned. These almost imperceptible insects give abundant proof of the activity of their appetites in the curious figures which they trace across the most precious pages of text, converting them in a few days into real lacework, and destroying all semblance of printing to such a degree as to render the pages undecipherable to the most persevering student. It is to these Traças, rather than to handling by students, that is due the destruction of those vocabularies which

made known in the sixteenth and seventeenth centuries the elements of the Indian languages; it is to these insects, as much as to the dampness of the old repositories in which they were stored, that is due the disappearance of the records which narrated the deeds of the old *conquistadores*, or the stories of intrepid voyagers. Happily some of these old records were copied in former centuries, and the copies taken to Europe. M. Franklin Ramiz Galvam, at present director of the rich national library of Rio de Janeiro, has given a sad description of the difficulties by which the studies of South American savants are beset, through the ravages of the Traça—an insect that he has not been able to destroy. Having enumerated the evils, let us cite such remedies as we know. Unfortunately we no longer possess a knowledge of those heroic methods of treating noxious insects which the old naturalist, Muffet, loves to tell about, while he instances the fact that the garments of Servius Tullius still remained intact from the incursions of moths after more than five hundred years. The *Bulletin of the Bibliophile* says that "it is an indisputable fact that the odor of Russia leather is so disagreeable to all insects that naturalists have given a beautiful beetle called the *Trichius* (which possesses this odor to a high degree) the surname of *eremicola*, because other species carefully avoid it. We have had the pleasure of preserving our books, and have attributed it to the care we



FIG. 12. LARVA OF TRAÇA.
(Highly magnified.)

have taken to keep some of these insects among them as much as possible. A large American *Trichius* (*T. scaber*), often met with, has this same powerful odor of Russia leather to such a degree that its presence may be detected by the scent alone at a distance of two or three yards from its retreat.

Unhappily the numerous insects which are continually feeding on our literary treasures do not all disappear under the influence of *Trichius eremicola*, and there is even some doubt about the efficacy of Russia leather itself, the odor of which it so powerfully exhales. Several insects make their primitive cradle in the paste and glue used by the binder; and from these it is difficult to dislodge the enemy. Many means have been proposed for preventing them from obtaining a lodging in such places; such as mixing alum, colocynth, arsenic, or corrosive sublimate with the paste before using. The learned Namur recommends against such beetles as the "Death Watches" and "Weevils" frequent fumigations of sulphur. But this while killing the perfect beetle has, of course, no effect on their eggs. The perfect insects as well as their larvæ may always be speedily killed when discovered by the application of a little chloroform; and that, too, without any injury to the book. The most efficacious means, however, of preserving a library where there is a large collection of books is to look them all over quite frequently and beat them out.

THE EARTHQUAKES OF 1877.

PROF. C. W. C. FUCHS states that during 1877 five important eruptions of different volcanoes took place. The eruption of the South American volcano Cotopaxi, which lasted from June 25 to 28, was of a most characteristic nature for this mountain. According to the phenomena by which it was accompanied, it must be designated as an eruption of ashes and mud. Although Alexander von Humboldt's view, that the South American volcanoes do not produce lava, has been refuted long ago (Cotopaxi sent forth a copious stream of lava in 1853), yet the most frequent eruptions from this mountain are those of ashes only, without a flow of lava. Streams of mud are often combined with eruptions of this kind, and have different causes; in 1877 they particularly devastated the valleys of Chila and of Tumbaco, and in the former many hundreds of lives were lost through them. The ashes which the volcanoes ejected so filled the air that complete darkness reigned everywhere, and the dust was so fine that it entered even into the interior of houses, although the doors and windows were shut.

The most violent eruption of 1877 occurred upon the island of Hawaii. Twice interrupted, the lava forced its way to the surface in three different places, and thus furnished the most undeniable proof that one and the same bed or hearth of lava may produce eruptions in any of the numerous craters of Hawaii, according to time and circumstances. The first part of the eruption occurred on February 14 from a little side crater close to the summit of Mauna Loa; its duration was six hours, and the height of the column of smoke, which assumed the shape of an Italian pine-tree, was estimated at 5,000 meters. The second part occurred on February 24, in the Bay of Kaluakua, well known as the place in which Cook, the great discoverer of the Sandwich Islands, was assassinated. This eruption was submarine, and lasted two days; its seat was in the middle of the bay, which is surrounded by numerous prehistoric records of its volcanic nature. On May 4 the lava found its usual way to the surface through the lavalake of Kilauea, which has solidified for some time. Here the wonderful phenomenon of high jets of lava occurred, a phenomenon which is peculiar to this spot only. During a period of six hours, now here, now there, vast jets of liquid lava rose from the ground, and their number was so great that at one time more than fifty simultaneous ones were counted, some reaching an altitude of thirty meters.

The third eruption was that of the small Japanese island-volcano, Ooshima, and lasted from January 4 to February 6 or 7. Violent subterranean noise and disastrous earthquakes accompanied the volcanic phenomena, particularly on January 20 and on February 4 and 5.

On June 11 an eruption occurred in a volcanic district almost unknown hitherto, viz., near the Colorado River in Southern California, at some sixty miles' distance from Fort Yuma. The last eruption was a submarine one, and happened on June 15, near the Peruvian coast.

The number of earthquakes during 1877, of which Prof. Fuchs was able to obtain reliable accounts, amounts to 109, and he remarks that this is very nearly the average number per year, if compared to his annual compilations, which now extend over a period of thirteen years. They were distributed over the seasons of the year as follows:

December, January, February33 earthquakes.
March, April, May31 "
June, July, August11 "
September, October, November34 "

On fifteen days several earthquakes occurred simultaneously in different places. Certain districts, such as Peru, Bolivia, Tokio (Japan), the Island of Ooshima, Hawaii, etc., were visited by real earthquake periods, consisting of a large number of more or less violent shocks and detonations, while in others several earthquakes, separated by long periods of tranquillity, were observed. Among the latter we note

Sudenburg (Styria): January 4, December 27 and 28.
Western Odenwald: January 2 and 10.
Wald (Styria): January 12 September 11.
Rattenberg (Tyrol): April 8, October 11.
Bad Tüffer (Styria): April 4, 7, 24, 25, September 12.
Callao: April 22, May 14, October 9.
Western Switzerland: May 2, October 8, November 30.
Lisbon: November 1 and 4, December 22.

The earthquakes in Switzerland spread over a very considerable area. The first shocks on May 2 began near the Lake of Zürich and proceeded in three directions, viz., as far as Glarus and St. Gallen in the east, Mühlhausen in Alsace in the west, and the Black Forest in the north. They were followed by others more violent, and even more widely spread, on October 8. These were felt most severely at Geneva, where many chimneys were thrown to the ground; but they were distinctly noticed in the whole canton of Geneva, as well as in the Vaud, the Valais, Neuchâtel, Berne, Freiburg, and Basel, and also in the French departments of Drome, Isère, Rhone, Savoie, Aix, Jura, Doubs, and even at Mühlhausen in Alsace. The extent of this earthquake toward the west was therefore a far more considerable one than toward the east, where the Alps seem to have hindered its progress; only in the broad Rhone Valley it was felt as far as Sitten. This is all the more remarkable since the Jura Mountains seem to have been without influence regarding its progress in the west. The greatest breadth of the area where the phenomenon was noticed, *i. e.*, from Lyons to Sitten, measures some 200 kilometers, while its greatest length, *i. e.*, from Valence to Mühlhausen, is 337 kilometers.

Another earthquake of large extension was the one felt on April 4 in the Eastern Alps; it was observed from Lower Styria as far as the junction of the Save with the Danube.

The most violent earthquake was the one which occurred on the South American coast on May 9, and in its whole course, as well as with regard to the minor phenomena which accompanied it, it can be compared only to the earthquake which occurred in the same region on August 13, 1868.

A VARIATION IN THE MOON'S MOTION CAUSED BY THE EARTH'S SPHEROIDAL FIGURE.

By D. P. BLACKSTONE, Berlin, Wisconsin.

SEMON NEWCOMB in his paper in the November number of the *Journal of Science and Art* admits that the lunar theory having occupied the attention of mathematicians and astronomers of every century for two thousand years is now incomplete. Mr. Newcomb is evidently entitled to much credit for the results he has obtained from his researches and his discussion of the observations of eclipses and occultations that occurred previous to 1750, extending back over a period of more than two thousand years. He has doubtless proven to the satisfaction of astronomers that Hansen's empirical term, eight times the mean motion of Venus minus thirteen times that of the earth, adjusted to satisfy the lunar observations between 1750 and 1850, is a failure outside these limits, making a column of residual errors worse than that of pure theory.

Mr. Newcomb has given us in his paper a column of outstanding corrections to pure theory, having secular acceleration $8''$, which he reconciles with observations from 1625 to 1875 by an empirical formula adjusted to the discrepancies between these limits. With this column of outstanding corrections I shall in this paper compare my column for the irregularity in the motion of the moon, due to the variation in the attractive force of the earth, caused by its spheroidal figure, and close up the gap between accepted pure theory and observation, with formulæ based on the law of gravitation.

The results of the pendulum experiments at places having latitudes from the equator to seventy-nine degrees fifty minutes, after due correction for centrifugal force and for distance from earth's center, are reconciled by my published formulæ to find the variation in gravity caused by the earth's spheroidal figure. Hence it is evident that my formulæ, admitting them to be truly empirical, must be accepted as reliable to be used in computing the length of the pendulum at any place on the earth's surface, or to find the variation in gravity due the earth's spheroidal figure, at least until a place can be found where the law does not hold true and not exceptionally explained.

My mathematical paper published in SUPPLEMENT No. 75, on "The Attractive Force of the Atom in Combination," develops formulæ to find the ratio of the attraction of the earth at any latitude and at any distance from center outside of surface, to the attraction of a sphere containing the same mass as the earth at the same distance. The above referred to paper with others I sent to three distinguished American mathematicians and astronomers, and received in reply: From first—"I have looked over your papers as far as my time will permit and have not noticed anything upon which I should differ from you." From second—"In the first step of your work you appear to make a mistake by making the component of a force proportional to the square of the cosine of its angle instead of simple cosine, which ought to be used." From the third—"I should say the course of reasoning you employ is not admissible. There seems to be some confusion in your mind as to the terms 'force' and 'power or work,' which you would do well to clear up. Force is by no means synonymous with work."

It is true in the first step of my work I made the component of a force proportional to the square of the cosine of its angle, which is accepted to be in accordance with the law of "power or work" for the rectangle, as I demonstrated in SUPPLEMENT No. 85. In the second step of my work I demonstrated that all the matter of the sphere can be represented on a certain arc of rotation or zone, B C D, by a certain amount of matter under such a condition that it will attract any outside atom, P, at any distance the same as the sphere. I applied this step of demonstration as though the representative matter on zone, B C D, was equal to all the matter of the sphere, which is true only when the attractive atom, P, is at an infinite distance. After receiving the second criticism I proved by clear demonstration, which I shall at some future time publish, that one of the two equal fac-

tors of cosine square in the first step of my work is due to the ratio, the whole matter of the sphere to its representative matter on zone, B C D. Of course such a demonstration nullifies the criticisms.

Taking the attractive force of a sphere of the same mass as the spheroid for the standard unit, computations from my integrated formulæ show that the difference in the attraction of the earth caused by figure varies very nearly as inverse square of distance. For an outside test of the validity of my investigation I have made three computations from the formula given in Newton's Principia, Book I, Prop. XCI., Cor. 2. I find in case of an oblate spheroid of uniform density, having polar to equatorial radius as 100 to 101, the attraction at the pole of the spheroid is to the attraction of a sphere at the surface, having radius 100 and same density as the spheroid, as 126.1 to 125.1; at one radius distance from pole or two from center, as 59.7 to 58.7; and at four radii distance from center, as 52.7 to 51.7. The solid contents of the oblate spheroid is to that of the sphere as 10,201 to 10,000. As the attraction of spheres at the same

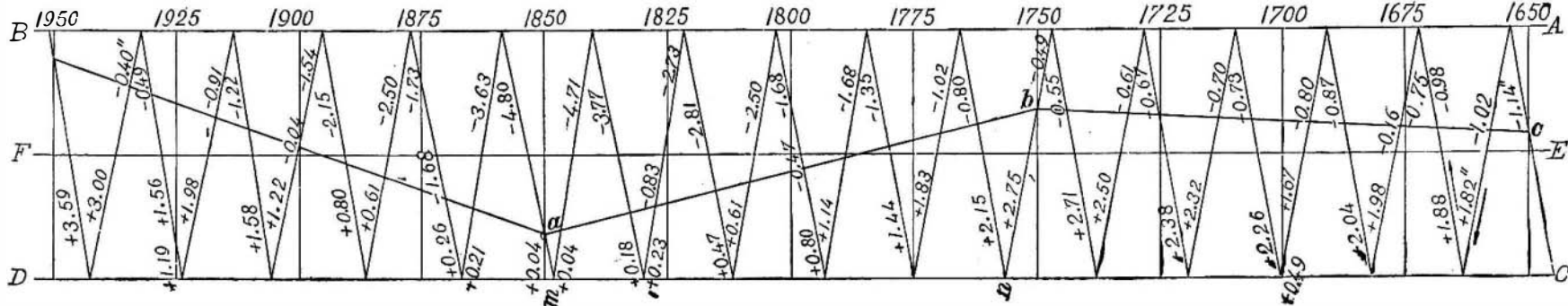
18° 18' gains 1.4". The standard measure of Hansen and Newcomb is from 1750 to 1850. Of course I must figure my column of fluctuations to line *b a* from 1750 to 1850, and to line *c b* from 1650 to 1750, and accordingly for other centuries, in order to compare my work with Newcomb's column of outstanding corrections to pure theory, having secular acceleration 8.8". Figures on diagram marked + and - show gain or loss in motion of moon in seconds of arc from the standard line *b a*, etc. Any of these numbers can be obtained by solving a simple problem in arithmetical progression.

Column 1 of the above table is Newcomb's column of outstanding corrections to accepted pure theory, having secular acceleration 8.8"; 2 is his computed terms from empirical formula; 3 is my computed terms due to the figure of the earth. I assume 6" for epoch 1650, and my other terms are obtained by summations of 6" with figures on diagram. Column 4 is Newcomb's differences, and 5 mine. The limit of error of observation in 1875 as shown by occultations and observations at Greenwich and Washington was 1.7". The

- 1.—212° F.....Boiling water.
- 2.—122° F.....Coagulation of albumen.
- 3.— 68° F.....Triassic and jurassic periods.
(Climate of Gulf of Mexico.)
- 4.— 48° F.....Miocene tertiary period.
(Climate of Lombardy.)
- 5.— 32° F.....(Climate of Labrador.)
- 6.— 0° F.....Present climate.

The interval between the first and second corresponds to the azoic rocks; that between the second and third to the palæozoic rocks; that between the third and fourth to the neo-zoic rocks. Calculating the relative time required for a cooling globe to pass through the temperatures from 212° F. to 48° F., Professor Houghton finds the lengths of the foregoing periods to be respectively 33, 41, and 26 per cent. of the time preceding the miocene period.

Converting the maximum thicknesses of the several geological strata in Europe into percentages, and comparing them with the percentages of time found from the theory



VARIATION IN THE MOON'S MOTION.

distance varies as mass, to find the ratio of the attraction of the spheroid to that of a sphere of same mass as spheroid, we must multiply in case first $\frac{126.1}{125.1}$ by $\frac{10,000}{10,201}$, which equals nearly $\frac{83.3}{84.3}$. In case second $\frac{59.7}{58.7} \times \frac{10,000}{10,201} = \frac{333}{334}$ nearly. In case third, $\frac{52.7}{51.7} \times \frac{10,000}{10,201} = \frac{1348}{1349}$ nearly. $\frac{1}{84.3} \cdot \frac{1}{334}$ and $\frac{1348}{1349}$ are in accordance with the law I deduced from my own formulæ. From this and the fact that my formulæ give the variation in the attraction of the earth as caused by figure, at any latitude as tested by the pendulum, I have concluded that my investigation must be true or Newton's law of gravitation and the pendulum are both delusive failures. I have no hesitation, then, in deciding, regardless of the criticisms of two distinguished mathematicians and astronomers, that the variation in the attraction of the earth due figure is a part of pure lunar theory, whether or not it meets Newcomb's outstanding column of corrections or his empiricism—with both of which I am now ready to compare my work.

Computations from my formulæ, based on mathematical demonstration and also proven empirically true, make the mean attraction of the earth greater on account of figure by $\frac{1}{3501500}$ on the moon for a revolution having the inclination of the plane of the moon's orbit to the plane of the equator 18° 18'. This shortens, as compared with standard unit, the time of such a revolution 0.7078 of a second, measured in arc 0.3886". For a revolution having inclination of the plane of the moon's orbit to the plane of the equator 28° 36', the attraction is greater by $\frac{1}{3555500}$, and time is shortened 0.5447 of a second, measured in arc 0.2991". The difference then in the two revolutions is nearly 0.09" of arc. The moon in 9.3 years or 124 revolutions passes from one of these limits of inclination to the other. The variation in time from revolution to revolution between these limits is not quite uniform; it is a trifle greater approaching the limit 28° 36'. The difference is, however, too small to affect materially the results given in this paper. Besides the variation in inclination is not quite uniform. If it were the object of this paper to establish a standard measure for the centuries from a period of a few years, it would become necessary to take into account such variations.

In diagram, line A B is 28° 36' limit, C D 18° 18', and E F 23° 27' inclination. Lines perpendicular to these are lines of epochs. The oblique lines, two of which are indicated by the arrows, are lines for tracing the position of the moon as regards inclination or declination.

Epochs.	1 Newcomb.	2 Newcomb.	3 Blackstone.	4 Newcomb.	5 Blackstone.
1650	- 6.9"	- 4.7"	- 6.0"	- 2.2"	- 0.9"
1675	- 7.4	- 7.1	- 6.2	- 0.3	- 1.2
1700	- 3.6	- 4.5	- 2.3	+ 0.9	- 1.3
1725	- 0.3	+ 1.2	+ 3.7	- 1.5	- 4.0
1750	+ 6.4	+ 7.3	+ 6.6	- 0.9	- 0.2
1775	+12.5	+11.0	+11.5	- 1.5	+ 1.0
1800	+11.1	+10.4	+11.4	+ 0.7	- 0.3
1825	+ 3.0	+ 4.8	+ 2.7	- 1.8	+ 0.3
1850	- 4.6	- 4.8	- 6.1	+ 0.2	+ 1.3
1875	-15.8	-16.0	-15.7	+ 0.2	- 0.1
1900		-26.4	-22.2		
1925		-33.0	-18.4		
1950		-35.0	-11.2		

The moon was at *a* 1850, at *b* 1750, at *c* 1650, at *m* 1849, and at *n* 1756. If Hansen had taken his standard unit from 1756 to 1849 or some multiple of 86 years, he would have had no trouble in adjusting his empiricism between these dates, and outside of them without becoming bewildered by the attractions of Venus. Besides his measuring rod for the centuries would have been more accurate. When Newcomb asks the question: "Is it possible that this correction to the term produced by the action of Venus can really be a result of the attraction of that planet?" he shows suspicion of the wily maiden, yet he courts her favor eighteen times in the empirical formula. The best line on which to adjust his fluctuations due the figure of the earth is E F, taking date about 1863, and any other differing from it any multiple of 18.6 years.

The moon in passing from limit 18° 18' to 28° 36' is retarded 5.6"; from 23° 27' to 28° 36', 1.4", and from 23° 27' to

quality of instruments used in 1725 is then a sufficient explanation for the discrepancy at that epoch. It did not require twenty years to prove Hansen's empirical term depending upon eight times the mean motion of Venus minus thirteen times that of the earth a delusion. I venture to predict that the next generation, including that "liberal supply of astronomers who scan our earth with powerful telescopes," will pronounce likewise on the empirical term depending upon eighteen times the mean motion of Venus minus sixteen times that of the earth minus the mean anomaly of the moon.

The discrepancy between the secular acceleration of observation and that due to the variation in the eccentricity of the earth's orbit is accounted for at least partially from using an inaccurate measuring unit for the centuries as shown by my investigation. It is no wonder then that astronomers by using different periods of time have disagreed five seconds on the secular acceleration of observation. It is doubtless true that the tides and the contraction of the earth very slowly but quite uniformly affect the length of the day. But such causes are not sufficient to produce fluctuations in the rotatory motion of the earth to account for such fluctuations as are discussed in this paper.

AN ESTIMATE OF GEOLOGICAL TIME.

A VERY ingenious attempt to fix a minor limit to the duration of geological time has been made in a paper lately read before the Royal Society by Professor Houghton of Dublin.

It involved, as a preliminary, the demonstration of the untenability of the theory that changes of climate in past ages can be explained by a supposed shifting of the pole. That it is not possible to account for the occurrence of tropical fossils in Arctic regions in this way was shown as follows:

"Let a great circle be drawn, joining Spitzbergen with Cook's Inlet, Alaska; this circle will pass nearly through the North Pole. In order to explain the tropical climate of these two localities, and also of the Parry Islands, the pole must be displaced at right angles to the great circle joining Spitzbergen and Alaska, along the meridian long. 117° E., nearly that of Pekin. The present difference of latitude between New Orleans and Spitzbergen is 45°; so that, in order to make the Arctic regions tropical, we must move the North Pole 45° on the meridian of Pekin, bringing it within three hundred miles to the north of that city. Hence it follows that, during the triassic period, Pekin lay under the North Pole, covered by the polar ice-cap. Let us now consider what the South Pole was doing; it had moved on the opposite meridian, and reached the mouth of the Rio Negro, on the east coast of Patagonia, about 1,000 miles to south-south-east of Valparaiso and the Chilean Andes. Jurassic strata have been found in the Chilean Andes at 34° S., containing the tropical *Ammonites bplex*, which is found also in Alaska, 60° N., and in Europe. This locality lies within 700 miles of the necessary position of the South Pole, and cannot have enjoyed a tropical climate. The proposed alteration of the North Pole is consistent with the occurrence of tropical animals in the Parry Islands, in Spitzbergen and in Alaska; while the proposed alteration of the South Pole would permit tropical animals to exist in New Zealand and New Caledonia; but the occurrence of jurassic ammonites within 700 miles of the South Pole is fatal to the proposed shifting of the axis of rotation, even if that were allowable to the extent required."

By a similar course of reasoning Professor Houghton shows that during the miocene period the North Pole must have been at or near the same place it now occupies. Whereupon he concludes that down to the miocene period, climates depended chiefly on the internal heat derived from the cooling of the earth, and that we may regard the fossils of the Arctic regions as self-registering thermometers, recording the mean temperature of those regions at successive epochs, marking so many fixed points on the earth's thermometer scale.

In addition to these points on the scale we have the present temperature of the Arctic regions directly observed, and two other temperatures determined by physical and physiological conditions, namely, the temperature of boiling water and the temperature at which albumen coagulates. No stratified rocks could be formed until the earth was cool enough to tolerate water, and no animal life could exist on the earth until it was cool enough to allow albumen to remain uncoagulated. Accordingly we find in the Arctic regions the following successive temperatures:

of a cooling globe, Professor Houghton finds the following scale of geological time:

Period.	From Theory of Cooling Globe.	From Maximum Thickness of Strata.
Azoic	33.0 per cent.	34.3 per cent.
Palæozoic	41.0 "	42.5 "
Neozoic	26.0 "	23.2 "
Total	100.0 "	100.0 "

The agreement between these figures, derived from independent sources, tends, he believes, to justify the principle held by many geologists that the proper relative measure of geological periods is the maximum thickness of the strata formed during those periods.

Extending the calculation founded on the theory of the cooling globe from period 4 to period 5 in the table, the interval of time from the miocene epoch, when the Parry Islands and Northern Greenland enjoyed a climate like that of Lombardy, to the epoch when those regions suffered a climate like that of Labrador, is found to be 32 per cent.; from which it appears that a greater interval of time now separates us from the miocene tertiary epoch than that which was occupied in producing all the secondary and tertiary strata from the triassic to the miocene epoch. This enormous time Professor Houghton believes sufficient to afford ample opportunity for the development of the gigantic mammals, which are commonly supposed to have somewhat suddenly made their appearance on all our continents, and to have disappeared as suddenly.

While believing that the condition of the earth's surface was profoundly different from its present condition during the geological periods when climates depended chiefly on the earth's internal heat, Professor Houghton goes on to estimate the duration of geological time from the present rate of continental denudation. After showing that atmospheric agencies are capable, at present, of lowering the land surfaces at the rate of one foot in 3,000 years, or of silting up the sea-bed at the rate of one foot in 8,616 years, he says: "If we admit (which I am by no means willing to do) that the manufacture of strata in geological times proceeded at ten times this rate, or at the rate of one foot for every 861.6 years, we have for the whole duration of geological time, down to the miocene tertiary epoch, $861.6 \times 177,200 = 152,675,000$ years," the multiplier being the maximum thickness in feet of all known stratified rock. To the time thus obtained we must add about one-third, as already shown, to bring in the period between the miocene and the time when Arctic regions had the climate of Labrador, giving for the whole duration of geological time a minimum of two hundred million years.

Estimates of this sort are instructive, even if not to be implicitly trusted. A peculiar feature of the foregoing is the large portion of time accorded to the more recent geological periods. The method of fixing thermometric points in the earth's history is original and ingenious, but it is evident that the first point, the temperature of boiling water, will not stand for the beginning of stratified rock formation. The liquid of the primeval sea must have been very different from the water of existing seas, so that the temperature 212° F. can hardly be taken as the beginning of erosion and consequent stratification.

THE MISSISSIPPI JETTIES.

In a letter to Congressman Crittenden, of Missouri, Capt. Eads says: "The jetty channel is now almost as good as the entrance to New York harbor. Larger ships and steamers visit the port of New Orleans than ever before. Ocean freights have been so greatly lowered in consequence that the saving on cotton alone from the port of New Orleans the past season was over \$1,600,000. Every intelligent man in Missouri knows that a revolution has been wrought in the grain trade as a result of this deep water. As the channel deepens and commerce adjusts itself to these new conditions the benefits to the producers in Missouri will be still more extensively enjoyed. The permanent improvement of the mouth of the Mississippi operates as a regulator of transportation charges, and thus adds to the value of every bushel of grain grown for export to Europe or for consumption in the Atlantic States; and it also cheapens to the farmer all of his merchandise and other supplies brought from the East."