

SCIENCE AT PORTLAND.

MEETING OF THE AMERICAN ASSOCIATION.
 HOW THE ANNUAL MILITIA MUSTER AFFECTED THE
 SCIENTIFIC ASSEMBLY—PLENTY OF HARD WORK
 ON A RAINY DAY—SAFETY IN NAVIGATION, AND
 PROF. PEIRCE'S VIEWS THEREON—THE DAR-
 WINIAN THEORY—SUDDEN INTERRUPTION OF AN
 EXCITING DEBATE.

[FROM THE SPECIAL CORRESPONDENT OF THE TRIBUNE.]

PORTLAND, Aug. 22.—This was a rainy day; raw and disagreeable. But there was no lack of interest among the members of the Association, nor, I may add, among the citizens of Portland. The latter in fact did themselves special credit, for the ladies of Portland provided a bountiful lunch for the Association and waited on the tables themselves. The town is full of country people, drawn together by the annual muster of the Maine militia. Old-fashioned wagons, drawn by horses that have seen service at the plow, carry through the streets bevy's of brown-cheeked lasses, with a goodly show of older members of families. Sometimes a homespun clad figure looks in upon the scientific folk, but for the most part the strangers who linger about the doors of the sections, and not understanding what is said saunter away, are dressed in their Sunday clothes.

Those who had studied the programme of the day and who recollected the faculty which Prof. Swallow of Missouri had on a previous occasion exhibited for "setting people by the ears," recognized in the announcement of his paper on the Origin of Species the prelude to a lively debate. But as the day wore away with the reading of papers it became evident that this one was to be the last. And while there was a good attendance all day in both sections it was very evident that the culmination of popular interest was toward the close of the afternoon meeting.

One of the most valuable papers read in yesterday's meeting was that of Gen. J. G. Barnard. I am unable by a days delay to present a better abstract of it than would have been possible yesterday.

ON THE RELATION OF INTERNAL FLUIDITY TO THE PRE-
 CESSION OF THE EQUINOXES—BY GEN. J. G. BARNARD.

Prior to the investigations by Sir Wm. Thomson concerning "the earth's rigidity," and his determination of the degree of rigidity needed in order that the actual precession should correspond so nearly as it does to the calculated precession for a perfectly rigid homogeneous spheroid, the earth, or even the "thin solid crust" of the geologists, had in researches concerning precession

always been regarded as perfectly rigid, or rather it had been taken for granted that the solid earth, or the solid crust, however thin, was practically rigid enough to be considered perfectly rigid. Hence the famous investigation of the late Prof. Wm. Hopkins of Cambridge, in which treating the solidified portion of the earth as rigid, it was attempted to find in the phenomenon of "precession" a test of the question of internal fluidity, and a determination of a minimum thickness admissible. In the treatment of this difficult problem by Prof. Hopkins there is a mastery of the higher analysis and a skill in its application to physical problems which extorts admiration; and yet there is in the fallacy of the final result and the general acceptance with which it has been received that which gives the investigation a claim to be ranked among the "curiosities" of modern mathematics. Although the discrepancy (one-seventh) between observed and calculated precession, which really forms the basis of his practical application, is however, believed to be very minute (owing to the less mass now attributed to the moon), and although the demand for rigidity demonstrated by Sir Wm. Thomson puts "out of court" the question of a thin crust, yet so late as 1868 the eminent French astronomer (then President of the Academy of Sciences) has attempted a formal "refutation," founded on an experiment with a glass globe ten inches in diameter, containing water, by which he would demonstrate that the neglected property of "viscosity" of a fluid by Prof. Hopkins vitiates all his results. The late Archdeacon Pratt, on the other hand, an authority on the "Figure of the Earth," attempts to vindicate Prof. Hopkins. Although neither the refutation nor the vindication are believed to be one or the other, they show that the problem has not by any means lost its interest. Papers read before the American Academy of Sciences, and published among the Smithsonian contributions to knowledge, are referred to for the proof given by the author that the centrifugal force of diurnal rotation of the tidal protuberances developed in a wholly fluid spheroid exactly neutralize the precession—producing couple due to the solar or lunar attraction—which causes the protuberance; hence that in such a spheroid there would be no precession. *Pari ratione*, to the extent protuberances are developed in a solid spheroid, or in the thin crust (in the latter case nearly as great as if wholly fluid), will the precession be neutralized. That such protuberances be not developed Sir Wm. Thomson demonstrates that the rigidity of the earth's substances must greatly exceed the actual rigidity of iron to depths of 1,000 or 2,000 miles. On the other hand, all heterogeneous mixed liquids in congeal-

ing separate. Observation shows that this law obtains in volcanic lavas. Hence, regarding the earth as a congealed spheroid once liquid, there would be large subterranean cavities still containing uncongealed liquid. By reference to these, Sir Wm. Thomson believes that the geological phenomena of volcanoes, earthquakes, upheavals, &c., may be explained.

The paper sets forth the "rationale" of the action and reaction between an internal fluid and an enveloping shell (or crust), and it is very elegantly treated by Prof. Hopkins, and thence declares the result of the latter, that for homogeneousness of shell a fluid, precession will be the same as if the whole were solid. It shows that this same result applies equally to the case of heterogeneousness of shell and fluid—that is, to the case of the actual earth; that Prof. Hopkins's famous result that there must be a solid crust to a depth of at least 800 to 1,000 miles is founded upon his fallacious manner of computing the pressure of a heterogeneous enveloped fluid upon its envelope; that this determination containing all the difficulties of the transcendental problem of the "figure" of a heterogeneous earth is made by Prof. Hopkins as extraordinary for its fallaciousness as for its simplicity—*i. e.*, by integration of the attractive forces on the elementary particles of the fluid as free forces.

Gen. Barnard solves the question by this proposition, and asserts that its denial would, carried to its legitimate consequences, involve violation of the law of "conversation of energy." Given a heterogeneous fluid wholly enveloped by a rigid shell, and a state of static equilibrium assumed in relation to internal forces and a foreign attraction, the pressure-couple of the fluid on the shell due to this attraction is one and the same as that which would be exerted on the fluid solidified.

According to Prof. Hopkins, this identity exists only in the case of homogeneousness; and hence, and hence only, his famous and fallacious result that precession is different for a heterogeneous shell and fluid from that which would belong to the spheroid wholly solidified, and that there must be a crust of 800 or 1,000 miles thickness.

Gen. Barnard shows that this simple correction converts Prof. Hopkins's formula into one exhibiting identity of precession in the two cases; he shows moreover that his actual formula as it stands expresses exactly the reverse from what he supposes; that it really gives greater (instead of less, what he needs) precession by thickening the crust.

The following "conclusions" quoted from Gen. Barnard's Smithsonian paper are deduced:

First: The analysis of Prof. Hopkins, in its application to a homogeneous fluid and shell, seems to establish (and the result is confirmed by its harmony with tidal phenomena as developed in p. 43) that the rotation imparts to the fluid a practical rigidity by which it reacts upon the shell as if it were a solid mass, while its pressure imparts to the shell the requisite couple to preserve the precession unchanged.

Second : The same practical rigidity is, with entire reason, attributed to the heterogeneous fluid by which (leaving out of view minute relative oscillations which do not affect the mean resultant in other natural phenomena and should not in this) the shell and fluid take a common expression.

Third : The two masses retaining their configurations, mutual relations, and rotary velocities, essentially unaltered by the hypothesis of internal fluidity, it would be a violation of fundamental mechanical principles were the resulting precession not identical with that due to the entire mass considered as solid.

Fourth : The common and identical precession of fluid and shell resulting from the analysis, is indispensable to any conception of precession for the earth as composed of thin shell and fluid; for otherwise internal equilibrium would be destroyed and the "figure of the earth" cease to have any assignable expression. The entire mass, fluid and solid, must (without invoking the aid of "viscosity") be carried along in the precessional motion of the earth. The analysis I have examined demonstrates the possibility and exhibits the *rationale* of such a community of precession, but fails in the attempt to exhibit a test of the existence or absence of internal fluidity.

Fifth : The powerful pressures that would be exerted upon a thin and rigid shell would probably produce in it noticeable mutational movements; while if the shell be not of a rigidity far surpassing that of the constituents of the cognizable crust, the precessional motion of the earth would, owing to the neutralizing effect of tidal protuberances, scarcely be observable.