Regalecus has a large orbitosphenoid, and Mr. Tate Regan has recently shown[12] that *Lampris* and *Velifer* also have one. I believe these and the Berycoid fishes to be the only spiny-rayed fishes in which the orbitosphenoid has been proved to exist.

Dr. Berg has apparently not appreciated the true significance of the presence of an orbitosphenoid in *Regalecus* when he remarks towards the end of his paragraph that this element has been found from so low a group as the Berycoids to so high a one as the Trachypteridæ. Instead of indicating that an orbitosphenoid may be looked for anywhere among the Acanthopterygii it rather indicates the primitive character of *Regalecus*. Mr. Regan (*op. cit.*) has, in fact, recently placed it in close relationship with the Berycoid fishes, but whether or not *Regalecus* (with its relatives forming the group Tæniosomi) originated from the Berycoid fishes, it is at least as primitive as they are, and belongs in the system not far from them. If it is true that *Grammicolepis* has an orbitosphenoid it would indicate its position also to be not far from the beginning of the series of spiny-rayed fishes.

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AN EXPLANATION OF THE CAUSE OF THE EASTWARD CIRCULATION OF OUR ATMOSPHERE

IN SCIENCE for December 20, 1907, I have shown that the principle of the conservation of energy demands that *temperature must be taken as a measure of the intensity of ether vibration;* this mandatory condition at once gives us the information that only the Newtonian law of radiation can be true, and this claim is upheld by my interpretation of existing observations (as explained in the closing paragraph of that paper). I then demonstrate that the absolute temperature of space at the earth's distance from the sun is probably less than two degrees centigrade.

As known gases become either liquid or solid when the temperature is reduced to within a few degrees of the absolute zero, a planet can have no atmosphere unless its surface-temperature is above the critical temperature of the gas which forms the atmosphere.

From the differences between the polar and equatorial temperatures near the earth's surface, and from the decrease in temperature with increasing height above the surface, it is known that the atmospheric layers near the surface of the earth act as a trap to retain the heat until the temperature reaches a limit which varies with varying atmospheric conditions; beyond this limit the loss of heat through radiation into space is just equal to the heat received, so that no farther increase in temperature takes place.

As the direct rays of the sun can strike only one half of the earth's surface at a given instant, while the equivalent heat is later on radiated from the whole surface of the earth, it is plain that the mean *solar* component of earth-radiation can not at its maximum exceed one half of the sun's radiant effect at the earth's distance from the sun, or 0°.75, if 1°.5 is adopted as the temperature of space; practically, therefore, the whole terrestrial radiation into space is due to inherent earth-heat.

Let us, provisionally, take it for granted that on the average the atmospheric layers near and in contact with the earth's surface have, by reason of the trapped heat, a temperature 100° higher than would be the case if no heat were stored in these lower layers, we then readily arrive at the results given in the following table:

Distance above Earth's Surface (in Miles)	Terrestrial Radiation		Temperature of Direct Solar Rays	Gravity
	Earth's Component	Sun's Component		
0	200°	0°.7	0°.7	1.00
10	199.	0.7	1.+	0.99
100	190.	0.7	1.+	0.95
1,000	128.	0.6	1.+	0.64
10,000	16.	0.1	1.5	0.08
100,000	0.1	0.0	1.5	0.04

From an inspection of the above table we learn that during the first few hundred miles the decrease in temperature, due to radiation, is only one degree for each additional ten

[12] *Proc. Zool. Soc. Lond.*, 1907, pp. 634–643.

miles of altitude, so that in the higher available regions of the atmosphere (where the decrease in the stored heat, for accessible increasing heights, is probably insensible) observational data should reveal a practically constant temperature for all superior distances that can be reached by the known means at our disposal. *The experimental results recently obtained by means of kites and balloons confirm in a striking manner the run of the data given in the above table,* in which the *earth,* not the sun, is taken as the controlling influence so far as temperature conditions are concerned.

The ever-varying unstable conditions in the lower strata of high temperature cause more or less continuous ruptures of these strata, each vent containing an uprush of the heated air fed by a horizontal inrush on all sides. In the equatorial regions the inrushing air has a more or less uniform temperature, and the direction of motion is nearly straight towards the axis of the uprush, so that great cyclonic motions are not to be expected as a regularly recurring phenomenon in these regions. In the middle latitudes, however, the conditions are always such that cyclonic movements of the lower air are almost inevitable.

Owing to the decrease in the diurnal surface-velocity of the earth with decreasing polar distance, an uprush of air in a middle latitude will, in general, be supplied as follows: on the equatorial side, by warm air rushing polewards, not directly towards the axis of the uprush, but always towards a region on the east side of this axis; on the pole side, by cold air moving equatorwards towards a region on the west side of the axis. Owing to this arrangement of the moving air, equilibrium can not at once be restored, and a great cyclonic motion of increasing intensity results, to be overcome later on by the destruction of the vertical motion through the now increasing want of sufficient air-pressure from below.

The cyclonic motion of the atmosphere, brought into action through the axial rotation of the earth, has long been known, but so far as I am aware no satisfactory answer has ever been given to the question—*Why does the atmosphere, taken as a whole, have a greater angular velocity of rotation (diurnal) than the earth itself?* I offer the following explanation:

An inspection of the above table shows that the uprushing expanding air may rise many hundred miles and still have a temperature far above the critical point.[1] *As the air-mass rises (and loses its moisture through condensation) its diurnal angular velocity diminishes, so that by the time this same (now dry) air again reaches the lower layers of the atmosphere, to cause an increase of pressure, the region of the uprush will be far to the east of the place where the pressure has increased. To restore the equilibrium the piled-up mass of air now flows back into the region of low pressure farther to the east and thereby causes an eastward motion of the atmosphere with reference to the earth's surface.*

As each "low" is forced to move eastward by its necessarily following "high," the general eastward circulation of our atmosphere is explained. It is evident that the observed equatorial acceleration of the sun's atmosphere, and of planetary atmospheres in general, can be explained in a similar manner.

In an atmosphere quiescent throughout, the different gases constituting the envelope would be arranged in concentric layers, the lightest gas being at the top; through the vertical circulation, however, a mechanical mixture of these gases must take place, and other phenomena must also result.

J. M. Schaeberle

Ann Arbor,
March 24, 1908

[1] It is proper to state here that during the progress of my investigations it was found necessary to reject the kinetic theory of gases and to substitute in its place a simpler and more rational theory, which is so general in its application that even gravitation is satisfactorily accounted for. According to this theory the force which causes an uprush, or which causes radiation in general, has the same source and the same properties as the force which causes gravitation and other physical phenomena of nature.