nearly horizontal suture, thus forming a strong suborbital bony wall.

In the Delphinoidea, the delicate character of the suborbital process of the jugal, and its union with the squamosal, render it difficult at first sight to determine its relation to the arch, and yet, when compared with that of the horse, its homological character cannot be disputed.

In the Balænoidea, much the same conditions are presented, except that the suborbital process of the jugal is both stronger and more curved. The small capacity of the temporal region, as well as the limited extent of the arch in the Cetacea, are correlated with the modifications presented by the mandible, in which the condylar surface is small, and looks directly backwards. There is no ascending ramus, and the coronoid process is quite rudimentary, — all of which conditions are in direct relation to the nature of the food, and absence of the masticatory movements.

The jugal arch in the Sirenia is enormously developed, being composed of the squamosal and the jugal. The former of these is much thickened and presents upon its external face a smooth convex surface.

In the Manatus, this process of the squamosal rests loosely upon the process of the malar, which, underlying it, extends back as far as the glenoid, having first formed a rim which is both suborbital and post-orbital, besides sending a broad plate downwards and backwards, thereby greatly increasing the vertical breadth. The orbital fossa is separated almost completely from the temporal by a bony partition.

The surface for the muscular attachments, both of the temporal and masseter, are extensive, while the pterygoid plates and groove are relatively enlarged. The vertical curvature of the arch is great, but the horizontal is inconsiderable. The ascending ramus of the mandible is broad, compressed, with rounded angle, and surmounted by an obliquely-placed small convex condyle, much raised above the molar series. The coronary surface is broad, directed forwards, and but slightly elevated above the condyle.

In the Dugong (Halicore), the jugal arch is much less massive; there is no post-orbital process from the jugal, and consequently no separation of the orbital and temporal fossæ by a bony orbit. The coronoid process of the mandible looks backward.

Although the horizontal curvature of the arch is very slight in both genera of the Sirenia, the temporal fossæ are deepened and extended — conditions owing to the walls of the cranium being compressed in a lateral direction, which materially increases the extent of surface for muscular attachment and development.

In the order Edentata, the jugal arch also offers unusual modifications. In the Myrmecophagidæ it is very incomplete, being composed of the proximal end of the jugal, articulating with a narrow projecting process of the maxilla, and a very rudimentary fragment of the squamosal. These separate portions, however, do not meet. In fact, they are widely separated. No boundary exists between the orbital and temporal fossæ, the latter being comparatively shallow. The glenoid fossa is a shallow cavity running antero-posteriorly, and well adapted to the pointed, backward projecting condyles of the mandible, whose long, straight horizontal rami present neither coronoid process nor angle. In Cycloturus, the mandible is somewhat arched, and presents a well-marked angular process, as well as coronoid surface slightly recurved.

In the Bradypodidæ, containing the two species Bradypus and Cholœpus, the arch is imperfect, consisting of the jugal, which is narrow at its articulation with the lacrymal and maxilla, but which, widening out into a broad, compressed plate, terminates posteriorly in two processes, the upper pointing backwards and upwards, while the lower looks downwards and backwards. The straight process of the squamosal, although fairly developed, fails to meet either of those of the jugal. There is a post-orbital process of the frontal, which is best marked in Cholœpus. The glenoid is shallow and narrow from side to side. The mandible, widest in Cholœpus, develops a rounded convex condylar surface, well raised up from the dental series, while the coronoid surface is large and recurved. The rounded angular process projects backwards to a considerable extent. The symphysis in both species is solidified, while in Cholœpus it projects forwards into a spout-like process. The temporal surface for muscular attachment is large, as are also the pterygoid plates.

In the Dasypodidæ, the arch is complete, and in its formation the jugal largely enters. This bone extends from the lacrymal and frontal to the process of the squamosal, the anterior third of which it underlies. There is no post-orbital process of the frontal. The glenoid presents a broad, slightly convex, transverse surface. The pterygoids are small. The mandible has a high ascending ramus, the condyle is transverse and high above the alveoli, while the coronoid surface is large and the angle broad and projecting.

In the Manidæ, the jugal arch is incomplete, owing to the absence of the malar, which, if present would occupy almost the exact centre of the arch, — the length of the squamosal process, and that of the maxillary, being nearly equal on either side. The temporal and orbital fossæ form one depression in the side of the skull. The rami of the mandible are slender and straight and without teeth, angle, or coronoid process. The condyle is not raised above the level of the remainder of the ramus.

In the Orycteropidæ the jugal arch is complete. The horizontal curvature is very slight. The post-orbital process is well developed. The mandible rises high posteriorly, with a coronoid slightly recurved, and with an ascending pointed process on the angular edge below the condyle.

In the Marsupialia, the jugal arch is always complete, and composed of the jugal, resting on the maxilla, and squamosal, the first extending from the lacrymal anteriorly to the glenoid fossa posteriorly, of which it forms the external wall. The process of the squamosal passes above the jugal, being united to it by an almost horizontal suture. The horizontal and vertical curvatures of the arch are considerable, and the space for both temporal and masseter muscular insertions is extensive, and the various ridges and crests are extensive, especially in the families of the Dasyuridæ and Didelphyidæ. The post-orbital of the frontal is present as a rule, although in most forms inconsiderably developed. The ascending ramus of the mandible is less elevated than in several of the orders of the Mammalia. The condyle is but little raised above the molar series. The masseteric fossa is extremely projected at its lower external border. The mandible has, with one exception, an inverted border to the angle.

In the Monetremata, the Echidnidæ possess an arch in which the squamosal is compressed, and sends forward a slender, straight process to join the corresponding slight, shaft-like process of the jugal. The horizontal curvature of the arch is extremely small.

In the Ornithorynchidæ, the arch is made up of the malar resting upon a process of the maxilla, which, passing straight backwards, unites with the squamosal process that rises far back on the sides of the cranium. While the mandible of the Echidna has but the rudiments of the parts which usually enter into its formation, that of the Ornithorynchus is more fully developed, in relation to the attachment of the horny teeth.

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

On request in advance, one hundred copies of the number containing his communication will be furnished free to any correspondent.

The editor will be glad to publish any queries consonant with the character of the journal.

The Mean Distance of the Earth.

THE interlinear readings to Sir Robert S. Ball's "The Course of an Ice Age" which Miss Hayes gives in *Science* for April 28 have been read and studied with much grateful appreciation by some readers of that book who find the higher mathematics rather slippery ground to walk on without help. On behalf of a group of such readers, I wish to say a few words on the interlinear reading given for the first selection from Sir Robert's book.

The passage is: "There can be no doubt that when the eccentricity is at its highest point the earth is, on the whole, rather nearer the sun, because, while the major axis of the ellipse is unaltered, the minor axis is least." Miss H. says: "This is equivalent to saying that the mean distance of the earth from the sun is a function of the eccentricity of the earth's orbit, . . ." and then she proceeds to find an expression for this mean distance, first from the standpoint of geology, and, second, from a consideration of the kinematical element of velocity. The result in the first case is that

$$r' \text{ (mean distance) } = a \sqrt{1 - e^2},$$

and in the second case that

$$r' = a \sqrt[4]{1 - e^2}.$$

From what is said in introducing the second case it appears as if the kinematical result were only an "as it were" mean distance, and not the actual average of all the different distances. If this were so, this part of the article would scarcely supply an interlinear reading for the passage from Ball, for it seems evident that he means the real average distance and not a virtual average. The geometrical result should give the real average, but does it — I mean does Miss H.'s geometrical result give it? This makes it equal to the semi-axis minor, but that surely cannot be true. Of course, it is quite true, and, as Miss H. says, it is easily shown that

$$\frac{1}{\pi} \int_0^\pi r \, d\theta = a \sqrt{1 - e^2},$$

but she does not show how it is shown that the mean distance

$$= \frac{1}{\pi} \int_0^\pi r \, d\theta.$$

As an assumption it does not seem to be convincingly reasonable.

The assumption made in the kinematical discussion seems much more reasonable. It is that the mean distance is the radius of a circle, in the circumference of which a point travels with the same areal velocity as that of the earth in its orbit. If the idea of velocity be dropped, we shall get back from kinematics into geometry, and the same assumption will give us for mean distance the radius of a circle whose area is equal to that of the given ellipse.

Thus $$\pi r_0^2 = \pi a b$$

and $$\therefore \quad r_0 = \sqrt{a b} = a \sqrt[4]{1 - e^2}.$$

This is the same as Miss H.'s kinematical result, and, like it, agrees with the dynamical result in her equation (4).

ALICE PORTER.

Yarmouth, N.S., May 15.

A Beautiful Spectacle.

I GIVE below a description of a phenomenon seen here on the evening of May 9 and wish you or some of your readers could tell me if it is rare or common, and what is the cause or its relation to other phenomena

On Tuesday evening, May 9, between 9.15 and 9.45 (north latitude 44°, west longitude 66°, but *time* is 60°), we were treated to a curious and beautiful spectacle. Right across the sky from west to east stretched a magnificent arch of luminous radiance. On the west it seemed to spring from a solid mass of black cloud which extended along the whole northwest horizon. Its width was nearly uniform from the western base up beyond the summit, and measured about two degrees. The summit was among the stars of Berenice's Hair, and was 15 to 20 degrees south of the zenith. The eastern branch narrowed as it neared the horizon, and tapered off to a point before quite completing the semi-circle. The color was fairly uniform throughout, and of a grayish or pale-bluish white, some say "yellowish." Except for the cloud-mass in the northwest the sky was beautifully clear, and the brighter stars along each side of the arch seemed to shine out with unusual brilliancy and sparkle. Those covered by the arch were not obscured, but twinkled through it as through a transparent veil. To some observers the summit seemed for a time to move very slowly a little farther south, and near the time of breaking up there were narrow, dark rifts crossing it obliquely; but, on the whole, the entire structure stood remarkably steady, without any of the swaying, or shooting, or shimmering, or wavering motion generally seen in auroras. There had been some auroral outbursts about half an hour earlier, and this phenomenon was probably connected with them. Whatever it was due to, it was a splendid sight — such a sight as the rings of Saturn must be as seen from the surface of that planet — and it was much admired by all who saw it. It broke up and melted away before 10, and in another quarter of an hour the sky was clouded all over.

ALICE PORTER.

Yarmouth, N.S., May 12.

A Fall of Colored Snow.

ON Jan. 8 1892, between one and five o'clock P.M., there fell about one inch of colored snow throughout the northern half of La Porte County, Ind.

Mixed with the snow was a large percentage of mineral and vegetable matter giving the snow a reddish-brown hue. Every flake of snow had a particle of this matter, that served as its nucleus, from which the mass became granular. The mass was moist enough to form a crust within twelve hours.

At the time it fell there were six inches of clean snow very evenly distributed over the surface, probably not any surface bare within fifty miles of the above-named area. This old snow was quite compact.

During the next twenty-four hours following the fall of colored snow about four inches of clean snow fell on top of it, and became a crust within a few days, thus embedding the colored snow between two compact strata of ordinary snow, by which it was kept free from contamination for about a month. During that time several persons procured samples of it for examination.

The meteorological conditions at the time of its fall were: Wind from west-southwest; all clouds moved in same direction. Temperature, about zero at 8 A.M. Jan. 8, 12 to 3 P.M., rising; 8 P.M., zero. Thermometer stood at zero Jan. 9. At Chicago from 4 until 4 30 there was light snow, too light to measure. At Grand Haven, Mich., it snowed almost continuously from Jan. 5 to 10; and on Jan. 8, thermometer fell from 18 to 8 above zero (the coldest of the season); while at Chicago it went down as low as 5 below from 12 above zero. That station reports a high-pressure area for the whole northwest country, weather cold and clear. This area closely followed an area of low-pressure, which was central over Upper Lake Michigan during the morning of Jan. 8, moving rapidly northwestward during the succeeding twenty-four hours, general snow marking its passage. The Chicago observing station records wind from west to northwest Jan. 8–9.

Having had my attention called to some of these facts by an article in a local newspaper by Honorable G. H. Teeter of Rolling Prairie, Ind., I began to collect samples, and procured one from that gentleman. I sought to make a survey of the area covered by its fall, but was unable to locate bounds in any direction, although I traced it over an area 25 by 45 miles.

To avoid uncertainty in an analysis of the matter, I drove several miles into the country with Professor F. M. Watters, then science teacher in La Porte High School, to procure samples of it that should not be affected by dust from chimneys and railroads.

I made three analyses of it, besides carefully examining it under the microscope, using both low and high powers. Meanwhile, Mr. Teeter procured an analysis by Professor H. A. Huston, chemist of Indiana Agricultural Experiment Station, at Purdue University, Lafayette, Ind., as follows: —

" Loss on ignition (water and other volatile matter)	15.04
Silica	65.64
Alumina and oxide of iron	15.50
Lime	2.19
Magnesia	1.38
Phosphoric anhydride	.10
Oxide of titanium and undetermined	.15
Total	100.00 "

Professor Huston adds: "The composition of the material is such that one is led to believe it to be of volcanic origin, as it approximates very closely to some of the analyses of lava from the