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ART. LVII.—*Archelon ischyros: A new gigantic Cryptodire Testudinate from the Fort Pierre Cretaceous of South Dakota;* by GEO. R. WIELAND. With Plate VI.

ALTHOUGH it is now some twenty years since Cope first described the genus Protostega, little or nothing has been added to our knowledge of it by the description of new American species. And save the Italian Protosphargis of Capellini this branch of the Sphargididæ has remained a quite isolated one.

I, therefore, propose to describe at this time certain portions of a new gigantic testudinate closely allied generically, from the Fort Pierre Cretaceous of South Dakota, for which the name *Archelon ischyros* is proposed.

The skeleton consists of carapace complete with ribs nearly entire, the procoraco scapulars and coracoids, one humerus complete, both femurs, radius and ulna, tibia and fibula one each, a number of carpals and tarsals, a number of phalanges, most of the cervical and caudal vertebræ, all the dorsal vertebræ, the pelvis entire, a nearly or entirely complete set of spine set plastral shields, fragmentary marginals, and certain bones whose reference has not as yet been decided upon.

As all the larger bones were found in place and the material for a restoration is so exceptional,—one will be given in a short time.

General description.

Carapace.—The carapace is composed of nine pairs of pleuralia, and eight medial pairs of plates or neuralia, followed by one single medial plate and the pygal, or 36 in all. These plates are all very thin and of finely striate surface. They unite very

imperfectly by means of loosely doubled interlocking and overlapping digitations grading into frequent free spines posteriorly. These digitations are mostly long, thin and ribbon-like, and produce a junction quite different from the usual suture. In many cases there is an appearance such as would result if the digitations of the one plate had lain upon the surface of the adjoining plate when it was in a plastic condition and thus raised rounded ridging about their edges. The order of the digitations and their size is rather irregular.

With the exception of the medial pair of plates corresponding to the eighth dorsal vertebra and the single medial following, which are small and crowded, and the pygal, which is comparatively large and heavy, the plates of the carapace are quite regular in size. The width and thickness are quite the same throughout, with a shade more of development of both in the pelvic region. One of the chief features of the carapace is the arching into a heavy dorsal ridge, beginning just back of the region of the first dorsal vertebra, and from thence continuous, except in the sacral region. It marks the position of the neural spines, and is very distinctly grooved from anteriorly to the region of the eighth dorsal vertebra. Immediately over the neural spines this groove inclines to widen, deepen and send out asteriations. In life, these grooves were no doubt filled with horny material, and the animal may have borne a dorsal row of spines. It is the appearance along this groove that makes me regard the medial carapace as consisting of a double row of plates. If these are not to be regarded as separate ossifications, the whole number of plates would be 28, consisting in the nine pairs which are morphologically* simply uncinoid expansions of the ribs, and a medial row of plates, ten in number. I shall have more to say about the carapace at a subsequent time. It consists of very thin, but dense and splintery, bone imbedded in exceedingly hard, indurated marl. In one section, through the medial dorsal ridge just back of the third rib, there is a large open space above the centrum, the thickness of the carapace being in no place much over ·5^{cm}. At another break, exposing in section more nearly through the end of a centrum, back of the sixth rib, the outer carapace may be said to form a very open V, consisting of very thin layerings, while there is a very thin laminated to honeycombed connection with the summit of the underlying neural spine ·3^{cm} in thickness by 1^{cm} in vertical height. There is a tendency to very small thin and irregular bony projection from both bases of this connection. In the

* On relation between carapace and endoskeleton, see Baur, Science, March 23, 1888; also a much more extended treatment in the Biologische Centralblatt, Nr. 5, 6, 1889 (Erlangen).

pelvic region the connection between the carapace and neura spines is no more than one of contact, while in the sacral and caudal regions there is no connection whatever.

Measurements of Carapace.

	Meters.
Total length of portion preserved (exclusive of nuchal and part of pygal)	1·515
Estimated total length, exclusive of nuchal	1·70
Breadth between 2nd and 3rd ribs	·40
" " 5th and 6th "	·40
" " 6th and 7th "	·45
" " 7th and 8th "	·36
" " 8th and 9th "	·28
Narrowest portion of pygal anteriorly	·10
Thickness of carapace	·002–·015

Ribs.—The ribs, of which there are nine pairs, are remarkable for their distal increase in thickness, only 2·5^{cm} in thickness at the edge of the carapace; the distal two-thirds of their length is very massive. In the five anterior pairs the thickness three-fourths out, that is at 75^{cm} from the centra, is from 4 to 5^{cm}. The width is quite regular, and the surfaces, for the four-fifths of the length free from the carapace, is markedly striate longitudinally. In cross section the ribs are T-shaped as they emerge from the carapace, medially they are triangular merging into flattened elliptical distally. The two anterior and two posterior pairs have shallow longitudinal grooving on their upper surface.

In cross-section the ribs show, following a very thin, dense outer layer of bone, a concentric lining, grading into a somewhat spongy interior.

Measurement of Ribs.

	Meters.
Length of 1st rib	·95
" " 2nd "	1·01
" " 3rd "	1·02
" " 4th "	1·02
" " 5th "	1·01
Average thickness of above ribs as they emerge from carapace	·025
Thickness of third and fourth ribs half way out,	·05
Width half way out, 1, 2, 3, 4, 5, 6, 7, 8, 9, respectively, ·075, ·075, ·078, ·075, ·07, ·065, ·06, ·055, ·05.	

Vertebral Column.—Five of the cervical centra with three arches were recovered, the last three being in place. The neu-

ral arches articulated with the centra, and were X-shaped bodies with spreading feet which stood well forward on the centra. Subquadrilateral projections extending well forward bear the prezygapophyses, which are somewhat broken away, but seem to have looked forward rather than upward. Immediately over the neural canal the neural spine retreats rather sharply, at the same time taking a keel shape anteriorly, but posteriorly dividing and spreading out into alæ, which form a distinct deep pit and bear on their under surfaces the postzygapophyses. Posteriorly, there is a groove connecting this cup with the neural arch. Anteriorly, the neural spine does not fork as distinctly above as in the very similar vertebræ of *Protostega gigas* Cope.*

The centra are very heavy and strong bodies, and indicate a neck of enormous strength. They are procœlous, and flat in front, except for the articulating concavity. The anterior upper half rises collar-like on either side of the neural canal, forming an upward and forward-looking articular surface, on which rests the base of the neural arch. The neural canal is scooped out very deeply, and as there is a somewhat similar longitudinal cavity on the nether side, the vertical distance through the centrum is considerably lessened. There are also two similar cavities beneath on the sides, with a heavy ridge, with convex edge, between these and the ventral cavity. Leading from the two lateral concavities around to the neural concavity is a very distinct groove, getting shallower just as it reaches the upper face.

Measurements of 3rd or 4th Cervical Vertebra.

		Meters.
The centrum.		
Length		·095
Width		·140
Diameter of anterior concavity	vertical	·065
	horizontal	·08
Diameter of posterior convexity	vertical	·08
	horizontal	·10
Depth between cup of neural canal and nether groove		·06
The articulating neural arch.		
Total length		·122
Basal width (total)		·11
Width between the bases		·045
Width at top		·075
Distance from base to summit of neural canal		·065
Total vertical depth of neural canal		·08

* Cretaceous Vertebrata of the West, Plate XI, fig. 5 *a*, *b*, *c*, *d*.

The *dorsal vertebræ*, ten in number, have not as yet been completely examined. They present, inferiorly, a striking resemblance to those of *Protosphargis* as restored by Capellini, but with this important exception: in *Protosphargis* the third dorsal vertebra is the largest, in *Archelon* the sixth is by far the largest.* They have nearly, or wholly, flat ends. The neural arches are evidently rather flat bodies, articulating with the centra and forming the heavy dorsal ridge mentioned before. They have little or no connection with the carapace. The dorsal centra increase in size to the sixth. The seventh, eighth and ninth rapidly diminish to the sacral, which are short and flat, and three in number. Following the sacral were five or more *caudal vertebræ* with articulating neural arches, and then fully ten whose arches, like those of the cervical vertebræ of *Protosphargis* and unlike the caudal vertebræ of *Sphargis*, were homologous parts of the centra.† Presumably these were situated beyond the pygal. Of these caudal vertebræ, ten or more were recovered, wholly or in part.

Coracoid.—The coracoid is a shapely and comparatively slender bone, 77^{cm} in length. The lateral surface is finely striate, with larger parallel striations distally. The articulating surface is very distinctly tuberculated, some of the tuberculations being somewhat rounded, others quite conical and so much as 1^{cm} across at base and 1·5^{cm} high.

The articular face is strongly convex anteroposteriorly, and a little less so laterally, but in such manner that near the outer edge of the surface for the procoracoscapula there is a slight concavity, while the humeral surface is broadly flat and looked well downward and forward. For the first two-fifths of its length the shaft is in section isosceles right triangular, with the right angle on the inner side. The upper inner side of the shaft, however, takes a long turn to the outer face just beyond the middle, leaving the distal end comparatively thin and flat. The coracoid is much larger than in *Protostega*, as are all the bones, but bears strong resemblances.

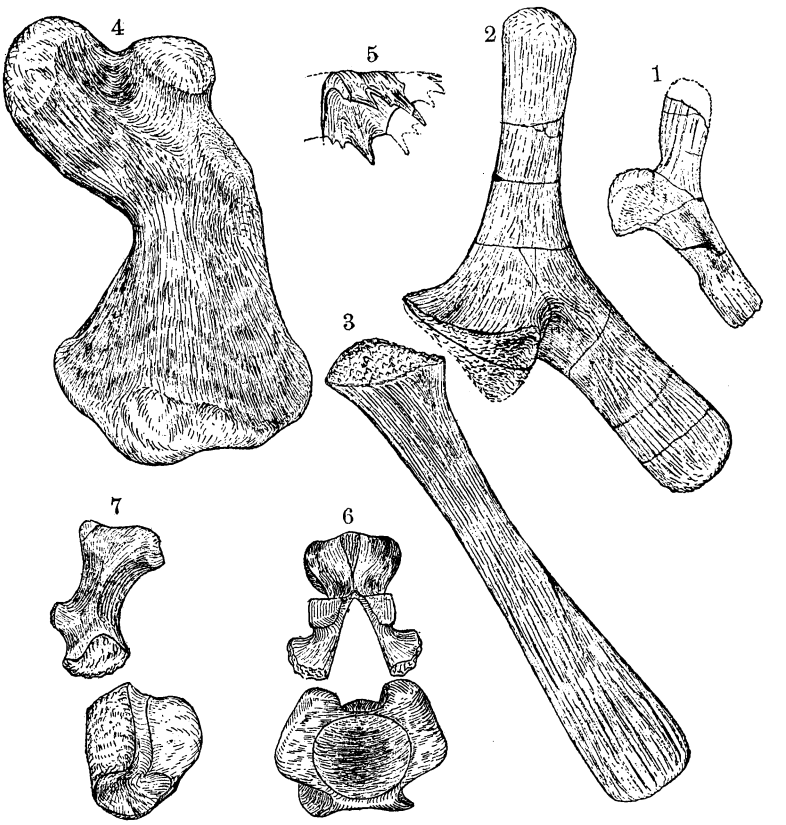
Measurements of Coracoid.

	Meters.
Greatest length	·77
Greatest distal width	·142
Least circumference of shaft	·25
Greatest length of articular face	·20
Greatest breadth of articular face	·145

* Il Chelonio Veronese, Reale Accad. dei Linci, 1883–4 (Rome).

† See the beautiful memoir,—Osteologie du Sphargis Luth. (Sphargis coriacea) par M. Paul Gervais, pp. 199–227 Planche V.—VIII. Nouvelles Archives du Museum, Tome 8, 1872 (Paris).

Procoracoscapular.—The procoracoscapular strongly resembles that of *Protostega*, the chief differences being that while the scapula of *ischyros* is rotund on the outer side, that of



PROTOSTEGA GIGAS Cope.—1. Right Scapuloprocoracoid, one-tenth natural size. And from same individual as Plate VI.

ARCHELON ISCHYROS.—2–7. All from the same individual as Plate VI, and one-tenth natural size, except 6 and 7, which are one-sixth.

2. Left Procoracoscapular, approximate outer view.
3. Left Coracoid Procoracoscapular, approximate outer view.
4. Left Humerus, inside view.
5. Portion of a Marginal.
6. Third or fourth Cervical Vertebra, front view.
7. The same, side view.

Protostega has a well-marked longitudinal depression near the middle and a shoulder-like expansion of the outer edge of the distal end. On the contrary, however, while the shaft of the procoracoid of *Protostega* is quite regular in outline, that of

ischyros bears an elongate ridge just opposite the coracoid border. The scapula and procoracoid stand at the same angle of 125° in both cases. Distally, both these elements are subtriangular in section, with the vertices well on the inner side, leaving the inner faces somewhat ridged distally, though medially there is very distinct flattening.

The outline of the articular face is approximately that of an isosceles trapezoid, with a broadly saddle-shaped convexity angling across it so as to leave on the one side of the upper and wider end of the articular face a concavity for the reception of the coracoid, and on the other side a broad, rather flat, humeral expanse. The entire articulating surface, like that of the coracoid, is tuberculated. The lateral surfaces are finely striate, the procoracoid having additional large striations, like those of the coracoid.

Measurements of Procoracoscapula.

	Meters.
Width of neck	·171
Width of articular extremity	·21
The greatest transverse width of same	·13
Length of precoracoid to inferior border of the scapula	·35
Length of scapula to inferior border of the precoracoid	·485
Length of the scapula to the glenoid cavity	·45
Distance between extremities of the scapula and precoracoid	·66
Width of precoracoid proximally	·117
Least width of precoracoid	·107
Distal width of precoracoid	·127
Distal thickness of precoracoid	·10
Least width of scapula	·078
Proximal thickness of scapula	·046
Distal width of scapula	·095
Distal thickness of scapula	·085

Humerus.—The humerus agrees with that of *gigas* in that it is flat, with a heavy globular head and an immense trochanter, which, with its base, is even larger than the head. In fact, though the head possesses a large articular surface, its general aspect is that of being a secondary projection from the trochanter. From the massive proximal end the shaft constricts slightly near the middle, at the same time flattening, but again expanding and thickening in the lower half into a flat, but massive, fan-shaped distal extremity, making an angle of about 105° with the proximal end. The most notable variation from *gigas* (also *tuberosa*),* aside from dis-

* Cretaceous Vertebrata of the West, p. 113.

parity in size, is in the minor development of the small trochanter, which is little more than a rugosity for ligamental attachment. It is 17^{cm} long and 11 wide, and subovoid in shape with the greatest expansion above, and slight concavity on its inner and obliquely upward facing expanse. The general aspect is, however, moderately convex, owing to a heavy, oblong ridge which crosses obliquely from the upper, outer portion to the lower, inner edge. In *gigas* the small trochanter is prominent, being set on an ala 8^{cm} in length and nearly 2·5^{cm} in height. The bases, therefore, bear out the general proportions of the two bones.

The bicipital groove is a wide and heavy channel, much more marked on the inner side, where it expands into a subovoid concavity whose greatest depth is about 2^{cm}. The inner surface of the fan-like distal end is longitudinally concave, both anteriorly and posteriorly, while the central portion forms a massive, expanding convexity, terminating in the articular face.

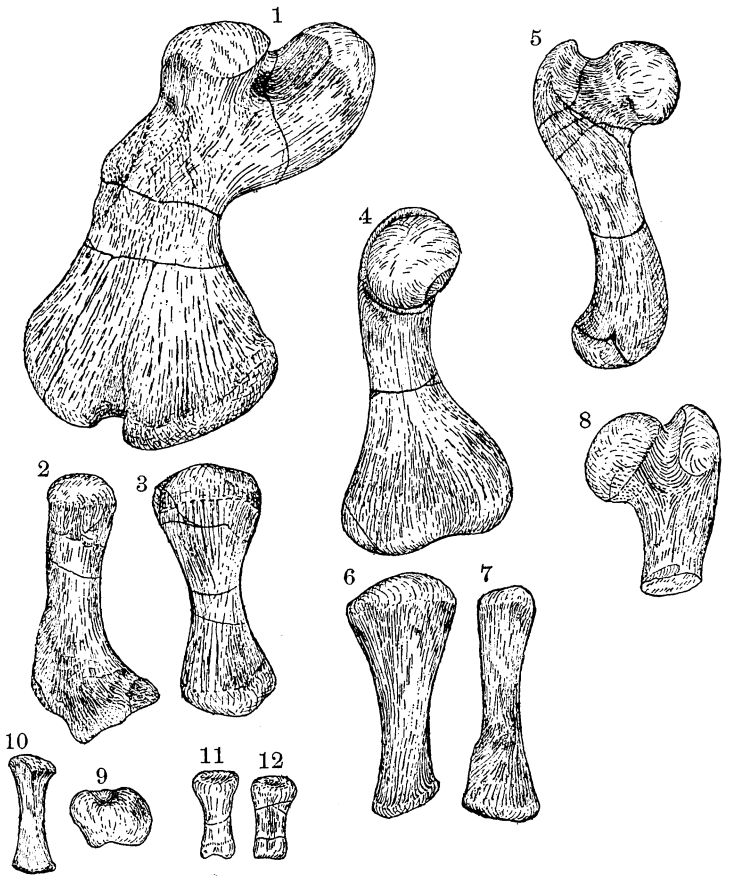
The outer surface is very flatly convex, and conspicuous for a deep groove 5^{cm} wide and 4^{cm} deep, as it ends in the articular surface. The posterior border of this groove lies in the exact distal center. The distal articular surface shows no very distinct divisions. It is both laterally and anteroposteriorly convex, and mostly posterior to the great distal groove, and the centrally place enlargement of the inner aspect which receives it. The surface of the humerus is covered with minute striæ, with larger striations, about 1^{mm} wide and several centimeters long, at short intervals. (Of the humeri, the left is entire, but only the distal third of the right was procured.)

Measurements of Humerus.

	Meters.
Greatest length	·65
Length from head	·58
Width at head, antero-posterior	·28
Greatest circumference about base of the head	·50
Circumference of great trochanter	·45
Least width of shaft	·17
Least thickness of shaft	·09
Circumference at least width of the shaft	·435
Greatest distal width	·34

Ulna.—The ulna is short and comparatively massive, but lacks the immense proportions of the humerus. The proximal articular surface is large and quite regular in outline, flat from side to side, and moderately convex antero-posteriorly (see dimensions). Anteriorly the proximal end bears a broad and shallow groove, disappearing at the middle of the shaft and

reappearing distally as a distinct concave expansion looking forwards and downwards as it rather abruptly merges into the articular surface. The bone has a distinct twist, the trend of the distal articular surface standing at an angle of 75° to that



ARCHELON ISCHYROS.

All one-tenth natural size and from the same individual as Plate VI.

1. Left Humerus, outer view.
2. Left Radius, outer view.
3. Left Ulna, outer view.
4. Left Femur, outer view.
5. Left Femur, anterior lateral view.
6. Right Tibia, outside view, drawn as the left tibia.
7. Right Fibula, outside view, drawn as the left fibula.
8. Proximal of Femur, posterior view.
9. Carpal (?)
10, 11, 12. Phalanges.

of the proximal. The articular surfaces are in area and outline nearly similar, except that owing to the concavity just mentioned the distal face is very slightly crescentic. In its general aspect it is concave and divided by a saddle-shaped antero-posterior ridge into two subequal areas, the exterior and smaller being somewhat elliptical, the interior and larger double concave in outline.

The surface striations are not so distinct as those of the humerus, tending to flatten and interlace. There is very slight pitting and grooving with a tendency to fluting at the extremities, especially the distal. When closely examined with a reading glass the surface is found to be quite ornate.

The ulna is a very compact bone of great strength and the unequal size as compared with the humerus is apparent rather than real. Taken as a homologous part of the huge forelimb that formed the propeller of the largest known marine testudinate, it was admirably adapted to its purpose.

Radius.—The radius, like the ulna, is short and its peculiar distal bow served to give width to the forearm without reducing its strength. The outline of the distal articular surface is that of an isosceles right triangle with the vertex external. It is but slightly concave centrally.

The surface is like that of the radius except along the anterior edge, which is slightly rugose along its entire length.

The set of the distal faces of the radius and ulna was slightly toward each other and they formed a strong base for the massive carpals. Of these one is figured. The phalanges recovered are not of unusual length. Several are figured.

Measurements of the Ulna.

	Meters.
Length	·33
Proximal diameters	·088 and ·138
Least diameters of shaft	·054 and ·063
Distal diameters	·093 and ·14

Measurements of the Radius.

Length (greatest)	·35
Proximal diameters	·049 and ·088
Distal diameters	·082 and ·114
Least diameters of shaft	·05 and ·067

Femur.—The femur is proportioned to the humerus as in *Thalassochelys caretta.* The head stands out at a full right angle on a heavy neck, high and prominent, the articular surface being very convex ovally, the largest diameter bearing an angle of about 45° to the main axis of the humerus. The great trochanter rises well above the head as a somewhat semi-

ovoid projection whose inner boundary as seen from above is a very shallow sigmoid curve. The trochanteric fossa is narrow and deep posteriorly, but widens and becomes slightly shallower immediately in front of the head, again narrowing and disappearing just beneath the head. Just above the most constricted portion of the shaft on the outer side is a lesser trochanter. It is merely a slight inconspicuous convexity. The distal extremity is broad and heavy with a marked downward turn. It is very regular in outline, the external and internal condyles being nearly equal and the intercondylar fossa very shallow. The surface of the bone, like that of the humerus is striate, the striations being most marked distally, with slight longitudinal pitting.

Measurements of left Femur.

	Meters.
Extreme length	·46
Diameters of head	11·5 and ·129
Diameter of neck	0·8 and ·11
Transverse distance through great trochanter	·185
Least diameters of shaft	·075 and ·095
Greatest distal breadth	·23
Greatest distal thickness	·105

Tibia.—The tibia is nearly as large a bone as the ulna, fully as large proximally. There are two slight concavities in the proximal articular face for the reception of the femoral condyles. These are separated by a triangular convexity heaviest on the outer side. The outline of the articular face is that of an ellipse very distinctly flattened on the inner side. The distal articular face is flatly convex and broadly elliptical in outline. It is expanded into a kind of collar or foot for the shaft.

Measurements of left Tibia.

	Meters.
Length	·33
Antero-posterior length of proximal articulating surface	·15
Transverse measure	·10
Least diameters of shaft	·042 and ·061
Diameter of distal extremity	·105 and ·109

Measurements of left Fibula.

Length	·31
Greatest proximal diameters	·082 and ·085
Least diameters of shaft	·035 and ·045
Distal diameters	·108 and ·085

Fibula.—The fibula is a much smaller bone than the tibia proximally, but nearly of the same size distally. The proximal extremity is subquadrilateral in outline with the long side turned to the tibia. Just beneath the articular face in the outer side there is a broad longitudinal scallop. Distally the bone expands, and the articular face is somewhat convex, and elliptical in outline, with a notch for the articulation with the tibia. These two bones have some resemblance to the tibia and fibula of *Protosphargis.*

Dimensions.

The very great width of *Archelon* as compared with either *Protostega* or *Protosphargis* will have been noticed. The ribs in the middle dorsal region are quite exactly 1^{m} in length; adding 13^{cm} as the approximate width of the centra, and 12^{cm} as the additional width due to the marginals, assuming them to have been present, we obtain a total width of $2{\cdot}25^{m}$; that is of more than 2^{m} after making full allowance for dorsal curvature, which must have been slight. If proportioned then as in *Thalassochelys caretta* the total length would be 11 feet. From the vertebral column the same length is indicated. From the five cervical vertebræ the average length would seem to be 9^{cm}. These vertebræ must have supported an enormous head, so that $\cdot 60^{cm}$ is certainly the lowest cranial length that can be assigned. The caudal vertebræ are estimated at $\cdot 70^{cm}$; that is:

	M.
Cranial length	·60
Eight cervical vertebræ	·72
Ten dorsal "	1·35
Three sacral "	·15
Eighteen (?) caudal vertebræ	·70
	3·52 or 11 ft. 4 in.

This latter will no doubt be a very little less than the actual length.

The most striking feature of this huge animal was formed by the massive forearms, which had a spread of from 16 to 20 feet. Had they had the proportions of *Thalassochelys* the distance would be 20 feet. But there is a wide difference in the structure of the two arms, and I favor the lower estimate.

The length of body I assign to *ischyros* is considerably less than that first estimated for *Protostega* by Prof. Cope and later by Hay on the basis of the hypo- and hyoplastron,* notwithstanding the great disparity in skeletal weight. While it is scarcely permissible to make calculations based so entirely

* Field Columbian Museum Publication 7, Chicago.

upon relations obtaining in different genera, I do think that when a complete skeleton of *Protostega* is once obtained it will be found to lack considerable of the enormous length which has been assigned to it. The cervical vertebra figured by Cope is of much the same size as in *Protosphargis*. Also, as Cope found ten ribs, he must have had at least one approaching the longest in length. From comparison of this kind including *Sphargis* itself, *Protostega gigas* must have been less than three meters in length.

Systematic.

In attempting to place the relationship of *Archelon* in existing classifications we are faced by some very heterogeneous characters.

From the characters which have been given I think it will be accepted that the fossil under consideration stands more nearly on the border line between the two *cryptodire* divisions than any form yet described. The endoskeleton strongly resembles that of *Protostega* and *Protosphargis*, while a connection, though slight, between carapace and endoskeleton points to the *Chelonidæ*. I cannot pass the strong likeness of the shoulder girdle, nor the great similarity in the vertebræ. I would define *Protosphargis*, *Protostega*, and *Archelon* as the gigantic Upper Cretaceous representatives of three genera of the *Dermochelydidæ* with the approach to the *Chelonidæ* in the order named.

Occurrence.

Archelon ischyros was obtained near the South Fork of the Cheyenne River, about 35 miles southeast of the Black Hills in the uppermost Fort Pierre or No. 4 of the Upper Cretaceous. The skeleton lay deeply imbedded at the side of a small ravine, extending out from the base of a butte of typical Miocene. It had formed the nucleus of a lenslike mass of very hard marl. The excavation of the ravine had no doubt broken down the portion containing the head and right forearm but a year or two since. At the time of interment the skeleton may have been subjected to the action of strong currents, coming from the direction in which it headed, as would be indicated by the fragmentary marginals near the head, the absence of smaller bones, phalanges and caudal vertebræ, except somewhat to the rear and beneath, and furthermore to the fact that the third and fourth (?) cervical vertebræ, with their articulating neural arches, were lodged between the carapace and plastron just against the coracoid full two feet out of their

natural position. All this could be due of course to scavengers, but I am strengthened in the opinion that it was owing to currents from the fact that across the Miocene Butte not more than a half mile away, on very much the same horizon, there were several very distinct gravel strata, the gravel ranging in size from one to three inches in diameter.

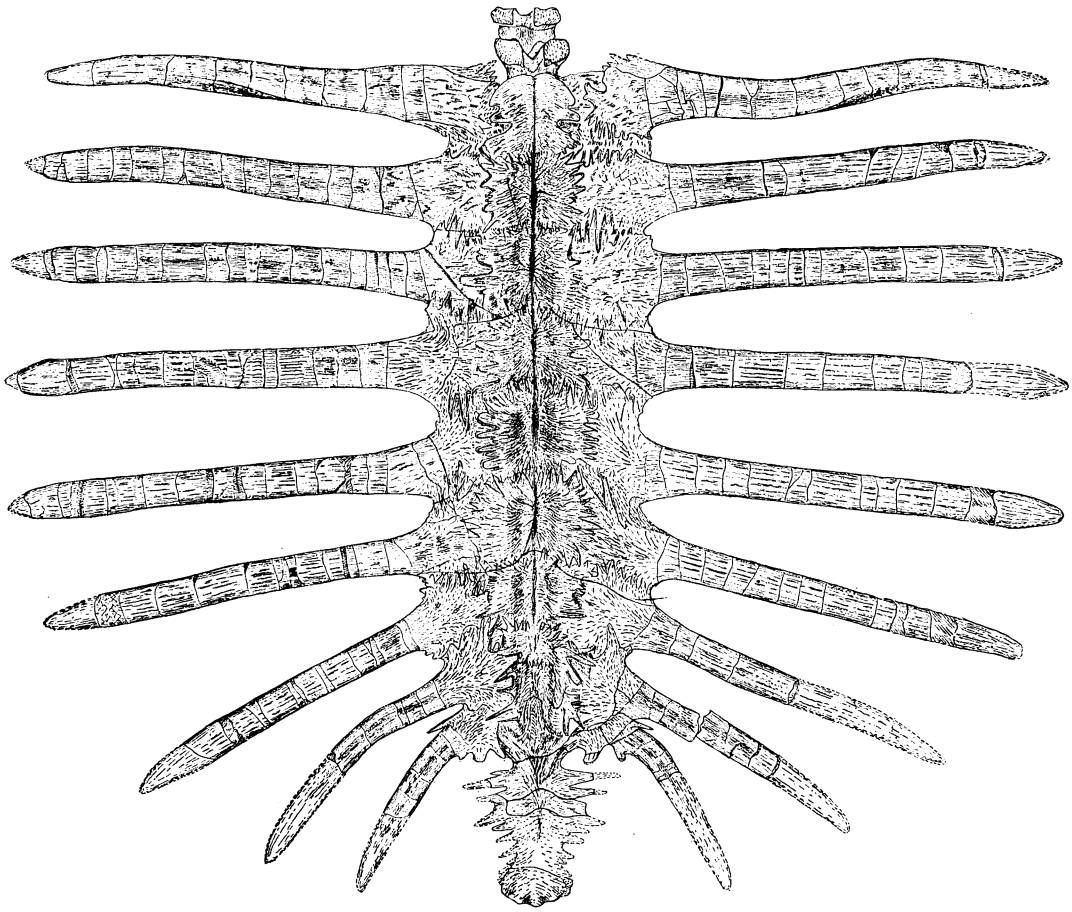
The vertical section above the position of the fossil was approximately as follows:

Miocene
- "Buttes" with a thickness of from 75 to 100 feet. Flat topped ("railroad buttes," as locally termed because of their embankment-like appearance) owing to a hard flinty to opalaceous layer which caps them. Mostly hard grayish white clays and marls, weathering into red bowlders containing frequent remains of *Testudo*, especially about 30 feet from the summit.

Cretaceous
- Gravelly clays with large flow-and-plunge structure only to be noted in the most favorable positions among the expanse of weathering hills; in most places appearing as a plain gravelly layer one or two feet thick, although the actua thickness is fifteen feet.
- Light red or yellow marly clays containing *Inoceramus*, and very rarely *Baculites*, with frequent masses of septaria, 30 ft.
- Deep red to black "gumbo," 5 ft.
- Thin band of yellow marly clay, 5 in.
- Deep red to black marl or "gumbo," 5 ft.

Underneath the plastron were found four or five species of Mollusca poorly preserved. There were also found in good preservation scales of a fish allied to *Beryx*, also of an unreferred *Malacopterygian*, and a shark's tooth—a very broad-toothed *Lamna*.*

* As a matter of convenience these two references are added: A. S Woodward, On Leathery Turtles Recent and Fossil, Proceedings Geologist's Association, vol. x. Also, Die Chelonier der Norddeutschen Tertiarformation (contains a description of *Pseudosphargis ingens* von Könen) von W. Dames, Palaeontologische Abhandlung, Jena, 1894.



ARCHELON ISCHYROS.

Carapace and ribs showing first dorsal and last cervical centra.
One-fifteenth natural size.