Structure of the Upper Cretaceous turtles of New Jersey : Agomphus / by G.R. Wieland.

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STRUCTURE OF THE UPPER CRETACEOUS TURTLES OF NEW JERSEY: AGOMPHUS.

By G. R. Wieland.

Art. XLIV.—*Structure of the Upper Cretaceous Turtles of New Jersey:* Agomphus;* by G. R. Wieland.

The genus *Agomphus* was first proposed by Cope for the reception of Leidy's *Emys firmus* and *Adocus petrosus* and *Adocus turgidus*,† all of which are based on very fragmentary and scanty remains from the Upper Cretaceous marl beds of New Jersey, indicating a genus of heavy shelled turtles next related to *Adocus*. Two of these original types, *A. petrosus* and *A. turgidus*, are now conserved in the Cope Collections in the American Museum of Natural History, where the writer has been extended the courtesy of seeing them, together with the allied *Adocus pectoralis* Cope. An additional type from the Tertiary of Georgia, *Amphiemys oxysternum*,‡ is no doubt correctly referred to *Agomphus*, but has not been accessible. Since the brief descriptions unaccompanied by figures were given by Cope, the only addition to the very meager knowledge of *Agomphus* was made by Baur,§ who briefly noted in addition to the close relationship to *Adocus* and inclusion in the Adocidæ as next related to the existing Central American Dermatemydidæ, the peculiar costiform processes and the interesting fact that *Agomphus* includes forms with relatively the heaviest carapace and plastron known. These latter facts were doubtless based on the specimens of the Marsh Collection obtained about the same time as the Leidy and Cope material, but never formally described or further mentioned although now found to make possible a complete description of the structure of the carapace and plastron, and to include at least two new species and a topotype as follows:

Agomphus tardus Wieland (sp. nov.). (Figures 1–7.)

By far the best specimen of the Marsh collection referable to the genus *Agomphus* is that numbered 774 (Accession No. 323), and now made the type of the new species *A. tardus*. This fine fossil was obtained from the Pemberton marl pits at Birmingham, Burlington County, New Jersey, in 1869. It is of especial interest as affording the structural characters of the

* The first paper of this series, on *Adocus*, *Osteopygis*, and *Propleura*, appeared in this Journal, vol. xvii (pp. 112–132, pl. I–IX), Feb. 1904, and the second on *Lytoloma*, in vol. xviii (pp. 183–196, pl. V–VIII), Sept., 1904.

† The description of these forms under the generic name *Emys* appears on pages 125–8 of Cope's Synopsis of the Extinct Batrachia, Reptilia and Aves of North America. Philadelphia, August, 1869.—*Agomphus* in Suppl't, 1871.

‡ On a New Species of Adocidæ from the Tertiary of Georgia; by E. D. Cope. Proc. American Phil. Soc., vol. xvii, July, 1877, pp. 82–4.

§ Notes on some little known American Tortoises (on pp. 429 and 430), Proc. Acad. of Natural Sciences, Philadelphia, 1891 (pp. 411–430).

shell of another genus of a well represented Upper Cretaceous to Tertiary family, the Adocidæ, and as being relatively the heaviest and most massive turtle shell yet discovered. Although originally a perfect fossil with suturally united carapace and plastron, only thirteen complete and five incomplete elements of the carapace, together with the hyo- and hypoplastron, have escaped the accidents of discovery and collection. Of the imperfect parts but four are diagnostic as to form, whence the recovered elements that are wholly determinative virtually number

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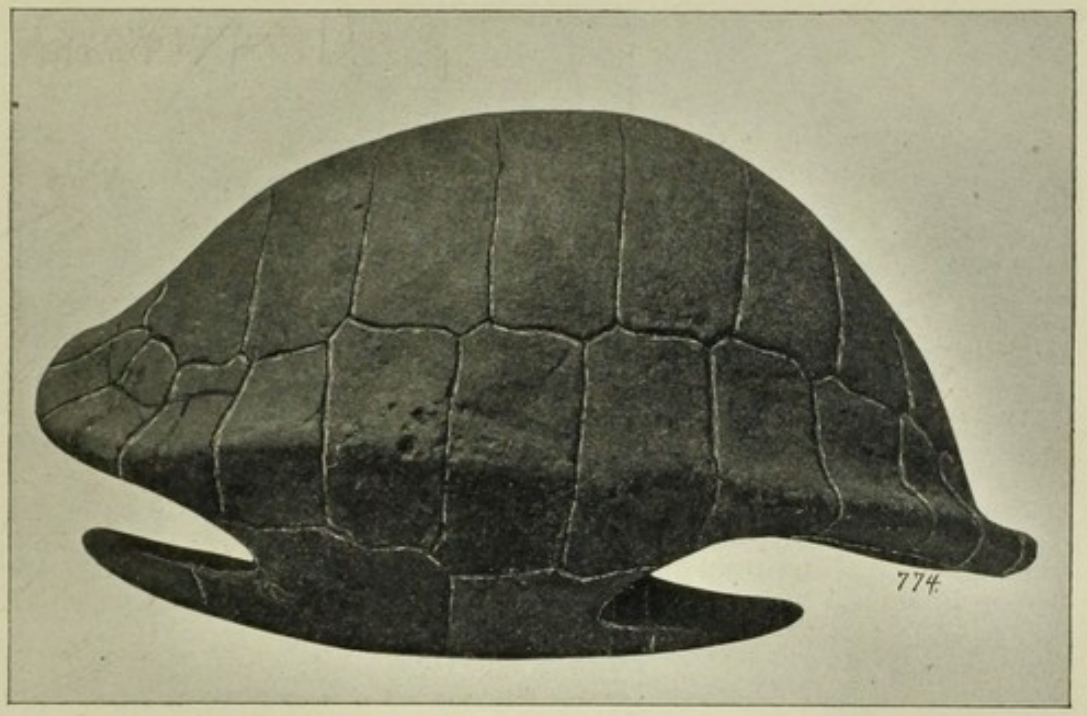

FIGURE 1.—*Agomphus tardus* Wieland (sp. nov.). Carapace and plastron of type specimen* with the missing portions restored in the estimated natural size and position. Actual length of carapace 33cm. Elements present indicated in the succeeding figures 2–5.

but nineteen, or exactly one-third of the original fifty-seven elements of which the carapace and plastron was composed. These recovered elements of grayish to dark, marl green color, are however perfectly fossilized, uncrushed, disarticulated, and without crumbling or breaking of the sutural faces. Moreover they are by a rare and noteworthy chance so distributed as to clearly outline the missing elements and make possible a restoration by the Museum preparateur, Mr. Gibb, and the writer, which it is confidently believed by both will be found essen-

* Elements present: nuchal (incomplete), 2d and 5th neurals, left 1st and 2d pleurals, right 4th and 5th pleurals (incomplete), right 6th and 7th pleurals, left 2d marginal, left 5th and 6th marginals (incomplete), left 10th and 11th marginals, right 8th–11th marginals, the left hyo- and the right hypoplastron.

tially correct as to form and size whenever a complete individual of this species is fortunately discovered. A side view of the restoration is shown in figure 1, this being perhaps the best view; for it was not found possible to bring all the elements into an absolutely symmetrical position, although they are virtually so indicated in the supplementary drawings, figures 2–6.

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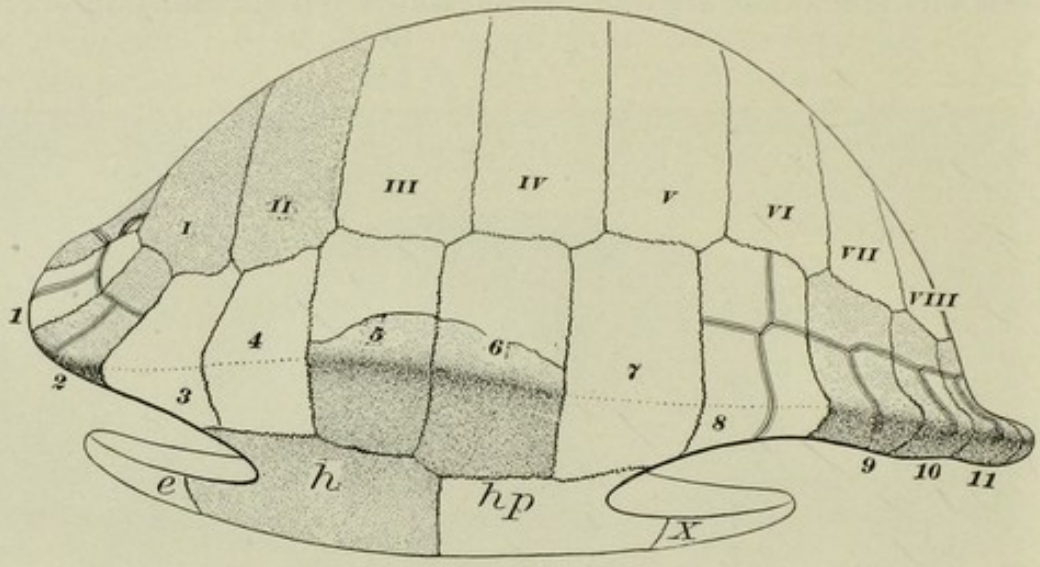

FIGURE 2.—*Agomphus tardus.* Left lateral view of the carapace of the type with elements present stippled (except 9th marginal). *I–VIII* and *1–11*, the respective pleuralia and marginalia; *e*, epiplastron; *h*, hyoplastron; *hp*, hypoplastron; *x*, xiphiplastron. [Actual length of specimen 33cm.]

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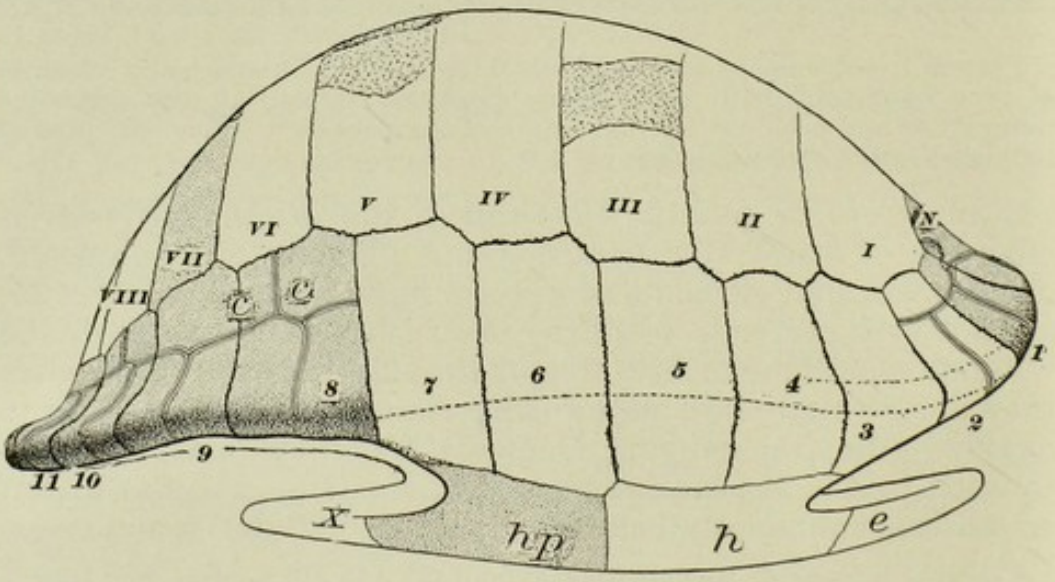

FIGURE 3.—*Agomphus tardus.* Right lateral view of carapace and plastron. Drawn from type with elements present stippled. *N*, nuchal; *c*, *c*, 3rd and 4th costalia. Other lettering as in the preceding figure.

As clearly shown in the figures, *A. tardus* was of robust oval form with marked depth over the inguinal region, and a distinct flanging of the nuchal region which gives the carapace a very symmetrical to ornate appearance. The rib capitulæ are diminutive. The medium-sized and heavy plastron without fontanelles is strongly interlocked by suture with the marginals, and the axillary buttress extends forward to the 3d, the inguinal buttress, back to the 8th marginal, as in *Adocus*.

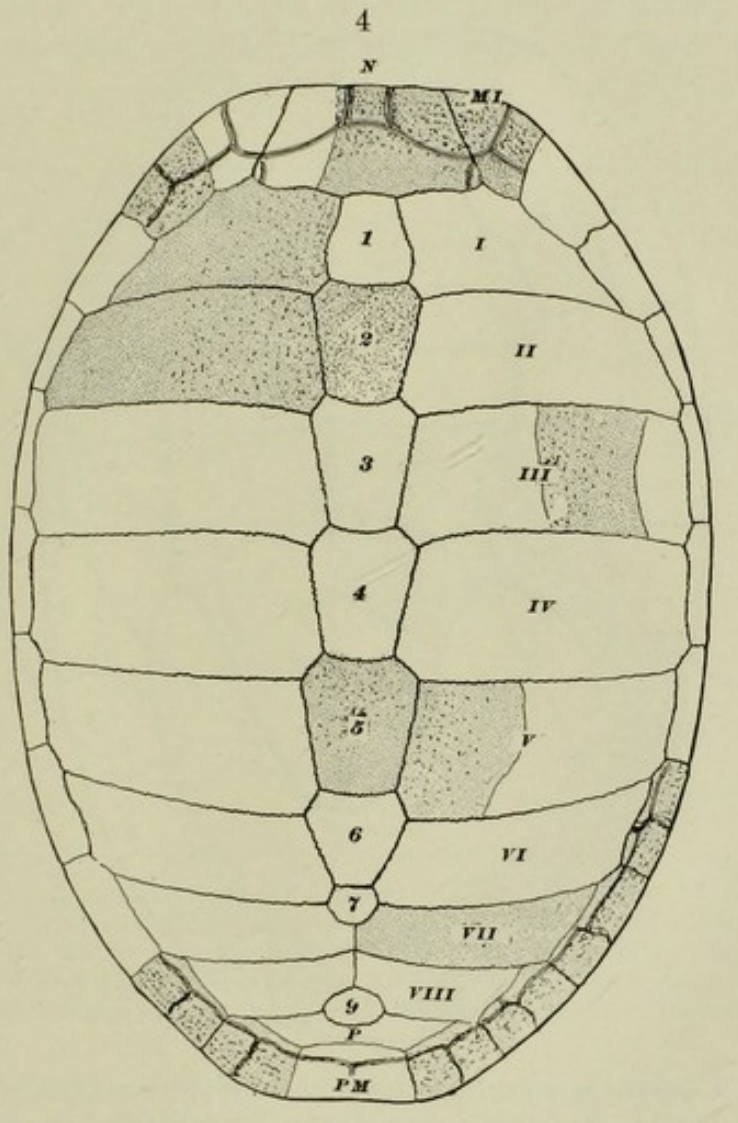

FIGURE 4.—*Agomphus tardus*. Dorsal view of the carapace. Drawn from the type with parts actually present stippled. *N*, nuchal ; *MI*, 1st marginal. *1–7* and *9*, the neuralia ; *P*, pygal ; *PM*, pygal marginal ; *I–VIII*, the respective pleuralia.

The most curious single feature is the complete perforation of the first marginals by the costiform processes of the nuchal. (Cf. figure 6.) The outlines of the transverse sections of the several elements as shown in the supplementary figures 6 and 7, in connection with the measurements may render more

detailed description of the form of the individual elements unnecessary. These figures show in particular the enormous thickness of the elements of the plastron, which is especially heavy near to the hypo-xiphiplastral suture. There was, however, no trace of fusion with the pubes. The hornshields are for the greater part indicated by narrow sulci not accentuated in the nuchal region as in *Adocus*, with the inner

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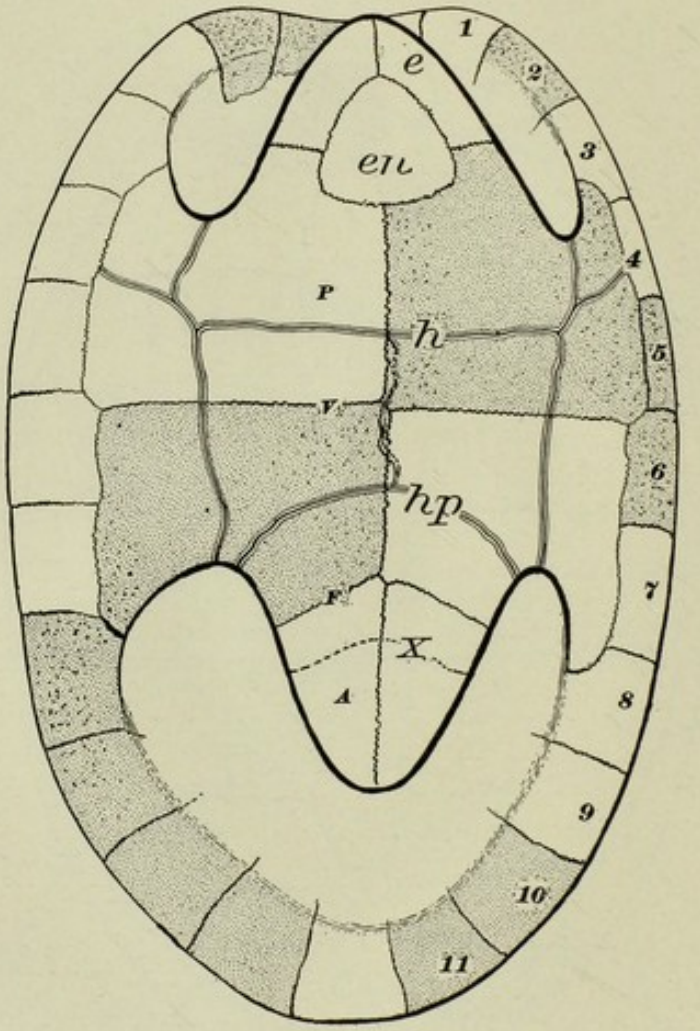

FIGURE 5.—*Agomphus tardus*. Plastral view drawn from the type. *P*, pectoral, *V*, ventral, *F*, femoral, and *A*, anal hornshields; *en*, entoplastron. Other letters and numbers as in figures 2 and 3.

borders of the marginalia, as is especially to be noted, not traversing the pleuralia as in that genus, but continuing below the pleuro-marginal sutures all round the carapace from the nuchal to the pygal region.

Specific Relationships.—The forms with which *Agomphus tardus* is to be compared are (1) *A.* (*Emys*) *firmus* (Leidy),

(2) *A. petrosus* Cope, (3) *A. turgidus* Cope, (4) *A.* (*Amphiemys*) *oxysternum* Cope, and (5) *Adocus* (*Pleurosternum*) *pectoralis* Cope,—all of which are either slightly or not illustrated and difficultly accessible or little known types, based on fragmentary materials of barely diagnostic value beyond family or generic limits. It appears, however, that in comparison with *Agomphus tardus* (sp. nov.), *A.* (*Emys*) *firmus* was a larger form with a shell relatively but not nearly so extremely heavy ; that *A. turgidus* Cope (as further described from the Marsh Cotype No. 900), is a small turtle of about the same size as *A. tardus* with minor differences of form and horn-

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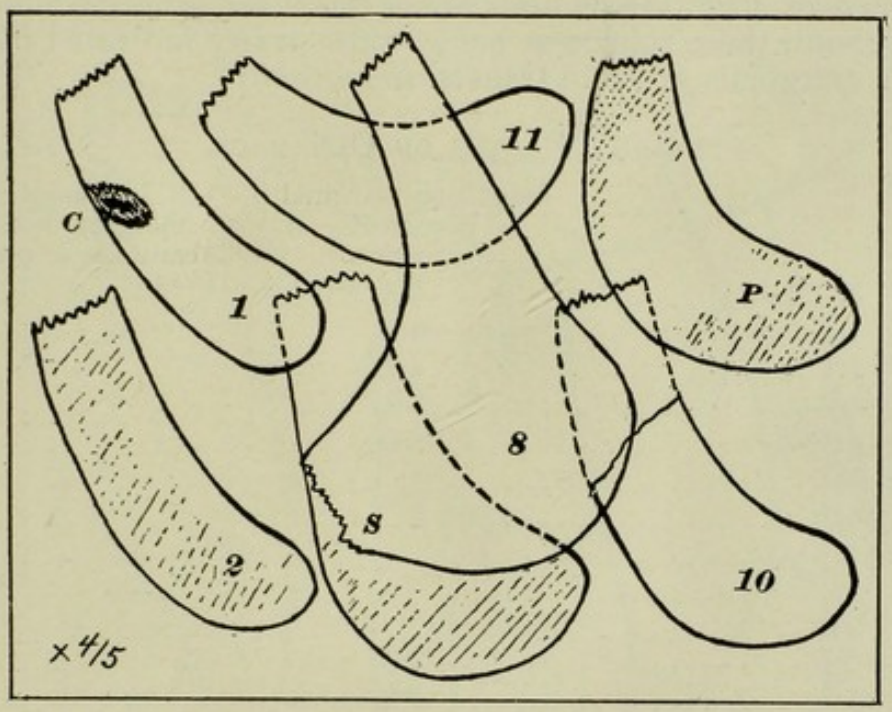

FIGURE 6.—*Agomphus tardus* (type). ×⅘. Outlines of the anterior sutural faces or transverse sections of the 1st, 2d, 8th, 10th, 11th and pygal marginals.—*C*, pit in anterior face of the right 1st marginal for the reception of the costiform process of the nuchal, which entirely perforates this marginal ; *S*, sutural face for union of 8th marginal with the hypoplastron.

shield boundaries and far less robust plastron ; that *A. petrosus* Cope had a steeper, less flanged or shovel-shaped nuchal region, with the hornshield sulci nearer the marginal border, and the plastron lighter ; that *Adocus* (*Pleurosternum*) *pectoralis* had a much less massive plastron and narrower bridge than *A. tardus ;* and that finally *A.* (*Amphiemys*) *oxysternum* from the Tertiary of Georgia is a fairly distinct species from all of the foregoing Cretaceous Agomphids.

Measurements of Agomphus tardus Type.

(Yale Museum Specimen No. 774. Skeletal elements uncrushed.)

THE CARAPACE.

Length on straight line	33· cm
Length over curvature	43·5 ±
Width (greatest, or over 4th neural)	23· ±
Distance over curvature (greatest)	38· ±
Projection beyond front end of plastron	1·5
Projection beyond anal end of plastron	7·

[Thickness of nuchal (anterior), 1·3cm ; (posterior), 7mm ; of the 2d neural 1·4cm ; of the 5th neural 1·5cm. With the exception of the distal extremity of the second pleural, which reaches the great thickness of 2·2cm, the pleurals are of much the same development throughout, their thickness being quite nearly indicated by that of the marginals given in transverse section.]

BONY PLATES OF CARAPACE.

	Length on marginal border of carapace.	Middle length from marginal border of carapace to pleurals.
Nuchal	5·2	5·3
1st marginal	4·	4·3
2d	4·2	4·6
3d	3·8	--
4th	3·8	--
5th	4·	--
6th	4·	--
7th	--	--
8th	--	--
9th	--	5·
10th	3·8	4·5
11th	4·2	4·
Marginalo-pygal	4·	3·

	Length (Antero-posterior).	Greatest width (lateral).
Nuchal	5·2	7·3
1st neural	--	--
2d "	4·	3·5
3d "	--	--
4th "	--	--
5th "	4·	3·6
6th "	--	--
7th "	--	--
8th "	(absent)	(absent)
9th "	--	--
Pygal	(3·)	--

(Lateral length 1st, 2d, and 7th pleurals 9·5cm, 12cm, and 8·7cm respectively.)

THE PLASTRON.

	Greatest length on medium line.	Greatest width.
Epiplastron	--	--
Entoplastron	4·3	4·5
Hyoplastron	6·0	10·
Hypoplastron	6·2	9·5
Xiphiplastron	7· ±	3·3

(Greatest thickness of the hyoplastron measured on interior border 2·7^{cm}, of the hypoplastron 3·1^{cm}. Least width of hyoplastron measured across axillary border 5·6^{cm}, of the hypoplastron across the femoral border 5^{cm},—whence least width of bridge, 10·6^{cm}.)

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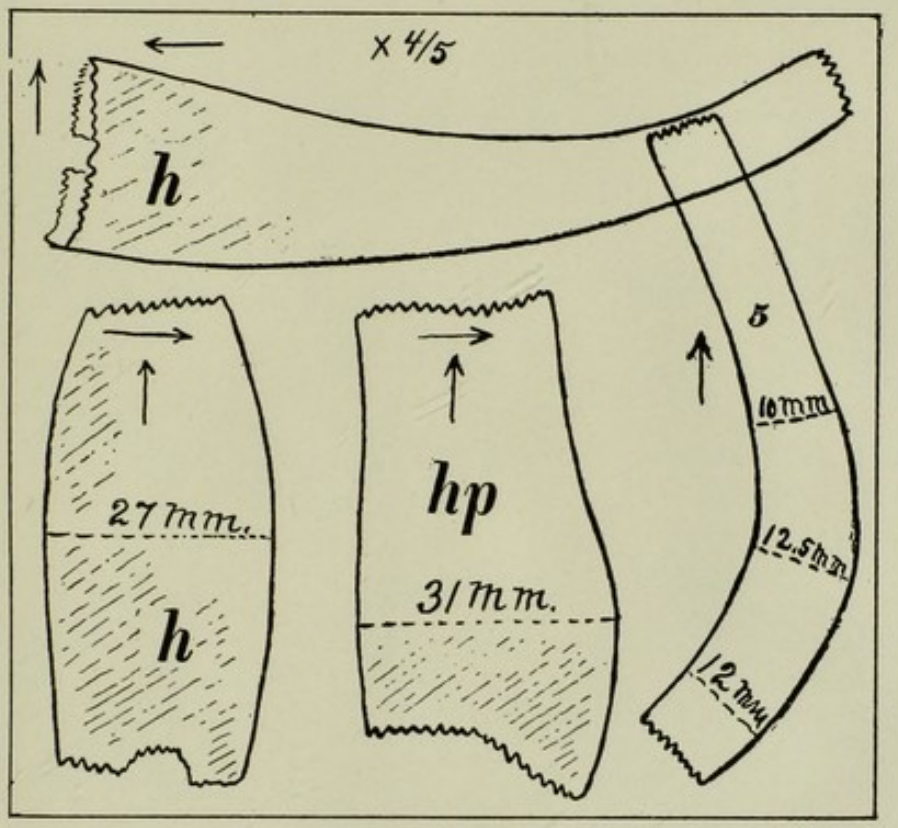

FIGURE 7.—*Agomphus tardus* (type). × ⅘. Outline of sutural faces (or transverse sections) of the hyoplastron, the hypoplastron, and the 5th marginal. *h*, *h*, posterior and internal sutural face of hypoplastron; *hp*, internal sutural face of hypoplastron, which placed tandem to *h* yields the median transverse section of the plastron, exclusive of the epi-, the ento- and xiphiplastron; *5*, anterior face, 5th marginal. The arrows orient to the vertical and median lines.

Agomphus masculinus Wieland (sp. nov.)—(Figure 8).

The beautifully fossilized plastron accompanied by various marginals, a nuchal and fragmentary pleurals of a smaller turtle than the preceding, received at the Yale Museum from the West Jersey Marl Co.'s pits, at Barnsboro, Gloucester

County, New Jersey, in April, 1872, and numbered 671 in the Marsh Collection, is here made the type of the new species *Agomphus masculinus*. This specimen undoubtedly pertains to

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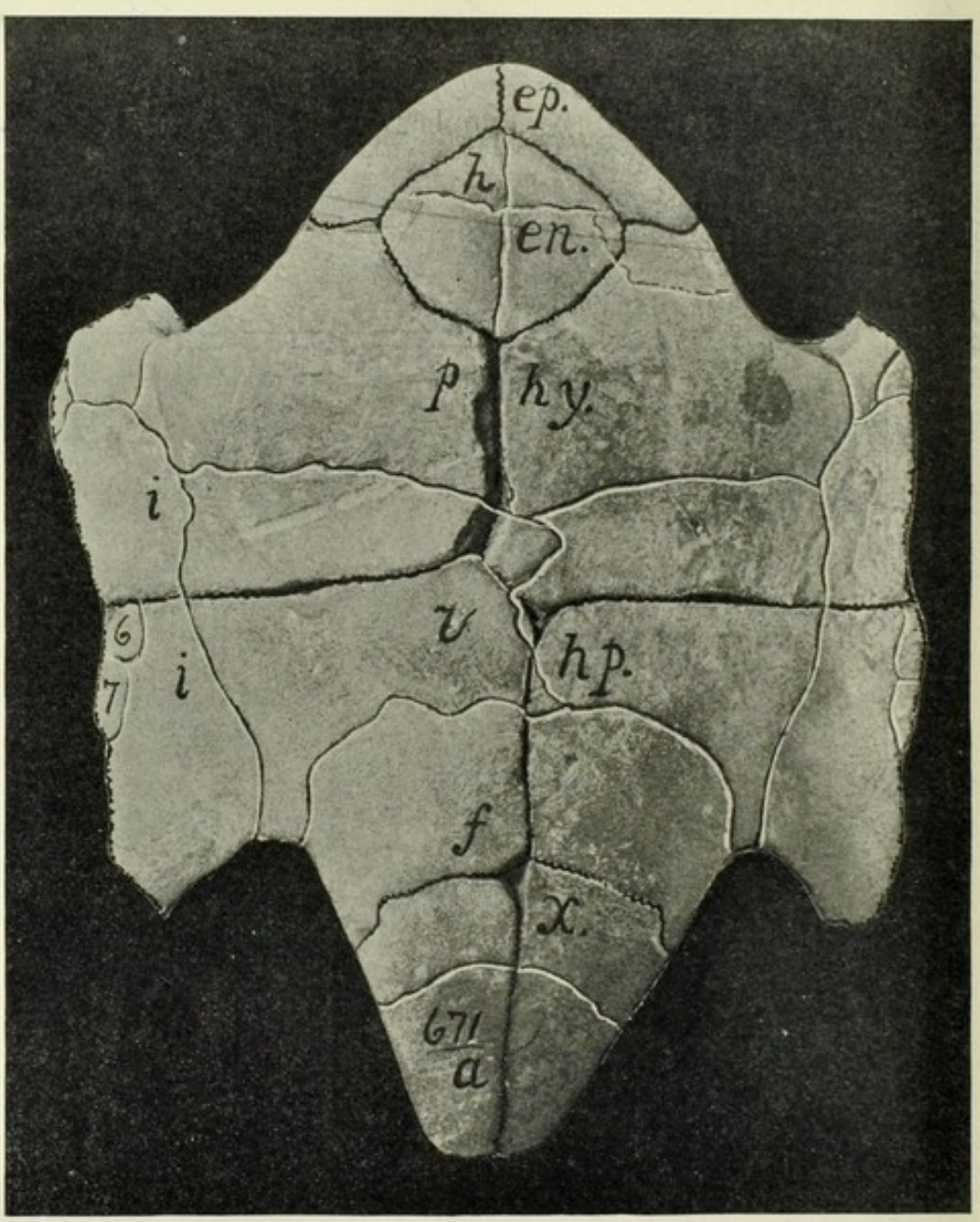

FIGURE 8.—*Agomphus masculinus* Wieland (sp. nov.). The plastron of the type specimen (No. 671, Marsh Collection), consisting in the entoplastron, hyoplastra, hypoplastra and right xiphiplastron complete (with the missing epiplastra and left xiphiplastron restored). $\times \frac{9}{14}$.

(1) Bone plates.—*ep*, epiplastron; *en*, entoplastron; *hy*, hyoplastron; *hp*, hypoplastron; *x*, xiphiplastron.

(2) Hornshields.—*h*, humeral (in part); *p*, pectoral; *v*, ventral; *f*, femoral; *a*, anal; *ii*, inframarginal region (above which the axillary inframarginal appears completely outlined); 6, 7, inner borders of the 6th and 7th marginal shields.

an originally complete fossil shell, but the several parts secured, although as numerous as in the preceding fossil, scarcely have the fortunate situation making possible a similar restoration.

The elements are all matrix-free, uncrushed and disarticulated, with the sutural faces all clearly outlined (save a small outer border portion of the left side of the plastron). Also the narrow to line-like hornshield sulci are all distinct in every instance. Unfortunately, but a single example of the present species is known with certainty.

The plastral features of *A. masculinus* as shown in figure 8 are more nearly similar to those of *A. tardus* than to those of any other known Agomphid. Specific identity is however clearly indicated by the slightly less robust form with relatively larger hypoplastra and ventral hornshields, and an entoplastron of sub-rhombic instead of sub-isosceles outline.

It is further to be observed that the doubly sigmoid antero-posterior curvature of the plastron is greater than in any other known species of *Agomphus*. Although this feature does not clearly appear in the photographic figure 8, it is so strongly accentuated in the fossil itself as to suggest that it is an individual peculiarity denoting an old male turtle, or perhaps better tortoise, whence the specific name.

In addition a new specific character is exhibited by the complete nuchal, and the third, eighth and tenth marginals accompanying the present plastron. These show that the marginal hornshields anterior to the eleventh did not overlap the pleuro-marginal sutures, and that the eleventh and twelfth did do so. As this peculiarity is not present in either *A. turgidus* or *A. tardus*, it in a sense unites *Agomphus* with *Adocus* since in *Adocus punctatus* at least, a similar hornshield overlap begins with the fifth marginal hornshield.

(*a*) *Measurements of the Plastron of Agomphus masculinus Type.*

Extreme length	17 cm
Extreme width	13
Length of bridge suture	10
Distance between the axillar and femoral borders	7·9
Length of the hyo-hypoplastral suture	5·5
Length of inner hyoplastral suture	4·
Length of inner hypoplastral suture	3·5
Length of inner xiphiplastral suture	4·5
Lateral width of entoplastron	3·6
Antero-posterior length entoplastron	3·4
Greatest thickness entoplastron	1·5
Greatest thickness hyoplastron	1·8
Greatest thickness hypoplastron	1·8
Greatest thickness xiphiplastron	1·6

*Specimens 775 and 776.**—(Figure 9).

The characters of the plastron in the genus *Agomphus* are shown in still further specific detail by the complementary specimens 775 and 776 of the Marsh Collection, as represented in the retouched photographic figure 9. These two specimens, the parts of which are enumerated in the legend of figure 9, do not necessarily pertain to the same species. In fact specimen 776 indicates a turtle with a slightly heavier plastron and broader bridge than 775, although quite similar in all other comparable respects.

Specimen 776 probably belongs to *A.* (*Emys*) *turgidus*, although we note that it may perchance be separated from this form by the different outline of the humeral hornshields, and from *Adocus* (or *Agomphus*) *pectoralis* by the relatively larger plastral bridge. The bones, while unusually robust, do not reach the great thickness seen in both *A. tardus* and *A. masculinus*.

It is furthermore to be observed that specimen 775 is distinguished from both the species just named as well as from all other Adocidæ so far as known, by the series of accessory parallel growth lines of both the anterior and posterior sulci of the femoral hornshields. This peculiarity, as distinctly shown in figure 9, recalls the obverse condition of change from deep sulci in the nuchal region to narrow line-like sulci on all the rest of the carapace seen in *Adocus punctatus*. An imperfect accompanying hyoplastron however suggests proportions similar to those of *Adocus* (*Pleurosternum*) *pectoralis*, which we are fairly satisfied is an *Agomphus*. Were specimen 775 assigned to a new species, no one could say nay on the basis of the material now known, but to do so could only be defended, were no further examples likely to be yielded by the New Jersey Cretaceous.

While it is not therefore convenient to assign these specimens to any of the half dozen known types, and much less so to propose a new species for No. 775, it is held that whoever is fortunate enough to discover additional new specimens illustrating the doubtful points involved, will first be entitled to determine these specific values. For the present it is therefore only attempted so far as fairly practicable to make accessible the features of Agomphid structure. Nor do we consider that on last analysis there is any essential difference between this structural study and the more purely taxonomic point of view.

* No. 775 is from the Cream Ridge Marl Co.'s pits, Hornerstown, Monmouth Co., New Jersey. It was received at the Yale Museum in April, 1871. No. 776 is doubtless from the same locality, but there is a discrepancy in the Museum record, so that it is not positively known where this fossil is from.

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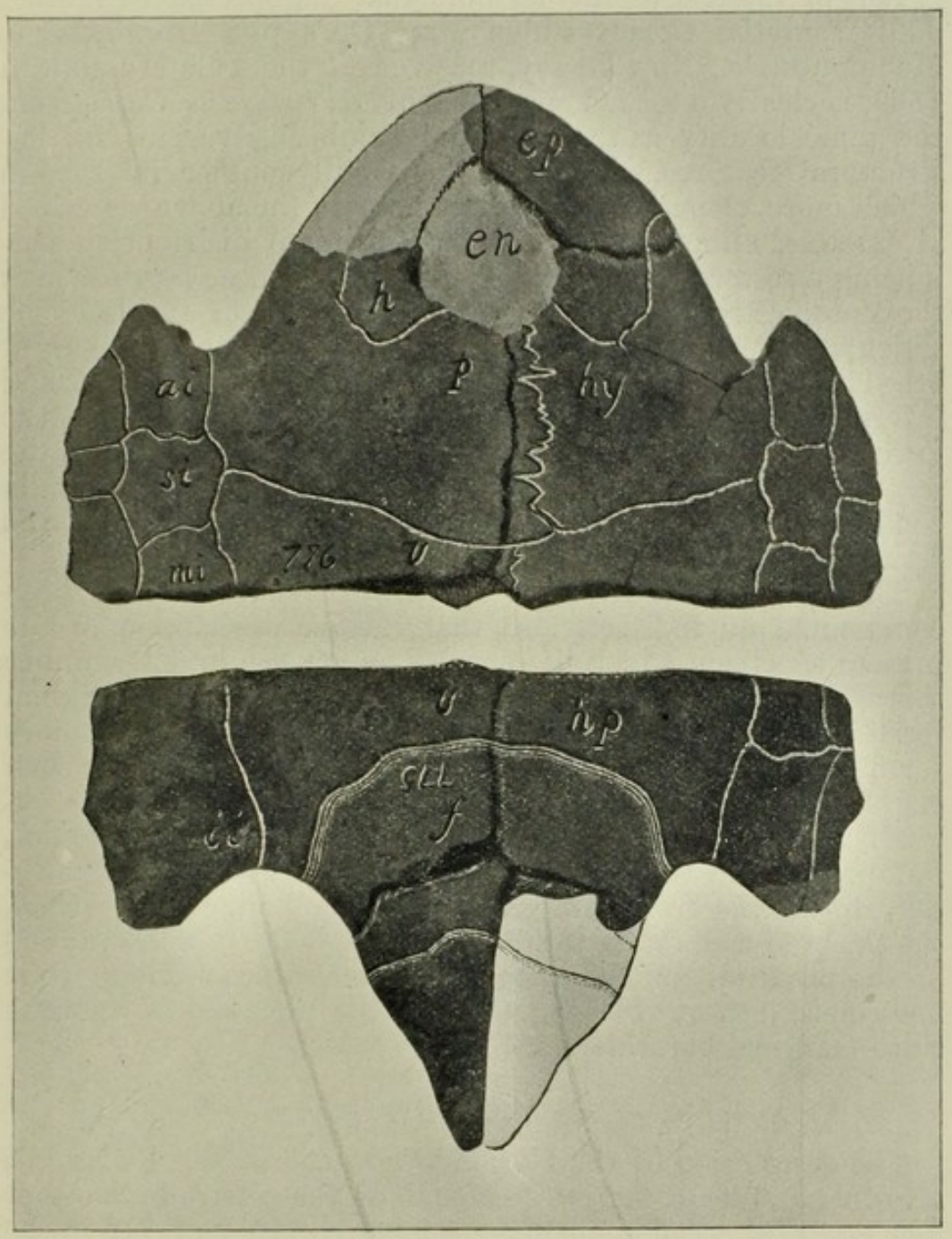

FIGURE 9.—*Agomphus.* Two complementary specimens illustrating plastral structure. No. 776, consisting in the hyoplastra and epiplastron, may be doubtfully referred to *A. turgidus.* No. 775, consisting in the hypoplastra and xiphiplastron, is of more uncertain specific reference. Both the specimens are shown exactly $\frac{5}{9}$ natural size.

(1) Bone plates.—*ep*, epiplastron; *en*, entoplastron; *hy*, hyoplastron; *hp*, hypoplastron; (xiphiplastron not lettered).

(2) Hornshields.—*h*, humeral (in part); *p*, pectoral; *v*, ventral; *f*, femoral; *ai*, axillary—*si*, sub-axillary—*mi*, mesial—and *ii*, inguinal inframarginalia; (anal hornshield not lettered).

Agomphus turgidus (Cotype).

It is of interest to further note that the specimen (number 900) from the Cream Ridge Marl Co.'s pits Hornerstown, Monmouth Co., New Jersey, received at the Yale Museum in 1869, is clearly a second specimen of *A. turgidus* Cope, from the same locality as the type, and exhibiting various further structural features. Indeed here is still another instance in which more elements are present than in the above described *A. tardus*, although without the fortunate distribution permitting a restoration as in that specimen. These portions are: the entoplastron and both *hyoplastra* (that of the left side articulating with the nearly complete 3d marginal), the right 5th–11th marginals (the 6th and 7th having the superior and inferior borders broken away), the pygal marginal and the lower halves of the left 4th, 6th and 7th marginalia; also the second, a 6th or 7th neural, and the third and fourth neuralia complete with the proximal ends of the left 3d–5th and the right 4th pleuralia attached.

The specific characters of *A. turgidus* have already been commented on indirectly, so that further description of the present specimen which has been of much use in determining the preceding new species, is scarcely required. The original fossil shell was doubtless complete, and had but a few more fortunately situated elements been recovered a restoration could be made.

A. turgidus did not have as massive a shell as *A. tardus*, but presents all the characteristic generic features distinguishing *Agomphus* from *Adocus;* in particular the heavy shell, the sharp to acuminate rather than rounded xiphiplastral end of the plastron, and the marginalo-costal suture resting on the marginals, instead of rising up onto the pleuralia beyond the third marginal hornshield.

Synopsis of the Characters of Agomphus.

The description of the foregoing new species of *Agomphus*, *A. tardus* and *A. masculinus*, and of the plastra of more or less doubtful specific identity numbered 775 and 776 in the Marsh collections, together with a topotype of *A. turgidus*, finally acquaints us with the shell structure of this interesting Upper Cretaceous genus as follows:

Carapace.—Medium sized to small, of elliptical outline, considerable depth, and with thicker walls in some species than in any other known Testudinates. Composed of 49 bony plates (one more or less, depending on the presence or absence of 7th and 8th neurals), and without fontanelles. Hornshield sulci small and line-like to indistinct.

(*a*) *Bony plates:*—Marginals, 11 pairs, very heavy; nuchal, large, of sub-pentagonal outline, without a nether process, but with costiform processes sometimes perforating the entire 1st marginals (*A. tardus*); neural series with but seven or eight members—the 9th or post neural being present with suppression of the 7th, or both 7th and 8th; pygal single as in *Adocus;* pleuralia very heavy with medium to slight development of the rib capitulæ.

(*b*) *Hornshields.*—A medium-sized nuchal and twelve pairs of marginals with the inner or marginalo-costal suture not rising onto the pleurals, as in *Adocus*, but traversing the marginal plates throughout (except in the single species *A. masculinus*, where the penult and final or pygal shields respectively overlap the 8th pleural and pygal plate.

Plastron.—Of medium size, without fontanelles and very heavy with the strong bridge suture extending from the posterior end of the 3d to the anterior end of the 8th marginal. Entoplastron large, of sub-isosceles triangular to rhombic outline. Epiplastral border rounded; anal region acuminate in every known species—not rounded as in *Adocus.*

Agomphus is held to be distinct from the earlier proposed genus *Adocus* mainly because of the position of the marginalo-costal suture on the marginals, the very characteristic form of the plastron, and the enormous thickness of shell. Although some of the imperfectly known species may prove to intervene and bridge these gaps—not large when taken singly,—it appears at present that they uniformly separate an Agomphid series of closely related, mostly small turtles ranging from the Upper Cretaceous into the Eocene. Therefore, as both *Adocus* and *Agomphus* are numerous in species, it would seem to be much the better policy to retain the latter genus so long as not definitely proven to merge into the former. The species respectively assigned to these two closely related genera of the Adocidæ therefore are:

1. *Adocus* (*Emys*) *beatus* (Leidy) Cope.
2. " *agilus* Cope.
3. " *pravus* (Leidy) Cope.
4. " *syntheticus* Cope.
5. " *punctatus* Marsh.
6. *Agomphus* (*Emys*) *turgidus* (Leidy) Cope.
7. " " *firmus* (Leidy) Cope.
8. " (*Amphiemys*) *oxysternum* (Cope) Hay.
9. " *petrosus* Cope.
10. " (*Adocus*) *pectoralis* (Cope) Wieland.
11. " *tardus* Wieland.
12. " *masculinus* Wieland.

From this numerous assemblage of species we naturally come to ask how turtles with such thick shells as the Agomphids, the more naturally ascribed to land forms, came to be so intimately associated with *Osteopygis*, *Lytoloma*, and the various other semi-marine to marine turtles and other forms which teem in all the *Agomphus* localities in the Upper Cretaceous marl beds of New Jersey. Being mostly small turtles the heavy specialized shells would mainly serve as a protection from the other larger and more powerful reptiles, which swarmed along and into the bays and estuaries of the New Jersey Cretaceous shore line, so that a salt water littoral habitat is not precluded. But while no specimens of the Marsh or other collections illustrating limb or cranial structure have yet been referred to *Agomphus*, it would seem that at least some of the species of the genus dwelt back from the shore line along the streams, on the more or less sandy river, ox-bow, or delta banks, and doubtless in the vast numbers paralleling the Orinocan *Podocnemis*, the easy prey of the jaguar, and once far more abundant on lower river courses than now. From such locations many shells might be carried forward to the shore front in flood time or in the course of estuarial change. Also, if congregating in any considerable numbers on the more nearly forest-free river banks, or on dune slopes, at egg-laying time, many individuals might then be either preyed on by other animals, or swept shoreward. It is a fact of some slight bearing on such a conjecture that while the Adocidæ are much more numerous than the other Testudinates of the marl beds, nearly all the limb bones recovered pertain to the semi-marine to marine Osteopygid and Lytoloman series. Moreover the abundance of the fossils of the marl beds is probably not generally understood, since almost no specimens have been secured in the past twenty-five years. Only a very few per cent of the specimens uncovered in the marl pits, when excavation was actively carried on thirty years ago, ever made their way into the museums; and these were all from restricted areas, although these fossils were for the greater part abundant everywhere in the several fossiliferous horizons of the entire New Jersey marl belt.

Yale Museum, New Haven, Conn.