NUCULITES FROM THE SILURIAN FORMATIONS OF WASHINGTON COUNTY, MAINE.

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CONTRIBUTIONS TO THE GEOLOGY OF MAINE.

In the year 1897 the writer began a study of the Paleozoic rocks and fossils of eastern and northeastern Maine.

As the work proceeded a series of publications have been issued, by several agencies, illustrating the new facts regarding the geology and paleontology as they have been elaborated.

As all of these papers are more or less intimately related to each other, it may be convenient for the reader to have before him a list of them, with date, place of publication, and general nature of contents.

I. Contributions to the Geology of Maine. Bulletin United States Geological Survey, No. 165, 1900, 8, 212 pp., 14 pls. and maps.

Part I. The Paleozoic faunas of Maine: a preliminary report upon the Paleozoic faunas already known and upon new faunas recently collected from Aroostook County, by Henry S. Williams.

Part II. Geology of the Aroostook volcanic area of Maine, including an account of the clastic rocks of Aroostook County, by Herbert E. Gregory.

Part III. List of Localities of Paleozoic, igneous and other crystalline rocks examined during the seasons of 1897 and 1898, by Henry S. Williams.

In this bulletin the following geological formations are named and defined and preliminary lists given of their fossils, by which their position in the geological time scale is determined:

9. Mapleton sandstone	Devonian.
8. Moose River sandstone	
7. Chapman sandstone	Silurian.
6. Square Lake limestone	
5. Ashland limestone	
4. Ashland shale	
3. Sheridan sandstone	
2. Graptolite shales	
1. Aroostook limestone	

No new species of fossils are described, but a couple of plates of figures of *Rhynchonella mainensis* Billings and other species from the Square Lake limestone, illustrating the variability expressed by representatives of this one genus in the restricted limits of this one limestone bed, are given and discussed.

II. The Silurian-Devonian boundary in North America, I, The Chapman Sandstone fauna. Amer. Journ. Sci., vol. 9, 1900, pp. 203–213.

III. The Silurian-Devonian boundary in North America. A discussion of the problems involved in determining geological boundary planes. Bull. Geol. Soc. Amer., vol. 11, 1900, pp. 333–346.

IV. Note on fossils collected by N. S. Shaler from the Cobscook Bay region of Washington County, Maine, incorporated in Smith and White's paper on The Geology of the Perry Basin in Southeastern Maine. U. S. Geol. Survey, Professional Paper No. 35, 1905, pp. 21–27.

V. A new Brachiopod, *Rensselaeria mainensis*, from the Devonian of Maine. Proc. U. S. Nat. Mus., vol. 32, pp. 267–269.

In this paper the new species, *Rensselaeria mainensis*, is described and figured. The types are from the Chapman sandstone of Aroostook County, Maine. The types are deposited in the United States National Museum.

VI. On the revision of the Mollusk genus Pterinea Goldfuss. Proc. U. S. Nat. Mus., vol. 34, pp. 83–90, published April 17, 1908.

In this paper the new genera *Tolmaia*, *Follmanella*, *Actinopterella*, and *Cornellites* are defined. This revision was incident to the classification and description of the Pterinoid fossils of the Chapman sandstone formation.

VII. Some new Mollusca from the Silurian formations of Washington County, Maine. Proc. U. S. Nat. Mus., vol. 42, No. 1908, pp. 381–398, with plates 49 and 50. Published July 3, 1912.

In this paper the new genus *Eurymyella* was defined and the species, *Eurymyella shaleri*, *E. shaleri*, var. *breva*, var. *longa*, and var. *minor*, and *Eurymyella angularis*, *E. simulans*, *E. plana*, *E. recta*, *E. convexa*, and *E. denbowensis*. The new genus *Cliopteria* and species *C. bicostata* and *C. unicosta*, *Pterinea laxata*, and the new species *Streptotrochus ione*, *S. regularis*, *S. carinatus*, and *S. sulcatus* were described and figured.

VIII. Correlation of the Paleozoic Fauna of the Eastport Quadrangle, Maine. Bull. Geol. Soc. Amer., vol. 23, 1912, pp. 349–356.

In this paper the formations of the Eastport quadrangle are subdivided into six (unnamed) divisions based on the faunal characteristics of the sediments.

IX. New Species of Silurian Fossils from the Edmunds and Pembroke formations of Washington County, Maine. Proc. U. S. Nat. Mus., vol. 45, July, 1913, pp. 319–352, with plates 29–31.

In this paper are described the species *Whitfieldella edmundsi*, *Chonetes edmundsi*, *Chonetes cobscooki*, *Brachyprion shaleri*, the new genus *Palaeopecten*, and species *P. cobscooki*, *P. danbyi* (McCoy) (*sensu stricto* Williams), *P. transversalis*, *Pterinea* (*?Tolmaia*) *trescotti*, *Tolmaia campestris*, *Dalmanella lunata* Sowerby was recognized and figured. *Chonetes bastini*, *Camarotoechia leightoni*, *Lingula scobina*, *Lingula minima*, var. *americana*, *Actinopteria bella*, *A. fornicata*, *A. dispar*, *Grammysia pembrokensis*, *Leiopteria rubra*, *Modiolopsis leightoni*, *M. leightoni*, var. *quadrata*, and *Nuculites corrugata* were described and figured and the species *Grammysia triangulata* (Salter) and *Platyschisma helicites* (Sowerby) were recognized and figured.

X. Correlation problems suggested by a study of the Eastport Quadrangle, Maine. Bull. Geol. Soc. Amer., vol. 24, 1913, pp. 377–398.

This paper announces the names adopted for the six divisions of the rocks of the Eastport quadrangle, and gives a tentative correlation of the formations with the divisions of the Silurian-Devonian formations of New York State and England.

XI. Eastport Folio Maine. U. S. Geological Survey, Folio No. 192, 1914, By Edwin S. Bastin and Henry S. Williams. Eight plates, 16 to 23, contain 148 figures illustrating the faunas of the Quoddy, Dennys, Edmunds, Pembroke, and Eastport formations, and in the text lists of the faunas are given and their correlation values discussed.

XII. New Spirifers from the Silurian Formations of Washington County, Maine.

Spirifer trescotti.
Slirifer cobscooki.
Spirifer edmundsi.
Spirifer lubecensis.

ON THE GENUS NUCULITES CONRAD, 1841.

The original definition of the genus *Nuculites* Conrad, 1841, is as follows:

"*Genus Nuculites. Equivalved; hinge with cardinal teeth as in Nucula, but apparently uninterrupted beneath the apex; an anterior rib like that of Solecurtus, but narrower, extends from the apex, either direct or slightly oblique, toward the base, never passing much beyond the middle of the valve.*" [1]

TYPE-SPECIES OF THE GENUS.

Nine species of "*Nuculites*" were defined by Conrad in the same paper with the definition of the genus (p. 50).

Of these, the first, *N. lamellosa*, was not figured, and the specimen appears to have been lost, as no further reference to it appears in the literature.

[1] Geol. Surv. New York, 5th Ann. Rept., 1841, p. 49.

The second species, *Nuculites emarginata*, was transferred by Hall to his new genus *Palaeoneilo*, the shells of which "*differ from Nuculites in having no anterior clavicular ridge.*" [1]

The third species, *N. triqueter*, the fourth, *N. oblongata*, and the seventh, *N. cuneiformis*, all from the Hamilton group, Devonian, of New York State, have been recognized as typical representatives of Conrad's genus *Nuculites*.[2]

FIGURES OF THE TYPE-SPECIES.

In the generally distributed edition of the 5th Annual Report of the Geological Survey of New York, published in 1841, containing Conrad's definition of the genus *Nuculites*, no figures were published.

The original plate, prepared by Conrad to illustrate the species described in that report, was reproduced in the fifteenth annual report of the regents of the University of New York on the state of the Cabinet of Natural History with the following explanation:

The plate is plate 2 opposite page 194, described as "*Copied from the original lithographic plate of T. A. Conrad, Esq.*" On page 193 it is stated that "*this is a copy of the lithographic plate—which was published with his* (Conrad's) *report in 1841 and circulated with some but not with all the copies.*"

In a footnote to page 192 is the additional remark: "*I* (James Hall) *inferred that only a small number of copies of the plate were published with the report, but it may have been more extensively distributed than I supposed, for I have found five copies among my own volumes.*"

In the explanation of this plate, figure 7 is cited as "*Nuculites cuneiformis;* Conrad, Annual Report, 1841, p. 50;" and figure 8 as "*Nuculites oblongatus*, Conrad, Annual Report, 1841, p. 50." Both of the figures show the anterior clavicle, and the figures of *N. oblongatus* shows the continuous series of crenulations on the hinge line.

Hall, 1885, recognized *Nuculites oblongatus* Conrad and *Nuculites cuneiformis* Conrad, as the types of the genus *Nuculites* Conrad, 1841,[3] and emended the definition with full illustration of the two species (see pl. 47).

The emended generic definition is as follows: "*Nuculites, Conrad* (Geol. Surv. N. Y.; Ann. Rep., p. 49, 1841) *Types, Nuculites oblongatus, Conrad, and Nuculites cuneiformis, Conrad.*

"*Shell equivalve, inequilateral, transverse. Anterior end rounded. Posterior sometimes obliquely truncate and pointed. Beaks anterior. Cardinal line arcuate. Post umbonal slope rounded or angular. Surface marked only by concentric striae in all the known species. Hinge furnished with a row of transverse narrow teeth beginning at the anterior*

[1] Prelim. Notice Lamellibranchiata, pt. 2, 1870, p. 8.
[2] Idem., p. 4. Pal. New York, vol. 5, pt. 1, Lamellibranchiata, pt. 2, pp. 26, 324, 325, and 326, 1885.
[3] Pal. New York, vol. 5, pt. 1, Lamellibranchiata, pt. 1, p. 26, 1885.

muscular scar and extending without interruption posteriorly as far as the posterior scars. Ligament external, contained in a narrow groove along the margin of the hinge. Anterior muscular scar deeply impressed, separated from the cavity of the shell by a vertical or slightly oblique clavicle or partition, extending about two-thirds the distance from the beak toward the base.

Posterior scar elongate, situated just below the termination of the hinge crenulations. Just anterior to the posterior adductor are one or two small retractor impressions. The cavity of the umbo also usually shows three or four impressions of umbonal muscles. Pallial line simple.

This genus differs very distinctly from Nucula in the anterior clavicle and absence of cartilage pit.

Examples: *Nuculites oblongatus*, plate xlvii, figures 1–12. *Nuculites triqueter*, plate xlvii, figures 17–28.[1]

NEW SPECIES FROM WASHINGTON COUNTY, MAINE.

The following species of *Nuculites* have been recognized from the faunules of the uppermost beds of the Edmunds formation (locality numbers 5.33.8 B, and 1443 D 7) and from the Leighton shale member of the Pembroke formation (locality numbers 1.43.9 A, 1.45.6 A, 1.55.1 A, 5.34.7 A^2, 5.44.2 A, 5.3.2 A, 5.3.8 F, E and M^1, 5.4.7 B, 5.25.4 B, 5.24.6 B).

EDMUNDS FORMATION.

Nuculites corrugatus, page 32, plate 11, figures 10, 18.
N. subplanus, page 34, plate 11, figure 17; plate 12, figure 8.
N. trescotti, page 35, plate 12, figure 1.
N. lentus, page 46, plate 12, figures 6, 13.

PEMBROKE FORMATION, LEIGHTON MEMBER.

Nuculites corrugatus, page 32, plate 11, figure 12.
N. amycus, page 43, plate 11, figure 5.
N. battus, page 43, plate 11, figures 11, 13.
N. galeus, page 44, plate 11, figures 1, 14, 19; plate 12, figure 2.
N. thyestes, page 41, plate 11, figure 8.
N. atreus, page 40, plate 12, figure 3.
N. chrysippus, page 39, plate 12, figure 5.
N. speciosus, page 38, plate 12, figures 9, 18, 19.
N. pelops, page 44, plate 11, figures 3, 7, 19.
N. eurylochus, page 45, plate 11, figure 4.
N. pholus, page 32, plate 11, figure 6.
N. ladon, page 33, plate 11, figure 15.
N. lichas, page 34, plate 11, figure 20.
N. nessus, page 33, plate 11, figure 21.

[1] Pal. New York, vol. 5, part 1, Lamellibranchiata, 2, pp. xxvi, xxvii.

N. robustus, page 36, plate 11, figure 9; plate 12, figures 4, 7, 10, 12, 14, 15.

N. abnormis, page 39, plate 11, figure 16.

N. crassus, page 37, plate 12, figures 16, 17.

DESCRIPTIONS OF SPECIES.

NUCULITES CORRUGATUS Williams.

Plate 11, figs. 10, 12, 18.

1913. *Nuculites corrugatus* WILLIAMS, Proc. U. S. Nat. Mus., vol. 45, p. 347, pl. 31, figs. 11 and 14.

In the original publication of this species two specimens were selected for illustration, both of which are more or less distorted. Considerable variation in form was recognized. Since then all the representatives of the genus, from the Eastport Quadrangle, have been critically studied with the result that the normal form of the species can now be more accurately determined. This normal form is fairly well represented by the new figures given in this paper (pl. 11, figs. 10, 12, and 18).

The average length of 18 specimens from the Leighton Cove locality is 23½ mm. The average height in proportion to length is 53/100.

The specimens from the Crowe Neck locality are smaller, rarely exceeding the average length of the Leighton Cove specimens. Their relative height is approximately the same.

Other forms, associated with this species in the typical locality, are represented by figures 6, 15, 20, and 21. These are described beyond under separate specific names.

Formation and locality.—Pembroke formation, in the Leighton gray shale member at the head of Leighton Cove, Pembroke Township (loc. 5.3.8 F) for the cotypes Cat. No. 58976 U.S.N.M. and the specimen figured on plate 11, figure 12.

Edmunds formation, gray shales, shore of the little cove in northeast part of Crowe Neck opening into northeast end of Straight Bay Trescott Township (loc. 5.33.8 B) for the specimens figured as figure 10 and 18 on plate 11, Cat. No. 62869 U.S.N.M.

This last locality is believed to be at the dividing line between the Edmunds and Pembroke formation. In the folio it is mapped as Edmunds.

Remarks.—Specimens of this species have been found in other outcrops of the Pembroke shales, at the head of Leighton Cove in lower beds of the same section (namely, loc. No. 5.3.8 m and 5.3.8 E also on the outside of Leighton Point (at loc. No. 5 : 4.7 B).

NUCULITES PHOLUS, new species.

Plate 11, fig. 6.

This is a small species, which in general form resembles *N. corrugatus*, but it is less than half the size; the beak is further back and both the front and back ends are more prolonged and narrowed. The

clavicle is distinct, dips forward and reaches half way across the shell. The hinge is crenulate. The posterior end is depressed without distinct unbonal ridge but with obscure traces of corrugations.

Dimensions, 14 by 6½ mm. = 46%.

Formation and locality.—Pembroke formation. Thin gray shales at the head of Leighton Cove (loc. 5.3.8. F).

Remarks.—The type-specimen of this species comes from the same faunule with typical *Nuculites corrugatus* (loc. No. 5.3.8 F).

The same species has been recognized in the faunules of other localities of the Pembroke, namely, Oak Hill (loc. No. 1.43.9 A) species No. 2087 A and C and 2089; a mile or so southeast of Oak Hill (loc. No. 1.55.1 A) species No. 1849; northeast of Leighton Point, in the shales continuing Kelley Point outcrops to the southeast (loc. No. 5.4.7 A) species No. 2124, 2125, and 2126.

Type-specimen.—Cat. No. 62870, U.S.N.M.

The following three species come from the same shales in which typical *Nuculites corrugatus* is found (loc. No. 5.3.8 F). Morphologically, they are specifically distinct from that species. Their present form is evidently secondary, not original. They have been figured and given separate names in order to discuss the problems they offer the paleontologist for solution.

NUCULITES LADON, new species.

Plate 11, fig. 15.

Nuculites ladon resembles in its present outline *N. battus*, represented in the figure immediately above it on plate 11. It differs in the narrowing of both front and back ends, associated with an arching of the center of the shell, which removes it from a subquadrate to an oval shape.

It is so near to *N. battus*, however, that taken alone one would naturally consider it a variety of that species. It is probable that it is a distorted specimen of *N. corrugatus*. There are no traces on the umbonal slopes of the corrugations characteristic of the latter species.

Formation and locality.—Pembroke formation, gray shale at head of Leighton Cove, (loc. No. 5.3.8 F), Leighton Neck, Pembroke.

Remarks.—The same form has been found in the Pembroke shales outside Leighton Point (loc. No. 5.4.7 B).

Type-specimen.—Cat. No. 62871 U.S.N.M.

NUCULITES NESSUS, new species.

Plate 11, fig. 21.

The second species, *Nuculites nessus*, is more like *N. corrugatus* in its general surface characters, but is a short, high form, with broadly rounded ends, a beak nearly central, high, overarching the hinge, and

a slender, long clavicle. Hinge short and arching. The corrugations are present on the umbonal slopes and the slight broad depression across the center is like *N. corrugatus*.

Formation and locality.—Same as *N. ladon*.

Remarks.—A specimen presenting this form has been seen in the shales of the Edmunds formation at northern end of Straight Bay (loc. No. 1443 D 7).

Type-specimen.—Cat. No. 62872, U.S.N.M.

NUCULITES LICHAS, new species.

Plate 11, fig. 20.

The third species, *Nuculites lichas*, is still closer in general form to *N. corrugatus*, but the front is higher, more broadly rounded, the back low and not projecting above the hinge, the posterior end is probably like that of *N. corrugatus* but low and flattened. Several wrinkle-like lines radiate backward from behind the beak, which in the specimen are nearly as prominent as the long, slender backward trending clavicle.

Formation and locality.—Same as *N. ladon*.

Remarks.—It would be misleading to speak of these three forms as varieties, in the biological sense, of *N. corrugatus*. There is no reason to suppose that the shells of the species *N. corrugatus* varied in these ways in life. Nor is it any more correct to call them varieties of *N. battus* to which in their present state they have close resemblance.

Strictly speaking, they are metamorphic species, real for the paleontologist, but mythical, as are their names, for the zoologist.

Type-specimen.—Cat. No. 62873, U.S.N.M.

NUCULITES SUBPLANUS, new species.

Plate 11, fig. 17; plate 12, fig. 8, magnified.

Shell thin, transversely elliptical, compressed, somewhat narrowed behind, basal margin regularly and gently rounded with a slight undefined constriction near the posterior end. Beak low and broad, rising but little above the hinge line, terminating a little in front of center. General surface depressed-convex, umbonal ridge low, undefined, and with a slightly depressed furrow in front of it. Surface crossed by fine concentric lines, the posterior umbonal ridge and slope crossed by fine radiating lines. Clavicle short but distinct, hinge with crenulate teeth.

The dimensions of the type-specimen are 20 by 12 mm., making the height 60 per cent of the length, which is within the limit already set for specimens of *N. corrugatus*.

Formation and locality.—Edmunds formations: Gray shales, shore of the little cove in northeast part of Crowe Neck, opening into north end of Straight Bay, Trescott Township (loc. No. 5.33.8 B).

This outcrop is believed to represent the uppermost beds of the Edmunds.

Remarks.—The discovery that specimens, from the Crowe Neck locality, Edmunds formation, in other respects having the characters of *N. corrugatus*, are crossed upon the umbonal ridge and slope by distinct fine radiating lines suggests intimate genetic relationship between the two species.

From a morphologic point of view *N. subplanus* and *N. corrugatus* are two distinct species. The fact that the radiating lines on the posterior end of the shell occur only in this Crowe Neck locality, suggests that they are a matter of preservation rather than of specific distinction.

From a taxonomic point of view, if the radiating lines be given specific value, then *N. subplanus* becomes the type of the Crowe Neck forms and the more elongate forms which in other respects agree with the typical *N. corrugatus* of the Leighton Cove locality become varieties of *N. subplanus* distinguished from *N. corrugatus* by the radiating lines.

With this interpretation the Leighton Cove (Pembroke) species *N. corrugatus* becomes the later representative of the Edmunds, Crowe Neck, species *N. subplanus* from which it differs by absence of the radiating lines on the posterior end of the shell.

Type-specimen.—Cat. No. 62874, U.S.N.M.

NUCULITES TRESCOTTI, new species.

Plate 12, fig. 1.

Shell obliquely ovate; front end short, narrowly rounded; posterior end large, subcuneate, produced both downward and backward. Beak prominent, arching over the hinge and terminating near the front. Valves convex, most so over the central portion. Umbonal ridge prominent, subangular, below and anterior to which is a well-defined depressed furrow extending from posterior side of beak obliquely across to the post-inferior margin. Basal margin broadly rounded from the front to the umbonal furrow, where it turns upward to form a distinct reentrant sinus. Hinge short, with crenulate teeth (evident behind the beak); the posterior margin, from the end of the hinge to top of the umbonal ridge, long and nearly straight. The cardinal slope abrupt and slightly concave. Surface crossed by sharp, fine concentric lines. The clavicle is approximately vertical to the hinge line, well defined, but slender, and in some specimens distinctly curved as in *Nuculites triqueter* Conrad.

The long axis, from the center of the front margin to extremity of the postumbonal ridge, cuts the shell into two approximately equal portions; the arched basal margin protruding below to balance the

umbonal extension forward. The height is slightly (one to two-tenths) greater than one-half the length.

The figured specimen (pl. 12, fig. 1) is the largest specimen seen. A smaller specimen (M 1773), presenting more fully the specific characteristics, has a length of 11 millimeters and is regarded as cotypical with the former.

Formation and locality.—Edmunds formation, northeastern part of Crowe Neck (loc. 5.33.8 B), Trescott Township, Washington County, Maine, gray shales near the top of the Edmunds formation.

Remarks.—This species recalls *Nucula coarctata* Phillips=*Cucullella coarctata* McCoy, from Fresh water, East, Pembrokeshire, England; especially Phillip's figure 47, plate 26, from which our species differs in its greater proportionate length. McCoy, in redefining the species, mentions the proportion of height to length as 65/100 which is approximately that of *N. trescotti.*

Type-specimen.—Cat. No. 62875, U.S.N.M.

NUCULITES ROBUSTUS, new species.

Plate 11, fig. 9; plate 12, figs. 4, 7, 10, 12, 14, 15.

1839 cf. *Cucullaea antiqua* SOWERBY, Murchison Sil. System, p. 602, pls. 3, 11 and 12*a*.

1855 cf. *Cucullella antiqua* (McCOY) British Pal. Fossils, p. 284.

A small, thick-shelled species, much resembling *Cucullaea antiqua* Sowerby, but having a more prominent overarching beak, stronger clavicle and more transversely elongate form.

Externally, the shell is transversely ovate, rather convex, beak prominent overarching, posterior end produced, basal margin broadly rounded, a shallow furrow below the inconspicuous umbonal ridge, front margin rounded (pl. 11, fig. 9).

Interior molds show prominent beak, arching over the hinge margins, terminating about ¼ length back from front margin. Clavicle strong, straight, reaching beyond middle of shell; the anterior muscular scar to within the space set off by the clavicle. Behind the beak the interior of the shell is strengthened by a broad rib bounding the posterior muscular scar on its front side. The cardinal edge is strongly developed and has a continuous series of crenulate teeth from near the front end of the hinge to a point beyond the front side of the posterior muscular scar.

In front the teeth incline inward toward the beak, and are slightly longer than those behind the beak, which also incline inward toward the beak. Those immediately under the beak are smaller than at either end.

Of 16 specimens measured, the average length is a little over 12 mm., the smallest 6½, the largest 18 mm. The average height 51/100, the length, varying from 42 to 69 per cent.

The figures of *Cucullaea antiqua* given by Sowerby are 8½ and 14 mm. long, with height about 70 per cent and 64 per cent of length.

McCoy gives the proportion 65/100 for height to length, thus showing, mathematically, the more slender form of our species.

Formation and locality.—Pembroke formation, gray shales on east side of Young's Point, Denbow Neck, Lubec (loc. No. 5.25.4 B).

Type-specimen.—Cat. No. 62876, U.S.N.M.

NUCULITES CRASSUS, new species.

Plate 12, figs. 16 and 17.

The definition of this species is founded upon two molds of the interior of left valves and a fragment of the exterior.

Shell large, long, elongate-ovate, anterior and posterior ends about equally narrowly rounded. A deep, broad posterior furrow on the exterior runs from the hinge to the basal margin separating off the strong umbonal ridge from the body of the shell. In the mold of interior the shell seems to have been thickened for a width of several millimeters in front of the posterior adductor, which is deeply impressed. The clavicle is strong and expanding at the inner surface of the shell; and extends more than halfway across the shell. The basal margin is broadly, evenly rounded up to the edge of the posterior furrow, which ends in a sinus. The surface curves down abruptly at both the anterior and posterior ends. The crenulations are strong both sides the beak. The beak arches over the hinge.

The exterior surface is marked by fine concentric lines.

Dimensions, 37 by 15½ mm. (41½ per cent); 30 by 13 (43 per cent).

The teeth behind the beak distinctly express the "V-shaped form" which Verrill and Bush considered to be a characteristic of modern genera of this group of shells.[1]

Formation and locality.—Pembroke formation, gray splintery shales on east side of Denbow Point, north side of a little cove on north side of Young's Point. Lubec (loc. No. 5.24.6. B).

Remarks.—This is a large, thick shell, having about the proportions of *N. robustus* but twice as large. Our specimens are larger than the largest reported specimen of *Nuculites oblongatus* Conrad, and proportionally the shell is longer and narrower. The height of two specimens of *N. crassus* is 41 per cent and 43 per cent of the length. The corresponding proportion of *N. oblongatus* is 57 per cent.

It agrees with *N. robustus* in the strong reinforcement of the inner surface of the shell between the umbonal cavity and the posterior muscular scar, the narrowing of the posterior end, and the flattening of the umbonal and central cavity of the shell shown in the interior molds. In these features, the resemblance to *Cucullaea antiqua* Sowerby is closer than to the Devonian *N. oblongatus* Conrad.

Type-specimen.—Cat. No. 62877 U.S.N.M.

[1] Amer. Jour. Sci., vol. 3, 1897, p. 58.

NUCULITES SPECIOSUS, new species.

Plate 12, figs. 9, 18, 19.

Shell thin, large, elongate, subcylindrical,[1] length nearly three times the height. Hinge line long, crenulate. Posterior end cuneate. Front rounded, clavicle in type-specimen strong but thin and inclining forward; in a second specimen (M 1809) inclining backward. Beak low, in the mold of interior scarcely projecting beyond hinge, terminating about one-fourth of length back of front margin. Posterior end prominently corrugated, apparently in part due to puckering of the shell by pressure.

The dimensions of the largest specimen are: Length 43, and height 15 mm. (pl. 12, fig. 19); another specimen from the same locality (M. 1807) measures 40 by 14 mm. Two other specimens from same locality, probably the same species, measure 33 by 13 mm., and 32 by 13 mm. (M. 1806, see pl. 12, fig. 9, and M. 2081).

Another specimen, from another outcrop of probably the same horizon (M. 1809, see pl. 12, fig. 18) has an estimated length 42, estimated height 14 mm.

In size and general form it resembles *N. crassus*, but differs from that species in its thin shell, inconspicuous beak, slender clavicle and absence of trace of muscular impressions.

In these latter characters, it approaches *N. corrugatus;* but it is longer, thicker, not so flat, and the extremities, both anterior and posterior, are lengthened and more attenuate than in *N. corrugatus.*

These differences from *N. corrugatus* may, in part, be accounted for by the slaty deformation of the rock in which they are contained. The rock containing the types of *N. corrugatus* is a similar shale, but does not show the splintery structure of the shale holding *N. speciosus*, and it is to be noted that all of the specimens referred to *N. speciosus* have their long axis in line with the long axis of the splinters.

The only specimen associated with them, lying crosswise to the direction of slaty elongation, is abnormally short (see *N. abnormis*, pl. 11, fig. 16).

Formation and locality.—Pembroke formation, gray shale on the west side of Coffin Neck, opposite Gooseberry Island, Lubec Township (loc. No. 5.44.2 A). These beds rest immediately upon some light greenish shales holding an unmistakable Edmunds fauna.

Remarks.—This species has been found in other outcrops of the shales near the border between the Edmunds and Pembroke formations, at the northern end of Coffin Neck (loc. No. 5.34.7 A[2]), and in the collection made by N. S. Shaler in Straights Bay, precise locality not known (loc. No. 1443 D 7), probably the same as locality No. 5.33.8 B.

Type-specimen.—Cat. Nos. 62878, 62880, U.S.N.M.

[1] A specimen (M 2013) from the collection made by N. S. Shaler (loc. 1443 D 7), probably the same locality as our 5.33.8 B, presents apparently the characters of this species undistorted—the subcylindrical form of the types is supposed to have been produced by pressure (see M 1805, *N. abnormis*).

NUCULITES ABNORMIS, new species.

Plate 11, fig. 16.

Shell rhomboid-ovate, flattened, resembling in outline a Devonian *Cypricardella*, but with the clavicle and crenulate teeth of *Nuculites*.

The antero-posterior diameter is 28 mm. and height (estimated) 20, or at least 70 per cent of length. Beak situated about one-third of length back of front margin. The umbonal ridge, as in *Cypricardella*, with central body of the shell depressed convex, the postumbonal slope is concave and falls off abruptly from the umbonal ridge. The hinge behind the beak is marked with the characteristic crenulate teeth of *Nuculites* and the clavicle is distinct and slants forward.

This specimen was found in the same shales with *Nuculites speciosus*, from which it differs very greatly in form; nevertheless it is quite possible that the difference in form is due to metamorphic distortion after fossilization.

Formation and locality.—Pembroke formation, gray shales on west side of Coffin Neck, opposite Gooseberry Island, Lubec (loc. No. 5.44.2 A). These shales lie immediately above some light greenish shales containing an Edmunds fauna.

Type-specimen.—Cat. No. 62881, U.S.N.M.

NUCULITES CHRYSIPPUS, new species.

Plate 12, fig. 5.

The name *Nuculites chrysippus* is given to an elongate, cuneate form similar to that of *N. cuneiformis* Conrad. Most of the terms used in describing that species apply equally well to this one.

Shell of medium size, elongate-ovate, cuneiform, widest in front and pointed behind; length (22 mm.) twice the height (11 mm.), thus differing from *N. cuneiformis*, the length of which is greater than the height. Basal margin gently curving in the anterior part, becoming nearly straight behind. Posterior extremity narrow, but less so and less elongate than in *N. cuneiformis* and obliquely truncate behind. This truncation of the margin lies between the two faintly expressed umbonal ridges which radiate from the beaks. At the base, they are 3½ mm. apart, the space between them is flat and marked by two intermediate faint corrugations as in *N. corrugatus*. The cardinal line is nearly straight. Anterior end sloping rapidly in a straight line from the beaks and abruptly rounded below. The beak is at the extreme front (if the axis of the shell be made parallel to the hinge line). If the margin of the base be made the transverse axis of the shell, the beak stands near the front, which is broadly rounded to the center of the base and the shell is very oblique and the umbonal slope is greatly elongate and bounded by two faint diverging ridges. In front of the more anterior of these ridges, there is a broad shallow

furrow extending from the middle of the shell to the basal margin, The post-cardinal slope is abrupt as is also that at the front end of the shell. The surface is marked by fine concentric stria and stronger lines of growth about two millimeters apart. The clavicle is slender, runs about half way to the base, and is directed backward at about 40 degrees from the hinge line.

Formation and locality.—Pembroke formation, splintery gray shales, in the southern part of West Pembroke, on west side Pennamaquam River (loc. No. 1.45.6 A).

Type-specimen.—Cat. No. 62882, U.S.N.M.

NUCULITES ATREUS, new species.

Plate 12, fig. 3.

The name, *Nuculites atreus*, is given to a transversely elliptical shell, the beak of which is situated almost central (about 1 mm. in front of the center). The valves moderately convex, beak low, protruding slightly beyond the hinge margin. The two ends are sub-equal, the anterior evenly rounded, the posterior obliquely truncated, forming a blunt angle with the base line. The umbonal ridge is only slightly angular, scarcely separating the body lope from the post-umbonal slope. The hinge line is slightly arching, corresponding to the gentle curvature of the basal margin, making the form nearly equilateral. The clavicle is thin and reaches less than half way to the basal margin, and inclines forward about 35° from a transverse line running through the middle of the shell. There are distinct crenulations on the hinge. The surface markings are as upon *N. chrysippus*.

The surface of this shell is evenly rounded from front to the umbonal angle, which is only slightly and broadly undulate. There are no indications of furrows or ridges radiating from the beak, and the only break in this even curvature of the margin is the posterior truncation spanning the end of the slope between the umbonal ridge and the end of the hinge line.

The shell presents some resemblance in outer form to *Palaeoneilo plana* Hall, and may be distinguished from Hall's figure (24 of plate 48) by the more central position of its beak, the broader curvature of the anterior end, and the wider and truncate termination of the posterior end. In addition to the crenulate teeth of *Palaconeilo*, this species has the clavicle of *Nuculites*. Dimensions: antero-posterior diameter 18 mm., height from beak to basal margin, 7 mm. (= 39 per cent). The beak is 8½ mm. from front and 9½ mm. from posterior extremity.

Formation and locality.—Pembroke formation, splintery gray shales in the southern part of West Pembroke on west side of Pennamaquam River (loc. No. 1.45.6 A).

Type-specimen.—Cat. No. 62883, U.S.N.M.

NUCULITES THYESTES, new species.

Plate 11, fig. 8.

Nuculites thyestes has a broadly ovate form; the length is about one-third greater than the height, valves depressed-convex, beak low, and (when viewed in such a position that the line connecting the middle of the anterior with the middle of the posterior end is horizontal), the beak is decidedly posterior to the center. From this point of view, the anterior end is evenly curved and is very broad, and the posterior end is short and not more than half the height of the front. The hinge is not in evidence, but the posterior slope indicates the position of the beak, and there is a gradually broadening furrow separating two very low umbonal ridges. The clavicle is short, reaching about one-third the distance to the margin and slants forward. The surface markings are the same as for *N. chrysippus* and *N. atreus*. Dimensions, greatest diameter 21½ mm. (which is on the line connecting the center of posterior end with center of anterior end); height 17 mm. (79 per cent).

Formation and locality.—Pembroke formation, splintery gray shales in the southern part of West Pembroke, on west side of Pennamquam River (loc. No 1.45.6 A).

Type-specimen.—Cat. No. 62884, U.S.N.M.

REMARKS ON N. CHRYSIPPUS, N. ATREUS, AND N. THYESTES.

These three quite dissimilar shells, found in a small outcrop of the splintery Pembroke shales in West Pembroke village, offer some particularly interesting facts for the paleontologist.

They are represented by figure 8 on plate 11, and figures 3 and 5 on plate 12.

At first glance they appear to represent three distinct genera neither of which is *Nuculites*. On closer inspection, however, a slender clavicle is discovered on each specimen and on one of them the characteristic crenulations are seen, so that upon comparing them with fuller collections of *Nuculites* from other outcrops of the Pembroke shales, it is clear that each of them is a distorted specimen of some species of *Nuculites*.

The three forms are so decidedly different that, from a morphologic point of view, they must be regarded as distinct species. In order to discuss them, I have given them names:

M 1787 = *Nuculites chrysippus* (pl. 12, fig. 5).

M 1788 = *N. atreus* (pl. 12, fig. 3).

M 1789 = *N. thyestes* (pl. 11, fig. 8).

Although neither of the forms has any near resemblance to *N. corrugatus*, nor has there been found in this locality any specimen that can be referred morphologically to that species, a study of the

collections leads very strongly to the belief that they are but distorted representatives of the same zoological species I have called *N. corrugatus*.

But on this hypothesis it would not be correct to refer to these species as varieties of *N. corrugatus* for there is no evidence to show that the zoological species *N. corrugatus* expressed anything like these divergences in form.

Further, they are not imaginary species, for the characters they express as fossils are as positive and real and exact as those expressed by any other fossils.

Nevertheless, taken separately, as figured and morphologically described, there is nothing to indicate that they are not as "good" species as any others described in this paper.

They are, however, evidently distorted as is demonstrated by the ollowing diagrams, which show the realtionship of the present form

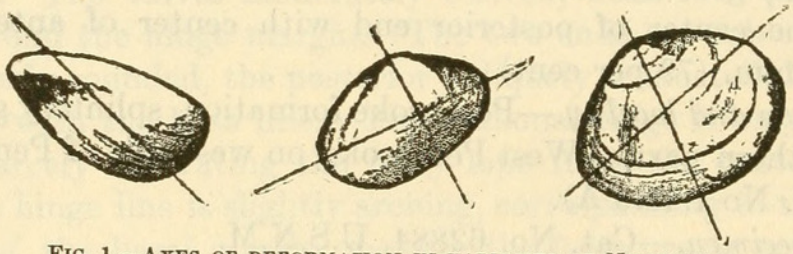

FIG. 1.—AXES OF DEFORMATION IN VARIETIES OF NUCULITES.

of each to the axis of general deformation of the splintery shales in which they lie.

The outline is here drawn as near as possible as it lay on the splintery shale, the long axis of which is here placed horizontal and the chief compression of which has been in a vertical direction.

The line C–D is, for each specimen, approximately its long transverse axis and A–B its vertical axis running through the tip of the beak, on the supposition that they were originally normal shaped specimens of *Nuculites*.

Taking these three specimens to be actually three distorted individuals of the same species, a study of the effects of the pressure and movement of the rock upon the original form is instructive.

In the first figure (*N. chrysippus*) the squeezing has changed the relations of the lines A–B to C–D from 90° for each arc to 145° for the arcs A–D and B–C and 45° for the arcs D–B and A–C, thus relatively shortening the height of the front and the back and lengthening the hinge margin behind the beak and the front half of the base; redistributing each of the elements of the circumference without markedly disturbing the general shape of the contour. The beak is shifted forward to the extreme front and the clavicle is turned strongly backward.

In the second figure (*N. atreus*) the squeezing has not greatly affected the angular position of the parts, as shown by the nearly normal relation of the axes A–B to C–D (90°); but has apparently thrust the front half of the shell upward and forward, elongating the part in front of the beak, while the posterior basal part has been forced upward toward the beak, thus shortening the posterior end.

In the third figure (*N. thyestes*) the arcs A–C and D–B have been reduced about 20°, with corresponding increase of the arcs A–D and C–B. But the effect of this squeezing has been very different from the first case, because of the different position of the beak, which was evidently more stable, the other parts of the shell moving about it. The result has been a great flattening out of the front half of the shell, a shortening and pushing forward of the posterior part, arching of the hinge margin, and thrusting of the beak into a nearly central position, leaving the clavicle in a normal relation to the beak.

NUCULITES AMYCUS, new species.

Plate 11, fig. 5.

Shell narrow, elongate, with a high, angular umbonal ridge. The beak low, terminating at about one-quarter distance back from front to posterior extremity. The umbonal ridge forms the most elevated part of the surface in the middle where it is sharply angular and flattens out both toward the beak and toward the postero-basal angle. On the posterior slope there is a slightly raised secondary parallel ridge. Anterior to the umbonal ridge, the surface slopes off gradually toward the front. The clavicle, inclines slightly backward, and extends scarcely halfway to the base.

Dimensions.—Antero-posterior diameter 13½ mm.; height, 7 mm. (52 per cent). There is a faint linear depression in the specimen (which is a mold of the interior) proceeding from behind the tip of the beak, crowning the umbonal ridge near its cardinal end, and terminating on the basal margin at a point about 3 mm. in front of the posterior extremity. This depression appears to have been a raised line on the interior of the shell about one-half the strength of the clavicle. It is possible that it is the expression of a crack of the shell, as its direction is parallel to the axis of elongation of the rock in which it lies.

Formation and locality.—Pembroke formation, gray splintery shales in the vicinity of Oak Hill, northwestern Pembroke (loc. No. 1.43.9 A).

Type-specimen.—Cat. No. 62885, U.S.N.M.

NUCULITES BATTUS, new species.

Plate 11, figs. 11 and 13.

Shell thin, subquadrate, flattened, height more than half the antero-posterior diameter. Both anterior and posterior ends broadly

rounded, clavicle slender, nearly erect, and reaching halfway to base. Beak low, terminating slightly anterior to the middle.

Dimensions.—M 1802, 18½ by 12 mm. (65 per cent), M 1803, 18 by 13 mm. (72 per cent).

Formation and locality.—Pembroke formation, gray splintery shales outcropping near Oak Hill, northwestern Pembroke (loc. No. 1.43.9 A).

Type-specimen.—Cat. No. 62886, U.S.N.M.

NUCULITES GALEUS, new species.

Plate 11, figs. 1, 14, 19*c*; plate 12, fig. 2.

Shell elongate-oval, the posterior end narrow and subangular, the anterior somewhat narrowed and evenly rounded.

The beak terminates at about the anterior third. The body of the shell is subcylindrical, swollen in the middle and tapers down toward both ends. The umbonal ridge is near the cardinal margin, its outer slope abrupt and rounded off toward its outer end. The umbonal furrow is faintly expressed and its termination forms a slight sinus at the margin. The clavicle is slender, reaches halfway across the shell and slants obliquely forward from the beak. The concentric growth-lines are distinct, the finer concentric lines also are in evidence.

Dimensions.—Transverse length 29 mm., height at beak 12 mm. (41 per cent). Tip of beak 11 mm. from front end; the lower end of clavicle, 6½ mm. from front end.

Formation and locality.—Pembroke formation, splintery gray shales on south side of Pennamaquam River at Kelly Point and westward, Pembroke Township (loc. No. 5.3.2 A).

Remarks.—Several specimens (one figured) from this same locality have the same general form. Specimens from the Oak Hill (loc. No. 1.43.9 A) outcrop of probably the same shales, have the same form. One of them is given on plate 12, figure 2. Another specimen from the Kelley Point shales (loc. No. 5.3.2 A) is figured (pl. 11, fig. 1) and is referred to this species. Their affinities with both *N. corrugatus* and *N. speciosus* are apparent.

Type-specimen.—Cat. Nos. 62887, 62888, U.S.N.M.

NUCULITES PELOPS, new species.

Plate 11, figs 3, 7, 19*a*.

Shell erect, obliquely ovate, height greater than the transverse diameter; beak narrow overarching the hinge. Shell moderately convex; posterior surface gently sloping off to the hinge and posterior margin; the anterior slope more abrupt than the posterior. The posterior margin forms a blunt angle with the hinge margin and

falls off toward the base in a nearly straight line to the middle, then gently curves around the postero-basal angle into the basal margin. The front margin is gently arched, running into the basal margin in a broad regular curved line. The anterior side is shorter than the posterior and their margins are subparallel. The hinge is arched and shorter than the transverse diameter of the shell. The clavicle is slender and short, extending about one-third distance to the base. The hinge is crenulate. The surface is marked by fine concentric lines; and, in this specimen, is marked by several small pustulous elevations, which are seen to be produced by Ostracods lying inside the shell and pressed into the shell during fossilization, thus showing the thin structure of the shell.

Another specimen from the same locality is M 1790 A (pl. 11, fig. 3).

Dimensions of 1791: length 15 mm.; height 17 mm. (113 per cent).

No. 1790, transverse diameter, 14, estimated height 19 mm. (135 per cent).

The type-specimen shows faint indication of an umbonal furrow, and in the umbonal region it is bounded by a slight indication of an umbonal ridge.

The second specimen shows some faint indication of wrinkling of the surface in the direction of the long axis of deformation of the shales in which it lies.

Both specimens lie with the transverse axis of the shell, at near right angles to the axis of elongation of the shales, thus clearly indicating the metamorphic nature of their specific characters.

Formation and locality.—Pembroke formation, gray, splintery shales, Kelley Point, south shore of Pannamaquam River (loc. No. 5.3.2 A).

Type-specimen.—Cat. No. 62889, U.S.N.M.

NUCULITES EURYLOCHUS, new species.

Plate 11, fig. 4.

Shell of medium size, subcircular, length and height about equal, margins regularly rounded. Valves moderately convex below, becoming gibbous a little above middle. Beaks a little anterior to the middle, small, rising but little above hinge line. Posterior slope a little longer than the anterior slope and marked by a curved depression fading out toward the hinge and toward the base. The clavicle distinct, erect and distinctly in front of the beak, reaching nearly half way across the shell. Test thin. Surface marked by fine concentric strias and at irregular distances stronger growth lines. The crenulations of the hinge are not actually seen, but their presence is inferred from the fact that the specimens of *N. galeus* on the same slab (1790 A) show the crenulations and the two agree in other characters of the shell except form.

This species, like *N. galeus*, is regarded as a metamorphic species (namely, the acquired are more prominent than the original char-

acteristics). Except for the presence of a distinct clavicle, this species might, on morphologic grounds, be classed with *Paracyclas*. Another specimen (M 1799) represents the same form.

Formation and locality.—Pembroke formation, gray, splintery shales, Kelley Point, south shore of Pennamaquam River (loc. 5.3.2 A).

Type-specimen.—Cat. No. 62890, U.S.N.M.

REMARKS UPON THE SPECIES N. GALEUS, N. PELOPS, AND N. EURYLOCHUS.

On plate 11 a figure is given (fig. 19) of a slab of the splintery shale from the Kelly Point locality (loc. No. 5.3.2 A) showing examples of these three species as they, at present, lie upon the surface of the shale.

At the top of the plate separate figures are given of each species oriented as is customarily done in preparing plates to illustrate fossil species. The straight lines drawn across the faces of the separate figures represent the long axis of the splintery slab upon which they lie, thus indicating roughly the direction in which the specimens have been distorted.

On the same plate, figure 7, is a more perfect specimen from the same shales of the species *N. pelops*, and its orientation in relation to the long axis of the splintery shales is the same as the specimen figured above it (fig. 3) seen on this particular slab (fig. 19).

This presentation of the facts will make it clearly evident that the morphologic characters upon which the specific descriptions are (and must be) based have been greatly affected by distortion incident to movement of the containing rock after the shells were embedded.

Paleontologists are familiar with this fact, but may not be aware of the great difficulty there is in determining from the literature, or from the actual specimens in museums, whether distortion has or has not taken place.

NUCULITES LENTUS, new species.

Plate 12, figs. 6 and 13.

1860 cf. *Clidophorus elongatus* HALL, Canadian Nat. and E., vol. 5, p. 150. Also Dawson, T. W., Acadian Geology, ed. 4, 1891, p. 601, fig. 206.

This species agrees in so many particulars with the definition given to *Clidophorus elongatus* Hall from the Silurian at Arisaig, Nova Scotia, that the definition will be given entire and note made of points of divergence from that definition.

Hall's definition is as follows: *Clidophorus elongatus*, Hall, figure 206.[1] Shell subelliptical, length about twice the height, beak much nearer to the anterior end, which is narrowly rounded; umbones rounded, prominent; a defined gradually widening depression extends from the umbo to the posterior basal margin, causing a straightening or slight sinuosity in the edge of the shell; a defined ridge along the

[1] The quotation is made from Dawson's Acadian Geology, 4th edition, p. 601.

posterior slope between the sinus and the cardinal margin. Surface very finely striated. A slender clavicle extends from the anterior cardinal margin a little more than halfway to the base, and curving slightly forward.

Arisaig, coll. J. W. D.

In the first place, *Nuculites lentus* has crenulate hinge teeth. The genus *Clidophorus* was, in its original definition, distinguished from *Nuculites* by the absence of crenulation upon the hinge. The application of the generic name *Clidophorus* to the species *C. elongatus* thus distinguishes the two species.

In our figure 6 (pl. 12) the two valves of the same shell are together, and comparison with Hall's figure shows that the right valve is narrower while the left valve is broader than his figure. The difference between the two valves is, however, clearly a matter of distortion. Figure 13 shows a specimen which differs from *C. elongatus* in the broader, less extended, posterior end; both of our figured specimens show the preumbonal furrow to be less strongly marked than in *C. elongatus*, and the beak is also broader and less conspicuous. The clavicle of *N. lentus* is apparently more slender and straighter than that of *C. elongatus*. The specific definition of the latter, however, is in all its particulars broad enough to include such specimens as *N. lentus* and not specific enough to exclude them.

Formation and locality.—Edmunds formation, gray shales on shore of small cove in northeast part of Crowe Neck forming the northern extremity of Straight Bay, Trescott Township, near the dividing line between the Edmunds and Pembroke formations, classified as Edmunds in the Eastport folio (loc. No. 5.33.8 A).

Type-specimens.—Cat. No. 62891 U.S.N.M.

ON THE INTERPRETATION OF FOSSILS.

In selecting *Nuculites corrugatus* for description, and in writing the description of the species, the chief purpose was to present to the reader the characteristic fossils of the several formations which were being mapped in the Eastport Folio.

It was a species met with in several of the outcrops of the Leighton member of the Pembroke formation and in one exposure of the Edmunds formation, which latter, by its fauna as well as position, was interpreted to be at the top of the Edmunds formation.

Specimens from the typical locality were found to express considerable variation in form. Two specimens (one transversely elongate and the other much shorter and higher in form) were selected to express this variability. In this description, therefore, several of the characters regarded as of specific value were described as varying in presence or absence or in strength of expression of the characters.

In this method of species-description I was following rules very commonly adopted by expert paleontologists.

In the present paper, the description of the representatives of the genus *Nuculites*, as expressed in the Silurian formations of Washington County, was made the chief purpose of the investigation. In this study the object in view has not been paleontological but zoological (or rather conchological), namely, the determination of the proper zoological categories to which the several specimens under investigation belong.

The first point to determine was the meaning of the generic category *Nuculites* and the validity of its name.

Having decided this point, all specimens from the whole collection, which belonged within this category were examined and their morphologic characters closely studied. They were classified, labelled and named strictly on the basis of their morphology. The reason for being strict in the application of this rule was the realization that there are several quite diverse causes both for difference and for likeness of morphologic characters, neglecting which must necessarily lead to a misinterpretation of the significance of the fossils.

Some of these diverse causes may be mentioned as self-evident:

1. The shells of the same zoological species may differ by reason of a natural variability in development of the shell in normal growth.

2. Morphologic differences may arise in addition to natural or inherent variability by reason of differences in food or in conditions of environment. Such a cause is likely to show itself on comparing specimens of the same species from distinct localities.

3. Differences may arise in fossil species from difference in the kind of sediment in which they are imbedded, due to chemical or purely physical causes incident to the solidifying of the rock.

4. Differences in fossil shells may be caused by movements of the rock magma after fossilization. Such changes may be considerable and of unknown amount and without leaving any indication upon the shell itself of such metamorphism.

5. Another cause may find its expression in the literature and figures by which knowledge of fossils is recorded and communicated. The author may associate as characteristics of the species characters observed on separate specimens which he imagines were originally the same species. This results in producing a composite idea of the species, the composition being made up in the author's mind, the reasons for which may or may not be manifest to the reader of the literature or the student of the fossil specimens.

From these considerations it becomes evident that the scientific record of carefully made observations may be affected by the relative importance the author (it may be quite unconsciously) assigns to one or other of these various causes of the morphologic differences he observes.

The fossils described in this paper offer such an admirable example of these diverse causes of difference that it has seemed to the author

worth while to supplement the purly descriptive part of the paper by a discussion of the more obscure problems of interpretation of fossils, particularly of those from the Paleozoic rocks.

I use the word interpretation purposly, because when the paleontologist gives a zoological name to a Paleozoic fossil he is necessarily interpreting the morphologic form impressed upon the rock into the category of living organisms.

Interpretation is very much more and a different process than description. In description we are narrating what is visible to our eyes and what we see; in interpreting we are explaining what we conceive to be the meaning of the thing before our eyes and thus are imagining what is supposed to be symbolized by the thing seen. Fossils are, like the cuneiform inscriptions on Babylonian cylinders, symbols, and their correct interpretation involves a hypothesis as to the cause or causes for the particular form they assume. In both cases it is of prime importance to determine with precision the exact form of the symbol, but in the interpretation, the complexity and difficulties are far greater for the fossils than for the cylinders. The general hypothesis that the fossils were produced by living organisms may be adopted with the same confidence we have that the cuneiform inscriptions were written by men.

It is a simple matter also to compare a fossil shell with the shell of a living organism and to interpret the various characters, such as beak, hinge, clavicle, muscular impressions, etc. The real difficulty comes when we attempt to give generic and specific names, and to assign taxonomic values to the characters observed. These difficulties are increased when we find, as is above stated, that the characters themselves have been modified after their original formation. Not only are there these difficulties in reaching a correct interpretation of fossils, but the evils resulting from misinterpretation are great and far-reaching.

They become misleading in the field of zoology and evolution, as well as in the field of stratigraphy and formational correlation. These misinterpretations of fossils are not to be corrected by accumulation of statistics, but only by a more careful attention to the processes of thinking and the conceptions formed in interpreting the facts observed.

It involves the training of the imagination as well as the training of the powers of observation.

THE NUCULITES FROM THE LEIGHTON COVE SHALES.

(Loc. No. 5.3.8 F.)

In order to give mathematical expression to the divergence of form of specimens associated in a single faunule, I have measured all the specimens (perfect enough for record) from the Leighton Cove locality,

Pembroke (loc. No. 5.3.8. F), giving in the following table the length, height, and percentage of height to length, and the specific definition under which they fall.

No.	Name.	Length.	Height.	Per cent.
		mm.	*mm.*	
M 1215 A	*N. corrugatus*	25	13	52
(Fig. 11)	do	26½	16½	62+
(Fig. 14)	do	33	14	42½
M 1215 B	do	26	11	42+
C	(?)	26	12	46
D	*N. corrugatus*	24	10	42
G	do	28	14	57
F	do	21	13½	65
I	do	2	13	65
K	do	24	12	50
N	do	18	10	55½
T	do	23	12	52+
O	do	22	13	59
R	do	19	10	52+
S	do	28	14	50
V	do	22	13	59
W	do	21	11½	55
Y	do	15½	8½	55
E	cf. *N. corrugatus*	26	10	33½
M 1767 L	*N. pholus*	14	7	50
M 1815	*N. nessus*	19	14	74
M 1817	*N. ladon*	17	12	70+
M 1816	*N. lichas*	19	11½	60+

It will be seen from the table that 18 specimens were definitely referred to the species *N. corrugatus*. The average length of these (omitting fractions) is 23 mm. and the average height 53 per cent of the length. The extremes of length are 33 and 15, and 12 of the 18 specimens vary but 3 mm. from the mean. The extremes of height are 42 per cent and 65 per cent, and 9 of them (namely, one-half) vary only 4 per cent from the mean, 53 per cent.

Another specimen is more slender than these (height 38 per cent,) but comes within the average length, 26 mm.

The other four specimens have a specifically different shape and have been given separate names.

The shales in which these specimens are imbedded are fine-grained fissile shales, showing no particular deformation since solidification. The specimens do not appear to have been elongated or shortened in any particular relationship to the angle of their position on the shales. Their general surface characters, also, are not so diverse as to furnish basis for good specific distinction.

It is, therefore, quite consistent with common usage to consider all of them zoologically as belonging to a single species and to regard those named *N. pholus*, *N. nessus*, *N. ladon*, and *N. lichas* as subspecies or varieties of *N. corrugatus*.

This interpretation will work no particular harm for purely paleontologic purposes, except in making the characters of this species indefinite and elastic; but, from what follows, it will be seen that it would be misleading to assume that the variability found to be a fact in the fossils represents actual variability of the species in producing its shell, from a zoological point of view.

It will be seen, also, that the calling of *N. ladon*, or any of the last four named forms, a variety of *N. corrugatus* or a distinct species is a matter of interpretation not of facts observed. For instance, in case 18 of the 23 specimens from this one faunule were of the form of *N. ladon* and only one of them was like *N. corrugatus*, common usage would lead the paleontologist to decide that *N. corrugatus* is a variety of *N. ladon*. And in case we had in evidence only a single specimen of *N. corrugatus* and *N. ladon*, there would be no question of their specific distinctness.

THE NUCULITES FROM THE SPLINTERY SHALES OF KELLEY POINT.

In the same Leighton member of the Pembroke formation, but above the Leighton Cove shales, there is a series of gray splintery shales outcropping along the northeastern side of the Leighton peninsula on the western shore of Pennamaquam River, extending from outside Leighton Point (at loc. 5.4.7 B) to West Pembroke and beyond. *Nuculites* have been found in these splintery shales from several localities (loc. No. 5.4.7 B, Kelley Point (5.3.2 A), West Pembroke (1.45.6 A) and Oak Hill (1.43.9 A)).

The following species come from these localities:

No.	Name.	Locality.	Length.	Height.	Per cent.
			mm.	*mm.*	
M 2922	*Nuculites corrugatus*	5.4.7 B	28	12	43
2124	*N. pholus*	5.4.7 B	17	8	47
2125	do	5.4.7 B	10	5	50
2126	do	5.4.7 B	10	5	50
2127	*N. ladon*	5.4.7 B	12	8	66+
1790 A	*N. pelops*	5.3.2 A	18	14	77½
1791 A	do	5.3.2 A	15½	17	109
B	do	5.3.2 A	15½	16	103
1790 B	*N. eurylochus*	5.3.2 A	14	13	93
1792	do	5.3.2 A	13½	11½	85
1798	do	5.3.2 A	12½	12	96
1799	do	5.3.2 A	15	15	100
1790 C	*N. galeus*	5.3.2 A	21	9	43
1793	do	5.3.2 A	29	12	41½
1794	do	5.3.2 A	24	12	50
1795	do	5.3.2 A	24	9	37½
1797	do	5.3.2 A	26	10	38½
1796	*N.* cf. *lentus*	5.3.2 A	21	9½	45
1787	*N. chrysippus*	1.45.6 A	22	11	50
1788	*N. atreus*	1.45.6 A	18½	11	59
1789	*N. thyestes*	1.45.6 A	22	17	72
1800	*N. galleus*	1.43.9 A	27	10	37
1801	*N. amycus*	1.43.9 A	12	6	50
1802	*N. battus*	1.43.9 A	18½	12	65
1803	do	1.43.9 A	18	13	72
2087 A	*N.* cf. *pholus*	1.43.9 A	19	15	79
2087 C	do	1.43.9 A	18	9	50
2087 D	*N. galeus*	1.43.9 A	26	11	42
2088	do	1.43.9 A	25½	10	39
2089	*N. pholus*	1.43.9 A	15	7½	50

The great diversity of form presented by the *Nuculites* from these splintery shales is evident from the fact that the attempt to classify and describe the 31 specimens has resulted in assigning them to 12 distinct species.

An average of less than three specimens are found sufficiently alike, morphologically, to be classed under the same definition. Also this diversity of form is shown by the distribution in the faunules. In the faunule 5.4.7 B, five specimens are distributed in three species.

Faunule 1.45.6 A with only three specimens has three species.

In faunule 1.43.9 A the 13 specimens fall into 7 species.

In order to obtain a mathematical expression of this diversity of form, we may take the relation of height to length expressed in percentages. Taking all the 31 specimens from these splintery shales, sufficiently perfect to give the percentage, the height averages 60 per cent of the length, and the extremes range from 37 to 109 per cent.

The averages for the specimens of each faunule are 51 per cent, 70 per cent, 60 per cent, and 52 per cent.

The form of the several species as expressed by the percentage of the height to the length is as follows:

N. galeus, 41 per cent; *N. amycus*, 44 per cent; *N.* cf. *lentus*, 45 per cent; *N.* cf. *corrugatus*, 43 per cent (the average for the type is 53 per cent); *N. pholus*, 50 per cent; *N. chrysippus*, 50 per cent; *N. atreus*, 59 per cent; *N.* cf. *ladon*, 66 per cent; *N. battus*, 68 per cent; *N. thyestes*, 72 per cent; *N. eurylochus*, 93 per cent; *N. pelops*, 96 per cent.

The greatest number of specimens falling under one specific definition is 8 for species *N. galeus*, the height ratio of which is 41 per cent, with range from 37 to 50 per cent. And the total number of the specimens coming within this range of form is 18 or over half of the total number of specimens in the list.

From this analysis, it is evident that, whatever may have been the original form of the specimens here under consideration, it was a narrower, more elongate form than *N. corrugatus*, the average height of which, in its typical locality (loc. No. 5.3.8 F), is 53 per cent of the length.

METAMORPHIC SPECIES.

Without going into further details, the evidence is sufficient to show that the species of the splintery shales, all of them, have an entirely different status from ordinary zoological species.

Independent of the question whether they are well or poorly described, or as to their taxonomic rank, the causes of their present form are evidently secondary and not (wholly) attributable to the organisms supposed to have produced the shell.

It is quite evident, also, that these secondary causes have more or less obliterated the original characters. Nevertheless, the characters they now exhibit are as clear and distinct as if they were original characters, and in description and illustration must be treated as any other fossils.

In the present case I have taken pains to bring together the morphological characters with the evidences of metamorphism exhibited by the shales in which they lie so as to demonstrate the real cause of the specific form.

The evidence of metamorphism is mostly obliterated, when the specimens have been detached and trimmed for the museum, and is entirely absent in the ordinary figures by which the fossil species are illustrated.

In order to distinguish such species from those fossil species which preserve their original characters, I propose to call them METAMORPHIC SPECIES, using the word metamorphic in the sense proposed in the Rules of Nomenclature and Classification adopted by the United States Geological Survey in 1903. In these Rules the following definition is given: "*Metamorphic including altered rocks of either sedimentary or igneous origin in which the acquired are more prominent than he original characteristics.*"

The species of the splintery shales of Kelley Point are metamorphic species in this sense that the acquired are more prominent than the original characteristics. With this definition in mind the paleontologist will be able to remove a large number of fossil species from zoological nomenclature, and place them in a category by themselves for the special use of the geologist.

In the present paper I have assigned names selected from classical mythology to those species which seem to me to come under this definition of metamorphic species. They are of importance to the paleontologist in defining the fossil contents of formations and the characteristic expression of the faunas of particular localities. But they have no legitimate place in zoological nomenclature as species or varieties, although their generic characters may be cited whenever these characters have not been obliterated by the metamorphic processes.

EXPLANATION OF PLATES.

PLATE 11.

The figures on this plate are all natural size.

The arrangement of the figures is designed to illustrate the effects of distortion by which the original form of the shells has been obscured or entirely obliterated.

Figure 19 is an elongated slab of the splintery shale from locality 5.3.2. A showing the specimens, illustrated in figures 1, 2, 3, and 4, as they lie upon the surface of the slab; the separate figures have been rearranged to correspond to the ordinary mode of representing such figures upon a plate.

The original orientation of these specimens is indicated by the lines, drawn across them, which represent the long axis of the slab on which they lie.

Nuculites galeus Williams.

Fig. 1. A right valve, the same as marked C on figure 19 (specimen number M 1790 C).

14. A left valve from the same locality, somewhat, larger than figure 1, but presenting the same elements of form (M 1793).

19*c*. The same specimen as figure 1, shown in its original position on the slab (M 1790).

Locality.—Slaty shale of the Leighton member of the Pembroke formation, on the south shore of Pennamaquam River at Kelley Point. Pembroke Township (loc. No. 5.3.2 A).

Nuculites, species indet.

Fig. 2. A nearly circular specimen, the outlines of which are too imperfect for exact delineation, figured in order to illustrate the extreme shortening of the shell. The same as figure 19 *d* (M 1790).

Locality.—Same as figure 1.

Nuculites pelops Williams.

Fig. 3. An imperfect specimen of a left valve, the same as figure 19 *a*, of the form better expressed by figure 7 which is made the type of the species.

19*a*. The same specimen as figure 3 shown in its original position (M 1790 A).

7. A left valve showing the full form. By the line drawn across its face (showing its original position in relation to the axis of deformation of the shale in which it lay) the agreement in form with figure 3 is explained.

Locality.—Same as figure 1 (loc. No. 5.3.2 A).

Nuculites eurylochus Williams.

Fig. 4. A left valve which might easily be mistaken for a *Paracyclas*. The different position of the cross lines in figures 6 and 4 demonstrates how the deforming force was exerted nearly at right angles upon the two specimens, thus accounting, in part, for the present diversity of form (M 1790 B).

Locality.—Same as figure 1 (loc. No. 5.3.2 A).

Nuculites amycus Williams.

Fig. 5. A left valve, probably narrower than normal, the umbonal ridge appears to be accentuated by pressure (M 1801).

Locality.—Slaty shales of Pembroke formation, near Oak Hill, northwestern Pembroke (loc. No. 1.43.9 A).

Nuculites pholus Williams.

Fig. 6. A small right valve, presenting some of the characters of *N. corrugatus*. Its narrower form and more central position of the beak may be the results of distortion (M 176).

Locality.—Pembroke shales at the head of Leighton Cove, Pembroke Township (loc. No. 5.3.8 F).

Nuculites thyestes Williams.

Fig. 8. A right valve in which the front half of the shell is evidently flattened and produced in the direction of the antero-basal angle, and the posterior part is shortened (M 1789).

Locality.—Slaty shales of the Pembroke formation from the southern part of West Pembroke (loc. No. 1.45.6 A).

Nuculites robustus Williams.

Fig. 9. A figure of the exterior surface; produced directly from the mold of the exterior of the same specimen, mold of the interior of which is represented by figures 12 of plate 12. This effect is produecd by reversing the figure on the plate from the position in which it was photographed, making it to appear convex instead of concave as is the original specimen (M 1786).

Locality.—Gray Pembroke shales from the east side of Young's Point near the end of Denbow Neck, Lubec (loc. No. 5.25.4 B).

Nuculites corrugatus Williams.

Fig. 10. A slightly elongated left valve, presenting otherwise the typical characters of the species (M 1764 A).

Locality.—Shales from the upper beds of the Edmunds formation, in the cove at the north end of Straight Bay, northeast corner of Crowe Neck, Trescott (loc. No. 5.33.8 B).

12. An undistorted specimen of a left valve, showing the normal shape of this species from the original locality. This specimen expresses the mean form of which the two figures originally published are extremes (M 1215 A).

Locality.—Pembroke shales at the head of Leighton Cove, Pembroke township (loc. No. 5.3.8 F).

18. A left valve somewhat crushed at the umbo, the clavicle forced outward toward the front margin (M 1764 B).

Locality.—Edmunds formation same as figure 10 (loc. No. 5.33.8 B).

Nuculites battus Williams.

Figs. 11 and 13. Two specimens of left valves. The quadrate form is probably produced by flattening of the very thin shells. The pustulose elevations of the surface are seen, in the original, to be impressions of ostracods pressed through the shell from inside (M 1803 and 1802).

Locality.—Slaty Pembroke shales from vicinity of Oak Hill, Western Pembroke Township (loc. No. 1.43.9 A).

Nuculites ladon Williams.

Fig. 15. A right valve, somewhat resembling *N. battus*, but a more gibbous form (M 1317).

Locality.—Same locality as figure 12 (loc. No. 5.3.8 F).

Nuculites abnormis Williams.

Fig. 16. An imperfect mold of interior of a left valve, showing a very high, flattened form. This specimen is probably distorted by pressure. The specimens of *N. speciosus* of plate 12 (M 1805) came from the same locality.

Locality.—Gray slaty shales at the base of the Pembroke formation on west side of Coffin Neck, opposite Goosberry Island, Lubec (loc. No. t.44.2 A).

Nuculites subplanus Williams.

Fig. 17. A compressed, oval left valve, entirely differing from *N. corrugatus* in form (compare with figs. 10 and 18 from the same locality) but resembling it in the possession in this locality of fine radiating lines on the posterior umbonal ridge and slope (see pl. 12, fig. 8) (M 1765 A).

Locality.—Edmunds formation. Crowe Neck locality same as figure 10 (loc. No. 5.33.8 B).

Nuculites lichas Williams.

Fig. 20. A right valve. In its present form this has little in common with *N. corrugatus*. It is quite easy to imagine, however, the specific characters of this shell to have been produced by distortion of a specimen originally like figure 12, with which it is associated (M 1816).

Locality.—Same as figure 12 (5.3.8 F).

Nuculites nessus Williams.

Fig. 21. A right valve of a thin shelled species, the puckering of the surface of which is quite evidently secondary. The lower half of the shell appears as if it had been thrust backward in relation to the upper half. The impressed grooves behind the beak are nearly as strong as the clavicle, but, as morphologic characters, are equally prominent (M 1815).

Locality.—Same as figure 12 (loc. No. 5.3.8 F).

PLATE 12.

All natural size, except figure 7, magnified 2 diameters; figure 8, magnified; and 11 and 14 magnified several diameters.

Nuculites trescotti Williams.

Fig. 1. A left valve, exhibiting the general characteristics of form, but larger than the average size of the specimen from the same locality (M 1766). Another specimen (M 1773) (not here figured) is cotypical with it and better represents the average characters of the species.

Locality.—Edmunds shales in the cove at the northern end of Straight Bay on Crowe Neck, Trescott (5.33.8 B).

Nuculites galeus Williams.

Fig. 2. Slightly elongate right valve referred to this species. Compare with figure 14 of plate 11 (M 1800).

Locality.—Pembroke shales in vicinity of Oak Hill, western part of Pembroke Township (loc. No. 1.43.9 A).

Nuculites atreus Williams.

Fig. 3. A right valve, having a shorter and more gibbous form than *N. subplanus* and differing also in surface characters (M 1788).

Locality.—Pembroke shales, southern part of west Pembroke village, west side of Pennamaquam River (loc. No. 1.45.6 A).

Nuculites robustus Williams.

Fig. 4. A small slab with three internal molds, showing the high prominent beak, strong clavicle and the strong reinforcement of the inside surface separating the umbonal cavity from the impression of the posterior muscular scar (M 1776).

Locality.—Pembroke shales on east side of Youngs Point near the end of Denbow Neck, Lubec (loc. No. 5.25.4 B).

7. A right valve, magnified two diameters (the same specimen represented on upper side of figure 4). In making this figure, the specimen has been turned upward so as to show under the beak the hinge margin with the crenulations (M 1776).

Locality.—Same as figure 4 (loc. No. 5.25.4 B).

10. Another specimen of the right valve (M 1777). The form is more elongate than figure 4.

Locality.—Same as figure 4 (loc. No. 5.25.4 B.)

12. An internal cast of a left valve (M 1786 D). In this specimen the strong clavicle is in evidence, but the internal ridge separating the umbonal cavity from the posterior muscular scar is wanting. The figure showing the external surface of this species (pl. 11, fig. 9) was made from the impression of the exterior of this same specimen, and the drawing of the hinge teeth enlarged represented by figure 14 is also made from this specimen.

Locality.—Same as figure 4 (loc. No. 5.25.4 B).

14. An enlarged drawing of the hinge border and its teeth made from the internal mold (fig. 12) on a scale to compare with the hinge of *Tindaria* reproduced in the figure 1 immediately above it.

Locality.—Same as figure 4 (loc. No. 5.25.4 B).

15. An umbonal view of a left valve associated with the other specimens of this species. Introduced to show the effect of changing the point of view in preparing illustrations (M 1781).

Locality.—Same as figure 4 (loc. No. 5.25.4 B).

Nuculites chrysippus Williams.

Fig. 5. A specimen of the right valve, oriented on the plate as seems consistent with the development of the lines of growth. If it were turned on its center about 20 degrees to the right, its characteristic form would be obscured. (M 1787).

Locality.—Pembroke splintery shales in the southern part of West Pembroke on west side of Pennamaquam River (loc. No. 1.45.6 A).

Nuculites lentus Williams.

Fig. 6. The two valves of a single specimen as originally attached at the hinge line. The much narrower and elongate form of the right valve than the left is readily explained by the different relation of the two valves to the compressing force which affected the whole rock in which the shell was imbedded (M 1769).

Locality.—Edmunds shale at north end of Straight Bay near east end of Crowe Neck, Trescott (loc. No. 5.33.8 B).

13. A detached right valve of apparently normal size and shape (M 1768).

Locality.—Same as fig. 6 (loc. No. 5.33.8 B).

Nuculites subplanus Williams.

Fig. 8. A magnified portion of the surface of the posterior end of the specimen figured on plate 11, figure 17, showing the radiating lines crowning the finer, more closely set concentric lines (M 1765 B).

Locality.—Edmunds shale formation, at north end of Straight Bay, Crowe Neck, Trescott (loc. No. 5.33.8 B).

Nuculites speciosus Williams.

Fig. 9. A right valve, of smaller size. The front is rather shorter than in the other examples of this species, showing, however, the normal characters of the posteroir end (M 1806).

Locality.—Pembroke shales on the west side of Coffin Neck, opposite Gooseberry Island, immediately underlain by shale carrying an Edmunds fauna (loc. No. 5.44.2 A).

18. A right valve, the basal margin of which is curved inward narrowing the front part of the shell (M 1809).

Locality.—Pembroke shale at north end of Coffin Neck, Lubec (loc. No. 5.34.7 A^2).

19. A right valve, imperfectly showing the surface characters of the posterior end, but in outline expressing approximately the normal shape (M 1804).

Locality.—Same as figure 9 (5.44.2 A).

Tindaria callistiformis Verrill and Bush.

Fig. 11. Hinge of a right valve (mag. 8 diam.) front view, introduced here for comparison of crenulate dentition with that of *Nuculites robustus*, figure 14. Copied from figure 21 on page 61 of Verrill and Bush article in Amer. Journ. Sci., ser. 4, vol. 3, 1897.

Locality.—Recent off Atlantic coast of North America.

Nuculites crassus Willlams.

Fig. 16. Mold of interior of a left valve, showing the strong clavicle and posterior muscular scar (M 1761 A).

Locality.—Pembroke shales, in cove between Youngs Point and extremity of Denbow Neck, Lubec (loc. No. 5.24.6 B).

17. Another mold of interior of a left valve, showlng the crenulate hinge both sides the beak, the strong clavicle and muscular scars (M 1761 B).

Locality.—Same as figure 16 (loc. No. 5.24.6 B).