

ORIGINAL ARTICLES.

I.—CONTRIBUTIONS TO OUR KNOWLEDGE OF THE GENUS *CYCLUS*, FROM THE CARBONIFEROUS FORMATION OF VARIOUS BRITISH LOCALITIES.

By HENRY WOODWARD, LL.D., F.R.S., Pres. Geol. Soc.,
of the British Museum (Natural History).

(PLATE XV.)

THE curious little shield-like Crustaceans, known under the generic name of *Cyclus*, were first noticed by de Koninck in 1841, and have been subsequently figured and described by various authors, but their exact systematic position has never been clearly understood owing to the absence of appendages or other indications by which their affinities might be satisfactorily ascertained.

In 1868 I gave a description, with figures, of two species:¹ one of which, the *Cyclus radialis*, had been previously noticed by de Koninck² and Phillips³; the other, *C. Rankini*, was then first made known.

In 1870, under the title of "Contributions to British Fossil Crustacea,"⁴ I redescribed the above-named species, and added *Cyclus bilobatus*, *C. torosus*, *C. Jonesianus*, *C. Wrightii*, *C. Harknessi*, *C. (Halicyne) laxus*,⁵ *C. (Halicyne) agnotus*.⁵

The next record of the genus is to be found in the fifth part of my Monograph of British Fossil Crustacea⁶ of the order Merostomata, which records and figures the then known seven British species of *Cyclus*, but adds no new forms.

In 1883 Mr. B. N. Peach, F.R.S., L. and E., F.G.S., published an account of *Cyclus testudo*, from the Carboniferous series of Langholm,⁷ to which reference will again be made later on.

In 1893 I noticed a new British species of *Cyclus*,⁸ discovered by Mr. George Scott in the "Gannister seam" of the Lower Coal-measures, Old Clough Colliery, Bacup, Lancashire, which I named *Cyclus Scottii*.

In the same year Mr. F. R. Cowper Reed, B.A., F.G.S., of Trinity College, Cambridge, gave a description of what he deemed to be probably a new species of *Cyclus*,⁹ from the Carboniferous Limestone of Settle, Yorkshire, near to, but not identical with, *C. Harknessi*, which he named *C. Woodwardi*.

¹ British Association Reports, Norwich, 1868, 4th Report on Fossil Crustacea, pp. 72-75, pl. ii. figs. 1 and 2.

² L. G. de Koninck, Descript. des Animaux Foss. Terr. Carb. de Belg. Liège, 1842, p. 591, pl. lii.

³ J. Phillips, Geol. Yorksh. vol. ii. p. 240, t. xxii. fig. 25, 1829.

⁴ GEOL. MAG. 1870, Vol. VII. Pl. XXIII. Figs. 1-7, pp. 554-560.

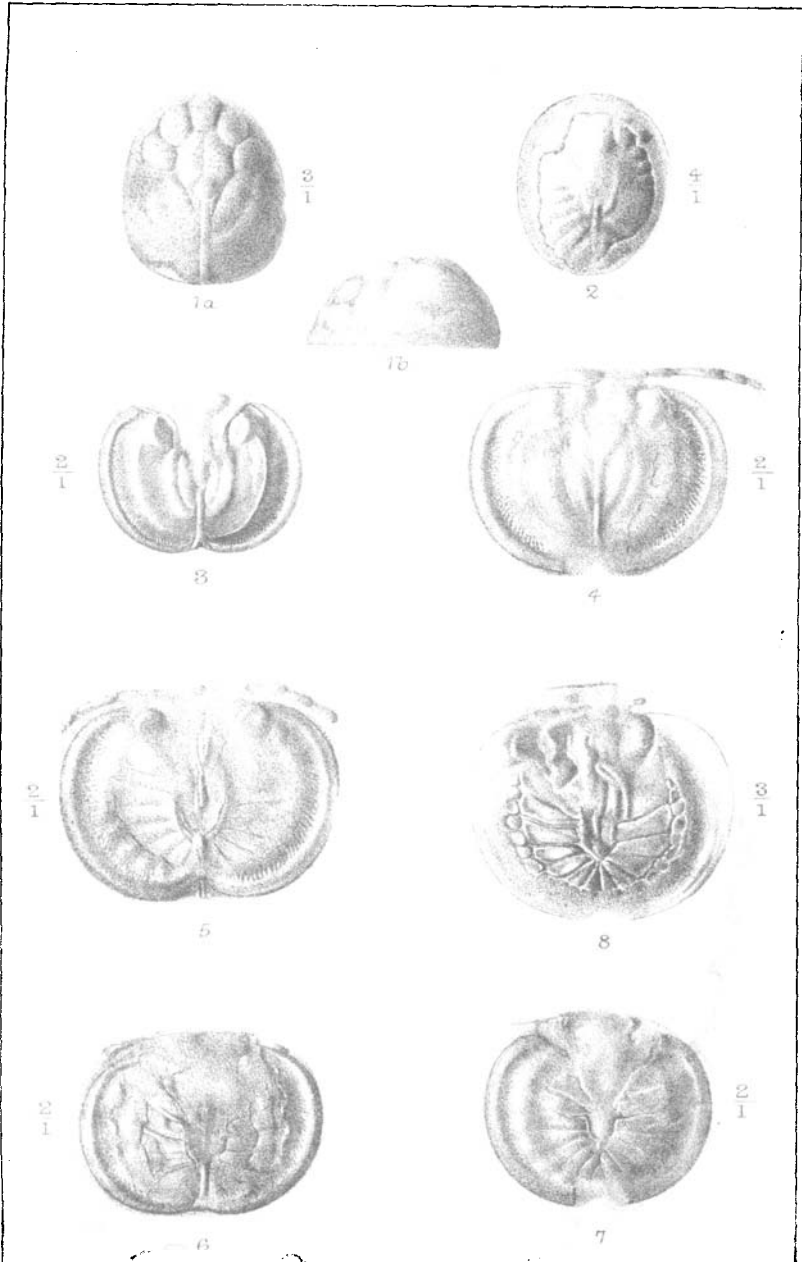
^{5, 5} These last-named species are not British, and had been previously described by Prof. Hermann von Meyer, in the Palæontographica, 1847, vol. i. p. 134, under the genus *Halicyne*. They are from the Muschelkalk of Rottweil in Germany. Goldfuss originally figured *Halicyne* as *Olenus serotinus* (Petrefactenkunde), afterwards from Münster referred it to *Limulus* (Beiträge, 1841, Bd. i. t. v. f. 1).

⁶ Palæontographical Society, 1878, vol. xxxii. pp. 248-255, pl. xxxii. figs. 42-49.

⁷ See Trans. Roy. Soc. Edinburgh, 1883, vol. xxx. pl. xxviii. figs. 9-9d, p. 227.

⁸ See GEOL. MAG. 1893, Decade III. Vol. X. (Woodcuts A, B), p. 28.

⁹ *Ibid.* pp. 64-66 (with a Woodcut).



H.C. & G.M. Woodward del. sc. lith.

West Newman imp.

Cyclops: Carboniferous.

Having, through the kindness of Prof. John Young, M.D., F.R.S.E. (Regius Professor of Natural History in the University of Glasgow), and Mr. John Young, LL.D., F.G.S., of the Hunterian Museum of the University of Glasgow, been allowed to examine and figure another of the late Dr. Rankin's specimens from Carluke—now preserved in the Museum of the University (Plate XV. Fig. 8)—and being also in possession of a long series of specimens obtained by the late Mr. Henry Johnson, C.E., F.G.S., of Dudley,¹ from the "Pennystone ironstone," over the thick coal of the Staffordshire Coal-field, at Coseley, near Dudley, I am desirous once more to call attention to these very singular little Arthropods.



FIG. 1.—*Cyclus Woodwardi*, Reed. The original specimen is in the Woodwardian Museum, Cambridge, and was obtained from the Carboniferous Limestone, Settle, Yorkshire. Magnified $\frac{3}{4}$ nat. size.

By far the most important contribution to the genus *Cyclus* recently published is to be found in the paper by Peach, entitled "Further Researches among the Crustacea and Arachnida of the Scottish Border."² These specimens, writes Peach, "occur chiefly as flat discs, or dome-shaped masses of radiating calculi which have coalesced into a polygonal mosaic of calcareous plates. They vary from 3 mm. to 10 mm. in diameter." . . . "Being embedded in shale they are more or less flattened, and apparently much in the same condition as the *Cyclus Rankini* described by Woodward as having been obtained from the Carboniferous (shales) of Carluke." They are considered by the author to belong to one species, which is, he thinks, different from any yet described. "A few of the specimens exhibit the dorsal shield, which is plain or slightly embossed; while others only show the dorsal aspect of the borders, the rest of the upper surface being broken away, exposing the ventral or sternal arches, which radiate much as in *Cyclus Rankini*." . . . "From the fact that several of the Survey specimens exhibit limbs, the radiating lines of the sternum are most probably the divisions between the coxæ, so that I am inclined to differ from Woodward and to look upon the opposite end to what he does as being the anterior." Then follows the specific description of *Cyclus testudo*, Peach, from the Calceiferous Sandstone series, Langholm.

In October, 1886, I became aware, from a study of Mr. Henry Johnson's collection of *Cyclus*, obtained from the clay-ironstone

¹ Purchased by the British Museum in 1886.

² Trans. Roy. Soc. Edinburgh, 1883, vol. xxx. p. 511, pl. xxviii. figs. 9 and 9a, b, c, d.

nodules of the Coal-measures, Coseley, Staffordshire, that the form which I had described in 1868 as *Cyclus Rankini*, from Carluke, and which differed in so very remarkable a manner from all the other carapaces referred to that genus from the Carboniferous Limestone, was really the *underside* of a *Cyclus* from which the shield or carapace had been removed. Unfortunately at that time I had not seen Mr. B. N. Peach's paper, nor was I aware that he had written upon the genus, until my paper on *Cyclus Scotti*, in 1893, was in print, when I added a note apologising for having overlooked it.¹

To Mr. Peach, therefore, belongs the merit of having been the first to explain (in 1883) the true nature of the peculiar structure observed in *C. Rankini*. But the interpretation put upon the genus by Mr. Peach remains to be considered. And here let me express my thanks to Sir A. Geikie, the Director-General, for granting me permission to study the original specimens of *Cyclus*, described by Mr. Peach, which Mr. J. G. Goodchild, in charge of the Survey Collection in Edinburgh, has most kindly forwarded to me.

An examination of these specimens at once reveals the extreme difficulties which Mr. Peach encountered in endeavouring to decipher these very obscure little organisms, most of which have had the details of their structure almost entirely obliterated by deposits of globular or orbicular calcite.²

I was fortunate also in obtaining twenty specimens of *Cyclus testudo* from Eskdale, early in the present year, from Mr. T. Stock; and, although most of these were similarly obscured by calcite-deposits, I have obtained some good results, which I will presently refer to.

The best preserved specimens which Mr. Peach had the good fortune to secure, not only show traces of an upper dorsal shield, but also evidence of the ventral surface with its sterna and radiating apodemata, as figured by me, in 1868, in *C. Rankini* from Carluke, and also in our present Plate XV. Fig. 8. Thus the enigmatical *Cyclus Rankini*—as Peach points out, and as the specimens here figured conclusively prove—is in reality the sternal surface of a *Cyclus*, the dorsal shield of which may, or may not, be known.

So far, we are in general agreement; but when Mr. Peach proceeds to suggest that I have mistaken the *anterior* for the *posterior* end of these carapaces, I am at once at issue with him, and can only conclude that the "globular calcite" has obstructed his clearer vision. Nor is it necessary to institute any very lengthy comparisons with other forms in order to ascertain, as in the famous Skye-terrier controversy, "which is his head and which is his tail." We are, fortunately, not dependent upon the Langholm specimens alone for settling this fundamental point, for in the numerous and beautifully preserved examples from Mr. Henry Johnson's collection we have evidence enough to establish our position beyond a doubt.

¹ See GEOL. MAG. 1893, Dec. III. Vol. X. footnote, p. 29.

² See note, p. 482, on globular calcite, on a new species of *Eurypterus* from Eskdale, by H. Woodward, GEOL. MAG. 1887, Dec. III. Vol. IV. pp. 481-484, Pl. XIII.

Without maintaining that the pair of large rounded prominences, observable in most of the specimens near the anterior border, are eyes, there is evidence both in Figs. 7 and 8, Pl. XV., of the presence of much smaller, and probably stalked, eyes near the front of the head. The evidence of antennæ-like organs, *in situ*, attached to the part which I designate as *the front* of the shield (represented on Plate XV. Figs. 4, 5, and faintly on Fig. 6), seems to me conclusive that this *front*, or *upper border*, as figured by me, is indubitably the head.

Mr. Peach mentions that where the dorsal shield, in his *Cyclus testudo*, "has been broken away, so as to expose the interior of the sternal portion to view, six triangular plates on each side, divided from each other by deep sulci, are seen to converge upon an oval sternum." These plates, he considers, "are the coxæ of limbs."

In discussing the question of the anterior and posterior ends of *Cyclus*, as raised by Peach, the following points must be taken into consideration:—

1. The large pair of jointed appendages at one end, when taken in conjunction with the entire absence of any prolongation of the body beyond the circular shield at either end, suggests that this is the head, and that these appendages represent a pair of swimming antennæ (ant. 2), similar to those of the Phyllopoda.

2. This is further strengthened by the arrangement of the radiating ventral plates at the opposite end of the body, which Peach suggests are enlarged coxæ. If the homology be the true one, which seems probable, then a comparison either with Arachnida or Crustacea, results in the same conclusion, for, in any of these Arthropods, where the limbs converge towards the mouth, or towards the sternum, we find them tending to meet in the middle ventral line, *behind* these structures, and *not in front*, as would be the case in *Cyclus* if Peach's view as to the anterior end of the body were the right one.

3. The *Eye*.—A (paired) small appendage, having somewhat the form of a stalked eye, but showing no facets, is present near the anterior margin of the shell (see Pl. XV. Figs. 7, 8).

Appendages.—The first visible appendages consist of one large jointed pair, extending outwards from the anterior end of the carapace. They suggest, from their position and development, the second pair of antennæ of the *Nauplius*-stage of the Phyllopoda, or of the adult *Cladocera*. No special mouth-parts are visible.

The remaining appendages, which possibly represent both the jaw-parts and anterior thoracic limbs of the higher Crustacea, appear to be 6–7 in number, each of which was provided with a greatly-developed basal joint radiating outwards from the mid-line, and probably had a wide attachment, which may account for their remaining *in situ*. The enlarged joints of the legs pressed against one another, and covered the ventral surface of the body everywhere, save in the centre, which was occupied by a V-shaped plate, towards the pointed extremity of which all the basal joints of the limbs converge. Distally each limb presents two small plates. The rest of the limb is lost in most specimens.

One specimen, however (discovered amongst those obtained by Mr. Stock from Eskdale), besides exhibiting a number of fragments of appendages, scattered irregularly over the surface of the matrix, shows one of the middle limbs in position, still attached to a shield



FIG. 2.—*Cyclus testudo*, Peach; Langholm. Enlarged 4 times natural size.

a. One of the biramous swimming-feet which remains attached *in situ*.¹

b. Base of another appendage, broken off close to the edge of the shield.

of *Cyclus testudo*. This limb is a typical biramous appendage, such as we find in the lower Crustacea, and persisting as the swimmerets in the Decapoda; that type of limb, in fact, which is generally believed to have been the most primitive form, and which is only a slight modification of the typical Phyllopod limb. The numerous broken fragments of appendages scattered over the surface of the matrix appear to have been of the same kind. We may, therefore, conclude it is most probable that the oral and post-oral appendages of *Cyclus* were all of the same type, *i.e.* simple swimming-legs.

The V-shaped median plate between the bases of the appendages must either be the coalesced sternites, or an enormously developed labrum. Against the first view we have the fact that this structure is apparently continued without a break up to the anterior margin of the ventral surface, thus giving no place for the mouth.

If, as the presence of the large antennæ and the swimming-legs prove, *Cyclus* is a Crustacean, then we should naturally expect to find a labrum; and as there is no other median-lobe-like development of the ventral integument, we must, I think, conclude that the structure represents an enormously developed labrum, and that the mouth opened at the posterior extremity of that structure—an exaggeration of what is met with in the Cladocera, where the mouth opens well back in the shell under cover of a great labrum. This would be further strengthened by the convergence of the bases of the limbs towards its posterior border, a condition similar to that met with in *Limulus* (and supposed by Bernard to have been the primitive condition of the jaw-parts of all Crustacea), these bases serving probably, as in *Limulus*, as masticatory organs.

Affinities.—The presence of antennæ and biramous swimming-legs prove undoubtedly that *Cyclus* was a Crustacean. The large size of the former and the homogeneous nature of the rest of the appendages (all biramous swimming-legs, with possibly masticatory

¹ The branching of the two rami may be due to rod-like deposits of lime in a paddle-shaped fin, two such structures being attached to each limb, representing the endopodite and exopodite. A slight indication of this is visible in the specimen.

bases), taken in connection with the large, slightly-bivalved carapace, suggest that it is an Entomostracan and probably one of the Phyllopoda, with a broad cephalic carapace like that possessed by *Apus* and by *Daphnia*; with large swimming second antennæ like the latter, and possibly with a pair of stalked eyes. *Cyclus*, however, differs from the Cladocera in being flattened dorso-ventrally, and from the lowest Crustacea in not apparently possessing any true jaw-parts—the head, with the labrum and mouth, being bent further back than in the living Entomostraca. These differences may either indicate very lowly characters or very much specialized ones. Two views suggest themselves:—

(1) That these animals were small, free-swimming Phyllopods, with expanded cephalic shield, swimming second antennæ, and biramous limbs, the bases of which served as masticatory organs, no true jaws having yet been developed; the backward position of the mouth may have been brought about in order to allow as many appendages as possible to serve as jaws, as is seen in *Limulus*. Or, possibly, the beast could attach itself like a living *Daphnia* by a cement gland on the dorsal side of the head, in which case it might be an advantage to have the mouth as near the freer end as possible and close to the swimming-legs, which were, by their movements, producing the foot-currents.

(2) The other view is that these animals were ecto-parasitic Phyllopods, although they had not lost their power of free-movement, yet had become specialized in the form of their body, which is flattened ventrally and only slightly convex above, the whole animal being expanded horizontally, unlike most other Phyllopods. This view might account for the two large round structures seen on the ventral surface (Pl. XV. Fig. 8), situated one on either side of the body, and close to the anterior margin of the shell. These might possibly represent a pair of ventral suckers, such as are seen in the modern fish-lice; these structures, whatever they may be, are evidently enormously developed, and possess great muscles, which produce prominent modifications of the dorsal shield, where they are attached (Pl. XV. Figs. 3-5). The great labrum might possibly represent the suctorial tube of *Argulus*, under cover of which are concealed the reduced mandibles, etc.

Some of the specimens show curious oblique scars on the coxæ of the legs, which may indicate the points of attachment of spines or setæ to enable the parasite to stick to its fishy host.

The following notes refer to the specimens figured on Plate XV.

- 1.—CYCLUS JONESIANUS, H. Woodward. Pl. XV. Figs. 1a, 1b.
× 3 times natural size.

Cyclus Jonesianus, H. Woodw., 1870. GEOL. MAG. Vol VII. pp. 557-558, Woodcut, Figs. 1 and 2.

Cyclus Jonesianus, H. Woodw., 1878. Mon. Pal. Soc. vol. xxxii. Fossil Mero-stomata, part v. p. 254, pl. xxxii. figs. 46a, b.

I was at first inclined to the opinion that the specimen of *Cyclus* lent to me by my friend Dr. John Young of Glasgow (see Pl. XV. Figs. 1a, 1b), was a new species; but after having carefully compared

it with that already figured in this MAGAZINE (1870, Woodcut, p. 558), from the collection of Mr. Joseph Wright of Belfast, and obtained by him from the Carboniferous Limestone of Little Island, Cork, and, making allowance for some slight variation between the two specimens, due to their different state of preservation, I am compelled to conclude that they are both referable to the same species, namely, *C. Jonesianus*.

Dr. Young's specimen measures 8 millimètres in length, 7 mm. in breadth, and 4mm. in height. The carapace, which is finely granulated all over its surface, is divided along the anterior border into five rounded lobes of nearly equal size, forming a semicircle, reaching almost to the margin of the shield. The middle area of the carapace, enclosed by these five encircling lobes, is divided down the centre by the dorsal line, thus forming a pair of oblong, somewhat pentagonal lobes, separated only by the median line; behind these, again, is a lesser unpaired subtriangular lobe, with its base directed forwards and having a raised rounded boss in its centre. The hinder and greater half of the carapace is occupied by two large lobes, forming together a semicircle, but divided down the mesial line by the well-marked dorsal ridge which extends to the posterior border. The upper and more central part of each lobe is marked by a slight semicircular furrow dividing faintly this inner and more elevated portion of the shield from the lower and outer encircling border. The two minute depressions observed in Mr. Wright's specimen, one on either side of the dorsal ridge, at the vertex of the shield, are not visible in Dr. Young's specimen, being probably covered by a shelly layer, which had been removed in Mr. Wright's Irish example.

Formation.—Carboniferous Limestone.

Localities.—Little Island, Cork; and Trearne, Beith, Ayrshire.

2.—*CYCLUS RADIALIS*, Phillips, sp. Pl. XV. Fig. 2. $\times 4$ times natural size.

Agnostus radialis, Phillips, 1836. Geol. Yorks. vol. ii. t. xxii. fig. 25.

Cyclus radialis, H. Woodw. and J. W. Salter, 1865. Cat. and Chart Foss. Crustacea, p. 15, fig. 14.

Cyclus radialis, H. Woodw., 1868. Brit. Assoc. Rept. p. 75, pl. ii. fig. i.

Cyclus radialis, H. Woodw., 1870. GEOL. MAG. Vol. VII. Pl. XXIII. Figs. 2 and 2a, p. 557.

* Dr. John Young, F.G.S., of the Hunterian Museum, Glasgow University, very kindly submitted the small specimen to me, which is drawn (Pl. XV. Fig. 2), as probably a new species; but, after comparing it, I am of opinion that it should be referred to Phillips's *Cyclus radialis*. The specimen, which is imperfect around the border, is from the Carboniferous Limestone of Beith, Ayrshire, and is attached to a portion of a frond of *Ptilopora* or *Fenestella*.

The carapace measures 6 millimètres long, by 5 mm. broad. As it is less perfect than the type it is needless to give a fresh description of it here.

Formation.—Carboniferous Limestone.

Localities.—Little Island, Cork; Bolland and Settle, Yorkshire; Trearne, Beith, Ayrshire; Visé, Belgium.

3.—*CYCLUS SCOTTI*, H. Woodw. Pl. XV. Fig. 3. \times twice nat. size.

Cyclus Scotti, H. Woodw., 1893. GEOL. MAG. Dec. III. Vol. X. p. 28 (Woodcuts A, B).

Notwithstanding the difference in the size between Mr. Scott's specimen from the Coal-measures of Bacup and Fig. 3, from Mr.

Henry Johnson's collection from Coseley, near Dudley, I am inclined to refer them both to the same species.

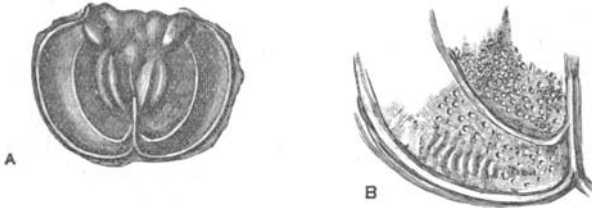


FIG. 3.—*Cyclus Scotti*, H. Woodw., Lower Coal-measures, Bacup, Lancashire.

A. Dorsal aspect of carapace (nat. size).

B. A portion of the left posterior border, magnified to show ornamentation.

[See GEOL. MAG. 1893, Dec. III. Vol. X. p. 28, for full description.]

Length of Bacup specimen 20 millimètres long and 25 mm. broad.

„ of Coseley „ 10 millimètres „ and 13 mm. „

The most striking feature about this specimen is the very strongly accentuated raised circular lines which give quite a character to this form, and also the very steep acclivity to the outer margin of the shield, save at the anterior border, which is marked by indistinctly preserved oval prominences.

As this species was so recently described (1893) in this MAGAZINE, it may be sufficient to point out that in our Plate XV. Fig. 3 the anterior border does not show the two inner oval prominences noticeable in *C. Scotti* (see Woodcut above), and which are very distinctly marked in *Cyclus (Halicyme) agnotus*, H. von Meyer, sp., from the Muschelkalk of Rottweil, Germany (see GEOL. MAG. 1870, Vol. VII. Pl. XXIII. Fig. 8), a form that, in some respects, comes near to our Coseley *Cyclus*. The ornamentation on the surface of the carapace has a similar finely granulated appearance in both specimens, and the encircling ridges in both are very strongly marked.

Formation.—Pennystone Ironstone of the Coal-measures.

Localities.—Coseley, near Dudley, Staffordshire, and Bacup, Lancashire.

4. *CYCLUS JOHNSONI*, H. Woodw., sp. nov. Pl. XV. Figs. 4, 5, 6, 7.

I have ventured to place the four examples (Figs. 4–7) and some others not figured, all from the “Pennystone” ironstone of the Coal-measures, Coseley, near Dudley, in one species. Fig. 4 exposes the outer dorsal surface; Figs. 5, 6, 7 (which, like the preceding Fig. 4, are all drawn twice the natural size) show the dorsal shield more or less removed, especially over the central part, revealing the fact of the similarity of all three species on the underside to *C. Rankini* (Pl. XV. Fig. 8). The following are the measurements of the four figured examples:—

Fig. 4.	Length, 14 mm.	...	...	Breadth, 16 mm.
Fig. 5.	„ 14 „	...	...	„ 18 „
Fig. 6.	„ 12 „	...	...	„ 16 „
Fig. 7.	„ 13 „	...	...	„ 15 „

Spec. char.—Carapace rounded, width somewhat greater than length, broader and flatter in front, narrower behind, and with a shallow rounded indentation at the centre; having a broad and well-marked flattened rim, followed by a corresponding shallow depression around the lateral and posterior borders; front border tumid, with two (or more?) raised rounded or ovoid prominences; carapace with a median dorsal ridge reaching from the posterior border rather more than half way up the centre of the shield, then bifurcating so as to embrace a triangular space, which widens out to the anterior border; carapace with moderately raised and roundly swelling side-lobes (not strongly ridged as in *C. Scotti*) and with a pair of smaller oblong faintly raised lobes next the median ridge.

Appendages.—These consist of a pair of rather stout antennæ (probably the second pair of antennæ), showing about four joints on each side, the rest having been broken off. These are seen on Figs. 4 and 5, and faintly on Fig. 6.

Eyes.—Fig. 7 shows traces of two small eyes occupying the same relative position as the one seen more distinctly in Fig. 8 (*C. Rankini*), and which appears to be pedunculated.

The under-surface of the animal is partly exposed in Figs. 5, 6, and 7 by the accidental removal of a part of the dorsal surface of the carapace which remained adhering to the other half of the clay-ironstone nodule when it was split open.

In each of these examples, the converging bases of 6-7 pairs of gnathopodites are seen uniting mesially behind the V-shaped oral area (already referred to on p. 533) the median ridge behind which may indicate the posterior prolongation of the straight alimentary canal.

In all these specimens, the bases of the limbs have a very close agreement with *C. Rankini* (Pl. XV. Fig. 8). In Fig. 5 there is a slight indication of the base of an appendage on the central posterior border, which may have been part of a tail-spine; but it has not been observed in the others. Wherever the surface is preserved there is a fine granular ornamentation observable, more especially in the hollow formed within the broad flattened rim that surrounds the greater part of the shield. Fig. 7 is distinctly *more rounded* in outline than the others, and may possibly belong to another species.

I have dedicated this form to the memory of the finder, the late Mr. Henry Johnson, F.G.S., to whose labours as a geologist in the Dudley area we are so largely indebted for our knowledge of the fossil fauna and flora both of the Coal-measures and the Wenlock Limestone.

I must not omit to record my thanks to my son, Mr. Martin Fountain Woodward, of the Biological Laboratory in the Royal College of Science, for much valuable aid in the examination of these minute specimens, and to my daughters for their excellent figures in illustration of this and so many other papers which have appeared in this MAGAZINE.

EXPLANATION OF PLATE XV.

- FIG. 1a, b. *Cyclus Jonesianus*, H. Woodw. (1870). $\times 3$ times nat. size. Fig. 1b. Lateral view. Carboniferous L. Trearne, Beith, Ayrshire. Coll. Dr. John Young, F.G.S., Glasgow.
- FIG. 2. *Cyclus radialis*, Phillips, sp. (1836). $\times 4$ times nat. size. Dorsal view. Carb. L. Trearne, Beith, Ayrshire. Coll. Dr. John Young, F.G.S., Glasgow.
- FIG. 3. *Cyclus Scotti*, H. Woodw. (1893). \times twice nat. size. Dorsal view. Clay-ironstone nodule, Coal-measures, Coseley, near Dudley, Staffordshire.
- FIGS. 4, 5, 6, 7. *Cyclus Johnsoni*, H. Woodw. (1894). \times twice nat. size. In Pennystone-ironstone nodules, Coal-measures, Coseley, near Dudley.
- FIG. 4. Dorsal view, showing (2) antenna on right side and surface of shield.
- FIG. 5. Dorsal view, showing parts of a pair of antennæ (imperfect), and trace of tail-spine. Dorsal shield partly decorticated, showing converging bases of limbs and labrum?
- FIG. 6. Dorsal view of shield, partly decorticated, showing under-surface and traces of bases of antennæ.
- FIG. 7. Dorsal view, decorticated, showing bases of limbs and traces of small eyes (pedunculated?).
- FIGS. 3-7 are from the late Mr. Henry Johnson's Collection, now in the Geological Department Collection of the British Museum (Nat. Hist.), Cromwell Road, London, S.W.
- FIG. 8. *Cyclus Rankini*, H. Woodw. (1868). \times three times nat. size. Dorsal aspect of shield showing 6-7 paired bases of limbs converging upon labrum; each limb giving rise to a biramous swimming or other appendage (see Woodcut in text, p. 534). A small eye (pedunculated?) is seen in front on the right side and traces of an antenna?; also impression for muscles of sucker-attachment? Coal-measures, Carlisle, Lanarkshire. Hunterian Museum Coll. University of Glasgow.

II.—PHYSIOGRAPHICAL STUDIES IN LAKELAND.

By J. E. MARR, M.A., F.R.S., Sec.G.S.

2. SWINDALE.¹

TO the west of the London and North-Western Railway, after it has surmounted the incline of Shap Fells, lies the valley of the River Lowther, which eventually flows into the Eamont, which in turn drains into the Eden. The Lowther, flowing in a general northerly direction, receives the drainage of three important streams, coming from the south-west. The first of these flows through the valley of Wet Sleddale, just north of the Fells, which exhibit the exposures of the Shap Granite. It is lettered W.S. in Fig. 1. The second, Swindale (S. Fig. 1), the subject of this paper, joins the Lowther stream at Rossgill Hamlet, about two miles north of Shap Village, whilst the third, Haweswater Beck (H.B. Fig. 1), flows out of Haweswater (H. Fig. 1) and joins the Lowther at Bampton.

Proceeding up Swindale from Rossgill, we follow the road over Rossgill Moor, a barren tract of country occupied by Skiddaw Slates, to Swindale Foot, near which the Borrowdale Volcanic Group appears, and causes the fine cliff scenery which marks the upper part of Swindale. The road proceeds at the foot of these cliffs to Swindale Head, a farm about four miles from Rossgill, and a little below the semicircular line of cliff, which has been a prominent

¹ For No. 1, "Church Beck, Coniston," see *GEOL. MAG.* November, p. 489.