From the preceding description it is evident that the fish, to which this strange and beautiful snout belonged, must take its place, not among the Ganoids proper, but among the *Dipnoi*. Of fossil fishes hitherto reckoned with certainty to the last-named order, we have only *Cheirodus*, *Dipterus*, *Ctenodus*, and *Ceratodus*; the position of *Phaneropleuron* and *Tristichopterus* being still doubtful. Our fossil is certainly neither *Dipterus* nor *Ceratodus*; *Cheirodus* is known only by its teeth; and as to *Ctenodus*, the front of the head has not yet been discovered, so that all evidence is wanting to connect it with that genus. It seems therefore, in these circumstances, best to frame a new genus for its reception; I propose, therefore, to bestow upon it the generic term *Ganorhynchus* (γάρος, ῥινχος), coupled with the specific name of *Woodwardi*, in honour of the distinguished palæontologist who first directed my attention to the fossil.

EXPLANATION OF PLATE XIV.

- FIG. 1.—Upper surface of the broken-off snout of *Ganorhynchus Woodwardi*.
 FIG. 2.—Lower aspect of the same fossil, showing the ganoid and pitted labial margin, the anterior nasal notches, portion of the roof of the nasal chambers, and the broken-off vomer in the centre.
 FIG. 3.—The same fossil seen from the left side. At the posterior inferior angle is seen the articular surface referred to at page 553. Both of these surfaces, right and left, are seen in Fig. 2, at the posterior external angles.
 FIG. 4.—A magnified view of the smooth ganoid surface of the upper lip, showing the large scattered punctures or pits with which it is ornamented.
 FIG. 5.—A microscopic section of the ganoid bone on the upper surface of the snout. This drawing, executed in the absence of the author from Great Britain, does not convey a very accurate or intelligible idea of the microscopic structure; the woodcut, page 554, has therefore been substituted.

III.—NOTES ON THE BRITISH GRAPTOLITES AND THEIR ALLIES.

By CHAS. LAPWORTH, F.G.S.

1.—ON AN IMPROVED CLASSIFICATION OF THE RHABDOPHORA.¹
PART II.

THE accompanying analytical Table of the genera of the *Rhabdophora* which are especially treated of in the present paper is here offered as a first and suggestive sketch for an improved arrangement of these forms. The foregoing conclusions have been employed in its construction, and are embodied in the general scheme. See Table I.

Of the several families under Mr. Hopkinson's well-known plan of arrangement, the first (*Monoprionidæ*) comprises the whole of the species distributed among the first three families in the Table. The *Tetraprionidæ* and *Mono-di-prionidæ*, as finally interpreted by himself,² are identical with two of the new families. Thus the alteration in this section is more apparent than real. It is a great proof of the value of Mr. Hopkinson's original classification that subsequent research has necessitated such a slight change in this department. In his scheme, however, the families were each founded upon a single structural peculiarity. The corresponding nomenclature was so precise and inflexible that it admitted of no modification or intercalation. In the proposed arrangement, on the

¹ For Part I. See *Geol. Mag.* Vol. X. pp. 500–504. ² *Geol. Mag.* Vol. X. p. 231.

contrary, the families are constituted by assemblages of species, linked together by a large community of morphological characters, and grouped around typical genera. The most characteristic genus in all cases furnishes the name for the family. The new scheme therefore admits of modification in matters of detail, or of the intercalation of new families, which the exigencies of science will certainly demand, in proportion as future research throws light upon doubtful points of structure, or furnishes us with certain evidence of the methods of multiplication and reproduction, among these ancient creatures.

The arrangement of the monoprionidian forms in the present scheme is, upon the whole, the natural one, and this view of their relationships is strikingly confirmed by the known geological distribution of the genera constituting the several "families." The latter are well circumscribed, and the slightest fragment of the branch of a monoprionidian species can be referred at a glance to its proper family. It was with great pleasure that I learnt from Mr. Hopkinson at the beginning of the present year, that he had independently arrived at a similar classification of these uniserial forms. To this eminently acute observer must also be assigned the credit of being the first in acknowledging the propriety and value of Professor Hall's separation of *Didymograptus* and *Dicellograptus*, and in carrying it out to its proper limits. His views upon these points are adopted in the Table. He was also the first to call attention to the fact that *Leptograptus flaccidus* (Hall sp.) could rightly be referred to neither of the foregoing genera, but more probably belonged to the genus *Nemagraptus* of Emmons.¹ The importance of his clear recognition of this circumstance, which may be said virtually to contain within itself the clue to the differentiation of the well-marked group of the *Nemagraptidæ*, I have in some degree endeavoured to acknowledge, by relinquishing my proposed title for this family, in favour of the MS. name applied to it by Mr. Hopkinson.

The classification of the Graptolites with two ranges of thecæ (*Diplograptidæ*), although in my opinion the best possible in the actual state of our knowledge, is to be regarded as confessedly temporary and provisional. Not only are the limits of the major divisions badly defined at present, but the minor grouping we are compelled to adopt is essentially artificial. Indeed it may be considered certain that future research will demonstrate the necessity for a very different distribution of many of these forms.

All that is attempted in this department is roughly to prepare the way for the next and future advance in the proper classification of these species. This will probably consist in the suppression of the family *Phyllograptidæ*, whose single genus may have to be included among the *Diplograptidæ*. From the latter it may ultimately be necessary to eliminate the genus *Climacograptus*, and to place it, together with *Lasiograptus*, near the family of the *Dicranograptidæ*. There is also evidence in support of the view that the more typical species of

¹ GEOL. MAG., Vol. VIII., p. 64.

Orthograptus, which have as yet offered no trace of a true sicula, belong in reality to the *Glossograptidæ*.

The genus *Diplograptus* is here divided into several sub-genera. This will be found of service in enabling us to group together, for convenience of reference, species having a certain amount of similarity in their external features. It will also have the further advantage of necessitating such close attention to those minor, and hitherto neglected points in outward form dependent upon internal structure, as may result in the detection of the true relationships of the very different fossils which are at present associated in this badly understood genus; and ultimately furnish us with the means of accurately defining the exact line of separation between the two great sections of the RHABDOPHORA.

The distinguishing characteristics of these sub-genera will, it is hoped, be sufficiently apparent from the analysis in the Table, and from the references to the typical species.

Regarding the controverted question of the relationships which exist between the *Diplograptidæ* and the genus *Retiolites* and its allies, it must be admitted that, trenchant as are the apparent distinctions in mode of development and general plan of structure which characterize these two sections, yet every new investigation results in the detection of fresh and striking correspondences in detail of form or structure. A full consideration of these numerous points of contact may here be dispensed with. It will be sufficient for the present merely to call attention to the following facts.

While in some Retioloid species the virgula is either entirely wanting, or is represented by a slender thread forming a portion of the external network, in others it appears to be a stout double rod, comparable in all respects with the virgula of the duplicate Graptolites.

Some siculate Graptolites have the outer angles of their thecæ in part strengthened by a chitinous thread, a structural feature especially characteristic of the *Retiolitidæ*.

In some forms of the *Diplograptidæ* the polypary on its obverse aspect presents us with a well-defined suture, while on its reverse aspect the periderm offers no trace whatever of a central groove, but is entire and unbroken; leading us to conclude, that in these abnormal specimens the common canal was only partially divided: thus in effect communicating with both rows of thecæ as in *Retiolites*.

On the other hand, in some true Retioloid species, the two lateral halves of the polypary fall asunder after death, remaining attached by their proximal ends only: thus presenting us with a form which, excepting in its reticulate structure, irresistibly reminds us of *Dicranograptus*, a genus notably illustrative of the duplicate nature of the polypary in the *Diplograptidæ*.

For these and many other reasons, some of which will become apparent on a study of the Table, it is evident that the great groups of the siculate and non-siculate *Rhabdophora* afford so many minor structural correspondences that no scheme of classification having any pretence of representing, even approximately, the order of

nature, but must place them in immediate proximity in the general arrangement. On the other hand, the two groups differ so greatly as a whole, in the early stages of their development, and in the general ultimate structure of the adult polypary, that we are certainly justified in considering them as forming two separate sections of the *Rhabdophora*. To the first of these sections the term GRAPTOLITIDÆ¹ should be restricted. For the second section I propose the title of RETIOLOIDEA.

It is impossible on the present occasion even to glance at the remaining differences in matters of detail between the present and former schemes of classification. One only will finally be noticed. The genus *Glossograptus* as here received includes all those peculiar forms furnished with the lateral appendages referred by Hall, Hopkinson, and Allman to the reproductive system of the Graptolites. While their apparently numerous points of affinity with the true Graptolites (*Graptoloidea*) cannot for a moment be denied, yet their internal structure furnishes incontrovertible evidence that they are most intimately related to the *Retioloidea*.

Future alterations in the arrangement of the *Rhabdophora* will in all likelihood be mainly dependent upon elements of classification derived from our improved knowledge of their various methods of multiplication and reproduction. Whatever evidence is at present afforded by our very limited acquaintance with these subjects has been, from its very vague and uncertain character, virtually ignored in the Table. The indications it gives of defects in the present scheme bear wholly upon the families *Diplograptidæ* and *Glossograptidæ*. Many of the species here associated with those of the former will probably have to be eliminated and located elsewhere, while the latter will have to be divided among several distinct families.

There are two genera of Silurian fossils unnoticed in the Table, which may eventually have to be included in the *Rhabdophora*. The genus *Corynoides* ought perhaps to be considered morphologically as a Graptolite, in which development never proceeds beyond the sicula stage. The polypary in *Thamnograptus* (Hall) appears to be furnished with a dorsal filament or solid axis, which enters into all the ramifications of the branches.

APPENDIX.

Description of new genera and species.

Sub. order: RHABDOPHORA (Allman).

Sect. I.—GRAPTOLITIDÆ.

Fam.: NEMAGRAPTIDÆ (Hopkinson).

LEPTOGRAPTUS (gen. nov.). (Gr. λεπτός, slender.)

Polypary consisting of two simple, slender, flexuous, monopronidian branches, proceeding in opposite directions from the major extremity of a well-marked persistent sicula, which is sometimes

¹ There are so many natural and obvious reasons at present for regarding this term as synonymous with Allman's term *Rhabdophora*, that it might prove of service to employ the term *Graptoloidea* for this section, as a second and convertible designation.

developed into a third and central branch. Thecæ of the form of those of *Pleurograptus*. Radicle and lateral spines usually invisible.

Example—*Leptograptus flaccidus*, Hall sp.

AMPHIGRAPTUS (gen. nov.). (Gr. ἀμφί, on both sides.)

Polypary consisting of two principal, compound, slender, mono-prionidian branches, proceeding in opposite directions from the major extremity of a small, inconspicuous sicula. Secondary branches normally simple; given off from both margins of the principal branches, in the neighbourhood of the initial point, usually in pairs. Thecæ of the form of those of *Pleurograptus*. Radicle and lateral spines invisible.

Example—*Amphigr. divergens*, Hall sp.

Section II.—RETIOLOIDEA.

Fam.: GLOSSOGRAPTIDÆ.

LASIOGRAPTUS, gen. nov. (Gr. λαιός—hairy, shaggy.)

Gen. char.—Polypary diprionidian, simple; with sub-parallel margins; section somewhat concavo-convex. Virgula slender, central. Periderm thickened. Thecæ somewhat resembling those of *Climacograptus*; separated by distinct and deep “excavations,” and having their proximal walls strengthened by a pair of chitinous filaments, which converge at the margin, and are prolonged outwardly as a simple spinous process. This process gives origin to a series of slender filaments, which anastomose with those derived in a similar manner from the processes immediately above and below, and form a row of meshes almost surrounding the polypary. Lateral spurs rarely present.

Example—*Lasio. costatus*, sp. nov.—Polypary $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in length—margins converging towards both extremities; maximum width $\frac{1}{10}$ of an inch, or, inclusive of the extraneous meshes, $\frac{1}{5}$ of an inch. Virgula slightly prolonged distally: Thecæ inclined to the axis of the polypary at an angle of about 45° : outer walls little shorter than the interspaces: apertures apparently situated within the general boundary of the polypary.

Horiz.: Lower Moffat Shales (Lower Llandeilo), S. Scotland.

Fam.: RETIOLITIDÆ.

CLATHROGRAPTUS (Lat. *clathrum*—a lattice).

Gen. char.—Polypary diprionidian; simple; elongate elliptical in form, or with sub-parallel margins: section square. Periderm reduced to a mere film, which is usually invisible; supported on a skeleton framework of chitinous threads. Virgula an extremely minute longitudinal filament, forming a portion of the supporting framework. Thecæ inclined, of the general form of flattened rectangular prisms.

Example—*Clathrograptus cuneiformis*, sp. nov. Polypary cuneiform; from $\frac{1}{4}$ to $\frac{1}{2}$ of an inch in length; attaining maximum width of $\frac{1}{10}$ of an inch at its distal end: proximal extremity pointed, destitute of ornamental processes. Virgula excessively slender. Thecæ 22 to 24 to the inch, making an angle of about 30° with the line of the virgula furnished with short, stiff, apertural spines.

(The genera Nos. 14, 15, 16, 17, and 27 of the Table have never been met with in S. Scotland, and are as yet without distinctive titles.)

NOTES.

(1). *Primordial Buds.*

The term "bud" is employed throughout this paper merely as a concise and at the same time convenient designation for the small, primary, lateral tubercle, from which the polypiferous branch is ultimately developed. This application of the term is open to some objection, as it appears, by implication, to include the theory that it is possible for the cœnosarc of the sicula to push out lateral buds through a dense continuous sheathing of chitine. Nevertheless, while it is impossible to find any other term which so exactly expresses what appears to be the mode of development in such forms as *Nemagraptus*, yet the designation is intended to be rather expressive of the appearance than of the fact. What that fact is supposed to be will be explained elsewhere.

(2). *"Angle of divergence."*

Two distinct angles of divergence are made by the opening of the principal branches in every bilateral polypary. They are the ventral or polypiferous angle, and the dorsal or nonpolypiferous angle. The latter is invariably bisected by the persistent sicula. I have therefore termed it the "sicular angle" in the former portion of this paper. This has been done merely as a matter of convenience, in order to bring into relief the relations that exist between the opening of the branches and the direction of the persistent sicula; and also ultimate relations of the latter to the proximal extremity of the adult polypary.¹ Strictly speaking, I would suggest that the term "angle of divergence" be in all cases restricted to the "distal angle" or that made by the opening of the branches on the side of the axil remote from the proximal extremity of the polypary.

(3). I have only become acquainted within the last month with the character of Herr Richter's latest researches among the *Graptolitidæ*. I have as yet been unable to procure his recent paper, and my only source of information on the subject is Prof. Allman's descriptive note in the Second Part of the Monograph of the Tubularian Hydroids (p. 185). I have therefore omitted all reference to his conclusions in the body of this paper. I hope to be able to do full justice to his original observations when I have been afforded an opportunity of perusing his remarkable memoir.

The assistance afforded me by the published views of Mr. Hopkinson and Professor Nicholson have been already alluded to. I have also to thank Professor Allman for the kindly expression of his opinions on some of the more doubtful points.

The Geological Distribution of the Graptolites will be treated of in a separate paper.

¹ The reference to the mode of growth in *Phyllograptus*, p. 502, is probably an error, and should be deleted.