9. JURASSIC CHRONOLOGY : I—LIAS. By S. S. BUCKMAN, F.G.S.
(Read June 6th, 1917.)

[PLATES XXVI-XXXI.]

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I. INTRODUCTION.

DURING the last few years¹ I have been engaged to examine a series of ammonites and brachiopods—some thousands of specimens—collected by the officers of the Geological Survey of Scotland in the islands of the Inner Hebrides off the west coast of Scotland—Mull, Skye, Raasay. As the thickness of these Oolite-Lias deposits is very considerable and specimens are in many places numerous, the faunal sequence is often observable to great advantage ; and, as new faunal elements have been disclosed in some cases, the Oolite-Lias chronology requires a certain amount of elaboration and revision. By the kind permission of the Director of the Geological Survey I am allowed to give an abstract of certain results. These data, when compared with those which have been gradually accumulating about other districts, throw an interesting light on the faunal sequence in certain strata, and, though admitting that all suppositions are not yet proved, I venture to offer to the Society an epitome of evidence and surmise with the idea of drawing the attention of other workers to the particular points about which further investigation is desirable.

¹ This paper was commenced in the winter of 1914-15.

The classical paper on the Scottish area is that by J. W. Judd.¹ He proposed the terms 'Scalpa Sandstone' and 'Pabba Shales,' and, though working under great difficulty, showed considerable acumen in his zonal classification: he recognized the presence of the zones of *humphriesianum*, *murchisonæ*, *spinatus*, *margari-tatus*, *ibex*, *jamesoni*, *armatus*, *oxynotus*, *semicostatus*, and *bucklandi*.

A more elaborate faunal sequence is put forward at the present day, as shown by various chronological lists which have been published by the present writer, for instance:—

1898. 'Jurassic Time' Q. J. G. S. vol. liv, p. 442.

1901. 'Hom. Brach.' Proc. Cotteswold F. C. vol. xiii (4), App. II, p. 265.

1910. 'Jurassic Strata' Q. J. G. S. vol. lxxvi, p. 86.

1910-13. 'Yorkshire Type Ammonites' i, p. xvi; ii, p. x.

1915. 'Pal. Class. Jur. Rocks'; 'Geol. Whitby' 2nd ed. Mem. Geol. Surv. 1915, chap. v, p. 60.

The tables in the two last-named publications may be taken as a basis of reference. But the excellent results obtained by Mr. W. D. Lang,² by most painstaking work on the Dorset Coast, show that still further elaboration is required. The same is the lesson taught by the Scottish deposits. I propose to illustrate and compare these results with each other, and with details from intermediate areas.

The present paper is entitled 'I--Lias' to indicate that it is the first of a proposed series, to be followed. I hope, by further papers on the Oolites so as to complete the Jurassic Chronology on the same lines. The present paper gives the information about the Lias by working downwards from younger to older deposits, because that presents the different sections of the strata in continuous orderly sequence. Strictly speaking, then, this series of papers should have commenced with the latest rocks of the Jurassic; but, as I am not prepared with their details, the sequence in the papers and that in the series must remain at variance—a technical blemish.

One could wish that, for geological and other records, printing and reading were from the bottom of the page to the top, because then results could be placed in their due order of developmental sequence.

For stratigraphical information, palæontological material, and generous assistance, I am very greatly indebted to several kind friends: for Scotland, to Dr. G. W. Lee and other officers of the Geological Survey, Scotland; for Yorkshire, to Dr. F. L. Kitchin, Mr. G. W. Lamplugh, Mr. G. Barrow, and other officers of the Geological Survey, England; for the Midlands, to Mr. B. Thompson; for Somerset and Gloucestershire, to Mr. J. W. Tutchet; for the Dorset Coast, to Mr. W. D. Lang; for varied information, to

¹ 'The Secondary Rocks of Scotland' (West Coast), Q. J. G. S. vol. xxxiv (1878) p. 660.

² Proc. Geol. Assoc. vol. xxv (1914) p. 293.

Dr. A. Morley Davies. To all I tender most grateful thanks.¹ For the Yorkshire area and for the South-Western Counties I have also had my own field experience—chiefly in the last-mentioned area.

Part of the following pages may be regarded as an extension of the principle applied with success to sundry brickyard exposures along a line of country—the principle of unlike faunas. Different contiguous exposures show faunas of partly or wholly unlike facies: therefore their deposits are partly or wholly heterochronous—find the sequence. In wider extension there are obviously other factors for consideration—agency of deposition, difference of basin, constituents of the fauna—like must be compared with like. But the following pages show, it is hoped, that the method of work may be extended and justified; and that it may answer both ways—for, as a proved sequence shows the meaning of dissimilar faunas, so dissimilar faunas give reason for expecting heterochronous deposition.

It is fairly evident that geologists have been using the principle of dissimilar faunas in separating strata, without recognizing it—much as M. Jourdain had written prose without knowing the fact. But it is not proposed to pursue the matter further now—it deserves a study to itself—and perhaps a terminology!

II. YEOVILIAN AND WHITBIAN.

The whole of the Yeovilian and a considerable part of the Whitbian are unrepresented by strata in the Scottish isles: a deposit, about 75 feet thick in Raasay, which I term the Dun Caan Shales, corresponding in date to the post-*moorei* part of the Bridport Sands of South Dorset² (early Aalenian), rests non-sequentially on the Raasay Ironstone, which is of the date of the lower part of the Whitby Alum Shale—post-*falciferum* hemera. This non-sequence represents a break of about 700 feet of strata on the evidence of various English localities³; and may prove to be very much more when Continental deposits come to be analysed with the same detail.

The chronology of the Yeovilian and Whitbian has been already rather fully particularized in the last two communications mentioned in the list of works on p. 258; but there is reason to suppose a fuller faunal sequence in the former, and (as regards the latter) it seems desirable, on the ground of palæontological uniformity, to class as early Whitbian the bed or beds hitherto regarded as latest Domerian, see Summary, pp. 275, 276.

The attention of investigators should be particularly directed to the sequence of strata on the Whitbian-Domerian border-line—

¹ To Mr. Tutchet my thanks are due for his careful photographic illustrations to the Palæontological Appendix.

² Q. J. G. S. vol. lxvi (1910) pp. 60, 61, 64.

³ *Ibid.* vol. lix (1903) p. 456; 'Geol. Whitby' 2nd ed. Mem. Geol. Surv. 1915, chap. v, p. 75.

the post-*spinatum* pre-*falciferum* deposits. This was a time of earth-movement and local non-sequences: the full succession—perhaps more elaborate than that to be recorded in the Summary—may possibly be made out by taking note of dissimilar faunas.

The strata of the Yeovilian, and, locally, even certain beds of the Whitbian, have until comparatively recent times been classed with the Inferior Oolite Series or as Passage Beds between Lias and Oolite—the dividing-line between Lias and Oolites (or Lias and Passage Beds) being roughly taken along the line of change from clay to sand; but this has been found to vary palæontologically by several hemeræ.¹ Such former association, however, suggests that there may be a more suitable opportunity to discuss these strata in a proposed later communication dealing with the faunal sequence of the Lower Oolites.

III. DOMERIAN.

The Scalpa Sandstone, about 240 feet thick, is in the main of Domerian date; some of the base is earlier. There is no direct evidence for the stratigraphical sequence, but the faunas of the *spinatum* and *margaritatus* dates are present, with that of *algovianum* indicated. There is, however, another remarkable fauna in a distinctive matrix: it yields *Amaltheus lævis* (Quenstedt), in some abundance, some massive Rhynchonellids and other brachiopods. The *Amaltheus*, a Würtemberg species, a very distinct dwarf form, has not hitherto been found in English strata, if my memory serves me truly; the massive Rhynchonellids² are quite new to this country; the other brachiopods agree in the main with Domerian species of Yorkshire.

It is suggested, on the principle of dissimilar faunas, that the Scalpa Sandstone shows a new faunal horizon—one post-*margaritatus* pre-*spinatum*—a deposit made during a hemera of *Amaltheus lævis*, well-developed and preserved in Raasay, possibly in part preserved in Yorkshire—it is to be looked for at the junction of the above-mentioned zones—partly, if not entirely, absent from the South of England; but to be found locally on the Continent, possibly in some thickness.

However, with this addition the sequence of Domerian faunas is certainly not complete. This is well shown in a paper by M. J. Monestier.³ The strata between the Charmouthian and the *spinatum* horizon hitherto placed in the zones *margaritatus*–*algovianum* (Oppel's upper and lower *margaritatus* zones) are separated out by him into three subzones, with, in some cases, further division into upper and lower horizons.

¹ 'Monogr. Inf. Ool. Amm.' (Pal. Soc.) 1890, p. 167.

² *Grandirhynchia*, S. Buckman, 'Gen. Jur. Brach.' 1914. Two species figured in 'Brach. Nanyau Beds, Burma' Pal. Ind. n. s. iii (2) 1917 (1918) pl. xiii, figs. 5 & 6, and described on p. 228.

³ 'Zone à *Amaltheus margaritatus*' Bull. Soc. Géol. France, ser. 4, vol. xiii (1913) p. 5.

From his excellent paper I extract the following as a summary of the sequence:—

TABLE I.—FAUNAL HORIZONS OF LOWER DOMERIAN.

(After J. Monestier.)

Subzone c.	{ Upper horizon.	' <i>Amaltheus gibbosa</i> Quenstedt.'
	{ Lower horizon.	' <i>Seguenziceras algovianum</i> Oppel.'
Subzone b.		' <i>Cœloceras acanthoides</i> Reynès'
Subzone a.	{ Upper horizon.	' <i>Hildoceras boscense</i> Reynès.'
	{ Lower horizon.	' <i>Grammoceras fieldingi</i> Reynès.'

Monestier (p. 11) gives *Amaltheus lævis* as a constituent of his subzone c. Perhaps this is due to local paucity of deposition, for the evidence of Raasay, so far as it goes, is to the contrary; *A. lævis* is from near the top of the Scalpa Sandstone, while the indication of an *algovianum* fauna is near the base—some 200 feet lower.

Over a considerable part of England it is possible that all, or nearly all, of Monestier's horizons are not represented, the Domerian beginning with the *algovianum* horizon, or even later than that locally. On the Dorset Coast, however, these lower strata may, perhaps, be found.

The thickness of the Domerian on the Dorset Coast exceeds, according to Day's evidence,¹ that of the Scottish deposits, and very considerably. From the Three Tiers to the Marlstone of the Junction Bed, inclusive, there are 364 feet.² It is possible that 180 feet of this—the lower part—represents strata missing from the Scottish deposits and from other English localities; for it is permissible to interpret Day's record of *Am. thouarsensis* in the Shell Bed (p. 291) as *Seguenziceras* aff. *algovianum*: this would give about 180 feet from *algovianum* to *spinatum* inclusive, which compares well with about 200 feet of Scalpa Sandstone within the same limits, leaving 180 feet below in which Monestier's pre-*algovianum* horizons may be sought—I have seen something of a *boscense* style with the matrix of the Dorset Coast.

Monestier quotes an *Amaltheus* fauna through all his horizons, and Day gives *A. margaritatus* through about 330 feet of strata on the Dorset Coast. It is to be regretted that investigators have too often placed all the species of *Amaltheus* under one name; for with careful discrimination much information might have been gained as to their horizons, with great advantage to correlation work.³ But this range of *Amaltheus*, followed by its allied genus *Paltoleuroceras*, induces the reflection that the strata yielding these Amaltheidæ ought alone to be classed as Domerian—the age of Amaltheids.

In certain cases, then, the division between Whitbian and

¹ 'Middle & Upper Lias of the Dorset Coast' Q. J. G. S. vol. xix (1863) pp. 283–85.

² *Amaltheus* has been found some 2 feet below the lowest tier, W. D. Lang, Prec. Geol. Assoc. vol. xxv (1914) p. 329.

³ Species of *Amaltheus* are enumerated in 'Yorkshire Type Ammonites' 1911, p. 25 d; but this by no means exhausts the series.

Domerian would fall in the upper part of the Marlstone. The highest layer of Marlstone on the Dorset Coast—the *serrata* bed¹ with Harpoceratoid ammonites,² may, on the principle of dissimilar faunas, be expected to be of different date from the Transition Bed of the Midlands with *Tiltoniceras* and peculiar Dactyloids—a bed of lithic condition similar to decomposed Marlstone. Removal of these two horizons to Whitbian would certainly make for greater zoological uniformity, see p. 276.

The following comparative table of Scottish and English Domerian may be given.

TABLE II.—DOMERIAN SEQUENCE.

Dates. Hemerae.	Strata.				
	RAASAY. ¹	YORKSHIRE. ²	CHELTENHAM DISTRICT. ³	N. SOMERSET. ⁴	DORSET COAST. ⁵
7. <i>spinatum</i>	×	3-11 ?	C.	S.	Base of Junction Bed.
6. <i>lævis</i>	×	(12-21) ?			
5. <i>gibbosa</i>	×	22-26	C.		<i>Margaritatus</i> Bed +
4. <i>algovianum</i> ...	×	27-34			Shell Bed +
3. <i>ecanthoides</i> ...					
2. <i>tescense</i>					(Strata about the 3 Tiers) ?
1. <i>fieldingi</i>					

¹ The Scalpa Sandstone.

² The numerals refer to beds in 'Geol. Whithy' *op. cit.* pp. 73, 74.

³ The *algovianum* fauna is not known from the Cheltenham district; but is recorded by Wright from Oxfordshire—Chipping Norton.

⁴ Even the *spinatum* deposit is often missing.

⁵ See Day, *loc. cit.* and S. S. Buckman, *op. cit.* p. 66. Intermediate beds cannot be placed on present evidence. A much fuller faunal sequence than is here recorded between *spinatum* and *algovianum* seems quite likely.

[× Fauna present, position surmised. C., S., Beds in known sequence.]

For a further illustration, see fig. A, p. 265, and for further details the remarks on that page.

IV. CHARMOUTHIAN.

Some small portion of the lower part of the Scalpa Sandstone belongs to the Charmouthian; but its main mass is made up of the Pabba Shales, 600 feet thick in Raasay, 700 feet in Skye.³ They are richly ammonitiferous, especially in the lower 400 feet or so

¹ 'Jurassic Strata' Q. J. G. S. vol. lxvi (1910) p. 65, bed i.

² The species figured by Wright, 'Monogr. Lias Amm.' (1884) pl. lxxxi, figs. 4-6 as '*Harpoceras radians*, Upper Lias Shale, East Brent Knoll, Somerset' bears a label in Dr. Wright's handwriting 'Down Cliffs, Charmouth,' and is from the top bed of the Marlstone of the Dorset Coast. It well represents the forms here alluded to: they require to be worked out and named. There is perhaps some connexion with *Am. pseudoradians* Reynès, 'Géol. Pal. Aveyron,' 1868, pl. i [bis], fig. 4. Wright's specimen is in the British Museum (Natural History) No. C. 2200.

³ These thicknesses were communicated to me by Dr. Lee.

representing the so-called zones of *armatum-raricostatum*, where they disclose a quite unexpected sequence of events. Concerning the upper part of the Charmouthian they do not give much information; but here Mr. Lang's detailed researches on the Dorset Coast come in.

Owing to the number of faunal horizons disclosed by the English and Scottish strata, it becomes necessary to divide the Charmouthian; and it is at once noticeable that in the upper part the Ammonite families Liparoceratidæ and Polymorphidæ are dominant, in the lower part the families Deroceratidæ and Echioceratidæ. But such division into two parts would leave the upper portion unduly large, while division into three parts gives better balance. In the upper third the Liparoceratidæ are the dominant feature with the Polymorphidæ subservient; in the middle third the position is precisely the reverse; while in the lower third the Deroceratidæ and Echioceratidæ keep alternating in their domination. Therefore it is proposed to divide the Charmouthian into three ages, named respectively Hwiccian, Wessexian, and Raasayan. These terms are governed as to their limits, not by stratigraphy, but by faunal constituents; and there should be no necessity to change them if future discoveries show the advisability of small additions to, or subtractions from, the stratigraphical units now respectively assigned to them.

Perhaps no author has proposed, and, in the light of present knowledge, perhaps no author can propose stratigraphical or chronological terms with fixed limits: non-sequences and the progress of palæontological discovery are against such results. Detailed investigation has often revealed that the upper and lower limits of a given stratigraphical term used by the same author really vary from area to area to the extent of the deposits made during several hemeræ in each case. Then the limits require corresponding adjustments; but to alter the names whenever small adjustments are made would produce a confusing multiplicity of terms for what is substantially the same thing. It is too much to expect that limits can be exactly fixed, even on the basis of dominance of certain Ammonite families: future discoveries may spring surprises on us. It is unlikely that the remarkable sequence disclosed at Raasay (Raasayan, p. 267) with the large adjustment which it involves will be the only discovery of its kind.

(1) Hwiccian.

The lower scarp of the Cotteswolds and the outliers which stand as sentinels along the valleys of Severn and Avon in the counties of Gloucester and Worcester show some fine developments of strata earlier than the Domerian. The Hwiccas,¹ whose country

¹ 'The Hwiccas ... the people of Gloucester, Worcester, and part of Warwick the old Diocese of Worcester before Henry the Eighth formed the sees of Gloucester and Bristol. The Bishops' Dioceses are generally the best guides to the boundaries of old principalities.'—(E. A. Freeman, 'Old English History' 3rd ed. 1873, p. 82.)

exhibits these deposits, may well give their name to the age—Hwiccian: it is the age when the Liparoceratidæ were dominant and the Polymorphidæ subservient. The following Table III gives an interpretation of the evidence in Scottish and English areas.

TABLE III.—HWICCIAN: SCOTLAND AND ENGLAND.

Dates.	Strata.			
Hemeræ.	RAASAY, YORKSHIRE. ¹	GLOUCESTER-SHIRE. ²	N. SOMERSET. ³	DORSET COAST. ⁴
9. <i>Oistoceras</i>	3			130. } <i>Oistoceras</i> 129. } + <i>hechei</i> .
8. 'henleyi'				126. Involute <i>Androgyn.</i> <i>henleyi</i> -type; <i>davæi</i> .
7. <i>davæi</i>				125. <i>davæi</i> .
6. (3rd capricorn). Capricorns, base of Scalpa Sandst.	5			
5. (2nd capricorn).	6	Capricorns, Pillee, Leckhampton.		
4. <i>latæcosta</i> (1st capricorn).	×7 (<i>Androg.</i> <i>maculatum</i> , <i>Androg.</i> <i>heterogenes</i>)	Dudbridge. (<i>Androg.</i> <i>latæcosta</i>)	Radstock; Bath. (Evolute <i>Androg.</i>)	124. } <i>Androg.</i> 123. } <i>latæcosta</i> 122. } group.
3. <i>Beaniceras</i> ...	×7 (<i>Beaniceras</i>)	Hewlett's Road (Yellow Lias); Stow-on-Wold. (<i>Beaniceras</i>)	Slopes of Dundry. (<i>Beaniceras</i>)	121. [<i>Beani-</i> <i>ceras</i> :] <i>Liparoceras</i> .
2. <i>carinatum</i>		Leckhampton? Hucclecote? (Stout <i>Acanth.</i>)		120b. [<i>Beanic.</i> ?] <i>Acanth.</i> <i>carinatum</i> ; <i>Ac. spp.</i> ; <i>Liparoc.</i>
1. <i>cheltiense</i>	×7 (<i>Lip. hept-</i> <i>angulare</i>)	Charlton Kings; Dumbleton, etc. (<i>L. cheltiense</i>)	Radstock; Dundry. (<i>Lip. zietenii</i>)	120a. <i>Liparoc.</i>

¹ The numbers refer to beds in 'Geol. Whitby' 2nd ed. Mem. Geol. Surv. 1915, p. 69; the strata are about 155 feet thick, Bed 7 being 35 feet.

² Specimens collected by my father, and personal observations.

³ Mr. J. W. Tutchter's information.

⁴ W. D. Lang, Proc. Geol. Assoc. vol. xxv (1914) p. 293; the numbers are those of his beds. In regard to this and the following tables, my best thanks are due to Mr. Lang for the great pains that he has taken to supply me with information, sending MS. notes of later researches and submitting specimens—my identifications are in square brackets. Since this paper was read he has published some of these MS. notes—'The Iber-Zone' Proc. Geol. Assoc. vol. xxviii (1917) p. 31.

[× Fauna present, position surmised.]

Fig. A.—Diagram illustrating the faunal sequences in the Domerian-Hwiccan.

The accompanying diagram (fig. A) shows the faunal sequences, and non-sequences, in the Domerian and Hwiccan of the areas under consideration. No account is taken of the thicknesses of strata; it is only a faunal record; but it becomes a stratigraphical illustration of the position of affairs when the concluding strata of the Domerian were deposited.

The datum-line is 7 Domerian (*spinatum*) proved in all areas.

The movement of the Mendip axis of North Somerset is quite obvious. Its influence apparently extended to Gloucestershire. On the Dorset Coast, though the Domerian strata are especially thick, there are two more non-sequences, due possibly to movement of the Weymouth anticline. The last of these, the pre-*spinatum* one, which presumably coincides with the lack of the *lævis* zone of Raasay, is particularly interesting. The base of *spinatum* has Blue Lias pebbles, the date of which it would be interesting to determine. If, as has been supposed, the pebbles are from early Domerian beds,¹ which happen to be about

¹ Q. J. G. S. vol. lxxi (1910) p. 82.

160 or 200 feet below, this indicates a movement of the Weymouth anticline to about that extent in order to expose the bed to denudation. But the pebbles may be very much earlier, and the movement may have been considerably greater.

(2) Wessexian.

The name for this age is taken from the Old English kingdom of Wessex, which embraced the South-West of England, though its boundaries diminished and enlarged from time to time, varying more than the boundaries of a stratigraphical term—yet, like a generic title, it kept the same name. The Dorset Coast, Somerset, and Gloucestershire, were all part of it at one time, and all this area shows strata of the age. The Radstock district in Somerset has the strata thinly developed, and therefore not lending themselves

TABLE IV.—WESSEXIAN: SCOTLAND AND ENGLAND.

Dates.	Strata.				
	HAASAY. ¹	YORKSHIRE. ²	CHELTONHAM. ³	RADSTOCK. ⁴	DORSET COAST. ⁵
10. <i>valdani</i>	?		×	R.	119 b. <i>Ac. valdani</i> group.
9. <i>iber</i>		×	×	R.	119 a. } <i>A. maugen-</i> 118 c. } <i>esti</i> group. <i>T. iber</i> & <i>wechsteri</i> .
		(<i>Tragophyl-</i> <i>loceras</i> fauna only)	(<i>T. iber</i> fauna only)		
8. <i>ellipticum</i> ...					118 b. <i>Ac. ellipticum</i> group.
7. <i>brunni</i>			×		{ 118 a. <i>U. brunni</i> forms [and fine- ribbed <i>Uptonia</i> .] 115 b. <i>U. brunni</i> forms.
			+ fine-ribbed <i>U. jamesoni</i> form (Wright).		
6. <i>Platypleur-</i> <i>ceras</i> .	R.	8		×	{ 115 a. [<i>Platypleur</i> .] 113. [<i>Platypleur</i> .?]
5. <i>trivialis</i>		8			111. [<i>Polym. tri-</i> <i>vialis</i> group.]
4. <i>jamesoni</i>	R.	9		R.	
3. <i>pettos</i>					110? [<i>C. pettos</i> , <i>C. grenouillouxi</i> .]
2. <i>peregrinus</i> ...					108. [<i>Polym. peregrinus</i> ? Haug]. ⁶ Deroceratid.
1. <i>Phricodoceras</i> .		11	×	R.	105. <i>Phricodoceras</i> .
			J. Buckman Coll.		

¹ R. beds in position; about 30 feet separates them.

² See former Table. About 120 feet involved.

³ As in Table III (p. 264) and in Wright's records.

⁴ As in former Table. R.=beds in known sequence; ×=fauna present, position surmised.

⁵ See former Table.

⁶ *Agoceras polymorphus* Wright, pl. xl, figs. 1-3, cited by Haug as near to his species.

very rapidly to the detailed sequence now asked for; but the deposits are very fossiliferous and especially ammonitiferous.

This is the age when the Polymorphidæ held chief position, while the Liparoceratidæ were inferior in importance.

Table IV (p. 266) gives the evidence in various areas. A presumed faunal repetition of *Uptonia* (*jamesoni* and *brunni*) seems to be the only method of reconciling this evidence. Such faunal repetition is, however, so much in accord with what Raasay shows in lower beds (see Table V) that the solution seems quite possible. Mr. Lang has also recorded faunal repetition in the case of series of *Acanthopleuroceras* in the Hwiccan and Wessexian of the Dorset Coast, as this and the preceding table show.

(3) Raasayan.

The Scottish evidence in this case is excellent and most important. The result is to show that in the strata hitherto assigned to the *armatum-raricostatum* zones the sequence is much more complicated. There are:—

7. Upper *Deroceras* horizon.
6. }
5. } Upper *Echioceras* horizons—three stages.
4. }
3. Lower *Deroceras* horizon.
- 1, 2. *Subplanicosta* and Lower *Echioceras* horizon—possibly two stages, possibly more, see p. 268.

The Scottish deposits show faunal repetition and faunal alternation of *Echioceras* and *Deroceras*, thus giving the clue to the correlation of the strata in other areas. The available evidence is brought together in the accompanying Table V; more precise details about the lower horizons would be desirable, and further investigation in Raasay may be expected to furnish them.

The great thickness of the Scottish strata—five, ten, and eighty times as thick as the English deposits—is the chief factor in displaying the sequence. Thus it will be seen that, between the *armatum* zone of the Midlands and that of Radstock, hitherto thought to be isochronous, the Scottish deposits exhibit a thickness of some 300 feet of strata.

When the English strata are compared with the Scottish, it will be noted that, although no one locality shows the full sequence, yet all put together prove the Scottish sequence. It is evidently the same on the Continent—the Rhone Basin, Freiburg Alps, Bavaria, Würtemberg, Hierlatz, contain to some extent heterochronous deposits with dissimilar faunas. Each area lacks something; but, when all are placed together, they are seen to supply one another's deficiencies, and to make up the sequence of Table V. Bavaria lacks what Würtemberg has, and supplies in part what Würtemberg lacks; and so with the other Continental areas.

There is reason to suppose that at the beginning of the Raasayan considerable earth-movement took place producing various local non-sequences—a legacy from Deiran times (see p. 273 and

fig. B, p. 272). As a consequence it may be expected that the faunal sequence in early Raasayan was more complicated than that shown in Table V. The Sodbury evidence gives the association of '*Am. aff. armatus*' and '*A. raricostatus*' [an armatoid and an *Echioceras*] below the *densinodus* [*obsoletum*?] horizon. The Midlands, according to Mr. Thompson's evidence, show the second at a lower horizon than various armatoids which he associates with *Am. subplanicosta*. Cheltenham has a very definite *subplanicosta* horizon, and it is below this that various armatoids occur. A consideration of these points suggests that, instead of the two horizons of the Table, there may be three if not four in the following descending order:—

- (d) *subplanicosta*.
- (c) *obsoletum* (*densinodum*).
- (b) armatoids.
- (a) *Echioceras*.

Attention to this point would be desirable. Ammonites are abundant, but small. They have not yet been examined in a sufficiently critical manner—a very long task; in many cases their identification with already named species is open to much doubt.

The faunal repetition in the Raasayan begins to make many things clearer. For instance, it is now possible to understand the absence of large *armati* from the Midlands; and the very remarkable number of species of *Echioceras*. The list in 'Yorkshire Type Ammonites' (p. 96c, 1914) enumerates 44 species, and is by no means exhaustive. As the product of development at intervals during a very long period of time, they are much more understandable than as the product of one date; and, as the outcome of repetitive series evolving on parallel lines, the frequent similarity but not identity in the *Echiocera* is explicable.

V. SINEMURIAN.

The Scottish deposits are not rich in Ammonites; but there is evidence for the sequence of certain faunas, while loose blocks on the Hallaig shore of Raasay indicate the presence of others. The evidence is instructive when compared with that of English localities, especially with the detailed work done by Mr. Lang on the Dorset Coast.

The great increase which the Scottish deposits have proved in the faunal phases of the Raasayan might have been anticipated from other localities, if strict attention had been paid to dissimilar faunas. Now, in the Sinemurian, the case may, perhaps, be reversed: by paying attention to faunal dissimilarities it is hoped to anticipate that full faunal sequence which may some day be proved in a thick deposit.

With increase of horizons the need for division of the Sinemurian seems to be great. It has been felt already. Choffat has divided it into Upper, Middle, and Lower Sinemurian,¹ and this

¹ 'L'Infralias & le Sinémurien du Portugal' Comm. Serv. Geol. Port. v (1903) pp. 54–106.

seems to fit the Ammonite development more satisfactorily than a division into two parts. Here it is proposed to adopt something of the same divisions, styling them Deiran, Mercian, and Lymian.

(1) Deiran.

This is the age when the gerontic phase of the Arietidæ was in full development: it is the period of the oxycone Arietids. Its strata are perhaps more developed in Yorkshire than in other English areas; and it takes its name from Deira, the ancient kingdom of which Yorkshire formed a considerable part.

The sequence of faunal horizons is suggested in the following table.

TABLE VI.—DEIRAN.

Dates. Hemereæ.	Strata.			
	RAASAY.	YORKSHIRE. ¹	CHELTHENHAM DISTRICT.	SOMERSET. DORSET COAST.
8. (<i>lymense</i>)?				(X)
7. <i>Radstockiceras</i> ²				Radstock, north of Mendips.
6. <i>Gleviceras</i> ² ...			Folly Lane, Cheltenham (lower part).	(X)
5. <i>polyophyllum</i> .		1? X	Vale of Glou- cester. X	
4. <i>oxynotum</i>			Lansdown, Cheltenham.	
3. <i>biferum</i>			Aston Cross, Tewkesbury.	Canards Grave, south of Mendips.
2. <i>simpsoni</i>		2	X	
1. <i>Gagaticeras</i> ...		3		

¹ 'Geol. Whitby' 2nd ed. Mem. Geol. Surv. 1915, p. 67.

² See Appendix III, Palæontology, pp. 287, 289.

[X Fauna present, position surmised. (X) Fauna present, supposed to be derived and redeposited in Raasayan (Table V, Bed 92): Mr. Lang, however, suggests paucity of sediment.]

The Deiran seems to have been a time of much earth-movement and consequent non-sequences, with the result that there is little correspondence of fauna in different English areas. This means that the sequence given is based mainly on supposition.¹

The certain evidence is the sequence *Gagaticeras-simpsoni* in Yorkshire with *polyophyllum* presumably later; the sequence *oxynotum-Gleviceras* in Gloucestershire with *biferum*, it is reasonably certain, earlier than *oxynotum*. There is no definite correspondence here to work upon, and other areas give no help as they show other dissimilar faunas.

It is here suggested that the Yorkshire *Gagaticeras-simpsoni* strata are earlier than the Gloucestershire deposits.

The position in the faunal sequence of the *polyophyllum* horizon

¹ See further remarks in Appendix III, Palæontology, p. 310.

(*Oxynoticer* *polyophyllum* Simpson sp., 'Yorkshire Type Ammonites' 1909, No. 8) may be worked out on theoretical grounds. If it were placed immediately above *simpsoni*, then the Yorkshire strata would be in sequence; but the biological features of *O. polyophyllum* seem certainly to suggest that it is a derivative of *O. oxynotum* with a suture-line of the same pattern, but details somewhat more elaborated, and with ribbing greatly intensified (renewed costation). In that case it should occur later than *O. oxynotum*, and, as there is no stratigraphical evidence to go upon, it seems advisable to work upon the basis of the biological interpretation. This, however, involves a theory of a non-sequence in the Yorkshire Deiran deposits, and the multiplication of non-sequences is inadvisable unless there be some evidence.

The sequence thus suggested for the noticeably dissimilar oxycone faunas of the different areas makes Yorkshire to show early Deiran deposits with a middle Deiran fauna separated by a break; Gloucestershire, to which the Midlands may be joined, to show middle Deiran faunas with, perhaps, a break in some localities due to removal in places of deposits of *polyophyllum* date: this would account for local appearances and absences of the species in this area; Somerset north of the Mendips to show late Deiran fauna, with little deposit and certainly a good deal of redeposition. Dorset shares with Gloucestershire an oxycone fauna of *Glevicer* date; but its special form, *O. lymense*, is not found in the other British areas, so far as I am aware. Both these forms are presumably derived and redeposited in Raasayan strata; for, if *O. lymense* were indigenous in Bed 92, it ought to have been found in the Raasayan deposits of other areas. The supposition, then, is that a *lymense* horizon is the latest phase of Deiran.

Much support for the general conclusions here advanced about the dissimilar faunas of the Deiran horizons may be found in Continental works: the Rhone Basin (Dumortier) shows only ammonites of the horizons *Gagaticeras*, *Glevicer*, and *Radstockicer*—those of the other horizons are lacking, for the examples figured as *A. oxynotus* by Dumortier are species of about the *Gagaticeras* horizon; Würtemberg (Swabia, Quenstedt) shows the *oxynotum* and *biferum* faunas certainly, doubtfully the *Glevicer* fauna, but no fauna of the others.

Thus Gloucestershire and the Midlands are to be bracketed with Würtemberg so far as the *oxynotum* fauna is concerned, and are separable from other English areas; Radstock, with its varied and remarkable oxynotes, agrees with the Rhone Basin: it shows special forms not yet found in other British areas—the *Radstockicer* fauna. Yorkshire shows many oxycones which seem to be peculiar to itself: it has little agreement with other English areas or with Würtemberg, but rather more with the Rhone Basin—not, however, on the same basis as Radstock.

Lastly, Dorset shares with Gloucestershire a little, but has *O. lymense* to itself. (For further remarks see fig. B, p. 272, and also p. 273.)

(2) Mercian.

The strata of this date are well developed in Gloucestershire and the Midlands—mainly the ancient kingdom of Mercia. The Mercian corresponds to the catagenetic phases of the Arietidae (post-tuberculate *Asteroceras* and incoiling phases of *Arietites*). In middle Mercian is a phase of degenerate Arietids which have lost keel and furrows—usually called degenerate *Asteroceras*. The fauna is very prominent in Yorkshire, and is found in Ireland and in Würtemberg. It is not, however, known from other British localities, with the exception of Pershore (Worcestershire); but the special Pershore degenerate is a species not known from the other localities. On the principle of dissimilar faunas it is reasonable to expect one, if not two, horizons in middle Mercian somewhat later than *obtusum*.

In early Mercian the Barrow-Gurney fauna has its own peculiarities, possibly indicating another horizon. But this cannot be discussed without a consideration of the Ammonites; so it must be relegated to the Palæontological Appendix, see p. 311.

In regard to *Arietites turneri*, Mr. Tuteher is of opinion that it precedes *birchi*,¹ and this would seem to be the position assigned to it by Tate & Blake. It is true that the name *A. turneri* has been very much misused, and that in a pre-*birchi* position there are, as I have reason to think, forms allied to *Arnioceras* with somewhat of an *Arietites* aspect which possibly require separation as a new genus from both. But an explanation on these lines does not satisfy me, where Mr. Tuteher is concerned; faunal repetition on the lines of *Echioceras* of the Raasayan may be more likely. It is evident that a prolonged stratigraphical and palæontological investigation is required to solve the problem.

The following table gives the evidence of faunal distribution and sequence in the Mercian.

TABLE VII.—MERCIAN: SCOTLAND AND ENGLAND.

Dates. Hemerae.	Strata.			
	RAASAY. YORKSHIRE. ¹	CHELTHENHAM DISTRICT. ²	BRISTOL DISTRICT. ²	DORSET COAST. ²
7. <i>denotatus</i>	4	× Cheltenham.		
6. <i>stellare</i>		× Cheltenham.	Radstock.	88
5. <i>planicosta</i>	9		Radstock.	85-87
4. <i>sagittarium</i> ...	10	× Pershore.		
3. <i>obtusum</i>	10	× Bredon.	Radstock.	83, 84
2. <i>brooki</i>	R.			78-82
1. <i>turneri</i>	R.	× Bredon.	× Barrow Gurney.	76, 77

¹ 'Geol. Whitby' *op. jam cit.* p. 67.

² As in previous Tables.

¹ See Appendix I, p. 280.

Fig. B.—Diagram illustrating the faunal sequences in the Raasayan, Deiran, and Mercian.

[For 'dendatum' read 'denotatus'.]

The accompanying diagram (fig. B, p. 272) shows the various earth-movements and denudations which took place during Raasayan and Deiran times, producing many non-sequences. It is constructed on the same principle as the previous diagram (fig. A, p. 265).

The datum-line is 1 Wessexian (*Phricodoæras*), proved in all areas except the Scottish one. Again the continuous movement of the Mendip axis is very noticeable; for, although there are several Raasayan faunas present in North Somerset, yet they are derived almost entirely, shown in the table by bracketing them with 7 Raasayan.

During Deiran times the movements were of several dates not always isochronous in the different areas—hence the fragmentary nature of the deposits and their lack of correspondence. One movement produced obliteration of the early Deiran deposits in Gloucestershire and the Midlands, another the obliteration of the latest deposits. Yorkshire would seem not to have suffered from the first movement, but it did from the last; and, if the position of *polyophyllum* in the sequence be correct, another movement of about middle Deiran time must be postulated: there are traces presumably of a slightly later movement—local obliteration of *polyophyllum*—in Gloucestershire. In North Somerset the first and second movements seem to have had full sway and to have effected complete obliteration, but there was a pause to allow the deposition of 7 Deiran, though the strata then laid down suffered considerably by the latest Deiran movement which continued, with perhaps occasional slight pauses, well into Raasayan times. On the Dorset Coast there would seem to have been continuous movement and penecontemporaneous erosion; at least the result, as I judge it, is that no Deiran deposits were left: there was denudation down to 6 Mercian, but the fossils of some of the later Deiran strata—laid down during short pauses—were swept together and redeposited in early Raasayan.

(3) Lymian.

The strata of this age are well-known and well-developed at Lyme Regis, from which the name may be suitably taken; but, so far as present records allow of interpretation, it seems that they are not complete there. The Lymian is the time of anagenetic and tuberculate Arietids.

The difficulty of ascertaining the number and sequence of horizons in the Lymian is due to the wholly uncritical use of names like *Ammonites bucklandi*. Instead of being a common and universally distributed species as records make out, *A. bucklandi* is a special massive form which I can only be certain of from Keynsham.¹ I suspect the occurrence of another horizon with a fauna of smaller Coronicerates, but whether pre- or post-*bucklandi* has yet to be determined: the placing of it as post-*bucklandi* is a surmise.

¹ See Palæontological Appendix, p. 302.

Mr. Tutchcr takes strong exception to the use of *Arnioceras* to indicate a horizon, because it has too wide an extension, ranging, he says, through most of the strata here placed as Lymian. But the Dorset evidence shows *Arnioceras* dominant in a particular set of beds; and, although this may be striking because of the absence of certain preceding strata, yet it is sufficient for the present: there is a post-*Agassiceras* horizon with *Arnioceras* shown at Raasay, and a pre-*birchi* horizon with *Arnioceras* in Dorset. A more suitable name for this faunal horizon must wait until the many species of the genus are better known. It is quite possible that here again may be faunal repetition.

The following table gives the evidence of the various areas:—

TABLE VIII.—LYMIAN: SCOTLAND AND ENGLAND.

Dates.	Strata.					
Hemereæ.	RAASAY. YORKSHIRE. ¹	GLOUCESTER- SHIRE, ² ETC.	BRISTOL DISTRICT. ³	DORSET COAST. ⁴		
8. <i>birchi</i>	×	×	Bredon, W.	×	Horfield.	75
7. <i>Arnioceras</i> ...	R.	Up. <i>Buck-</i> <i>landi</i> [b].	×	Radstock.		50-72
6. <i>Agassiceras</i> ...	R.	{ Up. <i>Buckl.</i> [a]. Mid. <i>Buckl.</i>	×	Bredon, W.	Keynsham.	49 ?
5. <i>gmundense</i> ...	×		×	Berkeley, W. Mon. pl. iv.	Keynsham.	
4. <i>vercingetorix</i> .		Low. <i>Buckl.</i> [c].	×	Fretherne, W. Mon. pl. iii.		(40-47) ?
3. <i>bucklandi</i>					Keynsham.	
2. <i>rotator</i>					Keynsham.	{ (26-29) ? × Wright, Mon. pl. v, f. 4.
1. <i>Vermiceras</i> ...	R.	{ Low. <i>Buckl.</i> [a]. Top <i>angulatus</i> .		{ Keynsham. Sodbury.		21

¹ See R. Tate & J. F. Blake, 'Yorkshire Lias' 1876, pp. 58-62, suggested interpretation.

² W., Wright's records in his 'Monograph of the Lias Ammonites' (Pal. Soc.).

³ Mr. Tutchcr's information, and a summary of MS. sections which he has most kindly allowed me to use.

⁴ My interpretation of Mr. Lang's records, Proc. Geol. Assoc. vol. xxv (1914) pp. 310 *et seqq.*, and one of Wright's records.

[R. Strata in relative position. × In all cases, fauna present, position surmised.]

The faunal sequence below the Sinemurian (Lymian) I leave in the most capable hands of Mr. Tutchcr, who has kindly contributed what is placed as Appendix I, p. 278. He has also given his reading of the lower part of the Sinemurian sequence, as he has observed it in the Bristol district: this, too, I am pleased to record. There are differences in our two accounts; but, as they are records of original observation and research, not statements for a textbook, there is no need to strive for uniformity. Several differences are merely details: he uses trivial names where I employ generic.

There are two main differences: one, his placing of *turneri*, upon which I have already commented (p. 271); the other, his placing, on the evidence of local deposits, a *scipionianum* zone between *Agassicerus (sauzeanum)* and *gmuendense*; this I am quite prepared to accept. The omission of the *vercingetorix* horizon was expected: the area under Mr. Tutchet's observation lacks the fauna, so far as my knowledge goes.

With regard to our use of the term *turneri* zone, it has been objected that this term should be employed in the sense and for the strata to which it was originally applied by Wright. This dictum I traverse. I would argue that the zone of *turneri* is determined not by the author, but by the fossil. The zone of *turneri* is the deposit made while *A. turneri* was in existence: it is the deposit of the hemera *turneri*. If a writer misidentifies *A. turneri*, he misnames its deposit *turneri* zone. If a future historian identified Queen Elizabeth as Queen Victoria, and called the Elizabethan Period the Victorian Age, he would not thereby make it so and shackle future writers. The Victorian Age was determined by the time when Queen Victoria lived; and the *turneri* hemera, and the deposit made then—the zone—must likewise be determined by the time when *A. turneri* lived.

As to who is right or wrong in the determination of *Ammonites turneri* I am not yet prepared to argue.

VI. SUMMARY.

The various horizons of the Ages dealt with in this paper may now be brought together in sequence; and a table (Table IX, pp. 276–77) may be given of certain notable areas of Great Britain and the Continent, recording the presence of the faunal horizons in Scotland, the North and South of England, the Rhone Basin (Dumortier), and Würtemberg (Swabia, Quenstedt). The results are interesting, and they suggest that a more extended analysis on these lines might yield some rather striking information. Such analysis may, perhaps, be attempted at some later date.

VII. CONCLUSION.

This is a sketch, much of it theoretical. Its main purpose is to be a basis for further work, indicating the details and evidence which investigators should look for. Much research is yet necessary to obtain perhaps even an accurate sequence; for it is not claimed that all the sequences are proved: they are offered as interpretations of the present available evidence.

One lesson which may, perhaps, be learnt from this study is that great indeed as is the advantage of collecting specimens *in situ*, yet it is not absolutely essential: in some cases, owing to paucity of sediment and to derivation of specimens, it may even lead to erroneous conclusions. As collecting *in situ* is very often quite impracticable, it may be well to remember that much can be done without it, provided specimens are properly localized. For the

TABLE IX.—GEOGRAPHICAL DISTRIBUTION.

Faunal Horizons.		Areas.				
		West Scotland.	Yorkshire.	Dorset Coast.	Rhone Basin.	Württemberg.
YEOVILIAN. Age of Dumortierians and Grammocerotids.	9. <i>moorei</i>	...	...	×	...	×
	8. <i>Catullocceras</i> ¹	...	...	×	...	×
	7. <i>Dumortieria</i>	...	×	×	×	×
	6. <i>Hammatocceras</i> ²	...	×	×	×	×
	5. <i>dispansum</i>	...	×	...	×	...
	4. <i>struckmanni</i>	...	×	...	×	...
	3. <i>pedicum</i>	...	...	...	×	×
	2. <i>eseri</i> ²	...	...	...	×	×
	1. <i>striatulum</i>	...	×	×	×	×
	11. <i>variabilis</i>	...	×	...	×	×
	10. <i>lilli</i>	...	×	...	×	×
WHITBIAN. ³ Age of Dactylroids and Harpoceratids.	9. <i>braunianum</i>	...	×	...	×	...
	8. <i>fibulatum</i>	...	×	...	×	...
	7. <i>subcarinata</i> { <i>Hild. bifrons</i> fauna <i>Frechiella subcarinata</i> ⁴	×	×	×	×	×
	6. <i>pseudovatum</i>	...	×	...	×	...
	5. <i>falciferum</i>	×	×	×	?	?
	4. <i>exaratum</i>	×	×	...	×	...
	3. <i>tenuicostatum</i>	?	×	?	...	?
DOMERIAN. Age of Amaltheids. See p. 260.	2. <i>acutum</i>	...	×	...	...	?
	1. Harpoceratoid	...	...	×	...	...
	7. <i>spinatum</i>	×	×	×	×	×
	6. <i>lævis</i>	×	×	...	×	×
	5. <i>gibbosa</i>	×	×	×	?	×
	4. <i>algovianum</i>	×	×	×	?	×
	3. <i>acanthoides</i> ⁵	...	...	?	...	...
HWICCIAN. Age of Liparoceratidæ. See p. 263.	2. <i>boscense</i> ⁵	...	...	?	...	...
	1. <i>fieldingi</i> ⁵	...	...	...	...	...
	9. <i>Oistoceras</i>	...	×	×	...	×
	8. 'henleyi'	...	×	×	...	×
	7. <i>davoi</i>	...	×	×	×	×
	6. (3rd capricorn)	×	×	...	?	...
	5. (2nd capricorn)	...	×	...	?	...
WESSEXIAN. Age of Polymorphidæ. See p. 266.	4. <i>latæcosta</i> (1st capricorn)	...	×	×	×	×
	3. <i>Beauiceras</i>	...	×	×	?	...
	2. <i>carinatum</i>	...	×	×	×	×
	1. <i>cheltiense</i>	...	×	×	×	×
	10. <i>valdani</i>	?	×	×	×	×
	9. <i>iber</i>	...	×	×	...	×
	8. <i>ellipticum</i>	...	×	×	...	...
RAASAYAN. Age of Deroceratidæ and Echioceratidæ. See p. 267.	7. <i>bronni</i>	...	×	×	?	...
	6. <i>Platypheuroceras</i>	×	×	×	?	×
	5. <i>trivialis</i>	...	×	×	...	×
	4. <i>jamesoni</i>	×	×	...	...	×
	3. <i>pettos</i>	...	×	×	...	×
	2. <i>peregrinum</i>	...	×	×	...	...
	1. <i>Phricodoceras</i>	...	×	×	...	×
	7. <i>leckenbyi</i>	×	×	×	×	×
	6. <i>aplanatum</i>	×	×	...	×	...
	5. <i>macdonnellii</i>	×	×	...	×	...
	4. <i>ravicostatoides</i>	×	×	×	ptly.	×
	3. <i>bispinigerum</i>	×	?	×	...	...
	2. <i>subplanicosta</i> (<i>densinodum</i>)	×	×	×	?	×
	1. 1st <i>Echioceras</i>	×	×	...	?	...

TABLE IX (continued).

Faunal Horizons.		Areas.				
		West Scotland.	Yorkshire.	Dorset Coast.	Rhone Basin.	Württemberg.
DEIRAN. Age of Oxycone Arietids. See p. 269.	8. (<i>lymense</i>)	..	..	×		
	7. <i>Radstockiceras</i>	..	..		×	
	6. <i>Gleviceras</i>	..	..	×	×	
	5. <i>polyphyllum</i>	..	×			
	4. <i>orynotum</i>	..	..	..		×
	3. <i>biferum</i>	..	..	..		×
	2. <i>simpsoni</i>	..	×			
	1. <i>Gagaticeras</i>	..	×		×	
MERCIAN. Age of Catagenetic Arietids. See p. 271.	7. <i>denotatus</i>	..	×			×
	6. <i>stellare</i>	..	..	×	×	
	5. <i>planicosta</i>	..	×	×		×
	4. <i>sagittarium</i>	..	×	..		×
	3. <i>obtusum</i>	..	×	×		
	2. <i>brooki</i>	×	..	×		
	1. <i>turneri</i>	..	..	×		
	8. <i>birchi</i>	×	×	×	×	
LYMIAN. Age of Anagenetic Arietids. See p. 273.	7. <i>Arnioceras</i>	×	×	×	×	×
	6. <i>Agassiceras</i>	×	×	?	×	×
	5. <i>gmueudense</i>	×	..		×	×
	4. <i>vercingetorix</i>	..	?	?	×	×
	3. <i>bucklandi</i>	..	..			?
	2. <i>rotator</i>	..	..	×	×	
	1. <i>Vermiceras</i>	×	×	×	×	×

[For the Hettangian sequence, see Appendix by Mr. Tutchet, p. 278.]

¹ Suggested on the evidence of a fauna in the Yeovil & Bridport Sands.

² See S. S. Buckman & E. Wilson, Q. J. G. S. vol. lii (1896) p. 688, footnote 2.

³ In Württemberg Quenstedt's Lias ϵ (=middle and lower parts of Whitbian) seems to be fragmentary; but, on the other hand, it would appear to possess certain horizons of its own not yet separated out in other areas.

⁴ *Frechiella subcarinata* is a notable and easily recognized species; but, perhaps, somewhat too rare to be quite suitable for this scheme. It is in use for the horizon where *Hildoceras-bifrons* forms are abundant. To prevent misconception it is advisable to analyse further. *F. subcarinata* without *H. bifrons* forms is not yet known to me; but the latter are found where the former is lacking. *F. subcarinata* occurs in Yorkshire, the Midlands, in Somerset, but not in Dorset nor Gloucestershire. It occurs in the Rhone Basin, the Austrian Alps, and Italy, but not in Württemberg. Its rarity may account for its absence, say, from Gloucestershire, but can hardly be pleaded for the well-searched Dorset Coast, and certainly not for so well-worked an area as Württemberg. Absence of a special deposit seems to be the explanation required there.

⁵ The fauna of horizons 1-3 are illustrated in Reynès, 'Géol. Pal. Aveyron.' 1868 Monestier's paper, *jam cit.*, refers to the same district.

best results the label should give not only the name of the place, but the exact exposure—the more detailed the better. Then the sequence of dissimilar faunas can be ascertained, especially when the exposures stretch across the line of strike.

But, even with localities alone, much can be done by analysis and comparison.

Another lesson may be learnt—it has been taught that the absence of the zone-species did not invalidate the placing of the strata in such a zone, provided that the stratigraphical position was accordant: it was only a local peculiarity. Such an assumption is now seen to be very unsafe: such cases must be looked upon with considerable suspicion. Dissimilar faunas, of locomotive organisms like Ammonites, in contiguous areas are products, not of zoological, but of stratigraphical differences. There are zoological provinces; but the absence of a southern fauna from a northern area may mean less for difference of date than the absence of a northern fauna from a southern area. Yet in the case of two areas in approximately the same latitude, the absence from one of a fauna well-developed at the other, both said to be on the same horizon, may well cause doubt as to their contemporaneity. This is a true case of dissimilar faunas.

The need for a much more systematic and continuous palæontological output and for fuller illustration of species is obvious from this investigation, where much difficulty of interpretation is due to the uncertainty of unillustrated records. Such an investigation as this is both hindered and hampered by the present condition of palæontology, which cannot keep pace with,—in fact, is continually falling behind, the discovery of new material. Such palæontological study requires very considerable time; and the facilities for its prosecution and publication seem to be inadequate.

Finally, I take the whole responsibility for the interpretations that I have placed on the information and evidence laid before me; it must not be thought that my informants necessarily concur in my views. For any mistakes—and it is too much to expect freedom from error—I shall be to blame; but I will be grateful for any facts which expose them.

APPENDIX I. THE ZONAL SEQUENCE IN THE LOWER LIAS (LOWER PART). By J. W. TUTCHER.

(1) Introduction.

The district of North Somerset and South Gloucestershire—approximately that occupied by the Bristol Coalfields—has chiefly come under my observation. In this district the Lias has been thrown into a series of folds having, in the main, an east-to-west trend. These folds increase in intensity from north to south, becoming more marked as the Mendip Hills are approached. Partial and repeated denudation of the Jurassic rocks has followed

folding, thus causing numerous local non-sequences. In the neighbourhood of Radstock the *sauzeanum* zone, in which occurs the large number of *Spiriferina walcotti* for which that place is noted, may be found resting indifferently on any earlier zone down to *langportensis* (White Lias, see Table X below).

In the Keynsham area, which lies in the middle of the district under consideration, the Lias occupies a shallow syncline, and the beds have not been denuded to the same extent as those on the south and north. Chiefly in this area the faunal sequence of the Sinemurian deposits has been determined.

The Hettangian deposits, as a whole, are best displayed in an area of which Bristol is the centre.

In the following table it will be observed that the White Lias is included with the Hettangian. In common with the late Dr. A. Vaughan and the late Edward Wilson, I have always held the view that, for palæontological reasons, the line dividing Lias from Rhætic (Hettangian from Rhætian) should be drawn at the base of the White Lias. Mr. Buckman, it may be remarked, has expressed the view that the Hettangian should be regarded as the final phase of the Trias—on the grounds of the biological characters of Ammonites, the decadent characters of *Psiloceras* and allies, and the new departure (anagenetic characters) of the Arietidæ of the Sinemurian.¹

TABLE X.—ZONES OF THE LOWER LIAS (LOWER PART).

Ages.	Zonal terms.	Name of Index fossil.
SINEMURIAN.	<i>turneri</i> .	<i>Arietites turneri</i> (J. de C. Sowerby).
	<i>sauzeanum</i> .	<i>Agassicerias sauzeanum</i> (D'Orbigny).
	<i>scipionianum</i> .	<i>Ætioceras scipionianum</i> (D'Orbigny).
	<i>gmüendense</i> .	<i>Coroniceras gmüendense</i> (Oppel).
	<i>bucklandi</i> .	<i>Coroniceras bucklandi</i> (J. Sowerby).
	<i>rotiforme</i> .	<i>Coroniceras rotiforme</i> (J. Sowerby).
HETTANGIAN.	<i>conybeari</i> .	<i>Vermiceras conybeari</i> (J. Sowerby).
	<i>angulata</i> .	<i>Schlotheimia angulata</i> (Schlotheim).
	<i>liasicus</i> .	<i>Alsatites liasicus</i> (D'Orbigny).
	<i>[megastoma]</i> .	<i>Wæhneroceras megastoma</i> (Wæhner)]. ¹
	<i>johnstoni</i> .	<i>Caloceras johnstoni</i> (J. de C. Sowerby).
	<i>planorbis</i> .	<i>Psiloceras planorbis</i> (J. de C. Sowerby).
	<i>Ostrea</i> .	<i>Ostrea liassica</i> Strickland, and its mutations.
	<i>tatei</i> .	<i>Pleuromya tatei</i> Richardson & Tutchet. ²
	<i>langportensis</i> (White Lias).	<i>Volsella langportensis</i> , Richardson & Tutchet. ³

¹ Not found in the district, but a *Wæhneroceras* fauna occupies this position elsewhere. See p. 280.

² Proc. Yorkshire Geol. Soc. vol. xix (1916) p. 52 & pl. viii, fig. 3.

³ *Ibid.* p. 54 & pl. ix, fig. 11.

¹ 'Jurassic Time' Q. J. G. S. vol. liv (1898) pp. 444–47.

(2) Remarks on the Zones.

The *turneri*=*semicostatum* Zone (*pars*) auctt.—More than one species of *Arietites* passes under this trivial name; it is, therefore, desirable to indicate the form intended. This is an evolute shell, with compressed sides, and rectangular whorl-section, agreeing with the upper figure in pl. cecclii of the 'Mineral Conchology,' but not with Wright's figs. 1-3 in pl. xii of his 'Monograph of the British Lias Ammonites.'

Numerous specimens of *Arnioceras* are associated with *A. turneri* in this district, but since *Arnioceras* spp. also occur abundantly in the *sauzeanum-gmuendense* zones, while *A. turneri* is not found at these levels, the last-mentioned makes the better zonal fossil.

The *sauzeanum* to *conybeari* Zones.—These zones are well exhibited in the quarries about Keynsham. The beds are of no great thickness, but they are very fossiliferous, and the faunal succession is quite clear. North and south of Keynsham some of these zones are missing, notably *conybeari* and *rotiforme*, while paucity of deposit and penecontemporaneous erosion have resulted in considerable compression of those remaining.

The *angulata*, *liasicus*, and *megastoma* Zones.—The beds containing numerous species of *Schlotheimia* are well developed over much of this district, although rarely complete at any one place. Careful study of these beds has suggested division into two well-marked zones which have more than local application. The *angulata* zone is thus restricted to the beds in the upper part of the series. These beds contain, in addition to the index-ammonite and numerous allied species, an abundance of *Rhynchonella calcicosta* Davidson (*non* Quenstedt). In the lower division (*liasicus* zone) *Alsatites liasicus* (D'Orbigny), *Schlotheimia gallica* S. Buckman, and *Ornithella sarthacensis* (D'Orbigny) are common fossils, and they do not pass into the upper division.

No species of *Wæhneroceras* have been obtained in this district, and a non-sequence between *johnstoni* and *liasicus* deposits is therefore assumed. Ammonites of this genus have, however, been recorded from Hock Cliff, near Fretherne (Gloucestershire),¹ and from Evesham (Worcestershire).²

An important *Wæhneroceras* fauna occurs at Kayes Cement-works, Long Itchington, near Southam (Warwickshire). The extensive quarry at this place shows the following sequence:—

<i>conybeari</i> .	<i>Vermiceras</i> spp., <i>Coroniceras</i> spp.
<i>angulata</i> .	{ <i>Schlotheimia angulata</i> , <i>Schl. striata</i> (Quenstedt). <i>Rhynchonella calcicosta</i> Davidson.
<i>liasicus</i> .	{ <i>Alsatites liasicus</i> (D'Orbigny), <i>Schlotheimia</i> spp. <i>Ornithella sarthacensis</i> (D'Orbigny).
<i>megastoma</i> .	{ <i>Wæhneroceras extracostatum</i> (Wæhner), with many other examples of the genus.

¹ L. Richardson, Proc. Cotteswold Nat. F. C. vol. xvi (1908) p. 141.

² S. S. Buckman, *ibid.* vol. xv (1906) p. 246 & pl. x, figs. 5-6.

The specimens of *Wæhneroceras* were obtained by Dr. Robson, of Birmingham. He was informed by the quarrymen that these specimens came from a temporary excavation at the base of the section. On the occasion of my visit this excavation was water-logged, and could not be examined. There is, however, every reason to believe that the statement of the quarrymen is correct. The state of preservation of the specimens is distinctive; they are cleanly-cut casts in a bluish-grey matrix with some pyrites, and no fossils have been found in a similar condition and matrix in any part of the quarry usually worked.

The *johnstoni* Zone.—The ammonite of most frequent occurrence in this zone in the Bristol district is *Caloceras intermedium* (Portlock), but fragments attributed to *C. johnstoni* have been obtained.

The *planorbis* Zone.—The true *Psiloceras planorbis* is rare in the Bristol district; a more evolute form, *Ps. sampsoni* (Portlock), and a costate form, *Ps. plicatum* (Quenstedt), are the dominant species.

The *Ostrea, tatei*, and *langportensis* Zones.—The term *Ostrea* Zone has generally been used to distinguish all the Lias deposits below those in which ammonites occur. It is now proposed to restrict this term to the beds immediately preceding the *planorbis* zone: in these beds *Ostrea liassica* and its mutations attain their maximum.

Ostreæ of the *liassica* type also occur in decreasing numbers in the lower beds; but, in these deposits, other fossils acquire greater importance.

The White Lias is characterized by *Volsella* (*Modiola*) *langportensis*, which appears to be confined to these beds.

Between the White Lias and the maximum of *Ostrea liassica* and its allies, there is a series of beds, more or less continuous from Dorset to Yorkshire, containing in abundance *Pleuromya tatei*. The application of this fossil to zonal purposes has, under an older name (*Pleuromya crowcombeia*), and in a somewhat less restricted sense, already been suggested by Dr. A. Vaughan in collaboration with the present writer,¹ and by Dr. Rendle Short.²

R. Tate & J. F. Blake designate the beds in which this fossil occurs in Yorkshire 'The *Pleuromya* Limestones.'³

¹ Proc. Bristol Nat. Soc. n. s. vol. x, 1903 (issued for 1901), pp. 52, 53 see also A. Vaughan, Q. J. G. S. vol. lix (1903) p. 400.

² Q. J. G. S. vol. lx (1904) pp. 187, 188.

³ 'The Yorkshire Lias' 1876, p. 38.

APPENDIX II.

MAYER-EYMAR'S STRATIGRAPHICAL TERMS.

Since this communication was read Dr. A. Morley Davies has kindly brought to my notice a paper by Mayer-Eymar containing a scheme of stratigraphical terms. This paper seems to have been overlooked generally, perhaps on account of its rarity. As there is no copy in the Geological Society's Library it seems desirable to transcribe the necessary portion. I am much indebted to the courtesy of Prof. Watts for the opportunity to do so. The paper is entitled 'Die Filation der Belemnites acuti' (Vierteljahrsschrift der Zürcher Naturforschenden Gesellschaft, April 1884), and the stratigraphical scheme is to explain the sequence of strata containing these belemnites. The author speaks of a previous scheme published three years earlier: substantially the same, one may presume, but I have not been able to see it. I am, however, indebted to our Librarian, Mr. C. P. Chatwin, for bringing to my notice in answer to my enquiries about this prior paper, another communication by the author in the same year (1884)—a paper of eight lithographed folios giving a classification of all strata.

The following Table XI (p. 283) is the table in the pamphlet first cited, with certain correlations.

By the side of Mayer-Eymar's table are placed the divisions adopted in the present communication, and, alongside those, Quenstedt's divisions of the Lias; but it cannot be claimed that the Swiss author's divisions are rightly interpreted. For instance, it is doubtful whether the Hwicceian is correctly correlated with his Mendin: that may be intended for the lower part of the Domerian; and perhaps it is incorrect to leave the Raasayan without equivalent: some of the basal strata of the Rottorfin and upper horizons of the Balingin may fall within its limits. But Continental authors have apparently only had the opportunity of seeing isolated fragments of strata of Raasayan date, and may perhaps have correlated these fragments criss-cross, placing earlier strata of one locality above later strata of another. We had certainly done that in this country before the Raasay deposits gave the clue.

Had I known about Mayer-Eymar's scheme I should have hesitated to propose some of the new terms; but my terms were in print before his paper came to my notice.¹ So I must leave selection in the hands of my fellow-workers.

¹ Abs. Proc. Geol. Soc. 1916-17, No. 1009, p. 84.

TABLE XI.—MAYER-EYMAR'S SCHEME, WITH CORRELATION.

Mayer-Eymar's Terms.

Terms of Quenstedt's
present Lias
paper. Divisions.²

Mittleres Jura-System.¹

'BATHIAN (Mayer-Eymar).	II. Bedfordin. — Niveau der <i>Terebratula lagenalis</i> .		
	I. Bradfordin. — Niveau des <i>Apicrinus Parkinsoni</i> .		
'VESULLIAN (Mayer-Eymar).	III. Falaisin. — Niveau der <i>Nerinea Voltzi</i> .		
	II. Stonesfieldin. — Niveau des <i>Clypeus Ploti</i> .		
	I. Cadomin. — Haupt-Niveau der <i>Ostrea acuminata</i> .		
	III. Ehningin. — Haupt-Niveau des <i>Ammonites Parkinsoni</i> .		
'BAJOCIAN (D'Orbigny).	II. Scarboroughin. — Niveau des <i>Ammonites Humphriesi</i> .		
	I. Maconin. — Haupt-Niveau des <i>Ammonites Sowerbyi</i> .		
	III. Cheltenhamin. — Niveau des <i>Ammonites Murchisonæ</i> .		
	II. Gundershofin. — Niveau der <i>Trigonia navis</i> .		
'AALENIAN (Mayer-Eymar).	I. Bollin. — Niveau des <i>Ammonites torulosus</i> .		
	III. Alfeldin. — Haupt-Niveau des <i>Ammonites Jurensis</i> .	Yeovilian.	ζ
'TOARCIAN (D'Orbigny).	II. Altortin. — Niveau des <i>Belemnites acuaris</i> .	Whitbian.	ε
	I. Pliensbachin. — Niveau des <i>Belemnites papillatus</i> .		

Unteres Jura-System.

'CHARMOUTHIAN (Mayer-Eymar).	III, a, b. Banzin. — Niveau des <i>Pecten æquivalvis</i> .	Domerian.	δ
	II a, b. Mendin. — Haupt-Niveau des <i>Ammonites fimbriatus</i> .	Hwiccian.	γ
	I, a, b. Rottorfin. — Niveau des <i>Ammonites Jamesoni</i> .	Wessexian.	
		Raasayan.	β
	II, a, b, c. Balingin. — Niveau des <i>Ammonites oxynotus</i> .	Deiran.	
	I, a, b. Filderin. — Haupt-Niveau der <i>Gryphæa arcuata</i> .	Mercian.	α
'SINEMURIAN (D'Orbigny).		Lymian.	
	II, a, b. Hettangin. — Niveau des <i>Ammonites angulatus</i> .	Hettangian.	
'RHÆTIAN ([Gümbel] M.-E.)	I. Kässenin. — Niveau der <i>Avicula contorta</i> .		

¹ The lithographed paper differs in not giving definite divisional terms such as 'Banzin' and so on, but speaks only of 'Couches de Banz' and so on.

² Quenstedt's Lias ζ includes beds higher and lower than Yeovilian, and his Lias ε is of less extent than Whitbian.

APPENDIX III. PALEONTOLOGY.

(a) Introduction.

In the following pages are given descriptions of certain Lias species which are of importance, either because they are additions to the British fauna, and therefore their recognition may be useful in future work, or because they are of stratigraphical significance. Some few of them happen also to be interesting morphologically and biologically; but only casual notice of such features is appropriate now.

A few words of explanation may be given here in reference to the descriptions. The proportions are stated always in the order proposed in 'Yorkshire Type Ammonites' ii, p. viii (1913).—Diameter in mm., breadth of whorl, thickness, size of umbilicus in percentage of diameter; S., measurements from actual specimens, F., from figures,¹ T., from text-statements of author. Other details about descriptive terms will be found in the same place.

At the close of the descriptions I append a few remarks as to the bearing of the described species on the geological-chronological problem (p. 307).

(b) Descriptions of Species.

Family HILDOCERATIDÆ.

Genus LEPTALEOCERAS,² nov.

Type, *L. leptum*, sp. nov.

Definition.—An umbilicate, plate-like, obscurely costate, gammiradiate, stoutly carinate, non-sulcate Hildoceratid. Carina apparently degenerately septecarinate, that is, the cast may not be carinate or so carinate, thus indicating a one-time septate condition; but there is apparently no distinct hollow in the keel: details, however, are obscure. The radial line is of the gamma pattern of *Grammoceras*, very slightly flexed laterally, produced ventrally, but not excessively.

Distinction.—The stout carina recalls *Tiltoniceras* S. Buckman,³ but shape, ornament, and radial line are wholly different. There is some suggestion of *Grammoceras* Hyatt, but this plate-like thin form could not give rise to the stout costates of that lineage. There is a nearer approach to *Protogrammoceras* Spath,⁴

¹ Measurements (especially of small forms) are difficult to obtain accurately. In the case of figures it seems best to lay tracing-paper, and then by a ruler mark diameter and proportions with a sharp pencil. This ensures a true diameter being followed, and saves the plate from the compass-points: the only error may be from the shadow of the umbilical wall.

² λεπταλέος thin, fine, delicate.

³ 'Yorkshire Type Ammonites' ii (1913) p. viii.

⁴ Q. J. G. S. vol. lxxix (1913) p. 547.

particularly in the plate-like shape; and the penultimate whorl-section of Spath's type agrees with the ultimate whorl-section of this genus, suggestive perhaps of common ancestry; but the present genus shows no peripheral sulcation, and has a decidedly different radial line.

Remarks.—Spath says that his genus is 'probably . . . far too comprehensive.'¹ It is, therefore, inadvisable to enlarge it for the reception of this form.

LEPTALEOCERAS LEPTUM, sp. nov. (Pl. XXVI, figs. 1 *a*–3 *b*.)

Description.—Serpenticone; substeno-leptogyral; subextremilatumbilicate; periphery subtabulate, joining a stout fastigate carina with only a slight angle; gammiradiate; lateral area smooth to costulate to smooth.

General details.—The flat, little-overlapping whorls give to the species a disc-like appearance. The inner whorls are somewhat elliptical in section, the outer whorl is suboblong, thickest about the middle, sloping slightly to the periphery, more to the umbilical edge, which is tabulate, narrow and defined in the last whorl, but indistinct previously. The inner whorls are smooth until about 14 mm. diameter; then furnished with subobscure, undulate costulae which die away nearly to smoothness at about 53 mm. diameter—there remain only occasional traces of the previous costulae with fine growth-lines, and ultimately only the latter.

Remarks.—Three specimens are before me, all very similar; but the medium-sized one seems to differ in thickness and slightly in other proportions from the holotype at the same diameter.

The likeness of the smooth anagenetic stage to the similar stage in *Arnioceras* is noticeable (see p. 268).

Distinction.—The considerable Italian literature on Domerian Hildoceratidae has revealed neither to Mr. Lang nor to myself anything really like this species. I am much indebted to Mr. Lang for kind assistance in bibliographic matters in connexion with this Appendix—an important aid at the present time when facilities are so much curtailed.

Below I give proportions of the examples of this species and of others which have some approximation. Of these *Ammonites fieldingi* seems to be the only one possibly of this genus; but its radial line is perhaps too curved: it would represent the smooth or almost smooth anagenetic stage in this or a parallel line; *A. pseudoradians* has the right style of radial line, but a different style of ribbing, and shows no sign of the smooth anagenetic stage; *A. normanianus* has the style of ribbing, but much too curved a radial line; and the others differ by being carinatisulcates, with also a too-much flexed radial line.

¹ Q. J. G. S. vol. lxiix (1913) p. 580.

History of figured specimens.—The holotype is from the collection of Mr. D. S. Darell, F.L.S., F.G.S., and was obtained from South Petherton (Somerset), evidently by its matrix from Marlstone or associated beds. The other two specimens were purchased by Mr. J. G. Hamling, F.G.S., at the sale of the effects of the late Rev. Ingle Dredge: they were in a drawer labelled 'Middle Lias, Gretton.' The piece of matrix which yielded the larger specimen was preserved too—a very good practice: it is a bluish calcareous stone of Marlstone character, and Gretton near Winchcomb (Gloucestershire) was a well-known Marlstone locality. See later, p. 308. I desire to express my thanks to Mr. Hamling for kind presentation of these specimens.

TABLE XII.—PROPORTIONS: *LEPTALEOCERAS* AND LIKE FORMS.

<i>L. leptum</i> , young shell	S. 25,	34,	19,	40.	
<i>L. leptum</i> , holotype ¹	S. {	24,	33,	18,	41.
		35.5,	30,	17,	43.
		66,	24,	16,	52.
<i>L. aff. leptum</i>	S. 35.5,	34,	20,	39.	
<i>Ammonites normanianus</i> D'Orbigny ²	T. 90,	31,	17,	45.	
<i>Protogrammoceras cornacaldense</i> , var. <i>zeugitanum</i> Spath, lii, 1 a ³ .	T. 60,	30,	18,	46.	
<i>Am. pseudoradians</i> Reynès, i [bis], 4 ⁴	F. 46,	37,	21,	37.	
<i>Am. fieldingi</i> Reynès, iv, 1 a, b ⁴ ...	F. 24,	33,	24,	47.	
<i>Harpoceras domeriense</i> Meneghini, App. i, 15 ⁵	F. 31.5	30,	26,	48.	

Family POLYMORPHIDÆ.

ACANTHOPLEUROCERAS RURSICOSTA, nom. nov. (Pl. XXVI, figs. 4 a–4 c.)

1884. *Ammonites valdani* Quenstedt (non D'Orbigny), 'Ammoniten d. Schwäbischen Jura' pl. xxxv, fig. 4 only.

Proportions.—S. { 260, 28, 20, 48.
 { 190, 32, 22, —.

Description.—The features of the type are its large size and the reclination of the ribbing. The general features are well shown in Quenstedt's cited figure—the reclination is less; but increase of reclination may be due to age, to which also is to be attributed loss of inner row of tubercles, rounding of periphery, and decay of keel. The proportions of Quenstedt's fragment I estimate at F. 112, 30, 20, 48.

Distinction.—Reclination of ribs, presence of many marked subsidiary costulæ on periphery, less size of tubercles, convexity instead of concavity of intertuberculate lateral area distinguish

¹ The specimen being broken, approximate measures of inner whorls can be given.

² 'Pal. franç.: Terr. Jur. Céph.' 1844, pl. lxxxviii & p. 291.

³ *Op. jam cit.*

⁴ 'Géol. Pal. Aveyron.' 1868.

⁵ 'Lias sup.' in Stoppani's Pal. Lomb. (4) 1881.

this species from *Ammonites valdani* D'Orbigny.¹ Its whorls are also somewhat broader and thicker. The proportions that he gives are T. 95, 27, 17-19, 48.

History of figured specimen.—Given to me many years ago by the late Rev. F. Smithe, F.G.S., with other large species, as having been found in the Middle Lias clays of Leckhampton (Gloucestershire), when the Banbury & Cheltenham Railway was constructed.

Family ARIETIDÆ.

Genus RADSTOCKICERAS,² nov.

Type, *R. complicatum*, nov.

Definition.—Oxycone, highly involute, septicarinatè; periphery concavifastigate. Radial line indistinct, laterally slightly flexed? slight curving forwards on outer third. Suture-line very highly complicated—one line touching the preceding at so many points as to make the separation of the chambers a very difficult process. The peripheral lobe has two long branches, and five well-developed branches penetrate the external saddle, four of them off the side of the peripheral lobe; the superior lateral lobe narrow-stemmed, strongly trilobate, unequal; inferior lateral lobe broad-stemmed, with short lobules; a considerable array of auxiliary lobes.

Distinction.—The high degree of specialization of suture-line distinguishes this genus from *Oxynoticeras*. Involution is rather more developed; periphery is on rather a lower grade, but is beginning to show the knife-edge of that genus, while suture-line is well beyond it: the array of lobes external to the superior lateral lobe is greater in number and more developed, that lobe is specialized into a long narrow-stemmed lobe of cruciform pattern; while it is the inferior lateral lobe which is in the same stage as the superior lateral of *Oxynoticeras*—broadly U-shaped with short lobules.

RADSTOCKICERAS COMPLICATUM, sp. nov. (Pl. XXVII, figs. 1 a & 1 b; text-figs. 6, p. 294 & 12, 21, p. 295.)

Description.—Oxycone; subextremiplaty-leptogyral; angustumbilicate; periphery concavifastigate, septicarinatè; subdistanti-obscuricostate, gammiradiatè; complicati-septate.

General details.—The type is wholly septate: there are indications of its having lost more than another half-whorl, so that it was a giant of about 380 mm. or nearly 16 inches in diameter. The periphery is not true knife-edge—the side falls into the keel with a concave depression; ribs are rather distant and obscure; greatest breadth is about one-third from the umbilical border which

¹ 'Pal. franç.: Terr. Jur. Céph.' 1844, pl. lxxi & p. 255

² Radstock (Somerset).

falls somewhat steeply to the umbilicus; excentrumbilication is apparent in the last half-whorl (beyond the part preserved)—the overlap decreasing from about four-fifths to two-thirds.

Remarks.—In ornament, periphery, and general appearance the species here described conforms with *Ammonites buvigneri* Dumortier; but it differs in having a larger umbilicus with a much steeper border and a thinner whorl the greatest thickness of which is not on the edge of the umbilical border but well removed from it.

Ammonites buvigneri D'Orbigny is a much thinner species than Dumortier's, and has passed beyond the costate stage. Its umbilicus is much smaller than the Radstock species; its suture-line shows the general pattern thereof, but is not truly conformable in many respects: it does not seem so highly developed: the lobules which penetrate the external saddle are much less developed and different—the first lobule is long and bipartite in the Radstock species, short and simple in D'Orbigny's; the superior lateral lobe has its outer lobule bipartite in the Radstock example, its inner one is so in D'Orbigny's: in the former the terminal lobule has its shortest side internal (endobrachysceles), in the latter external (ectobrachysceles).¹ The specimens figured by Dumortier and D'Orbigny are both separable from the Radstock species by greater occlusion—they are perangustumbilicate. Pompeckj says that these two ought to be considered as the same species:² I differ.

Phylloceras buvigneri Wright is also a perangustumbilicate oxycone, comparable as regards sculpture with D'Orbigny's species, but wholly different in whorl-shape and in suture-line. It looks as if all these oxynotes are homœomorphous terminals of different lineages—their polygenetic origin shown by the different character which each selects for acceleration—in one case suture-line, in another, ornament, in another, inclusion, in another, whorl-shape. Considerable inequality of characters is thus produced.

For references and proportions see Table XIII, below.

History of figured specimen.—From Radstock Grove (Kilmersdon Colliery), Radstock, Somerset, [from beds yielding Oxynotoids immediately below the so-called '*raricostatus* beds']. Purchased. See p. 310.

TABLE XIII.—PROPORTIONS: RADSTOCKICERAS AND LIKE FORMS.

<i>Radstockiceras complicatum</i> nov.	S. 186,	54,	25,	11.
	S. 262,	55,	25,	11.
<i>Ammonites buvigneri</i> D'Orbigny ³ .	F. 200 (93),	56,	21,	4.
	T. 200,	58,	21,	4.
<i>Ammonites buvigneri</i> Dumortier ⁴ .	T. 126,	58,	28,	4.
<i>Phylloceras buvigneri</i> (Wright), lxxvi, 1, 2 ⁵	F. 150,	54,	30,	7.
	T. 145,	56,	32,	4.

¹ 'Monogr. Inf. Oolite Ammonites' p. 381.

² 'Oxynot. Siném.' Comm. Serv. Geol. Port. vi (1906) p. 270.

³ 'Pal. franç.: Terr. Jur. Céph.' 1844, pl. lxxiv & p. 261.

⁴ 'Bassin Rhône' ii (1867) pl. xxxiv, p. 147.

⁵ 'Monogr. Lias Ammonites' (Pal. Soc.).

Genus GLEVICERAS,¹ nov.

Type, *G. glevense*, nov. (paratype).

Definition.—Involute, septicarinate suboxycone, passing to less involute, non-septicarinate platycone—the periphery broadening, carina declining (passing to rounded, uncarinate?), whorls inflating. Ribs subregular, simple. Radial line laterally nearly straight with distinct forward projection, less in stage of rib-decline. Suture-line somewhat complex—no long branches from the external lobe, one accessory lobule in the external saddle, superior lateral lobe rather long, narrow-stemmed, but declining to broad-stemmed later.

Distinction.—From *Oxynoticeras*, the suture-line is more developed, but the oxyconic character is much less developed,—return towards platycone commencing before anything like the knife-edge periphery of *Oxynoticeras* is attained. From *Radstockiceras*, with a lower stage of involution and a rather less developed periphery this genus combines a less complicated suture-line. From *Agassizoceras*, of which at one time I thought it might be an involute development, a suture-line too much developed. See also another character below, p. 292.

Remarks.—The various species which appear to belong to this genus are those cited in the Comparative Table. *Ammonites guibalianus* D'Orbigny and *A. victoris* Dumortier must be excluded for various reasons. See below, p. 293.

GLEVICERAS GLEVENSE, nom. nov. (Pl. XXVII, figs. 2 & 3; Pl. XXVIII, figs. 1 & 2; Pl. XXIX, fig. 3; Pl. XXX, fig. 4; text-figs. 4 & 5, p. 294; 11, 20, p. 295.)

1844. *Ammonites greenoughii* J. Buckman, 'Geol. Chelt.' new ed. p. 89.

1881. *Amaltheus guibalianus* Wright, 'Mon. Lias Amm.' pl. xlv, figs. 6 & 7 only.

1904. *Agassizoceras greenoughi* S. Buckman (non Sowerby) in L. Richardson, 'Handbook of the Geology of Cheltenham' p. 212.

Cf. 1879. *Ammonites guibali* Reynès (non *guibalianus* D'Orbigny), 'Mon. Amm.' pl. xlv, fig. 13 only.

General details.—Whorls broad (inner margin rounded), inclusion nearly to the inner edge of the preceding whorl up to 128 mm. diameter, in another $\frac{3}{4}$ whorl (not preserved) umbilical expansion rapid, inclusion only about $\frac{5}{8}$. Periphery sloping ogival, with raised hollow keel up to about 86 mm. diameter, in another half-whorl keel small, hollow character obsolescent, periphery flattening but narrower than dorsum, in another half-whorl periphery flatly ogival, almost as broad as dorsum, carina almost obsolete. Ribs indistinct, undulate, occasionally bifurcate on the outer margin: they tend to become irregularly obsolete at or after 145 mm. diameter, when irregular swellings (old-age rugosities) appear.

[Final stage (not preserved), smooth (or irregularly swollen) with rounded uncarinate periphery and excentrumbilication?]

¹ Glevum, the Roman name for Gloucester.

Remarks.—These details are drawn up from the holotype. The paratype, *Ammonites greenoughii* of the 'Geol. Chelt.', agrees so closely with Wright's cited figures of *Amaltheus guibalianus* and his description of that form (p. 386), that there need be added only these remarks:—The periphery in Wright's figure is sharper, possibly due to presence of test, the ribs are stronger—over-accenuation of such a character is quite usual in drawings,—and the inner edge of the penultimate whorl is more exposed: the paratype, and the holotype too, show a particularly concentric coiling of the umbilicus, which may be called thimble-shaped, indicating that in the young the species must be rather thin and somewhat widely umbilicate.

The paratype shows (Pl. XXVIII, fig. 2) a rather narrow-stemmed superior lateral lobe, with a fairly even arrangement of fine lobules towards the end: the broader-stemmed lobe of the holotype is presumed to be due to old age.

Below are given the proportions of certain comparable species with those of the species now described. The first three differ in proportions, especially in the greater umbilication; Reynès's *Ammonites guibali* is difficult to place in the series, as no information is given of thickness nor whether it is a large shell reduced.

The very longstanding and very general confusion of Oxynotoids of the *Gleviceras* pattern with *Ammonites greenoughi* J. Sowerby has now been exposed and corrected in a very careful paper by Mr. Spath.¹ But the likeness when, in large specimens of the present species, ribs are lost and the keel is obsolescent or obsolete is certainly remarkable.

History of specimens.—The holotype is from Lias clays above the *oxynotum* horizon, from the lower part of Folly Lane Brickyard, Cheltenham (Gloucestershire). The paratype was recorded as *Ammonites greenoughii* from Lias shales, Lansdown, Cheltenham, Coll. J. Buckman ('Geol. Chelt.' p. 89).

TABLE XIV.—PROPORTIONS: *GLEVICERAS* AND LIKE FORMS.

<i>Am. doris</i> Reynès, xli, 13–15 ² ...	F. 109,	48,	32,	22.
<i>Am. aballoensis</i> Dum. II, xxxviii. ³	F. 117,	48,	35,	20.
<i>Am. greenoughi</i> Hauer, xii, 2, 3, 4. ⁴	F. 112,	48,	29,	20.
<i>Am. guibali</i> Reynès, xlvii, 13 ² ...	F. 203,	47,	—,	20.
<i>Gleviceras glevense</i> , holotype	S. {	86,	47,	25, 19.
		128,	51,	26, 14.
		184,	51,	27, 14.
<i>G. glevense</i> , paratype	S. 148,	52,	26,	14.5.
(Am. greenoughii J. Buckman.)				
<i>G. glevense</i> .				
(<i>Amaltheus guibalianus</i> Wright,	(F. 157,	54,	26,	14.
xlv, 67, p. 386) ⁵	(T. 133,	56,	26,	15.

¹ 'Schlotheimia Greenoughi' Geol. Mag. dec. 6, vol. ii (1915) p. 97.

² 'Mon. Amm.' 1879.

³ 'Bassin Rhône.'

⁴ 'Ceph. N.O.-Alpen' Denkschr. k. Akad. Wissensch. Wien, vol. xi, 1856.

⁵ 'Monogr. Lias Ammonites' (Pal. Soc.) 1881.

[Since this paper was read various other items of *Gleviceras* belonging or akin to the present species have come to light, and are of particular interest.

A large septate specimen from the same place as the holotype, and like it only a half, has, however, stouter proportions: it is, perhaps, more phylogerontic. It shows about a quarter-whorl more; but, what is chiefly interesting is, that the mark of the inner margin indicates that another complete whorl at least must have been present.¹ As the specimen now measures 204 mm. it must, judging by the proportion of radius to diameter as well as by curvature, have been a giant of some 450 mm. diameter. But this inner margin line shows excentrumbilication; for, whereas about 80 per cent. of the whorl was enveloped at one time, in a whorl this has decreased to about 66 per cent., and in less than another half-whorl to about 50 per cent. From this specimen the following proportions may be ascertained:—

S.	{ 140,	52,	35,	(16 P).
	204,	51,	33,	19.
	450,	45,	—,	25.

The umbilicus in old age returns to the somewhat open condition of youth, which is possessed by the young form described in the following paragraph.

The next specimen, quite a young example, is also from the same place; envelopment is about half the whorl; ribs are regular, with occasional bifurcation; there are no signs of auriculoids on the exposed part of the whorl, but there is evidence that they existed in the young stage: the line of the inner margin does not follow a regular curve, but is angular (hexagonal in a turn), displaced at intervals, thrown out of its course, by the presence of the auriculoid excrescences—something similar may be noted in the umbilical margin of spinous species.

This example, which is depicted in Pl. XXVII, fig. 3; Pl. XXIX, fig. 3; and Pl. XXX, fig. 4, gives the following proportions:—

S.	{ 29,	49,	29,	24,	—K. ²
	31,	48,	27,	22,	+K. ²

The next specimen is from Charmouth, a 'pyritised *Oxyno-*

¹ In the course of these investigations I have made a discovery which may be of importance for the identification of types. In my father's descriptions of ammonites, 'Geology of Cheltenham' new ed. 1844 (1845), the diameter given is not that of the specimen as preserved, but is the assumed diameter of the perfect shell. Thus, in his description of *Ammonites gracilis* (p. 104), the diameter is given as 'about 9 in.' The specimen actually measures 145 mm. (5½ inches) in diameter, but is fully septate and carries indications of another half-whorl at least, shown by remains of inner edge. The diameter of 9 inches is obviously reckoned to include this extra half-whorl or so, but is, perhaps, rather an overestimate. This method of giving diameters, now that it is discovered, clears up many discrepancies in these descriptions. It may be that other authors have adopted this plan, which might easily raise doubts as to the identity of types. There is no possible question about the identity of *A. gracilis*.

² Without keel, with keel.

ticerias,¹ presumably from Bed 92,¹ and is in the cabinet of Mr. James Francis, F.G.S., who has kindly consented to its use in illustration. It was communicated to me by Dr. A. Morley Davies, who had noticed its interest in regard to auriculoids.

This is not the same species as the last, but it is near, and it illustrates that which there is reason to suppose is the hidden stage of that one. It is earlier—that is pre-*glevense*—biologically, and may, for the present, be inscribed as *Gleviceras auritulum/glevense*. It is earlier because, though exposing three-quarters of the whorl shown by the young *G. glevense*, it retains auriculoids all the time, which feature the other had lost about a whorl before. Its ribs are also of a different pattern, somewhat irregular, connate on the inner area, joined in button-and-loop style on the outer area by the reflected U-shaped auriculoid: a plain rib parts each connected pair. The umbilicus is angulate. Proportions are not much different; but the periphery is rather blunter. The specimen depicted in Pl. XXX, figs. 5*a*–5*b* & Pl. XXXI, figs. 1*a*–1*b*, gives:

S. 22, 44, 29, 26, ~ K.

The last of these specimens is much separated by its shape, but becomes of interest now as possessing auriculoids combined with a stout whorl and flattened broad periphery.² It is *Ammonites riparius* Oppel,³ from a well at Aston Cross, near Tewkesbury, presumably from the *biferum* horizon. It is thus additionally interesting, as another link between the Gloucestershire and Württemberg faunas.⁴

Neither Oppel's figure nor description lead one to expect auriculoids; but this example shows them well developed: they are connected too by a longitudinal ridge or pseudo-carina—this is shown by Oppel. The inner margin in the umbilicus is angulate, as noticed for the two preceding specimens: not shown by Oppel.

This species may presumably be inscribed as *Gleviceras riparium* (Oppel), for it shows a suture-line (Oppel)—not well exposed in my example (but see Pl. XXX, fig. 3*d*),—which appears to be somewhat more developed than one would expect for this stage of *Oxynoticeras*; but there are obviously several steps yet to be distinctively named connecting this species with the last specimen (*G. auritulum/glevense*): they are supplied to a certain extent by Quenstedt's figures, pl. xxiv, figs. 15 & 16 in 'Ammoniten d. Schwäbischen Jura.' At any rate something very near to this species may be looked for as common ancestor of *Oxynoticeras* and *Gleviceras*, which are thus presumably traceable to a form of *Agassiceras* pattern but possessing auriculoids, and thus differing from that genus.

For further remarks on auriculoids, *Ammonites auritulus*, etc., see 'Yorkshire Type Ammonites' *A. dennyi* 1909, No. 7.]

¹ See Chronological paper, Table V facing p. 267.

² Its approximate proportions are: S. 32, 48, 50, 29+.

³ Pal. Mitth. 1862, pl. xl, fig. 2.

⁴ See Chronological paper, p. 270.

Genus *GUIBALICERAS*, nov. (Figs. 14 & 18, p. 295.)

Type, *Am. guibalianus* D'Orbigny.¹

Distinct from *Gleviceras* by the intermittent character of its ribbing and also by its suture-line. *Am. aballoensis* Dumortier pars,² and *Amaltheus guibalianus* Wright pars³ (*non* D'Orbigny), have the intermittent style of ribbing, and presumably belong to this genus.

Genus *VICTORICERAS*, nov. (Figs. 13 & 19, p. 295.)

Type, *Ammonites victoris* Dumortier.⁴

Distinct from *Gleviceras* by different suture-line, peculiar character of test—striate and punctate,⁵—dichotomous style of ribbing and other characters. The dichotomy begins at the umbilicus, where there is a sort of bunching on the umbilical wall, and is repeated at several stages across the whorl, with short costulae, dichotomous or intercalated, on the periphery.

Fine examples of *Ammonites victoris* occur with *Radstockiceras* at Radstock, with many other remarkable Oxynotoids which must be left for another opportunity.

The suture-lines of some of these Oxynotoid genera are presented in figs. 1–6, p. 294:—

Fig. 1. *Oxynotoceras oxynotum* (Quenstedt), after his figure, Ceph. v, 11.

Figs. 2 a & 2 b. *O. oxynotum* (Quenstedt), from a paratype of *Am. cultellus* J. Buckman in my collection, to show increase of complexity due to age. The specimen, wholly septate, measures 123 mm. (nearly 5 inches) in diameter; and suture-line 2 a is taken at a diameter of about 31 mm., 2 b at about 90 mm.

Fig. 3. *Oxynotoceras polyophyllum* (Simpson), after the figure in 'Yorkshire Type Ammonites' 1909, No. 8.

Fig. 4. *Gleviceras glevense*, genotype, from the specimen figured in Pl. XXVIII, fig. 2.

Fig. 5. *Gleviceras glevense*, holotype, from the large specimen illustrated in Pl. XXVIII, fig. 1.

Fig. 6. *Radstockiceras complicatum*, from the specimen depicted in Pl. XXVII, fig. 1, the suture-line $\times 0.67$: from a photograph.

To facilitate comparison of the various Oxynotoid genera, outlines of the external lobe and saddle and the superior lateral lobe are given in figs. 8–14, p. 295:—

Fig. 8. *Oxynotoceras oxynotum*, after Quenstedt, $\times 2.5$.

Fig. 9. *O. oxynotum* (*Ammonites cultellus*), see above, fig. 2 b.

Fig. 10. *O. polyophyllum*, see above, fig. 3.

Fig. 11. *Gleviceras glevense*, see above, fig. 4.

Fig. 12. *Radstockiceras complicatum*, see above, fig. 5.

Fig. 13. *Victoriceras victoris* (Dumortier), after his fig. *op. cit.* pl. xxxi, fig. 1.

Fig. 14. *Guibaliceras guibalianum* (D'Orbigny), after his fig. *loc. cit.*

¹ 'Pal. franç.: Terr. Jur. Céph.' pl. lxxiii.

² 'Bassin Rhône' ii, pl. xxvii only.

³ 'Monogr. Lias Ammonites' 1881, pl. xlv, figs. 3, 4 only.

⁴ *Op. cit.* ii, pl. xlv, figs. 1 & 2.

⁵ See Dumortier, pl. xxxi, figs. 1 & 2.

Figs. 1-7.—*Suture-lines of Oxynotoids and a Deroceras.*

[For fig. 7, see p. 302.]

[In figs. 9 & 16, for Am. (cultellus) read (Am. cultellus).]

For the same purpose of comparison, outline rib-schemes are given in figs. 15-21, p. 295 :—

Fig. 15. *Oxynoticeras oxynotum*, after Quenstedt.

Fig. 16. *O. oxynotum* (*Ammonites cultellus*), see note to fig. 2 above.

Fig. 17. *O. polyophyllum*, after fig. in Y. T. A., see note to fig. 3 above.

Fig. 18. *Guibaliceras guibalianum*, after D'Orbigny.

Fig. 19. *Victoricerias victoris*, after Dumortier.

Fig. 20. *Glevicerias glevense*, from the specimen figured in Pl. XXVIII, fig. 2.

Fig. 21. *Radstockicerias complicatum*, from the specimen depicted in Pl. XXVII, fig. 1 : this outline is of the natural size.

The genotypes of these Oxynotoid genera are all in about the same stage of morphic equivalence, but all differ in degree of development of various characters. Thus, in regard to suture-line, some make more elaboration in the lobules of the external saddle, some in the superior lateral lobe; in regard to periphery, *Oxynoticeras* is the only one that has attained to the knife-edge stage, *Radstockicerias* approaches, *Glevicerias* is far from it. An analysis of the genera on these and other features gives the following results in descending order :—

Saddle.	Sup. lat. lobe.	Periphery.
5. <i>Radstockicerias</i> .	5. <i>Radstockicerias</i> .	5. <i>Oxynoticeras</i> .
4. <i>Oxynoticeras</i> .	4. <i>Glevicerias</i> .	4. <i>Radstockicerias</i> .
3. <i>Guibaliceras</i> .	3. <i>Victoricerias</i> .	3. <i>Guibaliceras</i> .
2. <i>Victoricerias</i> .	2. <i>Guibaliceras</i> .	2. <i>Victoricerias</i> .
1. <i>Glevicerias</i> .	1. <i>Oxynoticeras</i> .	1. <i>Glevicerias</i> .
Ribbing.	Umbilicus.	Result: Nat. Order.
5. <i>Victoricerias</i> .	5. <i>Radstockicerias</i> .	5. <i>Radstockicerias</i> (22).
4. <i>Oxynoticeras</i> .	4. <i>Victoricerias</i> .	4. <i>Oxynoticeras</i> (17).
3. <i>Radstockicerias</i> .	3. <i>Oxynoticeras</i> .	3. <i>Victoricerias</i> (16).
2. <i>Glevicerias</i> .	2. <i>Guibaliceras</i> .	2. <i>Guibaliceras</i> (11).
1. <i>Guibaliceras</i> .	1. <i>Glevicerias</i> .	1. <i>Glevicerias</i> (9).

The natural order is arrived at by adding the position-marks attained under the five different bases of analysis.

Amaltheus lymensis Wright (pl. xlv, figs. 1-3 & pl. xlvii, figs. 1-3) cited as *Oxynoticeras lymense* in my Chronological paper, p. 270, would seem not to belong to any of these genera. To be *Oxynoticeras* it should have a suture-line more complicated than that of *O. polyophyllum*, but its skeleton outline is more that of *Guibaliceras*.

Genus ARIETITES Waagen.

ARIETITES TURGESCENS, sp. nov. (Pl. XXIX, figs. 2 a & 2 b; Pl. XXXI, fig. 5.)

Cf. 1864. *Ammonites turneri* Wright (non J. de C. Sowerby sp.), 'Amm. of Lias' Proc. Cotteswold Club, iii, pl. ii, fig. 4.

Cf. 1879. *Arietites turneri* Wright (non J. de C. Sowerby sp.), 'Lias Ammonites' pl. xii, figs. 1-3; 1881, p. 292.

Cf. 1879. *Ammonites brooki* Reynès (non J. Sowerby sp.), 'Mon. Amm.' pl. xliii, figs. 6 & 7.¹

¹ These three references happen to be all figures of one specimen; see p. 322.

Description.—Serpenticone; platysubpachygyral, latumbilicate to perlatumbilicate, carinati-sulcate, costate, gammiradiate.

Remarks.—This inflated *Arietites* is sufficiently well represented in Wright's figure and description, although Wright's form attained to somewhat greater stoutness at an earlier age. Reynès's shell has similar proportions to Wright's 1879 figure, but is somewhat different in ribbing.¹ The shell now described is neither *A. turneri* nor *A. brooki*, as the proportions stated on p. 298 will show; it is an inflated development of *A. turneri*, and is not intermediate between *A. turneri* and *A. brooki*, as the latter belongs to the compressed stock.

Apart from its geological interest, which will be discussed presently (p. 311), and its biological interest as an inflated *Arietites*, the shell now described is noticeable for a pathological development. On the periphery of the last quarter of the outer whorl the strong keel and furrows suddenly cease, and a rounded venter is produced: the much ventrally-projected radii which accompanied keel and furrows—one of the generic characters of *Arietites*—also suddenly give place to radii crossing the venter with a slight linguiform bend (Pl. XXXI, fig. 5). This change is presumably due to injury, and the injury has brought on highly-accelerated catagenesis of the periphery, but has not affected the strength of the lateral ribs. We know that catagenesis is the reversal of anagenesis, and we know from allied stocks that keel and furrows ultimately die away leaving a rounded venter; also that highly-projected ventral radii will return to a less projected state. But such catagenesis is usually gradual, and comes on with general decay of ornament all over, usually after a period of compression with umbilical contraction. Here the catagenesis is local, and is produced in a sudden jump²; the specimen was in a flourishing state, and apparently was on its way (see Wright's example) to produce thicker forms.

I have had by me for many years a considerable series of these pathological specimens, having had hopes of illustrating and discussing them. They should be of more than ordinary interest, because in connexion with the law of tachygenesis, and with the law of catagenesis being the reversal of anagenesis, they might contribute important items of knowledge to the science of pathology.

History of the figured specimen.—From a hard bluish, decomposing to a soft white (chalky) matrix of Lower Lias, out of the excavation for the reservoir of the Bristol Waterworks at Barrow Gurney (North Somerset)—purchased. In the aperture is a small *Xipheroceras* of the *planicosta* style.

¹ But see p. 322.

² It is noteworthy that, as yet, there are no known descendants of *Arietites* reproducing the rounded venter of this sudden jump. The nearest analogues are the degenerate *Asteroceras* of the *sagittarium* pattern (see Chronological paper, p. 271), and so far as is known they are evolved by gradual change and normal earlier inheritance of characters (tachygenesis) as is the case with other ammonites.

TABLE XV.—PROPORTIONS: *ARIETITES*
(*BROOKI* AND *TURGESCENS* SERIES).

brooki, Series.	{	<i>Arietites</i> aff. <i>plotti</i> (Reynès). (<i>Ar. bonnardii</i> Wright, xi, p. 287). ¹	{	F. 114,	22,	20,	57.
				T. 110,	22.5,	20,	—.
		<i>Arietites plotti</i> (Reynès). (<i>Am. plotti</i> Reynès, xxxvi, 15, 16). ²	F. 97,	26,	25.5,	53.	
		<i>Arietites turneri</i> (J. de C. Sowerby). (<i>Ammonites turneri</i> Sowerby, cccclii, top fig.). ³		F. 79,	32,	[26],	46.
		(<i>Am. turneri</i> Reynès, xl, 18, 19). ²	F. 65,	31,	26,	46.	
		<i>Arietites</i> sp. (<i>Arietites</i> sp. Lang, from Bed 77). ⁴		S. 53,	34,	26?,	40?
		<i>Arietites brooki</i> (J. Sowerby). (<i>Ammonites brooki</i> Wright, ii, 5). ⁵	{	F. 92,	37,	27,	34.
		(<i>Am. brooki</i> Wright, vi, 4, p. 280). ¹		F. 142,	37,	—,	34.
			{	T. 140,	39,	28,	—.
		(<i>Am. brooki</i> Reynès, xxxvii, 5, 6). ²		F. 147,	36,	27,	35.
		(<i>Am. brooki</i> Sowerby, cxc) ³		F. 148,	40?,	—,	35.
turgescens. Series.	{	<i>Arietites turgescens</i> , nov. ⁶	{	S. 171,	33,	32,	45.
		<i>Arietites</i> aff. <i>turgescens</i> . (<i>Ar. turneri</i> Wright, xii, 1-3). ¹		F. 53,	35,	35,	42.
				F. 118,	37,	34,	37.
				T. 115,	35,	33,	—.

Genus ARNIOCERAS Hyatt.

ARNIOCERAS FLAVUM, nom. nov. (Pl. XXXI, figs. 2 a & 2 b.)

1878. *Arietites semicostatus* Wright (non Young & Bird sp.), 'Lias Ammonites pl. i, fig. 7 only.

Description.—Subplaty-subleptogyral; subextremilatumbilicate; periphery fastigate, distincti-carinate; whorls smooth; suture-line simple, external lobe about as long as superior lateral.

Remarks.—A smooth, keeled *Arnioceras*, possibly adult. Arniocerates in the smooth stage have been made types of five species, and names of other species have been applied to them. For consideration now are—

1. 1858, *Ammonites miserabilis* Quenstedt.
2. 1867, *Psiloceras acutidorsale* Hyatt.
3. 1867, *Arnioceras cuneiforme* Hyatt.
4. 1876, *Ægoceras nigrum* Blake.
5. 1878, *Arietites semicostatus* Wright (non Young & Bird sp.).
6. 1883, *Ammonites falcarius lævissimus* Quenstedt.

The species now described, however, agrees only with Wright's, judging his figure as depicting a keel, for Hyatt's and Blake's species are both ruled out by their peripheries. *Psiloceras acutidorsale* has 'abdomen prominent, acute,'—no mention of a distinct keel; Blake's *Ægoceras nigrum* has an 'angular front'; and Hyatt's *Arnioceras cuneiforme* is figured with merely a sharply angulate periphery; *Ammonites falcarius lævissimus* is different in proportions, so there remains only *A. miserabilis*, which Quenstedt

¹ 'Monogr. Lias Ammonites.'

² 'Mon. Amm.' 1879.

³ 'Mineral Conchology.'

⁴ See Chronological paper, p. 271.

⁵ Proc. Cotteswold F. C. vol. iii, 1864.

⁶ Where the keel ends.

described as having a keel like a piece of string rolled round.¹ This fits the present species well; there is a distinct angle at the junction of periphery and keel; but Quenstedt's is a more slowly coiled form. The present species has the side-view of Blake's *Ægoceras nigrum*, but the periphery of Quenstedt's *Ammonites miserabilis*.

Before proceeding further it is necessary to mention Hyatt's and Quenstedt's later interpretations of their species. In 1889 Hyatt recognized his *Psiloceras acutidorsale* as an *Arnioceras*, and identified it as one variety of *Ammonites miserabilis*, his *Arnioceras cuneiforme* being another. He then gave figures of these forms, and these figures must be regarded as at least the lectotypes of his original species. But his original description of *A. cuneiforme* speaks of 'pilæ' on the side, and 'a keel indicated by a ridge; channels obsolete'—characters which do not seem to appear in his later figures. In this case, if not in the former, he possibly combined various forms in his two species.

Quenstedt has also combined various forms in his later work—'Ammoniten d. Schwäbischen Jura' pl. xiii, figs. 27–30. His figs. 27 & 28 are without distinct keel, his fig. 29 has a distinct keel; and his fig. 30 from Tewkesbury has, in my opinion, nothing to do with *Arnioceras*: it is a young stage of *Bifericeras*.²

A table of the proportions of the various forms discussed may now be given.

TABLE XVI.—PROPORTIONS: *ARNIOCERAS*, SMOOTH SPECIES.

Periphery angulate.

1. <i>Arnioceras</i> cf. <i>acutidorsale</i> (Hyatt). (<i>Ammonites miserabilis</i> Quenstedt, xiii, 27) ³	F. 26,	22,	20,	60.
(<i>Am. miserabilis</i> Quenstedt xiii, 28) ³ ...	F. 17·5,	22,	21,	59.
2. <i>Arnioceras acutidorsale</i> (Hyatt), ii, 4 ⁴ ...	F. 32,	26,	—,	54.
3. <i>Arnioceras cuneiforme</i> Hyatt, ii, 5 ⁴	F. 20·5,	25,	24?	55.
4. <i>Arnioceras nigrum</i> (Blake). (<i>Ægoceras nigrum</i> Blake, vi, 6) ⁵	{ F. 20·5,	28,	—,	49.
	{ T. 19,	27,	26,	—.

Periphery with distinct keel.

1. <i>Arnioceras</i> aff. <i>miserabile</i> (Quenstedt). (<i>Ammonites miserabilis</i> Quenstedt, pl. xiii, fig. 29) ³	F. 17,	22,	19,	59.
2. <i>Arnioceras miserabile</i> (Quenstedt). (<i>Ammonites miserabilis</i> , Quenstedt, pl. viii, fig. 7) ⁶	F. 16·5,	25,	—,	56.
3. <i>Arnioceras flavum</i> , nov. (<i>Arietites semicostatus</i> Wright, i, 7) ⁷ ...	F. 28,	26,	—,	52.
(holotype, Pl. XXXI, fig. 2)	S. 25,	27,	20,	51.
4. <i>Arnioceras lævissimum</i> (Quenstedt). (<i>Ammonites falcarius lævissimus</i> Quenstedt, pl. xiii, fig. 18) ³	F. 30,	33,	21,	44.

¹ 'Ammoniten d. Schwäbischen Jura' p. 71.

² 'Yorkshire Type Ammonites' ii (1913) p. iii.

³ *Op. jam cit.*

⁴ 'Gen. Arietidae.'

⁵ R. Tate & J. F. Blake, 'Yorkshire Lias' 1876.

⁶ *Op. jam cit.* 1856.

⁷ 'Monogr. Lias Ammonites' 1878.

If these forms were to be combined under one name as *Arnioceras miserabile* without taking account of the differences of periphery and proportions, it is possible that certain facts of geographical and stratigraphical distribution might be overlooked for want of distinctive appellations. It is not yet known that the different forms are of strictly identical dates; and on the geographical distribution something will be said later (p. 314).

Facts of evolution might also be lost without distinctive names. For there seem to be really two lines developing side by side—one in which the periphery proceeds no further than the angulate stage but the whorl increases laterally—in thickness; the other in which the periphery proceeds past the angulate stage to a carina with indications of channels, but the lateral development lags behind—the increase in whorl-thickness is slower. Of the first series 1–3 are morphic equivalents of 1, 2 of the second; 4 of the first is in the same relation to 3 of the second, while 4 of the second stands isolated.

To Hyatt's idea that the smooth forms of *Arnioceras* are derivatives of *Psiloceras planorbis* I cannot assent. *Ps. planorbis* and like smooth forms of that genus are catagenetic—post-costate—developments with a degenerating phylloid suture-line. The smooth forms of *Arnioceras* are anagenetic developments—pre-costate—with a ceratitic suture-line, simple because undeveloped. The likeness is deceptive: it is a case of transversal homœomorphy.¹

The next species well illustrates the precostate character of smooth *Arnioceras*.

History of figured specimen.—From the Lias of Lyme Regis (Dorset)—purchased there. It is yellowish-brown—hence the trivial name—the colour which Sowerby illustrates for his *Ammonites brooki*.² This character may perhaps be a means of fixing its exact stratigraphical position. See later, p. 314.

ARNIOCERAS ANAGENETICUM, sp. nov. (Pl. XXXI, figs. 3 a–3 d.)

Cf. 1889. *Arnioceras semicostatum* Hyatt (*non* Young & Bird sp.), 'Gen. Ariet.' pl. ii, fig. 10 only.—Proportions: F. 34, 26, 26, 51.

Proportions. $\left\{ \begin{array}{llll} \text{S. 24,} & 23, & 25, & 44. \\ & \text{S. 42,} & 27, & 20(24), & 51. \end{array} \right.$

Description.—Serpenticone; subplaty-subleptogyral; subextremilatumbilicate; carinati-subsulcate; mainly smooth, finishing costate, parvinodate.

General details.—The distinctive feature of this species is a prolonged smooth or nearly smooth stage, for over most of this stage capillation and occasional very obscure costulae may be detected. On the last quarter-whorl are developed what must be regarded as adult or even old-age characters—costae plain at first, but later on bearing incipient tuberculation—small nodes.

¹ 'Yorkshire Type Ammonites' ii (1913) p. vi.

² 'Mineral Conchology' 1818, pl. cxc.

The periphery at the beginning of the last whorl is carinate and tabulate; at the end of it, carinate-subsulcate. Body-chamber just under half a whorl, specimen being presumably complete.

Remarks.—The smooth stage of this species being distinctly keeled connects it with the keeled series of smooth *Arniocerates*, and it is presumably a development of the *miserabile-flavum* line. The ribs being only slightly reclinate it may reasonably pass into the *Arnioceras-bodleyi* series of costate *Arniocerates*; less likely into the next species. In the species now described the ribs are an adult or old-age feature, in the costate *Arniocerates* a juvenile character—an illustration of the law of tachygenesis. In the species now described small nodes make their appearance almost as soon as ribs; but in some lines of costate *Arniocerates* nodes are long in appearing—may not appear at all. The difference in the time of developing nodes may be a means of distinguishing lineages in costate *Arniocerates*, as the time of carination seems to be among the smooth forms.

History of figured specimen.—From blue Lias Limestone of Lyme Regis (Dorset)—purchased there. The test has the same colour as *Arnioceras flavum*. In the matrix is a small example of what is perhaps *Cymbites*.

[Since this paper was read I have obtained the presumed holotype of *Ammonites semicostatus* Young & Bird. It is illustrated in 'Yorkshire Type Ammonites' 1918, pl. cxii.]

ARNIOCERAS FORTUNATUM, sp. nov. (Pl. XXVIII, fig. 4; Pl. XXXI, figs. 4 a & 4 b.)

Cf. 1883. *Ammonites ceratitoides* Quenstedt, 'Ammoniten d. Schwäbischen Jura' pl. xiii, fig. 8 (not of 'Cephalopoden' 1849, pl. xix, fig. 13).

Description.—Serpenticone; subplatygyral to substenogyral; leptogyral; subextremilatumbilicate; carinate-sulcate; rursisub-recticostate, parvinodate. Smooth stage to about 10 mm. diameter, costulate to about 18 mm., then an injury, costate from about 20 mm. onwards. The costæ are decidedly reclinate and nearly straight on lateral area, sharply projected beyond small nodi, which are situated on the periphero-lateral border. Suture-line simple.

Remarks.—This species is much larger than any *Arnioceras* known to me in literature; but Mr. Tutchet has a fragment of an *Arnioceras* from Radstock which would measure about $5\frac{1}{2}$ inches (140 mm.) in diameter. The species is distinct from *A. bodleyi* (J. Buckman) by its more reclinate, wider-spaced ribs and by a somewhat smaller umbilicus at the same diameter. It might be suggested that the reclinate ribs were due to the injury in the young stage, but it is evident that the specimen entirely recovered from this, and was so little affected that it grew to an unusual size. Mr. Tutchet has Radstock specimens of *Arnioceras* with much reclinate ribs. Also Quenstedt figures a form which has the same

style of reclinate and well-spaced ribbing. Quenstedt's specimen is not, however, quite the same: it is the next step onward; its smooth stage is evidently shorter, its whorl somewhat broader, and its umbilicus rather narrower.

For dimensions of this and comparable species, see below.

History of figured specimen.—Out of a dark (phosphatic?) limestone of the Lower Lias from Paulton, near Radstock (Somerset)—purchased from a workman.

TABLE XVII.—PROPORTIONS: *ARNIOCERAS FORTUNATUM* AND LIKE FORMS.

<i>Arnioceras fortunatum</i> , nov.	S.	{	62,	26,	—,	54.
			80,	23,	16(18),	57.
			121,	20,	16(17+),	60.
<i>Arnioceras</i> aff. <i>fortunatum</i> . (<i>Ammonites ceratitoides</i> Quenstedt, xiii, 8) ¹ .	F.	49,	27,	17(21),	51.	
<i>Arnioceras bodleyi</i> (J. Buckman). (<i>Ammonites bodleyi</i> J. Buckman, xi, 7) ² ...	F.	68,	25,	18(20)?,	56.	
(<i>Arietites semicostatus</i> Wright, i, 4, 5) ³ ...	F.	74,	24,	17,	57.	
(<i>Ammonites ceratitoides</i> Quenstedt, xiii, 10) ¹ .	F.	76,	25,	17(19),	58.	
(<i>Arnioceras bodleyi</i> S. Buckman) ⁴	S.	62,	23,	17(21),	57.	

CORONICERAS BUCKLANDI (J. Sowerby).

1816. *Ammonites bucklandi* J. Sowerby, 'Mineral Conchology' vol. ii, pl. cxxx & p. 69.

Mr. Tutchet has a large specimen from Keynsham, near Bath (Somerset)—a topotype, for Sowerby's 'Bath and the neighbourhood' doubtless meant Keynsham. He gives the following proportions, S. 493, 26, 32, 55; and Sowerby's figure, allowing for foreshortening, I estimate to give much the same: his figure is presumably reduced to about a quarter of the natural size.

Most interpretations of this species fail to allow for the great thickness of whorl maintained to 20 or more inches in diameter. See Chronological paper, p. 273.

Family DEROCERATIDÆ.

Genus DEROCERAS Hyatt.

DEROCERAS BISPINIGERUM, nom. nov. (P. 294, fig. 7.)

1903. *Deroceeras* sp., S. S. Buckman, Q. J. G. S. vol. lix, pl. xxvii, figs. 5 & 6 (holotype).

1914. Bituberculate Deroceeratid, Lang, Proc. Geol. Assoc. vol. xxv, p. 321.

Remarks.—This name is for a species already figured in the Society's Journal but without trivial appellation. As Mr. Lang has now found another example 37 mm. in diameter, with the same

¹ 'Ammoniten d. Schwäbischen Jura.'

² 'Geology of Cheltenham' new ed. 1844.

³ 'Monogr. Lias Ammonites' 1878.

⁴ Figured in 'Palæontologia Universalis' 1904, No. 36, T¹. The end of the whorl, it should be noted with regard to figs. T^{1a}, T^{1b}, is somewhat swollen with pyrites.

mineral condition, as he has obtained it *in situ* (which fixes the horizon for the first specimen), and, as it marks a definite horizon in the Raasayan, a full name is desirable.

This species is comparable with two of Geyer's, but differs from his *Ægoceras præcursor*, with which it shares the radial linear ornament, by whorl-shape—whorl widest at the periphery—the retention of the inner row of spines, and yet having less whorl-inflation. His *Ægoceras bispinatum* is separable by having a more rounded periphery, a different whorl-shape, more approximate spinicostæ, and less differentiation in spines of the two rows. For references and proportions, see table below.

History of the types.—Holotype, from a bed of Lias yielding pyritized fossils in the neighbourhood of Lyme Regis (Dorset)—purchased there. Paratype, 'in place, bed 94, about 4 feet above *Oxyotus* bed. About 800 yards west of Westhay Water, east of Charmouth,' Dorset; Coll. W. D. Lang, No. 2578. See Table V, facing p. 267.

TABLE XVIII.—PROPORTIONS: *DEROCERAS*, ETC.

<i>Deroceras bispinigerum</i> , holotype	S. 55,	28,	35,	50.	
Do. do. paratype	S. 37,	28,	34,	49.	
<i>Ægoceras præcursor</i> Geyer ¹	{	F. 48,	32,	38,	45,
		T. 50,	26,	30,	49.
<i>Ægoceras bispinatum</i> Geyer ²	F. 55,	30,	35,	46.	

Genus MICRODEROCERAS Hyatt.

MICRODEROCERAS DEPRESSUM, nom. nov. (Pl. XXX, figs. 1a & 1b.)

1867. *Ammonites birchi* Dumortier (*non* J. Sowerby), depressed variety, 'Bassin du Rhône' vol. ii, pl. xli, figs. 1, 2, p. 130.

Remarks.—This name applies to the shell figured by Dumortier, which he notes as different from that figured by Sowerby and A. d'Orbigny. He calls it a depressed variety, and that appellation is retained in the present trivial name. The holotype, however, is an English specimen which agrees with Dumortier's shell, except in one respect—Dumortier's shows peripheral radii (costulæ) nearly straight and parallel; in the English shell the radii connecting tubercles are nearly straight, but the intermediaries have rather more forward bending.

The stouter whorls with a more pronounced umbilical wall, a slightly shorter smooth stage, and a small increase in the number of tubercles to a whorl in middle age, are features of distinction from *Ammonites birchi*.

Proportions are given below (p. 306).

History of the specimens.—Figured specimen (No. 1280) from blue Lias, excavation for reservoir of Bristol Waterworks, Barrow Gurney (Somerset), presented by Mr. J. W. D. Marshall.

¹ 'Ceph. Hierlatz' Abhandl. k. k. Geol. Reichsanst. vol. xii (1886) pl. iii, fig. 27.

² *Ibid.* pl. iv, fig. 4.

Another example, about same size and matrix, and a smaller specimen with matrix decomposed to light yellow, presented by the late E. Wilson, F.G.S. Another example, matrix soft, decomposed to light blue (purchased): all from the same place. And see note to next species.

MICRODEROCERAS SEPTIGERUM, nom. nov. (Pl. XXX, figs. 2a & 2b.)

1844. *Ammonites birchii* J. Buckman *pars* (non J. Sowerby), 'Geology of Cheltenham' new ed. p. 88.

Description.—Serpenticonic; platy-perpachygyral, perlatumbilicate to pachygyral latumbilicate; bituberculate; septituberculate; periphery flatly rounded, subarci-costulate.

Remarks.—This is an inflated development of *Ammonites birchii* by way of the last species (*M. depressum*), but it has not attained to the inflated proportions of the next species (*M. inflatum*), though it has passed that species in the differentiation of the outer tubercles compared to the inner—the character seen at a later date in *Deroceras* (*D. bispinigerum*, p. 302) and later still carried to unituberculation.

This species is best understood by comparison with *M. inflatum*. Its thickness is some 7 per cent. less at 64 mm. diameter, and the periphery is somewhat flatter. The ornament is similar, but the spinicostæ are about 50 per cent. wider apart, and the outer row of spines is shown by the septate areas to be more developed and more differentiated from the inner. The conspicuous septate areas which are somewhat B-shaped suggest the trivial name: the outer (top) loop is broadly, and the inner narrowly, elongate with a thin connecting area—thus the partition extended not only under the spines, but also under the connecting rib.

Proportions are tabulated below (p. 306).

History of the figured specimen.—The original label, skeleton printed, on the specimen reads: 'Name *A. Birchii*, Loc. *Lias*, *Cheltenham*, Col. by *J. Buckman*,'—the words in italics filled in in his handwriting. The matrix is light blue with crinoid-stems, small gastropods, small lamellibranchs, and broken organisms. See below, p. 312.

[Note.—Since this paper was written I find that I have overlooked another of my father's specimens of *Ammonites birchii* (S. B. coll. No. 2115). It has a quite different matrix—blue and pyritic; but bears the same label, which thus may mean 'close to Cheltenham' rather than 'Cheltenham district': see below, p. 312. Its proportions are S. 72, 28, 29 (31), 49; S. 114. 26, 28 (29), 51. Spines are approximate and somewhat small—38 on last row of outer whorl. It is an example of *Microderoceras depressum*, see above. On one side is an impression of a portion of another *Microderoceras*, of about the same size, showing obsolescence of spines, of interest in connexion with remarks below, p. 307.]

MICRODEROCERAS INFLATUM, sp. nov. (Pl. XXVIII, fig. 3;
Pl. XXIX, fig. 1.)

Description.—Serpenticone; platy-perpachygyral, perlatumbilicate to subplaty-pachygyral, perlatumbilicate; bituberculate, septituberculate; periphery rounded, subarcilinate.

General details.—A much inflated development of *Ammonites birchi*, beginning with a similar smooth stage, rapidly developing bituberculate, whereof presently the outer row becomes rather stronger than the inner. Beneath spines and connecting rib there is a septum of subspatulate shape. Close-set hair-like lines occupy the interspaces and the arching periphery, which latter they cross with a slight forward bend.

Distinction.—The proportions (see below, p. 306) distinguish this from preceding species: it attains at one time an inflation of 50 per cent. of the diameter, but afterwards declines as if commencing to return to the *birchi* style.

Remarks.—According to indications of test on the periphery the specimen had another complete whorl at least. Its diameter may be roughly estimated, from the fact that from the centre to the farthest periphery is 55 per cent. of the diameter of the last whorl present: therefore the maximum radius becomes 45 per cent. of the diameter of the next half-whorl, which being thus ascertained, its maximum radius becomes the basis, roughly 45 per cent. of the second half-whorl. The indications of test on the periphery give umbilical width of 54 and 62 per cent. of the respective diameters (164 mm. and 198 mm.) so ascertained: these umbilical widths are perhaps too great, because possibly the 55 per cent. basis was not maintained; and so the diameters are perhaps understated—the whorl becoming thinner and broader. The umbilicus is expanding, as the inner line is leaving the outer spine-line.

As this specimen may be reckoned to have attained a diameter of 200 mm. or more, it was, considering its inflated proportions, altogether a much larger growth, had a greater bulk, than *Ammonites birchi*, though A. d'Orbigny does record a diameter of 240 mm. for his specimen. The species now described possibly represented the acme of development in *Microderoceras*; but some of the later Derocerates far exceeded these dimensions—some of the Radstock giants collected by Mr. Tatcher and myself from the *leckenbyi* bed attaining to 360–380 mm. (14–15 inches) in diameter.

History of the figured specimen.—From hard light-blue Lias weathered to light yellow and soft [white in places?], from excavations for reservoir of Bristol Waterworks, Barrow Gurney (Somerset)—purchased.

MICRODEROCERAS RHODANICUM, nom. nov.

Ammonites hebertyi Dumortier (non Oppel), 'Bassin du Rhône' vol. iii (1869) pl. viii, figs. 6–8 & p. 66.

Remarks.—This name is for Dumortier's species quoted above,
Q. J. G. S. No. 292.

which is not Oppel's species, for that was founded on *Ammonites brevispina* D'Orbigny (*non* Sowerby). Its proportions are different. Dumortier's is a thicker form; D'Orbigny's is a further stage on in compression and degeneration: it gets back to the smooth stage.

TABLE XIX.—PROPORTIONS: MICRODEROCERATES.

1.	<i>Microderoceras birchi</i> (Sowerby). (<i>Ammonites birchi</i> Sowerby, pl. cclxvii) ¹	F. 204,	25,	[26°],	57.
	(<i>Egoceras birchi</i> Wright, pl. xxiii) ² ...	F. 160,	22,	23,	58.
2.	<i>Microderoceras depressum</i> , nov. (Holotype. Barrow specimen)	S. 75,	29,	32,	47.
	(<i>Ammonites birchi</i> Dumortier, xli, p. 130) ³	{ F. 197(94), T. 197,	28,	29, 31,	51. 50.
	<i>Microderoceras septigerum</i> , nov. (<i>Ammonites birchi</i> J. Buckman)	{ S. 42, S. 89,	33, 35,	43, 40,	45. 42.
	<i>Microderoceras inflatum</i> , nov.	{ S. 64, S. 131,	34, 30,	50, 38,	45. 44.
	<i>Microderoceras bispinatum</i> (Geyer). (<i>Egoceras bispinatum</i> Geyer)	F. 55,	30,	35,	46.
	<i>Microderoceras rhodanicum</i> , nov.	{ F. 35, T. 35,	32, 31,	—, 42,	44. 37.
	(<i>Ammonites heberti</i> Dumortier).	{ F. 77, T. 74,	34, 32,	—, 29,	45. 45.
	3. <i>Microderoceras heberti</i> (Oppel). (<i>Ammonites brevispina</i> D'Orbigny, lxxix) ⁴	{ F. 74(47), F. 140(90), T. 140,	32, 32, 31,	24, 24, 25,	45. 47. 47.
	<i>Microderoceras roberti</i> (Hauer). (<i>Ammonites roberti</i> Hauer, iii) ⁵	T. 97,	36,	23,	40.

Microderoceras septigerum and *M. inflatum* are species sufficiently alike to make it probable that they indicate beds of the same date. More will be said on this point presently (p. 311). Curiously enough, I have not found in literature anything really like these inflated forms. The most comparable species are *Egoceras præcursor* and *Æ. bispinatum* Geyer, possibly of basal Raasayan, *Deroceras bispinigerum* (p. 302), low in Raasayan, *Microderoceras rhodanicum* (p. 305), presumably top of Raasayan (*leckenbyi*). All differ in proportions from the inflated forms, as Tables XVIII & XIX show.

The placing of certain bituberculate species to *Microderoceras* and others to *Deroceras* must be regarded as conventional. I am not prepared at present to state the difference between them: the study necessary for that might delay this Appendix for several years; and it is a biological matter.

This, however, may perhaps be said: various branches of *Microderoceras* may be noted:—

1. The *birchi* set—the *A. birchi* of Sowerby, Wright, D'Orbigny,

¹ 'Mineral Conchology.'

² 'Monogr. Lias Ammonites.'

³ 'Bass. Rhône,' vol. ii.

⁴ 'Pal. franç.: Terr. Jur. Céph.'

⁵ 'Capric.' Sitzungsber. k. Akad. Wissensch. Wien, vol. xiii (1854) p. 94.

and others with the forms to which Quenstedt has given names—*M. nodosissimum*,¹ *M. enode*,² *M. gigas*.³ In this set catagenesis to smooth occurs without an inflated stage and without much umbilical contraction.

2. The *inflatum* set:—This starts from *M. depressum*, an offshoot of the *birchi* set while in its prime, and it continues anagenesis until a maximum whorl-inflation of about 50 per cent. is reached, after which decline sets in. Between *M. depressum* with 32 per cent. of inflation and *M. inflatum* with 50 there is evidently room for another species: *M. septigerum* comes here, but does not quite satisfy as a link, because of its more distant ornament.

3. The *heberti* series:—This branches off from *M. depressum*, perhaps, or some morphic equivalent; but it is a series much later in date. It goes through an inflated period similar to the last, running up to 42 per cent. Then it rapidly declines, broadens and compresses the whorl, becomes smooth, and presumably ends off in a smooth subplatycone series—such as *Ammonites roberti* Hauer,⁴ Reynès,⁵ *A. lorioli* Hug,⁶ *A. steinmanni* Hug,⁷ *A. plumarius* Dumortier.⁸ Specimens with the catagenetic characters of those just named are in Mr. Tutchter's cabinet from about *leckenbyi* of Radstock: they have a bituberculate Microderoceratan stage in inner whorls and a Microderoceratan suture-line.

4. The *Deroceras* stock:—This would branch like the last from some morphic equivalent of *M. depressum*, an early stage being represented by *Deroceras hispinigerum*. This line does not go through an inflated stage while bituberculate, but it loses this character early, dropping the inner row of spines, compensating by enlarging the outer row and broadening the periphery, producing in some cases in the unituberculate stage not true inflation but forms broad in the venter with much divergent sides—a method of producing cadicones ultimately. But there must be several lineages now combined in *Deroceras*—and in some of them the morphogeny must be complicated, with apparently alternations of anagenetic and catagenetic stages of ornament.

(c) Geological Inferences from the Described Species.

Domerian.—*Leptaleoceras* is interesting for its rarity. Among the hundreds of British Domerian (Marlstone Series) ammonites that have passed through my hands, I remember only the three specimens now dealt with; and I can recall but few cases of similar Hildoceratids.⁹ Mr. Spath says that 'even in the British Museum collections Mesoliassic Hildoceratids are almost unrepresented.'¹⁰

¹ 'Ammoniten d. Schwäbischen Jura' xviii, 7, *Am. birchi nodosissimus*.

² *Ibid.* xviii, 9, *Am. birchi enodis*.

³ *Ibid.* xviii, 13, *Am. birchi gigas*.

⁴ *Loc. jam cit.*

⁵ 'Mon. Amm.' pl. xxx, figs. 13 & 14 (copy of Hauer).

⁶ Abh. Schweiz. Pal. xxvi (1899) pl. viii, fig. 1 & pl. ix, fig. 2.

⁷ *Ibid.* pl. ix, figs. 1 & 2.

⁸ 'Bassin du Rhône' vol. iii (1869) pl. xvii, figs. 1–3.

⁹ Excluding *Seguenziceras*.

¹⁰ *Op. jam cit.* p. 547.

Such Hildoceratids find their home in the Mediterranean area: whether their rarity here is due to stratal failure or inequality of zoological distribution is for future work to determine.

An attempt to ascertain the position of *Leptaleoceras* in the Domerian may be made by comparison of its matrix with that of other Ammonites. Taking the Gloucestershire area first—the matrix of *A. nautiliformis* J. Buckman,¹ from a neighbouring Marlstone eminence, Alderton-Dumbleton, a few miles north of Gretton, is light blue, compact, arenaceo-calcareous (micaceous?) non-oolitic—very suggestive of the ‘bluish gray calcareous grit’ mentioned for a bed of ‘Marlstone’² (lower Domerian, below the Rock-Bed). The matrix of *Leptaleoceras* is blue, less compact, calcareous and shelly. That of specimens of *Amaltheus armiger*³ (*Am. amaltheus spinosus* Quenstedt, *pars*) from Gretton and Alderton is feebly blue, oolitic, very shelly; while that of *Paltopleurocerates* from the latter place varies from somewhat similar, not so shelly, to yellow, not shelly, not oolitic.

On the principle that the blue colour and the arenaceous character are indices of lower beds, the following Gloucestershire sequence may be surmised:—

5. *Paltopleuroceras*.
4. *Amalthei* (spinous forms).
3. *Leptaleoceras*.
2. *A. nautiliformis*.
1. —?

In regard to South Petherton, colour fails to make distinction between the matrices of such ammonites: all are a yellowish, more or less ironshot oolite, with only the distinction of larger browner limonitic grains in the cases of the Amaltheids. The absence of blue colour and of micaceous grains with presence of ironshot oolite seems to show that all come not lower—and it may be in, the Rock-Bed—equivalent to Bed 4, 8 to 12 feet thick, of Woodward’s section from the neighbourhood⁴—this Rock-Bed being some 150 feet from the base of the Marlstone Series of which the lower 100 feet is described as ‘blue and grey’ micaceous marls.’ In this Rock-Bed it may be assumed that the Amaltheids occupy the higher part, and the other ammonites the lower; and now that the Gloucestershire district has suggested somewhat of a clue, perhaps the differentiation of the Somerset Rock-Bed into zones can be made: there is room enough for several, and the need is obvious.

This interpretation with regard to *nautiliformis* and its matrices would mean, if correct, that in the Ilminster district of Somerset the Marlstone Rock-Bed began earlier than in Gloucestershire;

¹ ‘Yorkshire Type Ammonites’ 1911, No. 37.

² ‘Geology of Cheltenham’ new ed. 1844, p. 38, Bed 2.

³ ‘Yorkshire Type Ammonites’ 1911, p. 25 d. As one finds this and like spinous *Amalthei* labelled *Am. spinatus* on occasion, a clue may be afforded to some old records.

⁴ ‘Lias of Engl.: Jur. Rocks’ vol. iii, Mem. Geol. Surv. 1893, p. 202.

but much variation in this respect may be expected as well as, the more minutely subdivision is carried on, a great increase in local non-sequences.

The position of the *Leptaleoceras* and *A. nautiliformis* horizons in regard to the faunal sequence discussed in the stratigraphical portion of this paper (p. 260), may be surmised to this extent—they are pre-*gibbosa*—a spinous species near to, perhaps as used by Monestier including, *Amaltheus armiger*. Whether they are pre- or post-*algovianum* as now restricted is uncertain; but it may be surmised that they do not correspond to this *algovianum* horizon, because the localities yielding the respective faunas seem to be geographically separate.

Evidence for other pre-*gibbosa* horizons in this country and their relation to the Mediterranean sequence will chiefly depend on certain *Amalthei*, *Lytocerata*, and an occasional *Hildoceratid*. On the Dorset Coast very low down in the Domerian—in the strata just above the Three Tiers—are *Amalthei* of the *clevelandicus* pattern, and the same occur low down in marls at Lightpill, near Stroud (Gloucestershire). Large *Amalthei* of the *stokesi* pattern occur in sandy strata at South Petherton—perhaps the *A. margaritatus* of Woodward's Bed 2¹; but whether this is pre- or post-*algovianum* in its restricted sense is uncertain. The original *Ammonites stokesi* came from the Dorset Coast; but there is the same doubt about its position: one can only judge from the colouring of Sowerby's plate that it is from blue marls. Fine *Lytocerates* occur in the Marlstone Series at Dudbridge, near Stroud, and at two horizons on the Dorset Coast: there are various species, recorded incorrectly as *A. fimbriatus*. Day cites the good specimens from his *Margaritatus* stone² where I have found them, and he places others lower.³ Whether the Dudbridge species are on the same horizon as either of the Dorset species cannot yet be said: there may be three horizons.

All this evidence, faulty though it may be, seems to suggest that there are the following pre-*gibbosa* horizons in the English Domerian to deal with:—

Leptaleoceras.
Sphærocones (*A. nautiliformis*).
Amalthei (of *stokesi* pattern).
Sequenziceras (and small *Amalthei*).
Lytocerata.
Amalthei of *clevelandicus* pattern.
Lytocerata.

These divisions may not all be separable, and it is not claimed that they are in correct descending order; but a table of some sort is required as a preliminary to making out our home sequence. Only when that is understood will it be possible to correlate with the Mediterranean sequence, and bring all into one hemeral time-scale.

¹ *Loc. cit.*

² Q. J. G. S. vol. xix (1863) p. 292.

³ *Ibid.* p. 291.

Hwiccian-Wessexian.—The importance of the giant *Acanthopleuroceras* is that during considerable collection in the brickyards of the Cheltenham district nothing at all approaching the size of this specimen and of another fragment, *Acanthopleuroceras gigas* (Quenstedt),¹ nearly as large, rewarded my efforts. These specimens were found by the late Rev. Dr. F. Smithe, F.G.S., during the making of the Banbury & Cheltenham Railway at Leckhampton; and the inference is that a stratum different from any of the brickyard exposures must have been cut through. Whether the stratum belongs to any of the *Acanthopleuroceras* horizons discovered by Mr. Lang on the Dorset Coast, or whether it is distinct from them is a point towards which the attention of future workers should be directed.

The local distribution of *Acanthopleuroceras* in the Cheltenham district seems to indicate two separate horizons, apart from the horizon of the giant forms. Battledown near Cheltenham yields mainly thin species; Leckhampton Station near Cheltenham and Hucclecote near Gloucester yield chiefly stout-whorled species. Further afield Northamptonshire and Radstock yield the thin species—solely, I think, more commonly at any rate. Hitherto these *Acanthopleuroceras*-yielding strata have been reckoned as all in the same zone, but it is now evident that more investigation is required.

In the Cheltenham district a great variety of *Acanthopleurocerata* are found, but rarely otherwise than as body-whorl fragments, which makes their specific identification difficult.

I cannot call to mind anything in literature of the size of the large *Acanthopleuroceras* (260 mm.). Quenstedt's *A. gigas* (pl. xxxv, fig. 14) I estimate at about 170 mm.; his 'largest fragment' (fig. 15) may go up to 200 mm.: the Leckhampton fragment—a body-whorl—reaches 244 mm. in diameter, however. Dumortier's *Ammonites flandrini*² measures 202 mm.; but this is a species of quite a distinct type, special perhaps to the South of France. Würtemberg, then, is the only area at all congruous with Gloucestershire in regard to these large forms; and it would seem, if these large forms occupy a distinct horizon, that this horizon has been preserved in areas limited and isolated geographically.

Raasayan.—*Deroceras bispinigerum* marks a *Deroceras* horizon below the main outbreak of Echiocerata. It is interesting as a representative of the bituberculate ancestor of the unituberculate *armati*, and shows the obsolescence of the inner row of tubercles.

Deiran.—The species of *Radstockiceras* and *Gleviceras* are chosen as representatives of the faunas of the Radstock and Gloucestershire Oxynotoid horizons, now separated from the *oxynotum* horizon; but there are several other species in the latter area

¹ 'Ammoniten d. Schwäbischen Jura' pl. xxxv, figs. 14 & 15.

² 'Bassin du Rhône' vol. iii (1869) pl. xiv.

and quite a considerable number in the former which require investigation: they do not necessarily belong to the present genera. In fact, the Oxynotoids appear to represent the catagenetic terminals of many different lineages, of which the majority came into view suddenly in the European Deiran without any ancestry. Only *Ammonites oxynotus* Quenstedt, and *A. oxynotus* Dumortier, two quite different species, seem to have traceable ancestors—the former being connected with a tuberculate¹ and the latter with *Arietites* of the *fowleri-collenottii* pattern.²

The placing of the Radstock Oxynotoid fauna later than the Gloucestershire one (*Gleviceras*) is a surmise not yet proved; but their difference in species shows that they are distinct in date. To place the Radstock fauna before the Gloucestershire one would involve the supposition of another non-sequence in Gloucestershire.³ *Gleviceras* belongs to a distinctly higher horizon than the *oxynotum* beds in Gloucestershire; but, if that were not known, the absence of *Gleviceras* from Württemberg, where *A. oxynotus* is conspicuous, would be presumptive evidence of a difference of date.

It is notable that no specimens of the Radstock Oxynotoid fauna are figured by Quenstedt, and only two examples which have the aspect of constituents of the *Gleviceras* fauna—*Ammonites guibalianus* Quenstedt, 'Ammoniten d. Schwäbischen Jura' pl. xxviii, figs. 3 & 4—not from any *oxynotus* locality, and from a higher horizon (Lias γ). Pompeckj has named them *Oxynoticeras paradoxum*, and places them in *jamesoni* [*leckenbyi*?] zone. They have neither suture-line nor ribbing of *Gleviceras*; and not the ribbing of *Guibaliceras*. Present experience would suggest that their position may be due to derivation.

Mercian-Lymian.—The Barrow Gurney fauna (*Arietites turgescens*, p. 296, and *Microderoceras inflatum*, p. 305) is congruous with that of Bredon (Worcestershire), certainly as regards the *Arietites* and presumably with regard to the *Microderoceras* (see below, p. 312). But this special fauna is not known from intermediate areas, is absent from Dorset and also from Yorkshire so far as my experience goes. Dumortier shows a partly comparable *Microderoceras* fauna, but not *Arietites*; Reynès shows *Arietites*, but not any *Microderoceras* of the style required.⁴ Quenstedt shows nothing comparable.⁵ A first inference may

¹ See 'Yorkshire Type Ammonites' i (1909) p. 7 b.

² To these may now be added *Gleviceras*, see above, p. 292.

³ See p. 272.

⁴ But Reynès is unsafe: his specimens are from many areas; and see p. 322.

⁵ One can in the main only go by what is published. I know from my own and other collections that a great mass of new material is unpublished. I write with some knowledge of that, although memory necessarily has its limitations in this respect, owing to the difficulty of fixing new forms in one's mind because of their lack of names. Even photographs help little without names to serve as tags for the memory. But, if similar conditions obtain on the Continent, then of course the statements made above might be invalidated. On the other hand, Continental Ammonitology is far more complete in many areas than is the British.

certainly be drawn, that the special *Microderoceras-Arietites* fauna did not occupy the horizon of either *turneri* or *birchi*, otherwise they should be found in the areas where those species occur; and a second inference may more tentatively be made—that the *Microderoceras* and *Arietites* did not occupy the same horizon.

If it were possible to proceed on strictly biological lines, then a solution would be quite easy; but biological and geological position are not always in accord: *Xipheroceras* above *Microderoceras*, *Paltopterooceras* later than *Amaltheus*, *Hildoceras* after *Harpoceras* in geological position, when they should respectively precede biologically. But these are distinct genera: in regard to species, *Harpoceras exaratum* below *H. falciferum*, *Hildoceras bifrons* below *H. semipolitum*, *Arietites turneri* below *A. brooki*, and this again much below *A. denotatus*, show very well the agreement of geological position and biological development.

In the present case the assumption of the agreement of biological and geological position is all that there is to go upon. No record of the Barrow exposure seems to have been made. Specimens were very few, so I understand, for the great area opened up; and what have been saved were only the finds which the navvies took the trouble to bring home with them.

The matrix of the Barrow Gurney exposure is a hard blue Lias, which weathers or decomposes to a soft white, almost chalky substance. This matrix is quite unlike any other with which I am acquainted in the South-West, and it would serve well to distinguish Barrow specimens. I find, however, that some specimens in my father's Cheltenham collection show a similar matrix, perhaps rather more cream-coloured; and Wright says of his *Arietites turneri* [*A. aff. turgescens*]:

‘The specimen figured was collected from a light-coloured clay and limestone in the deep cutting of the Bristol & Birmingham Railway, near Bredon [Worcestershire], associated with *A. Bonnardii*, d'Orbigny, [*Arietites aff. plotti* (Reynès)], *A. semicostatus*, Y. & B., [*Arnioceras bodleyi* (J. Buckman)], and several other mollusca, with many fragments of the stems and side arms of *Pentacrinus tuberculatus*, Miller, and *Cidaris Edwardsii*, Wright.’¹

The character of matrix and the remarks about the *Pentacrinus* well fit the condition of *A. birchi* J. Buckman (*Microderoceras septigerum*); and, though it is labelled Cheltenham, yet Bredon is quoted as a locality for *A. birchi*,² and I suspect that the label ‘Cheltenham’ possibly denoted in such cases ‘Cheltenham district,’ just as ‘Vale of Gloucester’ was possibly used to include Bredon. Judging by the light-coloured matrix it may be suggested that from Bredon came my father's holotype and various paratypes of *Ammonites halecis*, the figured specimen and another with perhaps a third of his *A. erugatus* (*Agassicerus*), the specimen he called *A. costatus* (*Agassicerus*), two paratypes of his *A. bodleyi*, and the present holotype of *Microderoceras septigerum*.

¹ Proc. Cotteswold Nat. F. C. vol. iii (1864) p. 177, repeated in ‘Monogr. Lias Ammonites’ 1881, p. 293; see below, (e) p. 318.

² ‘Geology of Cheltenham’ new ed. 1844, p. 88.

Turning now to the biological argument—the biological facts are: 1, *Microderoceras* which are developments of *M. birchi*; 2, *Arietites* which are developments of *A. turneri*: the geological facts are a special matrix for these developments and the position of *M. birchi*–*A. turneri* on the Dorset Coast: the geographical facts are the presence of the special fauna (and a distinctive matrix) only at isolated places in England, the absence of the fauna from well-known, much-searched localities, and its very limited range upon the Continent.

On these various grounds it may be suggested that the full Mercian–Lymian sequence, instead of being

3. *Arietites brooki*,
2. *Arietites turneri*,
1. *Microderoceras birchi*,

is rather

5. *Arietites brooki*,
4. *Arietites turgescens* (+ *A. aff. turgescens*),
3. *Arietites turneri*,
2. *Microderoceras inflatum* + *M. septigerum* + *M. depressum*,
1. *Microderoceras birchi*.

This involves the supposition of non-sequences between *birchi* and *turneri* and again between *turneri* and *brookii*, on the Dorset Coast and over other wide areas; but it may be unnecessary to suppose a non-sequence at Barrow for, I think, *turneri* forms were found there. Then the absence of *Arietites brooki* and *Microderoceras birchi* from Barrow might be explained by supposing that the excavation began below the *brookii* bed, and did not go so deep as *birchi*; but other explanations are possible: the area just north of the Mendips was in constant movement.

Another suggestion may be made: that the sequence is

5. *Arietites brooki*.
4. *Arietites turgescens*.
3. *Microderoceras inflatum*.
2. *Arietites turneri*.
1. *Microderoceras birchi*.

This would require only one non-sequence at Lyme Regis, and would meet the case if the true *A. turneri* has not been found at Barrow. This sequence shows faunal repetition such as that found in the Raasayan and in the Hwiccian–Wessexian. Nos. 3 and 4 might be called the Barrow Beds.

In the first case the division between Mercian and Lymian would be drawn between 2 and 3. In the second case, however, it would seem desirable not to draw it between 2 and 1 as proposed earlier in this paper (pp. 271, 274), but to draw it below 1, to prevent divorce of the *Microderocerates*.

In the case of Bredon there is evidence that earlier faunas were uncovered than at Barrow; and there is reason to suppose that they were found in the peculiar chalky Lias, also that there was

not a non-sequence due to lack of *turneri* beds, for the species cited by Wright as *A. bonnardii* is possible evidence for them.

The true *birchi* beds were presumably present—on the supposition that Wright was referring to the true *birchi* or a very near form, and not to *Microderoceras septigerum*, when he says ‘I have several specimens [of *Agoceras birchii*] which were collected from the railway-cutting near Bredon.’¹

The evidence for an *Arnioceras* fauna being there and occurring in a chalky matrix has already been given; the same details refer to *Agassiceras*, see above, p. 312, to which may be added that Wright figures a large *Agassiceras* from Bredon.²

Lymian.—*Arnioceras* is in the main a genus easy to recognize from other Arietidae, with its straight sharp ribs and smooth inner whorls: the only difficulty may be with body-chamber fragments. But the species of *Arnioceras* are numerous and not easy to separate; yet for the detailed work now required such recognition will be necessary, in order to see what the succession of species is in time. Old records, where the various species of *Arnioceras* are just cited as *Ammonites semicostatus* without further distinction, serve but a limited, and it may be a somewhat misleading, purpose. For there is reason now to be sceptical whether the placing as isochronous of *semicostatus* beds—that is beds containing *Arniocerata*—is really correct. Faunal repetition and non-sequences may have been overlooked.

Of the species now figured the characters are sufficiently obvious: *Arnioceras flavum* is a carinate smooth form, *A. anageneticum* shows the beginning of ribs, *A. fortunatum* is almost wholly ribbed, distinguished by its markedly-recline somewhat distant costæ.

Thirteen species of *Arnioceras* are enumerated from the Whitby district of Yorkshire,³ and (speaking from memory) all of them are more or less distinct from the species now figured. In Lincolnshire there is a rather heavy form with strong ribs usually called *Ammonites geometricus* Oppel, if and when distinguished from *A. semicostatus*. There may be more than one species involved; but the shells are of very distinct character. This form (or these forms) are constant among all series of Lincolnshire Lower Lias ammonites; but from other British localities they are lacking, or only occur exceptionally.

From the Cheltenham district *Arnioceras bodleyi* seems to be the special form; it is not quoted from Yorkshire in the list cited above; it occurs in Würtemberg, but can hardly be usual there, for only a poor fragment is figured by Quenstedt, see p. 302.

Arnioceras fortunatum is known to me at present only from

¹ Proc. Cotteswold Nat. F. C. vol. iii (1864) p. 179, repeated in ‘Monogr. Lias Ammonites’ 1882, p. 333; and see below, (e) p. 319.

² Proc. Cotteswold Nat. F. C. vol. iii (1864) pl. ii, fig. 1, refigured in ‘Monogr. Lias Ammonites’ 1878, pl. viii, figs. 1, 2, *Arietites sauzeanus*: below, (e) p. 321.

³ ‘Geol. Whitby’ 2nd ed. Mem. Geol. Surv. 1915, p. 98.

Radstock, but Quenstedt figures an approximate form. *A. anageneticum* is a Dorset shell: something similar is figured by Hyatt from Semur¹; but nothing like either is figured from Würtemberg.

The distribution of the smooth forms is interesting. Yorkshire yields an angulate species and Dorset a carinate one, while no smooth forms are recorded from the Cheltenham area. Neither of the English smooth forms is shown for Würtemberg nor Semur: both yield less advanced angulate and carinate forms, and the former a more advanced carinate, see p. 299. The Rhone Basin seems to lack smooth forms altogether.

It is for future work to determine, on the one hand, whether such differences are due to incompleteness of records and collections or to want of discrimination; on the other hand, whether they are due to chronological (stratigraphical) or geographical causes.

Arnioceras fortunatum is interesting for its size. Now bigness seems to be a character of the ammonites of the Radstock district at several dates of the Lias. Roughly speaking, much the largest British examples of *Arnioceras*, the Oxynotoids, *Echioceras*, *Deroceras*, *Phricodoceras*, and *Uptonia* are all from the Radstock district, and yet its remarkable ammonite fauna is almost unknown in British literature. To these may be added, from the neighbourhood, *Vermiceras* 18 in. (Wright, Monogr. p. 273, *Arietites conybearei*), the most massive *Coroniceras* (*C. bucklandi*), the most bulky *Microderoceras*, the largest *Arietites*. In some cases this phenomenon of local bigness is due to the presence in the district of special strata which have presumably been destroyed in other areas; but is this the whole explanation?

I conclude this palæontological survey with the impression that the principal need of British Jurassic stratigraphy at present is palæontological work—the figuring of the large amount of material which has accumulated.

(d) Synopsis and Index Details.

Below is a Synopsis of newly-described or named genera and species—new names being in **heavy type**. The index details are given with the following contractions:—

- T.d.* Type-description, original description (protolog).
- T.f.* Type (original) figure (protograph).
- Nom.* When and where the present trivial name was given.
- L.* Locality which furnished the type.
- Hor.* Geological position—in words of original description, or label.
- Date,* Age and hemera (η) as accurately as can be surmised.
- Coll.* In whose collection when described, or present resting-place, if known.
- Form.* Proportional formula—that which seems most representative, if that of more than one size of holotype has been given.

¹ 'Gen. Ariet.' 1889, pl. ii, fig. 10, *Arnioceras semicostatum* Hyatt.

The details so given refer to the holotype, or, in default, to the lectotype only. Plate or page quoted without reference refers to the present paper.

Acanthopleuroceras **rursicosta.**

T.d. P. 286.
T.f. Pl. XXVI, fig. 4.
T.l. Leckhampton, Cheltenham (Gloucestershire).
Hor. Middle Lias clays.
Date, Hwiccian-Wessexian.
Coll. Author.
Form. 360, 28, 20, 48.

Arietites **turgescens.**

T.d. P. 296.
T.f. Pl. XXIX, fig. 2 ; Pl. XXXI, fig. 5.
T.l. Barrow Gurney (Somerset).
Hor. Barrow Beds of Lower Lias.
Date, [Mercian, post-turneri].
Coll. Author, No. 833.
Form. 171, 33, 32, 45.

Arnioceras **anageneticum.**

T.d. P. 300.
T.f. Pl. XXX, fig. 3.
T.l. Lyme Regis (Dorset).
Hor. Lias Limestones.
Date, [Lymian, *Arnioceras* η].
Coll. Author, No. 728.
Form. 42, 27, 20(24), 51.

Arnioceras **flavum.**

T.d. P. 298.
T.f. Pl. XXXI, fig. 2.
T.l. Lyme Regis (Dorset).
Hor. Lias Limestones.
Date, [Lymian, *Arnioceras* η].
Coll. Author.
Form. 25, 27, 20, 51.

Arnioceras **fortunatum.**

T.d. P. 301.
T.f. Pl. XXXI, fig. 4.
T.l. Paulton, Radstock (Somerset).
Hor. Lower Lias [phosphatic bed],
Date, Lymian, *Arnioceras* n .
Coll. Author, No. 936.
Form. 80, 23, 16(18), 57.

Deroceras **bispinigerum.**

T.d. S. S. Buckman, Q. J. G. S. vol. lix (1903) p. 460.
T.f. *Ibid.* Pl. xxvii, figs. 5 & 6.
Nom. P. 302.
T.l. [Charmouth], Lyme Regis (Dorset).
Hor. Lias with pyrites.
Date, Raasayan, *bispinigerum* η .
Coll. Author, No. 591.
Form. 55, 28, 35, 50.

Gleviceras, genotype, *G. glevense* paratype (p. 289, Pl. XXVIII, fig. 2).

Gleviceras glevense, holotype.

T.d. P. 289.
T.f. Pl. XXVIII, fig. 1.
T.l. Cheltenham (Gloucestershire).
Hor. Lower Lias Shales [above *oxynotum*].
Date, [Deiran; *Gleviceras* η].
Coll. Author.
Form. 128, 51, 26, 14.

Guibaliceras, Genotype, *Am. guibalianus* D'Orbigny (p. 293).

Leptaleoceras, Genotype, *L. leptum* holotype (p. 284).

Leptaleoceras leptum.

T.d. P. 285.
T.f. Pl. XXVI, fig. 1.
T.l. South Petherton (Somerset).
Hor. Middle Lias Marlstone [Rock-Bed].
Date, [Domerian, pre-*gibbosa*].
Coll. Author, No. 1113.
Form. 66, 24, 16, 52.

Microderoceras depressum.

T.d. P. 303.
T.f. Pl. XXX, fig. 1.
T.l. Barrow Gurney (Somerset).
Hor. Barrow Beds of Lower Lias.
Date, [Mercian-Lymian, post-*birchi*].
Coll. Author, No. 1280.
Form. 75, 29, 32, 47.

Microderoceras inflatum.

T.d. P. 305.
T.f. Pl. XXVIII, fig. 3; Pl. XXIX, fig. 1.
T.l. Barrow Gurney (Somerset).
Hor. Barrow Beds of Lower Lias.
Date, [Mercian-Lymian, post-*birchi*].
Coll. Author, No. 1281.
Form. 64, 34, 50, 45.

Microderoceras rhodanicum.

T.d. Dumortier, 1869, vol. iii, p. 66, *Am. heberti*.
T.f. *Ibid.*, Pl. viii, fig. 5.
Nom. P. 305.
T.l. Saint-Fortunat, South of France.
Hor. Lias moyen, zone à la *belemnites clavatus*, Couches à *Am. armatus*.
Date, [Raasayan, *leckerbyi* η].
Coll. Dumortier.
Form. T. 74. 32, 29, 45.

Microderoceras septigerum.

T.d. P. 304.
T.f. Pl. XXX, fig. 2.
Loc. Cheltenham [District], Gloucestershire [Bredon,
Worcestershire].
Hor. Lower Lias Shales [with *Pentacrinites*].
Date. [Mercian-Lymian, post-*birchi*].
Coll. Author, No. 688.
Form. 89, 35, 40, 42.

Radstockiceras, Genotype, *R. complicatum* holotype
(p. 287).

Radstockiceras complicatum.

T.d. P. 287.
T.f. Pl. XXVII, fig. 1.
T.l. Radstock (Somerset).
Hor. Lower Lias with *Oxynotoids*.
Date. Deiran, *Radstockiceras* η.
Coll. Author, No. 2768.
Form. 186, 54, 25, 11.

Victoriceras, Genotype, *Am. victoris* Dumortier
(p. 293).

(e) Concerning some of Wright's figured *Ammonites*.

To Vol. iii of the 'Proceedings of the Cotteswold Naturalists' Field Club,' parts 2 & 3, published in the years 1864-1865, Wright contributed a paper 'On the *Ammonites* of the Lias Formation' (pp. 162-79, 235-45) describing various species illustrated in four quarto plates, drawn by J. W. Salter. In his subsequent Monograph he makes no reference to this prior work; and yet the descriptions therein of the species concerned are almost word for word identical—just a few alterations like millimetres for inches, changing one technical term for another, and occasionally a few additional remarks; while the figures of the species are in very many cases apparently not redrawn from the specimen, but merely copies of the illustrations in the prior paper.

The search for information as to the localities of certain of Wright's specimens, in connexion with the discussion on the Bredon fauna referred to above (p. 312), led to the discovery that the Cotteswold Club paper was important for the understanding of Wright's Monograph, for the identification of some of his species, and for the recognition of some of his figured specimens, several of which do not seem to have been found. Therefore I append the following notes, commencing with a list of the species figured in the Cotteswold Club paper, marking those which are refigured in the Monograph.

TABLE XX.—COMPARISON OF FIGURES.

Species.	Cotteswold Club paper.		Monograph.	
	Pl.	fig.	Pl.	fig.
<i>A. planorbis</i>	i,	1, 1 a, 1 b.		
<i>A. bucklandi</i>	i,	2, 2 a.	i,	1-3.
<i>A. birchii</i>	i,	3.	xxxii,	5, 6.
Do. do.	i,	3 a.	xxxii,	7.
Do. do.	i,	3 b.	xxxii,	8.
<i>A. angulatus</i>	i,	4, 5.		
<i>A. sauzeanus</i>	ii,	1 a, b, c.	viii,	1-3.
Do. do.	ii,	1 d.	viii,	5.
<i>A. semicostatus</i>	ii,	2, 3.		
<i>A. turneri</i>	ii,	4.	xii,	1, 2.
Do. do.	ii,	4 a.	xii,	5.
Do. do.	ii,	4 b.	xii,	6.
<i>A. brooki</i>	ii,	5 side.	vi,	4.
Do. do.	ii,	5 front.		
Do. do.	ii,	5 a.	vi,	5.
<i>A. rotiformis</i>	iii,	1.	v,	4.
Do. do.	iii,	1 a.		
<i>A. conybeari</i>	iii,	2, 3.	ii,	1, 2.
Do. do.	iii,	3 a.	ii,	3.
<i>A. obtusus</i>	iv,	1 a, 1 b.	xxi,	1, 2.
Do. do.	iv,	1 c.	xxi,	5?
<i>A. multicostatus</i>	iv,	2 a, 2 b, 2 c.		
(A. bisulcatus in text).				

A. bucklandi.—Same figures in Mon. as C. C. paper, just under half of the natural size. Thickness of whorl given by Wright in text in both cases = 33 per cent., but figure shows only 25·5.

A. birchii.—Mon. figs. appear to be tracings of C. C. figs.: there is the same omission in both—failure to show inner row of tubercles in front view. The suture-line is said to be from a Bredon specimen. The point was whether figs. 5 & 6 represented a specimen from this locality, and if it was of the natural size what it could be. I come to the conclusion that it is from Lyme Regis and is a large shell reduced, on these grounds:—

In the C. C. paper, p. 179, Wright says, 'The finest specimens of this shell are found near Charmouth and Lyme Regis.' On p. 178 he gives the 'transverse diameter of a large specimen 8 inches,' and the proportions he gives work out as 203, 19, 21·5, —; he also mentions that the shell has 7 turns and 32 to 34 lateral costæ. The C. C. example has 7 turns, has 33 spines on outer row of last whorl, and the proportions of the figure are 84, 22, 18 (22), 61. I think that the figure represents the 8-inch example reduced—the dimensions of aperture transposed by Wright—and that when he transferred the figures to the Mon. he called it, in error, a small shell. It will be interesting to see where this leads.

In the Mon. Wright describes (p. 332) his large specimen as 160 mm. diam., and the proportions that he gives work out as 160, 22, 22, 60. The figure, however, is 166, 22, 23, 58. He goes

on to describe, not this specimen, but his large example of 8 inches in diameter as in the C. C. paper, though occasionally referring to the figures of pl. xxiii—the 160 (166) mm. or $6\frac{1}{2}$ -inch specimen.

In regard to the figs. in pl. xxxii he says 'Small specimen Pl. xxxii, figs. 5-8 [5, 6], Diameter 80 mm.,' and so on—the proportions which he gives work out as 80, 19, 19, 62, though the fig. gives 83, 22, 18, 61. It might be urged from this that Wright must have measured from the actual specimen, and not from the C. C. figs. But, in view of what comes out in other cases, this fact of the measurement hardly carries the weight that it might. Suppose, however, that this be accepted—that this specimen was a small one—it leads to curious difficulties. The specimen certainly does not show what Wright figured it for in the Monograph—'that *Ægoceras Birchii* maintained its original form and structure through the various phases of its life'—Explanation of pl. xxxii. For the shell shows that if small it could not possibly be a young *birchi*. It has the proportions of an adult. To be a young *birchi* it would have to show no more than 6 turns at this diameter, only about 23 spines on the outer row of the outer whorl, and proportions 83, 27, —, 53. Also it should show a smooth stage up to half an inch in diameter, as Wright says in his C. C. paper—his figure shows only a smooth stage up to about a fifth of an inch in diameter, which would be correct for a shell reduced to less than half.

If, however, this be not a young *birchi*, but is still figured of natural size, then it must be regarded as a development of *birchi* which has taken on the characters of adult *birchi* at a smaller size—an instance of acceleration or tachygenesis. That it shows so exactly the number of turns, the width of umbilicus, the narrow whorl of an adult, that it has kept exactly the number of tubercles—33—on outer row of last whorl, that it shows no change in character of tubercles, no further differentiation between outer and inner rows of tubercles, no sign of degeneration, and no change except a degree of whorl-compression which might be found to a great extent in a specimen of 203 mm. as compared with one of 160 mm., strains credulity too greatly. That a small shell, being a morphic representative of an adult, and necessarily as a development of it separated from that adult by a very great number of generations, should yet be almost a photographic likeness of the adult, is a degree of similarity in morphic representation which seems far too exact.

I think, therefore, that Wright's C. C. fig. of *Ammonites birchii* which he reproduced in his Monograph as a small shell, is really his large 8-inch example figured less than half natural size, that it is only understandable on that basis, and that therefore it is from Lyme Regis and not from Bredon. At any rate the 8-inch *birchi* which Wright described in his C. C. paper ought to be still in existence, and Curators would be well advised to look out for it.

A. sauzeanus.—The large specimen is said to be of the natural size—Explanation of pl. viii of Mon.; it is actually $\times 0.7$. It is figured half of the natural size in C. C. Diameter there given as 8 inches, in Mon. as 205 mm.

The small shell is said to be of the natural size in Mon. It is figured $\times 0.73$ of this in C. C. paper.

A. turneri.—Shell figured of reduced size, $\times 0.7$, in C. C., but same side shows nearly all inner whorls as missing. Same proportions given in C. C. & Mon. In C. C. fig. 4a is described as 'Quenstedt's figure of the septa,' Explan. of Plate. In Mon. fig. 5 is an exact copy but enlarged, apparently from Bredon specimen (p. 292).

A. brooki.—Dimensions.—Transverse diameter $5\frac{1}{2}$ inches [140 mm.]; height of outer whorl at the aperture, $2\frac{2}{10}$ inches [56 mm.]; width $1\frac{1}{2}$ inch [38 mm.]. C. C. p. 174. In Mon. 140 mm., 55 mm., 40 mm. Shell figured 0.65 in C. C. paper and front view given—a detail lacking in Mon. Fig. 5a in C. C. 'lobes and saddles from Zieten' (Explan. of Plate). Fig. 5 in Mon., copy of C. C., 'foliations ... from another specimen ... My Collection.'

A. rotiformis.—Specimen figured in C. C. paper, peripheral view only, ' $\frac{1}{2}$ nat. size' inscribed on Plate. Diameter (p. 238), 7 inches; therefore figure is $\times 0.74$. Natural size in Mon.

On p. 279, Mon. the sentence 'Compare, for example, the sutures in Pl. iii, fig. 2, with those in Pl. iv, fig. 2' does not refer to Mon., but is understandable from C. C. paper.

A. conybeari.—In C. C. ' $\frac{1}{2}$ nat. size' inscribed on Pl. Figure 175, 19, 20, 64.5. Dimensions (p. 236): $10\frac{1}{4}$ inches, 2 inches, 2 inches = T. 260, 19.5, 19.5, —, figured therefore $\times 0.67$. Same figs. same size in Mon.; but Wright (p. 273) gives dimensions 340 mm. ($13\frac{5}{8}$ inches), 60 mm., 68 mm., —, = T. 340, 17.5, 20, —. Wright has roughly doubled the diameter of the C. C. fig. instead of giving the dimensions of his text. Loc. Weston, C. C. p. 236, Salford, Mon. p. 273, Saltford, Expl. Pl. ii.

A. obtusus.—Inscribed on C. C. pl. ' $\frac{2}{3}$ nat. size,' shows a contracted umbilicus and inner whorls wanting or hidden in matrix. Dimensions not given in C. C. Same figures, same size given in Mon., but with more open umbilicus showing inner whorls. 'Nat. size' in Explanation of pl. xxi. Dimensions in Mon. (p. 293) 155 mm., 65 mm., 58 mm., 55 mm. This makes figs. $\times 0.70$. Figures in C. C. and Mon. do not agree one with the other, nor with the text as regards proportions.

A. multicostatus.—In text C. C., p. 240, '*A. bisulcatus*.' The figure of C. C. not reproduced in Mon. In C. C. 'Dimensions.—Transverse diameter 8 inches; height of aperture $2\frac{3}{4}$ inches; width of aperture $2\frac{1}{2}$ inches.' In Mon. p. 276 are the same dimensions turned approximately into millimetres 200, 70, 64, but applied to

a specimen 'Pl. iii, fig. 1,' which figure shows 186, 51, 45 mm. in these cases, comes from another locality, and has different ribbing. The proportions of the C. C. shell are F. 148, 34, 32, 44, T. 203, 34.5, 31, —, and of the Mon. shell, F. 186, 28, 24, 49.

The whole of the article in Mon. is practically that of the C. C. paper. On p. 276 is a reference (footnote) to Vol. iii of the Proceedings of the Cotteswold Club. In the C. C. paper this footnote cited a prior page of Wright's own paper; in Mon. it cites a page to which it has no reference—another paper, already cited in footnote of previous page of Mon.

It will thus be seen that the C. C. paper gives much information necessary to an interpretation of the Monograph; and that there are several specimens figured in that paper which should have been in the Wright collection, and have been lost sight of: Curators should look out for them.

Now, however, comes another point of interest—Wright's C. C. paper and his plates of the year 1864 were known to Reynès in Marseilles within a short time of publication.

The plates of Reynès's Monograph contain (as we know) many original figures, but also many copied from other works. Most of these are easily recognizable, although there are no statements as to source. All the text issued with the work is the small pamphlet edited by Dr. P. de Ronville, introduction dated 1879. In this is the first part of the text of the 'Monographie des Ammonites,' dated 1867, presumably the year in which the Monograph would have been issued, but for the Author's premature death.¹ The preface to this part is dated by Reynès July 14th, 1866. The immediately following Bibliography extends to the year 1864, and under 1863 is '*Wright, On the Ammonites of the lias formations, London.*'

In his pl. xxxvii, figs. 3 & 4, as *A. brooki*, Reynès has slightly reduced copies of Wright's *A. brooki*, C. C. pl. ii, fig. 5; and in his pl. xliii, figs. 6 & 7, Reynès has again as *A. brooki* copies of Wright's *A. turneri* from Bredon, C. C. pl. ii, fig. 2. On the other hand, *Arietites scipionianus*, Wright, pl. xiii, published in 1879, and Reynès's *Ammonites scipionis*, pl. xxviii, figs. 7–9, illustrate the same specimen; and, looking at the identity of details, Wright's plate is presumably a copy of Reynès's plate in existence 10 years earlier, though not formally published until 1879.

It follows from the above remarks, about the specimens reproduced by Reynès from the C. C. paper, that the suggested possible presence of the Barrow-Bredon *Arietites* fauna in the Rhone Basin fails (p. 311), that the isolation of this fauna is thus more remarkable, and that any argument for a chronological difference of these *Arietites* and the *Microderocerates* of the *inflatum* set is strengthened. It also follows that the difference of ribbing noted for Reynès's figure of *A. brooki* is merely due to reduction in size.

¹ However, his '*Essai Géol. Aveyron.*' bears date 1868.

Reduction when not accompanied by a note to that effect is most misleading, as it makes ribs appear unduly approximate. Such reduction may be misleading in other cases in Reynès's figures.

I have not altered what was previously written about these matters, but have appended references to this page.

It is greatly to be desired that some one with access to the material in the Marseilles Museum should issue an explanatory text of Reynès's plates, indicating which are figures of original specimens and their localities, which are copies and their sources. It would be a grand monument to one who must have possessed an almost unique knowledge of Ammonites, and a fitting accompaniment to a wonderful series of plates. It would help to repair the loss which science undoubtedly sustained in the premature death of an author who gave promise of discriminative ability much in advance of his time.

[Since this paper was read I have found that Neumayr made much the same suggestion, in his review of the work (Neues Jahrbuch f. Min. etc., 1880, vol. ii, Referate, p. 394).]

EXPLANATION OF PLATES XXVI-XXXI.

[All figures are of the natural size, unless otherwise stated. All specimens are in the Author's collection, unless otherwise stated.]

PLATE XXVI.

Figs. 1 a-2 b. *LEPTALEOCERAS LEPTUM*, sp. nov., p. 285.

Fig. 1 a. Side view; fig. 1 b, apertural view. Holotype from Marlstone, South Petherton (Somerset) [Domerian, pre-*gibbosa*]; ex coll. D. S. Darell. Figs. 2 a & 2 b. Same views of a young shell from Middle Lias, Gretton, Winchcomb (Gloucestershire); pres. J. G. Hamling.

Figs. 3 a & 3 b. *LEPTALEOCERAS* aff. *LEPTUM*, p. 285.

Fig. 3 a. Side view; fig. 3 b, apertural view. From Middle Lias, Gretton, Winchcomb [Domerian, pre-*gibbosa*]; pres. J. G. Hamling.

Figs. 4 a-4 c. *ACANTHOPLEUROCERAS RUSCOSTA*, nom. nov., p. 286.

Fig. 4 a. Side view, body-chamber, $\times 0.5$; fig. 4 b, whorl-section, $\times 0.66$, taken at the break: left side is somewhat crushed; fig. 4 c, view of dorsum of end of last whorl, showing subsidiary costulae of penultimate whorl. Natural size. From Middle Lias clays, Leckhampton (Gloucestershire) [Hwiccian-Wessexian]; pres. late Rev. F. Smithe.

PLATE XXVII.

Figs. 1 a & 1 b. *RADSTOCKICERAS COMPLICATUM*, sp. nov., p. 287.

Fig. 1 a. Side view, test and carina only on first half-whorl; fig. 1 b, peripheral view, first half of outer whorl; both figs. $\times 0.5$. Lower Lias, (Radstock) Somerset; Deiran, *Radstockiceras* n. See also pp. 294-95, figs. 6, 12, 21.

Figs. 2 & 3. *GLEVICERAS GLEVENSE*, nom. nov., p. 289.

Fig. 2. Sectional view of holotype, $\times 0.5$. See Pl. XXVIII, figs. 1 & 2, and p. 294, fig. 5. Fig. 3. Side view of a paratype, a young example, $\times 2$; 'Middle Lias, *varicostatum*,' lower part of Folly Lane Brickyard, Cheltenham (Gloucestershire); Deiran, *Gleviceras* η . See Pl. XXIX, fig. 3, and Pl. XXX, fig. 4, for other illustrations of same example.

PLATE XXVIII.

Figs. 1 & 2. *GLEVICERAS GLEVENSE*, nom. nov., p. 289.

Fig. 1. Side view of holotype, $\times 0.5$; Middle Lias, '*varicostatum* hemera,' lower part of Folly Lane Brickyard, Cheltenham (Gloucestershire); Deiran, *Gleviceras* η . For sectional view see Pl. XXVII, fig. 2, and see also fig. 5, p. 294. Fig. 2. Side view (part) of paratype taken as genotype; Lower Lias Shales, Cheltenham, ex J. Buckman Coll. ('*Am. greenhoughii*') [Deiran, *leviceras* η]. See also pp. 294-95, figs. 4, 11, 21.

Fig. 3. *MICRODEROCERAS INFLATUM*, sp. nov., p. 305.

Fig. 3. Apertural view, $\times 0.66$. See Pl. XXIX, fig. 1.

Fig. 4. *ARNIOCERAS FORTUNATUM*, sp. nov., p. 301.

Fig. 4. Peripheral view, natural size. See Pl. XXXI, fig. 4.

PLATE XXIX.

Fig. 1. *MICRODEROCERAS INFLATUM*, sp. nov., p. 305.

Fig. 1. Side view, $\times 0.66$; Lower Lias, Barrow Gurney (Somerset) [Lymian-Mercian, post-*birchi*]. See Pl. XXVIII, fig. 3.

Figs. 2 a & 2 b. *ARIETITES TURGESCENS*, sp. nov., p. 296.

Fig. 2 a. Side view; fig. 2 b, peripheral view showing loss of carina, with long ventral projection and sudden return to a rounded venter with a much shortened rostrum; both figures $\times 0.5$. Lower Lias, Barrow Gurney (Somerset) [Mercian, post-*turneri*]. See Pl. XXXI, fig. 5.

Figs. 3 a-3 c. *GLEVICERAS GLEVENSE*, nom. nov., p. 289.

Fig. 3 a. Side view; fig. 3 b, peripheral view; both figs. $\times 1.25$; fig. 3 c, part of side view showing suture-lines marked in on photograph, $\times 2$. See also Pl. XXVII, fig. 3. Pl. XXX, fig. 4, for other illustrations of same specimen; also Pl. XXVII, fig. 2 & Pl. XXVIII, figs. 1-2.

PLATE XXX.

Figs. 1 a & 1 b. *MICRODEROCERAS DEPRESSUM*, nom. nov., p. 303.

Fig. 1 a. Side view; fig. 1 b, apertural view of holotype; Lower Lias, Barrow Gurney (Somerset) [Lymian-Mercian, circa *birchi*]; pres. J. W. D. Marshall.

Figs. 2 a & 2 b. *MICRODEROCERAS SEPTIGERUM*, nom. nov., p. 304.

Fig. 2 a. Side view; fig. 2 b, apertural view. 'Lower Lias Shales, Cheltenham [District]; Gloucestershire, Bredon, Worcestershire], [Lymian-Mercian, post-*birchi*]; ex J. Buckman Coll. ('*Ammonites birchii*').

Figs. 3 *a*-3 *d*. *GLEVICERAS RIPARIUM* (Oppel), p. 292.

Fig. 3 *a*. Side view, last half of whorl somewhat crushed; fig. 3 *b*, peripheral view of first half of whorl; fig. 3 *c*, peripheral view with ribs, auriculoids, and their connecting pseudo-carina marked diagrammatically; fig. 3 *d*, part of side view with auriculoid marked diagrammatically, also suture-line (approximate): the incipiently-trilobulate superior lateral lobe is on the edge of the periphery in line with auriculoids. All figures $\times 2$. Lower Lias '*oxynotum*,' Aston Cross, Tewkesbury (Gloucestershire) [Deiran, *biferum* η].

Fig. 4. *GLEVICERAS GLEVENSE*, nom. nov., p. 289.

Fig. 4. Radial line and rib-scheme of example figured in Pl. XXVII, fig. 3, and Pl. XXIX, figs. 3 *a*-3 *c*, marked diagrammatically in photograph, $\times 2$. See also Pl. XXVII, fig. 2 & Pl. XXVIII, figs. 1-2, for illustrations of other examples.

Figs. 5 *a* & 5 *b*. *GLEVICERAS AURITULUM/GLEVENSE*, p. 291.

Fig. 5 *a*. Suture-line of specimen figured in Pl. XXXI, figs. 1 *a* & 1 *b*, marked in diagrammatically on the photograph; fig. 5 *b*, rib-scheme with auriculoids similarly marked in; both figures $\times 2$.

PLATE XXXI.

[A white $\times$ marks the beginning of the body-chamber.]

Figs. 1 *a* & 1 *b*. *GLEVICERAS AURITULUM/GLEVENSE*, p. 291.

Fig. 1 *a*. Side view; fig. 1 *b*, peripheral view; both figures $\times 2$. From Lias, Charmouth (Dorset) [Bed 92]; Coll. James Francis. [Deiran, *Gleviceras* η .] See Pl. XXX, figs. 5 *a* & 5 *b*.

Figs. 2 *a* & 2 *b*. *ARNIOCERAS FLAVUM*, nom. nov., p. 298.

Fig. 2 *a*. Side view; fig. 2 *b*, peripheral view; holotype; Lias Limestones, Lyme Regis (Dorset) [Lymian, *Arnioceras* η].

Figs. 3 *a*-3 *d*. *ARNIOCERAS ANAGENETICUM*, sp. nov., p. 300.

Fig. 3 *a*. Side view; fig. 3 *b*, apertural view; fig. 3 *c*, peripheral view, taken at the end of the whorl, showing ribs, nodes, keel, and incipient sulci—all these figures are of the natural size; fig. 3 *d*, part of whorl, showing suture-lines, $\times 2$. Lias Limestones, Lyme Regis (Dorset) [Lymian, *Arnioceras* η].

Figs. 4 *a* & 4 *b*. *ARNIOCERAS FORTUNATUM*, sp. nov., p. 301.

Fig. 4 *a*. Side view, natural size; fig. 4 *b*, suture-lines, approximate delineation of last one, not clearly shown, taken at $\times$. Lias, Paulton, near Radstock (Somerset) [Lymian, *Arnioceras* η]. See Pl. XXVIII, fig. 4.

Fig. 5. *ARIETITES TURGESCENS*, sp. nov., p. 296.

Fig. 5. Part of periphery, with rib-curves marked diagrammatically, showing change after loss of keel. See Pl. XXIX, figs. 2 *a* & 2 *b*.

DISCUSSION.

Mr. W. D. LANG said that, while heartily welcoming the paper, he would wish to criticize it from two points of view.

(1) In applying the principle of faunal dissimilarity, the

Author appeared to disregard the alternative possibility: namely, that, in certain cases, ammonites may have had very restricted horizontal ranges. It is not enough to point to ammonites as being strongly-swimming organisms. So are fishes: yet many marine fishes are strictly limited in their horizontal distribution. The details of the temperature and currents along the Liassic shore-line were not known sufficiently for us to decide how far the ammonites of any one locality would be restricted; nor did our knowledge of their bionomics enable us to say whether these or other factors might have limited their distribution.

It is extremely improbable that the *Oxycones* in the *Oxynotus*-Bed of the Dorset Coast are derived, since, with the pyritized specimens are found others, manifestly un-derived, consisting as they do of films on the clay.

(2) Concerning the nomenclature of stages and of zones, two opposing principles are followed by different authors. According to the one, the name of a stage or zone is taken, and its boundaries altered, if desired. According to the other, the original connotation of the term is retained, and, if new divisions are needed, the original stages are subdivided. Thus, Bonarelli subdivided the Charmouthian into Domerian and a lower, unnamed division, which was subsequently termed 'Carixian'; but the Author had meanwhile restricted the term 'Charmouthian' to this lower division, which he now subdivides. Nor was this all, for most of his Raasayan is part of the Sinemurian. Therefore, it would be necessary to say Charmouthian of Mayer-Eymar, Charmouthian of Buckman, and so on. Similarly, Wright instituted a zone of *A. turneri*, but this is by no means the zone of *A. turneri* of the paper now under discussion; and instances might be multiplied.

It would be advantageous if an agreement were to be arrived at among geologists as to which principle should be adopted. The speaker strongly advocated the latter principle, and added that its application should not reach back to old and well-established terms.

Dr. A. M. DAVIES said that, for nearly thirty years, the Author had been developing ideas on the Jurassic Period in a series of papers in the Society's Journal. Starting with the Inferior Oolite, in which non-sequences could be demonstrated by stratigraphical as well as palæontological evidence, he was now extending this principle in the investigation of strata where only the latter was usually available. While the conditions of deposition of the West European Jurassic were such as to favour local alternations of erosion and deposition, it was possible that some inconsistencies of faunal sequence might be explained in another way—by alternate contraction and expansion of the geographical range of a genus. Even if the Author's explanation should not be confirmed in every case, the Society ought to be grateful to him for bringing so many new facts and suggestions before them; and also, incidentally, for having induced Mr. Tatcher to present them with some of the results of his long and careful work in the Bristol area.

Mr. G. W. LAMPLUGH said that, while recognizing the scientific value of this intensive study of the Liassic ammonites, he feared that the Author's continued refinements of the nomenclature and zonal classification had carried the subject beyond the reach of the ordinary field-geologist. From the imperfect nature of the evidence, such exactitudes as those shown in the tables could rarely be applicable in the field. The use of fossils by the stratigrapher in the past, though crude, had generally been effective for his purpose; but he could not be expected to master the complicated technicalities of these new methods. The stratigraphical deductions drawn solely from these palæontological studies did not inspire confidence.

Dr. J. W. EVANS thought that the questions raised by the paper were of considerable importance, with reference to the problem of determining the time occupied in the deposition of sediments. If the numerous non-sequences believed by the Author to exist were substantiated, there could be little doubt that there must be many more of shorter duration for which no palæontological evidence was available, and the conclusion would be justified that the geological record was of a far more fragmentary character than generally believed, and represented only a small fraction of the time that actually elapsed. In this way would be explained the contrast between the hundreds of millions of years for the age of the Palæozoic formations postulated by workers in the field of radioactivity, and the tens of millions arrived at by those who based their conclusions on the rate of deposition (see *Proc. Geol. Assoc.* vol. xxiv, 1913, pp. 243-44).

J. W. Tutcher, Photo.

Bemrose, Collo, Derby.

LEPTALEOCERAS, ACANTHOPLEUROCERAS.

J. W. Tutchter, Photo.

Bemrose, Colln., Derby.

MICRODEROCERAS, ARIETITES, GLEVICERAS.

J. W. Tutchter, Photo.

Bemrose, Colla, Derby.

GLEVICERAS, ARNIOCERAS, ARIETITES.