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ON THE  
  
FORAMINIFERA  
  
OF THE  
  
FAMILY ROTALINÆ (*Carpenter*)  
  
FOUND IN THE  
  
CRETACEOUS FORMATIONS;  
  
WITH  
  
NOTES ON THEIR TERTIARY AND RECENT REPRESENTATIVES.

BY  
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§ I.—In preparing lately some critical notes\* on the Foraminifera from the Chalk of Gravesend and Meudon, figured in Dr. Ch. G. Ehrenberg's 'Mikrogeologie' (1854), we were much impressed with the desirability of pointing out as clearly as we could the specific relationship of those members of the "Rotaline" family of Foraminifera which have been found in the Chalk and associated strata, and have been figured and described by various palæontologists. This seemed the more requisite, inasmuch as these Foraminifera are mostly disguised by an old-fashioned and incorrect nomenclature. The relationship, also, of the Cretaceous to the Tertiary and Recent *Rotalinæ* seemed to require elucidation.

\* Published in the 'Geol. Mag.' Nos. 89 & 90, Nov. and Dec. 1871.

§ II.—Without further preface, we proceed to notice that among Ehrenberg's figures (i.) from Meudon, near Paris ('*Geol. Mag.*' vol. viii. pp. 511 & 563), we recognize only :—

- |   |  |
|---|--|
| 1. <i>Planorbulina ammonoides</i> (Rss.). | 3. <i>Pulvinulina truncatulinoides</i> (D'O.). |
| 2. — <i>globulosa</i> (Ehr.).             | 4. — <i>Micheliniana</i> (D'O.).               |

(ii.) From Gravesend :—

- |   |  |
|---|--|
| 1. <i>Planorbulina ammonoides</i> (Rss.). | 2. <i>Pulvinulina Micheliniana</i> (D'O.). |
|---|--|

§ III.—From Meudon, Sens, and St. Germain, near Paris, M. d'Orbigny had already obtained (in 1840\*) :—

- |   |  |
|---|--|
| 1. <i>Planorbulina Voltziana</i> (D'O.).                        | 5. <i>Pulvinulina Micheliniana</i> (D'O.). |
| 2. — <i>Lorneiana</i> (D'O.).                                   | 6. — <i>crassa</i> (D'O.).                 |
| 3. — <i>Clementiana</i> (D'O.).                                 | 7. — <i>Cordieriana</i> (D'O.).            |
| 4. — (subgen. <i>Truncatulina</i> ) <i>Beaumontiana</i> (D'O.). | 8. <i>Rotalia umbilicata</i> (D'O.).       |

All of these M. d'Orbigny found also in the English Chalk.

§ IV.—In our own Collection we have :—

1. *From the Chalk (Upper) of Thorpe, near Norwich.*

- |  |  |
|--|--|
| 1. <i>Planorbulina Haidingerii</i> (D'O.).     | 5. <i>Rotalia umbilicata</i> (D'O.).                               |
| 2. — <i>Ungeriana</i> (D'O.).                  | 6. <i>Tinoporus concavus</i> (Lamk.) et <i>globularis</i> (Phil.). |
| 3. — <i>ammonoides</i> (Rss.).                 |  |
| 4. — (Truncatulina) <i>lobatula</i> (W. & J.). |  |

2. *From the Chalk of Gravesend.*

- |  |  |
|--|--|
| 1. <i>Planorbulina Ungeriana</i> (D'O.).       | 5. <i>Pulvinulina Micheliniana</i> (D'O.).                         |
| 2. — <i>ammonoides</i> (Rss.).                 | 6. <i>Rotalia umbilicata</i> (D'O.).                               |
| 3. — (Planulina) <i>ariminensis</i> (D'O.).    | 7. <i>Tinoporus concavus</i> (Lamk.) et <i>globularis</i> (Phil.). |
| 4. — (Truncatulina) <i>lobatula</i> (W. & J.). |  |

3. *From the Chalk-marl of Kent †.*

- |  |  |
|--|--|
| 1. <i>Planorbulina Ungeriana</i> (D'O.). | 4. <i>Tinoporus concavus</i> (Lamarck) et <i>globularis</i> (Phil.). |
| 2. — <i>ammonoides</i> (Rss.).           |  |
| 3. <i>Pulvinulina Menardii</i> (D'O.).   |  |

4. *From the Gault of Kent.*

- |  |   |
|--|---|
| 1. <i>Planorbulina Ungeriana</i> (D'O.). | 5. Pl. (Truncat.) <i>variabilis</i> (D'O.). |
| 2. — <i>ammonoides</i> (Rss.).           | 4. <i>Pulvinulina caracolla</i> (Rœm.).     |

5. *From the Gault of Biggleswade, Bedfordshire.*

- |  |                                      |
|--|--------------------------------------|
| 1. <i>Planorbulina ammonoides</i> (Rss.).  | 3. <i>Rotalia umbilicata</i> (D'O.). |
| 2. — (Truncat.) <i>lobatula</i> (W. & J.). |                                      |

\* *Mém. Soc. Géol. France*, vol. iv. part 1.

† Partly from Dover, but mostly from Charing, collected by W. Harris, Esq., F.G.S.

6. *From the Greensand of Warminster.*

- |  |  |
|--|--|
| 1. <i>Planorbulina Ungariana</i> (D'O.). | 4. <i>Pulvinulina caracolla</i> (Ræm.).        |
| 2. — <i>ammonoides</i> (Rss.).           | 5. <i>Tinoporus concavus</i> ? (Lamk.)*.       |
| 3. — (Trunc.) <i>lobatula</i> (W. & J.). | 6. <i>Patellina lenticularis</i> (Blumenbach). |

Of these there are also subvarieties corresponding more or less closely not only with those named by M. d'Orbigny †, but also with many of the numerous Rotaline varieties recorded by Prof. Reuss and others from the Chalk of Europe. This will appear more distinctly in the promised Monograph on the British Cretaceous Foraminifera by ourselves and Mr. H. B. Brady. Thus, although wonderfully constant in chief characters, the little *Planorbulina ammonoides* is linked by slightly divergent subvarieties with *Pl. (Planulina) ariminensis* on the one hand, and with *Pl. Ungariana* on the other; and the latter is but a feeble form of *Pl. Haidingerii*, and so on. So also the small forms of *Planorbulina* figured by D'Orbigny from the Chalk of France may be said to radiate from *Pl. ammonoides* with gentle modifications.

*Eley. Encl. (Chalk. 1859.*

§ V.—Among Dr. EHRENBURG'S figures of Foraminifera from (1) the Chalk of Møen, Denmark ('Mikrogeol.' pl. 14), we find:—

- |   |   |
|---|---|
| 1. <i>Planorbulina ammonoides</i> (Rss.).   | 4. <i>Pulvinulina elegans</i> ? (D'O.). |
| 2. — <i>globulosa</i> (Ehr.).               | 5. — <i>Orbignyi</i> ? (Ræm.).          |
| 3. — (Planulina) <i>ariminensis</i> (D'O.). | 6. — <i>spatiosa</i> (Ehr.).            |

(2.) From the Chalk of Rügen, in the Baltic, Ehrenberg figures ('Mikrogeol.' pl. 15):—

- |  |  |
|--|--|
| 1. <i>Planorbulina Haidingerii</i> (D'O.). | 4. <i>Pulvinulina Micheliniana</i> (D'O.). |
| 2. — <i>ammonoides</i> (Rss.).             | 5. — <i>squama</i> (Ehr.).                 |
| 3. — <i>globulosa</i> (Ehr.).              |  |

(3.) From the Russian Chalk of Volsk ('Mikrogeol.' pl. 16):—

- |   |   |
|---|---|
| 1. <i>Planorbulina Haidingerii</i> (D'O.).  | 3. <i>Pulvinulina caracolla</i> (Ræm.). |
| 2. — (Planulina) <i>ariminensis</i> (D'O.). |   |

(4.) From the North-American Chalk of Missouri ('Mikrogeol.' pl. 17, i.):—

1. *Pulvinulina caracolla* (Ræm.).

(5.) From that of Mississippi ('Mikrogeol.' pl. 17, ii.):—

- |   |   |
|---|---|
| 1. <i>Planorbulina ammonoides</i> (Rss.). | 2. <i>Planorbulina</i> (Planul.) <i>ariminensis</i> (D'O.). |
|---|---|

In these determinations from Ehrenberg's plates we cannot aim at catching the subvarietal minutæ very clearly; for the figures are

\* This species and its var. *globularis* (Phil.) of the Chalk-marl and Chalk are usually termed *Orbitolina*; but they belong to the Rotaline genus *Tinoporus* (see Carpenter's 'Introd. Foram.' pp. 223 &c.). The very similar specimens, however, from the Greensand of Haldon and Milberdown, Devonshire, and some of those from Warminster, are *Patellina*, also of the ROTALINÆ family.

† Prof. Morris's 'Catalogue of British Fossils,' 2nd edit. 1854.

little more than sections, the object being seen by transmitted light. *Planorbulina globulosa* (Ehr.), must not be regarded as worth much, being a very minute Rotaline, and such a form as several species might present in their earliest stage of growth.

§ VI.—For the recorded Cretaceous ROTALINÆ (Carpenter), besides those of England, France, the Baltic, Russia, and North America already noticed, the most convenient plan will be to simply enumerate them in their groups of alliance, and according to the authors describing them. Thus:—

1. F. A. RÖEMER. 'Versteinerungen des Norddeutschen Kreidegebirges,' 1840–41; Rhizopoden, pp. 95–99. (Lower Cretaceous.)

- |    |                  |                                |  |
|----|------------------|--------------------------------|--|
| 1. | Pl. 15. fig. 23. | <i>Truncatulina lævigata</i> . | <i>Tr. lobatula</i> (W. & J.).   |
| 2. | 22.              | <i>Gyroidina caracolla</i> .   | } <i>Pulvinulina</i> near <i>P. elegans</i> (D'O.), a<br>subtype of <i>P. repanda</i> (F. & M.). |
| 3. | 24.              | <i>Planulina Orbignyi</i> .    |  |
| 4. | 25.              | — ornata.                      |  |
| 5. | 20.              | <i>Rotalia sulcata</i> .       | <i>Planorbulina</i> ( <i>Truncatulina</i> ) near <i>Tr. advena</i> (D'O.).                       |
| 6. | 21.              | — conica.                      | <i>Planorbulina</i> ? Near <i>Pl. rosea</i> (D'O.)?  |

2. FR. VON HAGENOW. 'Monographie der Rügen'schen Kreide-Versteinerungen;' iii. Abtheilung,—Mollusken. In *N. Jahrb. für Min. ꝓc.* 1842, pp. 528–575.

1. Not figured. *Rotalia constricta*. Figured by Reuss, 'Sitzungsb. Ak. Wien,' xlv. pl. 6. f. 7, pl. 7. f. 1. Very near *Planorbulina ammonoides* (Rss.).
2. Fig. 23. *Planorbulina angulata*. According to Reuss=*Pl. ammonoides* (Rss.).
3. Not figured. — umbilicata. According to Reuss=*Anomalina complanata* (Rss.), which is evidently *Planorbulina* (*Anomalina*) *rotula* (D'O.).
4. Not figured. *Truncatulina sublævis*. According to Reuss=*Tr. convexa*, Rss. (Thick *Tr. lobatula*.)
5. Fig. 22. *Rotalia turgida*. According to Reuss=*R. umbilicata*, D'O.
6. Not figured. *Nonionina globosa*. Figured by Reuss, *op. cit.* pl. 7. f. 2, as *Rotalia globosa*, and near *R. umbilicata*, D'O.
7. In Fr. von Hagenow's 'Die Bryozoen der Maastrichter Kreide-Bildung,' 1850, we see *Cymbalopora radiata*, von Hag., p. 104, pl. 12. fig. 18 (Carpenter's 'Introd. Foram.' p. 215).

3. A. E. REUSS. 'Versteinerungen der Böhmischen Kreideformation,' 1845–46; Rhizopoden, i. 1845, pp. 25–28, pls. 8, 12, & 13; ii. 1846, pp. 106–110, pls. 24 & 43.

1. Pl. 8. fig. 53, & pl. 13. fig. 66. *Rosalina ammonoides*. *Planorbulina* (subgenus *Anomalina*) *ammonoides*, very near to *Planorb.* (*Anom.*) *Lamarckiana* (D'O.), Foram. Canaries, pl. 2. figs. 13–15.
2. Pl. 12. fig. 17. *Rotalina lenticula*. *Planorbulina* near *P. Dutemplei* (D'O.).
3. 30, & pl. 13. fig. 67. *Rosalina moniliformis*. *Pl.* (*Anom.*) near *Pl. ammonoides*.
4. 8. *Rotalina nitida*. *Pulvinulina* near *P. crassa* (D'O.).
5. 18. — polyrraphes. *Planorb.* (*Truncatulina*), a neat and thick subvariety of *Tr. lobatula*.
6. Pl. 8. fig. 71. *Truncatulina lævigata*, Rœm. An attached *T. lobatula*?
7. Pl. 12. fig. 31. *Rotalina Micheliniana*, D'O. *Pulvinulina Micheliniana* (D'O.).
8. Pl. 8. fig. 52, & pl. 12. fig. 20. *Rotalina nitida*. *Pulvinulina* closely allied to *Pulv. Micheliniana* (D'O.) and *Pulv. crassa* (D'O.).

[Pl. 8. figs. 54, 74, & pl. 13. fig. 68, *Rosalina marginata*, is not a Rotaline, but a *Globigerina*, discoidal, neat, limbate, and hirsute; it is better figured, together with another specimen of the same kind, *Ros. canaliculata*, in Dr. Reuss's Memoir on the Chalk of the Eastern Alps, 1854, pl. 26. figs. 1 & 4. *Globig. Linnæi* (D'Orb.), 'Foram. Cuba,' pl. 5. f. 10-12 is similar, but without prickles. These are Globigerine isomorphs of *Planulina ariminensis*, *Discorbina biconcava*, and *Pulvinulina Menardii*. *Glob. marginata* (Rss.), is common in the English Chalk.]

4. ALOIS ALTH. 'Geognostisch-paläontologische Beschreibung der nächsten Umgebung von Lemberg.' In *Haidinger's naturwiss. Abhandlungen*, vol. iii. 1850. Foraminifera, pp. 262-271.

1. Pl. 13. fig. 21. *Rotalina depressa*. *Planorb. ammonoides* (rather flat).
2. 20. *Rosalina galiciana*. *Truncat. lobatula*.

5. A. E. REUSS. 'Die Foraminiferen und Entomostraceen des Kreidemergels von Lemberg.' *Haidinger's naturw. Abhandl.* vol. iv. 1851. Foraminifera, pp. 22-46.

1. Pl. 4. fig. 2. *Rotalina ammonoides*. *Planorb. ammonoides*. See above.
2. 3. *Anomalina complanata*. *Pl. (Anom.) rotula* (D'O.).
3. 1. *Rotalina polyrraphes*. *Truncatulina*. See above.
4. Pl. 3. fig. 14. — involuta. *Truncatulina* rather thicker than the *Tr. polyrraphes* (Rss.).
5. Pl. 4. fig. 4. *Truncatulina convexa*. Thicker still, only slightly differing from *Truncatulina Beaumontiana*, D'O.

6. A. E. REUSS. 'Beiträge zur Charakteristik der Kreideschichten in den Ostalpen, besonders im Gosauthal und am Wolfgangsee.' *Denksch. kais. Akad. Wissensch. Wien*, vol. vii. 1854. Foraminifera, pp. 66-72.

1. Pl. 25. fig. 15. *Rotalina stelligera*. *Pulvinulina* of the *elegans* group.
2. Pl. 26. fig. 2. *Rosalina squamiformis*. } *Pulvinulina*, extreme forms (peculiar
3. 3. — concava. } to deep water) of the *Schreibersii* gr.
4. — canaliculata. } *Globigerina marginata* (Rss.). See above].
1. — marginata. }

7. A. E. REUSS. 'Beitrag zur genaueren Kenntniss der Kreidegebilde Meklenburgs.' *Zeitschr. d. deutsch. geol. Gesell.* vol. vii. 1855, pp. 261-292.

1. Pl. 9. fig. 6. *Rotalia Brueckneri*. *Planorbulina Haidingerii* (D'O.).
2. 8. *Rosalina Kochi*. *Planorb. (Anom.) rotula* (D'O.).
3. Pl. 11. fig. 3. *Rotalina deplanata*. } *Truncat. lobatula*; neatly formed.
4. 4. *Truncatulina concinna*. }
5. Pl. 9. fig. 6. *Rotalia Karsteni*. *Pulvinulina*, one of the medium forms of the *Schreibersii* group, and near *Pulv. antillarum* (D'O.).

8. A. E. REUSS. 'Die Foraminiferen der Westphalischen Kreideformation.' *Sitzungsb. Akad. Wiss. Wien*, vol. xl. pp. 147 et seq. 1860.

1. Pl. 11. fig. 5. *Rotalia umbonella*. *Planorbulina* belonging to the *Ungeriana* subgroup.

2. Pl. 11. fig. 4. *Rotalia exsculpta*. A true *Rotalia*, near *R. ornata* (D'O.), *Amér. Mérid.* p. 40, pl. 1. figs. 18–20.  
[6. *Valvulina allomorphinoides*, seems to be a *Spheroidina* between *bulloides* and *dehiscens*.]

9. A. E. REUSS. 'Palæontologische Beiträge.' *Sitzungsb. math.-naturw. Cl. kais. Akad. Wiss. Wien*, vol. xlv. 1861.

I. 'Die Foraminiferen der Kreidetuffes von Maastricht,' pp. 304–324.

1. Pl. 2. fig. 2. *Rotalia tuberculifera*. *Planorbulina Ungeriana*, var. profusely granulated.  
2. — involuta, var. *Pl. Ungeriana*, without even so many granulations as shown on D'Orbigny's figured specimen.  
3. 5. — hemisphærica. *Planorbulina* belonging to the *Haidingerii* group.  
4. Pl. 3. fig. 2. *Truncatulina tenuissima*. *Planorb. (Anom.) rotula*, compressed subvariety.  
5. 1. *Rosalina Bosqueti*. *Truncatulina lobatula*.  
6. Pl. 2. fig. 3. — Binkhorsti. *Discorbina Binkhorsti* (Rss.). Essentially the same as the somewhat slighter *D. valvulata* (D'O.), living at the Canary Islands and West Indies: this is a well-grown, limbate form, allied to *D. vesicularis* (D'O.), a subtype of *D. turbo* (D'O.), 'Phil. Trans.' vol. clv. p. 385.  
7. Pl. 4. figs. 1–4, 6. *Calcarina calcitrapoides* (*Lamk.*), and f. 5, var. *lævigata* (*Lamk.*).  
8. 7–9, and pl. 5. figs. 1–5. *Orbitoides Faujasi* (*Defr.*).

II. 'Die Foraminiferen der Schreiekreide von Rügen,' pp. 324–333.

1. Pl. 6. fig. 7, and pl. 7. fig. 1. *Rotalia constricta*, v. *Hag.* *Planorbulina ammonoides*, thin-edged.  
2. Pl. 7. fig. 2. *Rotalia globosa* (v. *Hag.*). A true *Rotalia*, near *R. umbilicata*, D'O. See above, p. 106.

III. 'Die Foraminiferen des senonischen Grünsandes von New-Jersey,' pp. 334–340.

1. Pl. 8. fig. 1. *Rotalia Mortoni*. *Planorbulina Ungeriana*, thick subvariety.  
2. Pl. 7. fig. 6. *Truncatulina Dekayi*. *Truncatulina lobatula*, neat form.

10. A. E. REUSS. 'Die Foraminiferen der norddeutschen Hils und Gault.' (Including also the Gault of Folkestone.) *Sitzungsb. Akad. Wiss. Wien*, vol. xlvi. 1863.

1. Pl. 10. fig. 3. *Rotalia lenticula*. *Planorbulina*, of the *Haidingerii* group.  
2. Pl. 11. fig. 5. *Rosalina Schlenbachi*. *Planorbulina*, a variety, with inflated chambers, between *Pl. Haidingerii* and *Ungeriana*.  
3. 4. — nitens. *Planorbulina*, a simple form of *Pl. farcta*.  
4. Pl. 10. fig. 2. *Rotalia nonionina*. *Planorb. (Anom.)*, a thick, few-chambered, subsymmetrical variety of *Pl. farcta*.  
5. Pl. 11. fig. 6. *Rosalina inflata*. *Planorb.* close to *ammonoides*, but with large chambers, even larger relatively than in *Pl. (Anom.) badenensis*, D'O.  
6. Pl. 13. fig. 1. *Nonionina bathyomphalus*. A very symmetrical (*Anomaline*) variety of *Planorbulina ammonoides* (Rss.).  
7. Pl. 11. fig. 3. *Rosalina complanata*, Rss., var. The same as *Pl. (Anom.) rotula*, D'O.





8. Pl. 11. fig. 7. *Rosalina rudis*. *Planorb.* (*Truncatulina*) *lobatula*, well grown, with full chambers.
9. 2. *Rotalia sulcata*. *Planorbulina*. The same as *Pl. sulcata* (Rœm.). See p. 106. *Truncatulina dispar*, D'O., and *Tr. advena*, D'O., are not distant allies, on the one hand; and *Pl. umbonella* (Rss.), on the other hand, leads it into *Pl. Ungeriana*.
10. Pl. 10. fig. 4. — *reticulata*.
11. 5. — *Schlœnbachi*.
12. 6. — *caracolla* (Rœm.).
13. Pl. 13. figs. 3-5. — *spinulifera*.
14. 6. — *Carpenteri*.
15. Pl. 10. fig. 7, & pl. 11. fig. 1. *Rotalia hemisphærica* (semiglobosa, in the text, p. 85). This is near *Pulv. Cordieriana* (D'O.), a smooth member of the "elegans" group of *Pulvinulina*.

All these are scarcely separable sub-varieties, belonging to the "elegans" group of *Pulvinulina repanda* (F. & M.). The mutual alliance and gradational features of these and *Pulv. Orbigny* and *Pulv. ornata* (Rœmer, see above, p. 106), can readily be seen on a comparison of the beautiful figures given by Reuss, and the less elaborate, but recognizable, figures in Rœmer's 'Norddeusch. Kreidegeb.' Prof. Reuss finds *spinulifera* the most abundant form in the Gault of Folkestone. His *reticulata* is almost exactly the same as *P. Berthelotiana* (D'O.).

*Neer & Kaufman, Urwelt d. Schweiz, 1865, †*

11. F. KÄRBER. 'Ueber ein neues Vorkommen von oberer Kreideformation in Leitzersdorf bei Stockerau, und deren Foraminiferen.' *Jahrb. k. k. geol. Reichsanstalt*, 1870. Foraminifera, pp. 163-184.

1. Pl. 11. fig. 14. *Truncatulina horrida*. *Planorbulina Ungeriana*, granulose subvariety, rather thinner and poorer than *Pl. tuberculifera* (Rss.).
2. 15. *Discorbina danubia*. *Truncatulina lobatula*.
3. 16. *Rotalia fontana*. *Planorbulina (Anomalina)*, a neat compact ornate form.

§ VII.—In selecting the figured varieties of *Planorbulina*, *Pulvinulina*, *Discorbina*, and *Rotalia* enumerated in the foregoing lists, as examples of the known Cretaceous ROTALINÆ, we must not lose sight of the other Rotalines, such as *Calcarina*, *Cymbalopora*, *Patellina*, &c., in the Chalk and its associated strata. Of these, several interesting species are known. We must also explain that, besides the figured species and varieties, there are in most cases many allied forms enumerated in the respective memoirs, but not represented there, having been previously figured. Fortunately several of the forms noticed in the earlier memoirs have been refigured by our German fellow-labourers, in the first style of modern lithography, and with real naturalistic art. In the appended Table we have introduced, as far as we can recognize them, the other forms referred to, besides those figured in the several memoirs, for the different localities.

§ VIII.—As an example of a local group of Foraminifera of the Family ROTALINÆ (Carpenter) amongst a special fauna, corresponding, though of later age, with such other groups as are depicted by

+ *Lacuna globosa*  
*Planorbulina globulosa*  
*Testularia globulosa*  
*Globicarinæ cretacea* } *Seeuathk*

Reuss from the Bohemian, the Westphalian, and other Cretaceous formations, we here enumerate the ROTALINÆ which D'Orbigny figured and described in 1846 from the Miocene strata of the neighbourhood of Vienna. And we reduce his nomenclature to that adopted by ourselves, so that the comparison of varieties (or, rather, in most cases, subvarieties) may readily be made by others. Were, for instance, all the Cretaceous Planorbuline *Rotalinæ* figured by Reuss, and all these Tertiary Planorbulines figured by D'Orbigny, copied out on a sheet of paper, and arranged in the order of their alliances, a close *specific* relationship would be clearly observed, but modified by varietal and subvarietal (or rather individual) differences, which give the groups a different *facies*. So also the several Cretaceous faunas, local or successive, will be found to have somewhat different *facies*, without changing much as to species and definite varieties.

For another reason, too, have we produced this critical list of the fossil ROTALINÆ from Vienna,—because the naming of these and of some of the German Cretaceous Foraminifera by Prof. Reuss was contemporaneous. It is, however, the naming of the *type* (or average form) of a group or subgroup that takes priority among Foraminifera, the names of minor varieties becoming merged in those of the more important types, as we have stated elsewhere.

The 'Foram. Foss. Bassin de Vienne,' is also an accessible book for most students; and other species determined by D'Orbigny in former years can be readily found in the 'Ann. Nat. Hist.' of 1865 and 1871, in plates attached to memoirs by ourselves and our colleague Mr. H. B. Brady.

1. For the *Planorbulinæ*, which chiefly concern us now, it will be remembered that *Pl. farcta* (Fichtel & Moll) is the type; *Pl. tuberosa* (F. & M.) is the subtype; and all other known forms of *Planorbulina* can be grouped with one or the other of these. Or, in other words, *Pl. farcta* may be termed the species, *Pl. tuberosa* the chief variety, and other forms inferior varieties of one or the other. This is zoologically true, though rather confusing. At all events, in indicating the *precise* relationships of the *Planorbulinæ*, the latter plan has to be followed. A critical account of *Planorbulinæ*, *Pulvinulinæ*, *Discorbinaæ*, and *Rotalinæ*, useful to the readers of this paper, will be found in the 'Phil. Trans.' 1865, pp. 378 *et seq.*

*Rotalinæ* extracted from A. D'Orbigny's 'Foraminifères fossiles du Bassin tertiaire de Vienne,' 1846.

#### PLATE VII.

- Figs. 19–21. *Rotalina kalebergensis*. *Planorbulina*, a compressed variety of *Pl. tuberosa* (F. & M.), near *Pl. Dutemplei* (D'O.), but thinner.  
 22–24. — Hauerii. *Pulvinulina* near *P. auricula* (F. & M.).  
 25–27. — Boueana. *Pulvinulina* near *P. pulchella* (D'O.).  
 28–30. — Partschiana. *Pulvinulina* near *P. peruviana* (D'O.).

#### PLATE VIII.

- Figs. 1–3. — Partschiana. *Pulvinulina* near *P. peruviana* (D'O.).  
 4–6. — Schreibersii. *Pulvinulina* near *P. Alvarezii* (D'O.).  
 7–9. — Haidingerii. *Planorbulina*, a conical subvariety of *Pl. tuberosa* (F. & M.).

- Figs. 10-12. *Rotalina Soldanii*. *Rotalia* near *R. umbilicata* (D'O.).  
 13-15. — Akmeriana. *Planorbulina* (*Truncatulina*), stout, compact, and many-chambered variety of *Pl. farcta*; or it may be regarded as a variety of *Pl. tuberosa*, quite flattened on one face.  
 16-18. — Ūngeriana. *Planorbulina* (*Anomalina*), neat, compressed, and symmetrical subvariety of *Pl. tuberosa*.  
 19-21. — Dutemplei. *Planorbulina*, a subvariety of *Pl. tuberosa*, much depressed on one face.  
 22-24. — Brongniartii. *Pulvinulina auricula* (F. & M.).  
 25-27. — aculeata. *Calcarina Spengleri* (Gm.), var.

## PLATE IX.

- Figs. 16-17. *Planorbulina mediterraneensis*. *Planorbulina*, var. of *Pl. farcta* (F. & M.).  
 18-23. *Truncatulina lobatula* (W. & J.). *Pl.* (*Truncat.*), a variety or arrested form of *Pl. farcta*.  
 24-26. — Boueana. *Pl.* (*Tr.*) *lobatula* (W. & J.), a neat and round subvariety.  
 27-29. *Anomalina variolata*. *Pl.* (*Tr.*) *lobatula*, coarse-pored.

## PLATE X.

- Figs. 1-3. *Anomalina badenensis*. *Planorbulina* (*Anomalina*), a discoidal, inflated subvariety of *Pl. tuberosa*.  
 4-9. — austriaca. *Planorb.* (*Anom.*), discoidal, compressed, a thin-edged subvariety of *Pl. tuberosa*, = *ammonoides* (Rss).  
 10-12. — rotula. *Pl.* (*Anom.*), a flat subvariety of *Pl. tuberosa*.  
 13-15. *Rotalina complanata*. *Discorbina*, a neat, compact, helicoid subvariety of *D. elegans* (D'O.).  
 16-18. — imperatoria. *Discorbina* related to *D. pileolus* (D'O.).  
 19-21. — dubia. ?  
 22-24. — viennensis. *Rotalia*, var. of *R. Beccarii* (Lin.).  
 25-27. — simplex. *Planorbulina*, a simple, neat, helicoid subvariety of *Pl. tuberosa*.

## PLATE XI.

- Figs. 1-3. *Asterigerina planorbis*. *Discorbina rosacea* (D'O.), a thick specimen.  
 4-6. *Rosalina obtusa*. *Discorbina*, a good variety, related to *D. globularis* (D'O.).

2.—To apply this critical determination of D'Orbigny's Viennese species to our study of the Cretaceous ROTALINÆ, we must group them in their natural order, so as to render them comparable with the Table of Cretaceous Rotalines appended to this memoir; we must also insert with them such other forms from the Vienna Tertiary beds as Czjžek, Reuss, and Karrer have discovered.

Those figured and described by Karrer are as follows:—

- Anomalina Suessi*, Karrer\*. Sitzb. Ak. W. 1861, xlv. pl. 2. f. 2. A very much compressed *Anomalina austriaca*, D'O. From Ödenburg.  
*Rotalia speciosa*, Karrer. Sitzb. Ak. W. 1864, pl. 2. f. 12. *Anomalina coronata*, P. & J. From Baden.  
*Rotalia scutellaris*, Karrer. Sitzb. Ak. W. 1864, l. pl. 2. f. 13. *Planorbulina Haidingerii* (D'O.), subvariety. From Mödling.  
*Rosalina granulosa*, Karrer. Sitzb. Ak. W. 1864. l. pl. 2. f. 14. *Cymbalopora granulosa* (Karrer). From Forchtenau.  
*Rotalia tuberosa*, Karrer. Sitzb. Ak. W. 1867, lv. pl. 1. f. 4. *Rotalia Schrateriana*, P. & J. From Laa, Lower Austria.  
*Globigerina arenaria*, Karrer. Sitzb. Ak. W. 1867, lv. pl. 1. f. 10. (Non *Globigerina*.) *Discorbina*? From Grund, Lower Austria.

\* Some valuable Tables of the distribution of the Foraminifera in the several formations of the Vienna Basin are given by Herr Felix Karrer in his paper "Ueber das Auftreten," &c. in the Sitzungsberichte, 1861-67.

The species determined by Czjžek and Reuss are indicated, with references, in the following list, which gives the results of our critical study of the published forms of Miocene Foraminifera from Lower Austria (Vienna Basin).

*Foraminifera from Tertiary strata of the Vienna Basin, after  
D'Orbigny, Czjžek, Reuss, and Karrer.*

PLANORBULINA FRACTA (type).

Conical varieties.	{	Planorbulina Haidingerii ( <i>D'O.</i> ).
		P. scutellaris ( <i>Karrer</i> ).
		P. reticulata ( <i>Cz.</i> * pl. 13. f. 7-9).
		P. ( <i>Siphonia</i> ) fimbriata ( <i>Rss.</i> † pl. 47. f. 6) = <i>Pl. reticulata</i> ( <i>Cz.</i> ).
		P. kalemburgensis ( <i>D'O.</i> ).
		P. Ungeriana ( <i>D'O.</i> ).
		P. Dutemplei ( <i>D'O.</i> ).
		P. affinis ( <i>Cz.</i> pl. 12. f. 36-38) = <i>Pl. Dutemplei</i> ( <i>D'O.</i> ).
		P. Akneriana ( <i>D'O.</i> ).
		P. cryptophala ( <i>Rss.</i> pl. 47. f. 2.) = <i>Pl. Akneriana</i> ( <i>D'O.</i> ).
Nautiloid varieties.	{	P. badenensis ( <i>D'O.</i> ).
		P. austriaca ( <i>D'O.</i> ).
		P. rotula ( <i>D'O.</i> ).
		P. simplex ( <i>D'O.</i> ).
		P. Suessi ( <i>Karrer</i> ).
Plano-convex varieties.	{	P. speciosa ( <i>Karrer</i> ) = <i>Pl. coronata</i> , P. & J.
		P. mediterraneensis, <i>D'O.</i>
		Truncatulina lobatula ( <i>W.</i> ‡ <i>J.</i> ).
		T. Boueana, <i>D'O.</i>
		T. variolata ( <i>D'O.</i> ).

PULVINULINA REPANDA (type).

"Elegans" group.	{	Pulvinulina Partschiana ( <i>D'O.</i> ).
		P. badenensis ( <i>Cz.</i> pl. 13. f. 1-3).
"Schreibersii" group.	{	P. Schreibersii ( <i>D'O.</i> ).
		P. spinimargo ( <i>Rss.</i> pl. 47. f. 1).
		P. Boueana ( <i>D'O.</i> ).
"Auricula" group.	{	P. Brongniartii ( <i>D'O.</i> ).
		P. scaphoidea ( <i>Rss.</i> pl. 47. f. 3).
		P. Hauerii ( <i>D'O.</i> ).

DISCORBINA TURBO (type).

Discorbina complanata ( <i>D'O.</i> ).		D. nana ( <i>Rss.</i> pl. 46. f. 23).
D. imperatoria ( <i>D'O.</i> ).		D. arenata ( <i>Rss.</i> pl. 47. f. 4).
D. planorbis ( <i>D'O.</i> ) = <i>D. roseacea</i> ( <i>D'O.</i> ).		? D. arenaria ( <i>Karrer</i> ).
D. obtusa ( <i>D'O.</i> ).		? D. dubia ( <i>D'O.</i> ).
D. patella ( <i>Rss.</i> pl. 46. f. 22).		

ROTALIA BECCARII (type).

Rotalia tuberosa, <i>Karrer</i> , = <i>R. Schrateriana</i> , P. & J.
R. viennensis ( <i>D'O.</i> ).
R. Soldanii, <i>D'O.</i>
R. conoidea ( <i>Cz.</i> pl. 13. f. 4-6) = <i>R. Soldanii</i> , <i>D'O.</i>

\* Johann Czjžek, "Beitrag zur Kenntniss der fossilen Foraminiferen des Wiener Beckens." *Haidinger's naturwiss. Abhandl.* vol. ii. 1848.

† A. E. Reuss, "Neue Foraminiferen aus der Schichten des österreichischen Tertiärbeckens." *Denkschr. Akad. Wiss. Wien*, vol. i. 1850, pp. 365-390.

## CALCARINA SPENGLERI (type).

*Calcarina aculeata* (D'O.).

## CYMBALOPORA POEYI (type).

*Cymbalopora granulosa* (Karrer).

The relationship between the fossil fauna of Vienna and the living Foraminifera of the Mediterranean is shown in the Table opposite to page 302, Quart. Journ. Geol. Soc. vol. xvi. The species there numbered 104–107 are *Planorbulina*; 108–118 are *Pulvinulina*; 119–123 are *Rotalia*; and 127–132 are *Discorbina*.

§ IX.—To render our conception of the Rotaline portion of local and successive Foraminiferal faunæ more complete, we here add tabular abstracts of those treated of by D'Orbigny from the West Indies\*, the Canary Islands†, and South America‡, revising his nomenclature. The ROTALINÆ which we have described from the Arctic and North-Atlantic Oceans are also herewith tabulated. Thus we shall have before us comparative synopses of this important and characteristic Rhizopodal group, not only from several parts of the great Atlantic, but from the long-preceding Cretaceous ocean. This old water-area was not so wholly altered by changed limits and oscillating floor, but that its deeper portions may have continued as the sunken abysses of succeeding periods, and not ceased to receive the shells and ooze of succeeding generations.

An intermediate and local fauna, also, is represented in the Table of the fossil Rotalines from the vicinity of Vienna, such as lived in a large but “mediterranean” sea succeeding (not immediately) a portion of the Cretaceous ocean, after the Nummulitic ocean had been formed by limitation of the latter, and had itself dwindled into the Mid-Tertiary seas, one of which the Viennese deposits under notice represent.

The “Nummulitic” period had Rotalines of very great interest, which we treat of in three selected lists further on. To complete the subject, we will in another paper give a sketch of the distribution of the very important genus *Globigerina*, including its earlier and present stages of existence.

I. *Rotaline Foraminifera from Cuba, West Indies.* D'Orbigny, 1839.

## PLANORBULINA FARCTA (type).

Conical.	Pl. 3. f. 9–11.	<i>Planorbulina rosea</i> , D'O. (A. d'Orbigny's <i>Modes</i> , No. 35).
Plano-convex.	{	Pl. 6. f. 11–15. <i>Pl. vulgaris</i> , D'O. = <i>Pl. mediterraneensis</i> , D'O.
		Pl. 3. f. 6–8. <i>Truncatulina Candei</i> , D'O. Close to <i>T. lobatula</i> .
		Pl. 6. f. 8–10. <i>T. Edwardsiana</i> (D'O.). Limbate on one face. f. 3–5. <i>T. advena</i> , D'O. <i>Tr. lobatula</i> , neat and many-chambered.

\* Hist. Nat. Cuba, Foraminifères, 1839.

† Hist. Nat. Canaries, Foraminifères, 1839.

‡ Voyage Amér. Mérid., Foraminifères, 1839. See Ann. N. Hist. ser. 4, vol. viii. p. 253, &amp;c.

## PULVINULA REPANDA (type).

- "Repanda" group. { Pl. 5. f. 4-6. Pulvinulina antillarum (*D'O.*). Near *P. punctulata* (*D'O.*)  
 f. 1-3. *P. caribæa* (*D'O.*). Near *P. pulchella* (*D'O.*)  
 "Menardii" group. { f. 7-9. *P. cultrata* (*D'O.*)  
 Pl. 2. f. 29, 30, & Pl. 3. f. 1. *P. dubia* (*D'O.*)  
 "Auricula" group. { Pl. 5. f. 13-15. *P. Sagra* (*D'O.*)=*P. auricula* (F. & M.)  
 Pl. 4. f. 9-11. *P. deformis* (*D'O.*)

## DISCORBINA TURBO (type).

- Pl. 3. f. 21-23. *Discorbina valvulata* (*D'O.*). A limbate variety of *D. globularis*, Modèles, No. 69.  
 Pl. 4. f. 2-4. *D. Candiana* (*D'O.*)=*D. globularis* (*D'O.*)  
 f. 5-8. *D. Auberii* (*D'O.*)  
 Pl. 3. f. 15-17. *D. semistriata* (*D'O.*)  
 f. 24, 25, & Pl. 4. f. 1. *D. opercularis* (*D'O.*)

## ROTALIA BECCARII (type).

- Pl. 4. f. 22-24. *Rotalia Catesbyana* (*D'O.*) } Varieties scarcely separable from *R. Beccarii*.  
 f. 25-27. *R. Parkinsoni* (*D'O.*) }  
 Pl. 5. f. 16-18. *R. pulchella* (*D'O.*) } Spinous variety.  
 f. 19-21. *R. lobata* (*D'O.*) }  
 f. 25, & Pl. 6. f. 1, 2. *R. carinata* (*D'O.*) } Astralorasterigerine varieties.

## CALCARINA SPENGLERI (type).

- Pl. 5. f. 22-24. *Calcarina calcar* (*D'O.*)

## CYMBALOPORA POEYI (type).

- Pl. 3. f. 18-20. *Cymbalopora Poeyi* (*D'O.*)  
 f. 12-14. *C. squamosa* (*D'O.*)  
 f. 2-5. *C. bulloides* (*D'O.*)

## 2. Rotaline Foraminifera from the Canaries. D'Orbigny, 1839.

## PLANORBULINA FARCTA (type).

- Plano-convex varieties. { Pl. 2. f. 30. *Planorbulina vulgaris*, *D'O.* = *Pl. mediterraneis*, *D'O.*  
 f. 22-24. *Truncatulina lobata*, *D'O.* = *Tr. lobatula* (W. & J.)  
 f. 29. *T. variabilis*, *D'O.* Wild-growing *Tr. lobatula*.

## PULVINULINA REPANDA (type).

- "Menardii" group. { Pl. 2. f. 25-27. *Pulvinulina truncatulinoidea* (*D'O.*)  
 f. 34-36. *P. canariensis* (*D'O.*)  
 f. 37-39. *P. Berthelotiana* (*D'O.*)  
 "Elegans" group. { f. 31-33. *P. hirsuta* (*D'O.*)  
 "Auricula" group. { f. 40-42. *P. oblonga* (*D'O.*)  
 f. 43-45. *P. excavata* (*D'O.*)

## DISCORBINA TURBO (type).

- Pl. 2. f. 19-21. *Discorbina valvulata* (*D'O.*) } In the form of *D. Binkhorsti*, this is the oldest known *Discorbina*.  
 Pl. 1. f. 28-30. *D. Berthelotiana* (*D'O.*) }

## ROTALIA BECCARII (type).

- Pl. 2. f. 16-18. *Rotalia contecta*, *D'O.* Near *R. Soldanii*.  
 f. 13-15. *R. Lamarckiana*, *D'O.* Near *R. orbicularis*.

3. *Rotaline Foraminifera from South America.* D'Orbigny, 1839.

## I. From the Atlantic.

## PLANORBULINA FARCTA (type).

- Nautiloid. Pl. 6. f. 1-3. *Planorbulina vermiculata* (*D'O.*).  
 Plano-convex. Pl. 5. f. 25-27. *Truncatulina dispar*, *D'O.* *Tr. lobatula*.

## PULVINULA REPANDA (type).

- "Schreibersii" { Pl. 2. f. 6-8. *Pulvinulina patagonica* (*D'O.*).  
 group. { Pl. 1. f. 21, & Pl. 2. f. 1, 2. *P. Alvarezii* (*D'O.*).

## DISCORBINA TURBO (type).

- Pl. 2. f. 12-14. *Discorbina rugosa* (*D'O.*).  
 Pl. 6. f. 10-12. *D. Isabelleana* (*D'O.*).  
 f. 13-15. *D. Villardeboana* (*D'O.*).

## ROTALIA BECCARII (type)

- Pl. 1. f. 18-20. *Rotalia ornata* (*D'O.*). { Subglobular, limbate  
 variety of *R. Beccarii*.  
 Pl. 2. f. 18-20. *R. monticula* (*D'O.*). { Asterigerine variety of  
*R. Beccarii*.

## II. From the Pacific\*.

## PLANORBULINA FARCTA (type).

- Plano-convex. { Pl. 6. f. 4-6. *Truncatulina depressa*, *D'O.* A thin *Tr. lobatula*.  
 f. 7-9. *Tr. ornata*, *D'O.* Slightly limbate.

## PULVINULINA REPANDA (type).

- "Schreibersii" { Pl. 2. f. 3-5. *Pulvinulina peruviana* (*D'O.*).  
 group. { f. 15-17. *P. auris* (*D'O.*).  
 "Auricula" { Pl. 7. f. 10-12. *P. inæqualis* (*D'O.*).  
 group. {

## DISCORBINA TURBO (type).

- Pl. 1. f. 15-17. *Discorbina pileolus* (*D'O.*).  
 Pl. 6. f. 16-18. *D. araucana* (*D'O.*).  
 Pl. 7. f. 7-9. *D. inflata* (*D'O.*). Thick *D. elegans*.  
 Pl. 1. f. 12-14. *D. peruviana* (*D'O.*). Near to *D. globularis*.  
 Pl. 2. f. 9-11. *D. Sauleyi* (*D'O.*).  
 Pl. 6. f. 19-21. *D. Cora* (*D'O.*).

## ROTALIA BECCARII (type).

- Pl. 7. f. 1-3. *Rotalia inca* (*D'O.*). A thin *R. Beccarii*.  
 f. 4-6. *R. consobrina* (*D'O.*). A helicoid *R. Beccarii*.

We are well assured that the foregoing lists represent portions only, and those chiefly littoral, of the several Foraminiferal faunas;

\* Other local faunas from the Pacific may be collected from the Tables vii. and x. in the 'Phil. Trans.' 1865.

but we have no hesitation in offering them to the student as representative examples, and as nuclei for further observations.

4. *Rotaline Foraminifera from the Arctic Ocean.* Parker & Jones, 1865. *Phil. Trans.* vol. clv. pp. 338 &c.

PLANORBULINA FARCTA (type).

Nautiloid. *Planorbulina (Anomalina) coronata*, P. & J.  
Plano-convex. Pl. (*Truncatulina*) *lobatula* (W. & J.)

PULVINULINA REPANDA (type).

"Repanda" group. *Pulvinulina punctolata* (D'O.).  
"Menardii" group. *Pulv. Micheliniana* (D'O.).  
"Schreibersii" group. *Pulv. Karsteni* (Rss.).

SPIRILLINA VIVIPARA (type).

DISCORBINA TURBO (type).

*Discorbina globularis* (D'O.).      D. *obtusa* (D'O.).

PATELLINA CONCAVA (type).

*Patellina corrugata*, Williamson.

5. *Rotaline Foraminifera from the North-Atlantic Ocean.* Parker & Jones, 1865. *Phil. Trans.* vol. clv. pp. 338, 432, &c.

PLANORBULINA FARCTA (type).

Conical. { *Planorbulina Haidingerii* (D'O.).  
          { *Pl. Ungeriana* (D'O.).  
Nautiloid. Pl. (*Anomalina*) *coronata*, P. & J.  
              { *Pl. mediterraneensis*, D'O.  
Plano-convex. { *Pl. (Truncatulina) lobatula* (W. & J.).  
                  { *Pl. (Tr.) refulgens* (Montf.).

PULVINULINA REPANDA (type).

"Repanda" group. { *Pulvinulina repanda* (F. & M.)  
                      { *P. concentrica*, P. & J.  
"Menardii" group. { *P. Menardii* (D'O.).      *P. pauperata*, P. & J.  
                      { *P. canariensis* (D'O.).      *P. Micheliniana* (D'O.).  
"Elegans" group. *P. elegans* (D'O.).  
"Schreibersii" group. *P. Karsteni* (Rss.).

DISCORBINA TURBO (type).

*Discorbina rosacea* (D'O.).      D. *globularis* (D'O.).  
D. *ochracea* (Will.).            D. *Berthelotiana* (D'O.).

ROTALIA BECCARII (type).

*Rotalia Beccarii* (Lin.).      R. *Soldanii* (D'O.).  
R. *nitida*, Will.                R. *orbicularis* (D'O.).

TINOPORUS LÆVIS (type).

*Tinoporus lævis*, P. & J.

PATELLINA CONCAVA (type).

*Patellina corrugata*, Will.



6. *Rotalinæ from the Tropical Atlantic.* Parker & Jones, *Phil. Trans.* vol. clv. 1865, Tables vii. & x., column 21.

PLANORBULINA FARCTA (type).

- Conical. { *Planorbulina Clementiana* (*D' O.*).  
 Pl. culter, *P. & J.*  
 Plano-convex. *Truncatulina lobatula* (*W. & J.*).

PULVINULINA REPANDA (type).

- "Menardii" group. { *Pulvinulina cuneiformis*, *P. & J. MS.* *P. Micheliniana* (*D' O.*).  
*P. Menardii* (*D' O.*). *P. canariensis* (*D' O.*).  
*P. crassa*, (*D' O.*). *P. pauperata*, *P. & J.*  
 "Elegans" group. *P. elegans* (*D' O.*).

7. *Rotalinæ from the Azorhos Bank, South Atlantic.* Parker & Jones, *Phil. Trans.* clv. 1865, Tables vii. & x., Columns 22, 23, 24.

PLANORBULINA FARCTA (type).

- Conical ..... { *Planorbulina Haidingerii* (*D' O.*).  
 — *Ungeriana* (*D' O.*).  
 — (*Siphonina*) *reticulata* (*Cz.*).  
 Nautiloid ..... { — *ammonoides* (*Rss.*).  
 — *ariminensis*, *D' O.*  
 Plano-convex ..... — *mediterraneensis*, *D' O.*

PULVINULINA REPANDA (type).

- "Repanda" Group ... *Pulvinulina pulchella* (*D' O.*).  
 — *Menardii* (*D' O.*).  
 "Menardii" Group ... — *canariensis* (*D' O.*).  
 — *M Micheliniana* (*D' O.*).  
 — *crassa* (*D' O.*).  
 "Schreibersii" Group. { — *Schreibersii* (*D' O.*).  
 — *Karsteni* (*Rss.*).  
 "Elegans" Group..... — *elegans* (*D' O.*).

DISCORBINA TURBO (type).

- Discorbina globularis* (*D' O.*).  
 — *rosacea* (*D' O.*).  
 — *Berthelotiana* (*D' O.*).

CYMBALOPORA POEYI (*D' O.*).

§ X.—Having thus provided a series of synoptical views of the Rotaline faunas in the several Cretaceous periods, in a Mid-Tertiary period, and in the existing Atlantic Ocean, as far as present opportunities permit, we will make the series more complete by supplying a link between the Chalk and the Miocene—namely, the Rotalines of the London Clay, of the Kressenberg Nummulitic, and the Paris Tertiaries,—and one between the Mid-Tertiary and the existing times, namely the Rotalines of the Crag of Suffolk and Antwerp.

1. *Rotalines from the Lower Eocene (Nummulitic) Strata of Kressenberg, North Alps.* C. W. Gümbel, 1868. *Abhandl. k. bayr. Akad. Wiss. Cl. 2*, vol. x.

PLANORBULINA FARCTA (type).

Conical .....	{	Planorbulina megomphalus (Gümb.).	} Near <i>Pl. Haidingerii</i> (D'O.).
		Pl. pteromphalia (Gümb.).	
		Pl. kallomphalia (Gümb.).	
		Pl. truncana (Gümb.).	
		?	
		Pl. eocana (Gümb.).	
		?	
		Pl. subumbonata (Gümb.).	
Nautiloid .....	{	Pl. capitata (Gümb.).	} Near <i>Pl. (Anomalina) ammonoides</i> (Rss.).
		Pl. rudis (Gümb.).	
		Pl. grosserugosa (Gümb.).	
		Pl. cochleata (Gümb.).	
		Pl. calymene (Gümb.).	
		Pl. cristata (Gümb.).	
		Truncatulina ammophila, Gümb.	
Plano-convex .....	{	Tr. macrocephala, Gümb.	} Near <i>Pl. (Trun.) lobatula</i> (W. & J.).
		Tr. sublobatula, Gümb.	

PULVINULINA REPANDA (type).

"Menardii" Group ...	{	Pulvinulina bimamata (Gümb.).
		P. campanella (Gümb.).
		P. asterites (Gümb.).

A deep-sea form of *P. Menardii*.

DISCORBINA TURBO (type).

*Discorbina polysphaerica* (Gümb.).

*D. megasphaerica* (Gümb.) = *D. globigerinoides*, P. & J. *Phil. Trans.* clv. p. 421.

*Calcarina tetraëdra* Gümbel

2. *Rotaline Foraminifera from the London Clay (Eocene).* Jones & Parker. 'Geologist,' vol. vii. p. 83, &c. 1854.

PLANORBULINA FARCTA (type).

Conical .....	{	Planorbulina Haidingerii (D'O.).
		Pl. Ungeriana (D'O.).
Nautiloid .....	{	Pl. ammonoides (Rss.).
Plano-convex .....	{	Truncatulina lobatula (W. & J.).

PULVINULINA REPANDA (type).

"Menardii" Group ...	Pulvinulina Micheliniana (D'O.).
"Elegans" Group.....	P. elegans (D'O.).

ROTALIA BECCARII (type).

*Rotalia orbicularis* (D'O.).

In the Paris Tertiaries (Grignon, &c.), the *Discorbinae* are very numerous, varied, and characteristic, as seen in the annexed list; and in comparing the European Eocene *Foraminifera* with existing forms, we must remember that it is to the Red Sea, and particularly to the Australian seas, rather than the Atlantic, that we have to look for their recent analogues.

3. *Rotaline Foraminifera from the Eocene Tertiaries of Grignon, &c., France.* Compiled from Authors and Collections.

PLANORBULINA FARCTA (type).

- |                   |   |
|-------------------|---|
| Nautiloid.....    | { Planorbulina (Anomalina) coronata, P. & J. (From the Eocene of Normandy.)<br>Pl. mediterraneensis, D'O. |
| Plano-convex..... |   |

PULVINULINA REPANDA (type).

- "Auricula" Group ... { Pulvinulina auricula (D'O.).  
 P. excavata (D'O.).

SPIRILLINA VIVIPARA, Ehr.

DISCORBINA TURBO (type).

- |                                   |                            |
|-----------------------------------|----------------------------|
| Discorbina trochidiformis (Lam.). | Discorbina rimosa, P. & J. |
| — turbo (D'O.).                   | — elegans (D'O.).          |
| — lenticulina (Lam.).             | — globularis (D'O.).       |
| — rosacea, (D'O.).                | — globigerinoidea, P. & J. |
| — pileolus (D'O.).                | — parisiensis, D'O.        |
| — vesicularis (Lam.).             | — Berthelotiana, D'O.      |
| — Gervillii (D'O.).               |                            |

ROTALIA BECCARII (type).

- |                           |                          |
|---------------------------|--------------------------|
| Rotalia Beccarii (Linn.). | Rotalia carinata (D'O.). |
| — ariminensis (Lam.).     |                          |

CALCARINA SPENGLERI (type).

Calcarina armata (D'O.).

PATELLINA CONCAVA (type).

- |                                  |                            |
|----------------------------------|----------------------------|
| Patellina corrugata, Williamson. | Patellina simplex, P. & J. |
| — semiannularis, P. & J.         |                            |

TINOPORUS LÆVIS, P. & J.

POLYTREMA MINIACEUM (Esper).

4. *Rotaline Foraminifera from the Crag of Eastern England (Pliocene).* Jones, Parker, and Brady, *Monogr. Foram. Crag* (Pal. Soc.), 1866.

PLANORBULINA FARCTA (type).

- |               |   |
|---------------|---|
| Conical ..... | { Planorbulina Haidingerii (D'O.).<br>Pl. Ungariana (D'O.). |
| Plano-convex  |   |

PULVINULA REPANDA (type).

- |                          |  |
|--------------------------|--|
| "Repanda" group .....    | { Pulvinulina repanda (P. & M.).<br>P. pulchella (D'O.). |
| "Auricula" group .....   |  |
| "Schreibersii" group.... | P. Karsteni (Rss.).                                      |
| "Elegans" group .....    | P. elegans (D'O.).                                       |

SPIRILLINA VIVIPARA, Ehr.

ROTALIA BECCARII (type).

Rotalia Beccarii (Linn.). R. orbicularis (D'O.).

TINOPORUS LÆVIS, P. & J.

5. *Rotalinæ* from the Antwerp Crag. Reuss\*, *Sitzungsb. Akad. Wiss. Wien.* vol. xlii. pp. 355 et seq. 1860.

PLANORBULINA FARCTA (type).

Conical ..... { *Planorbulina kalebergensis* (*D'O.*).  
 Pl. tenuimargo (*Rss.* pl. 1. f. 11).  
 Plano-convex. *Truncatulina varians*, *Rss.* (Pl. 2. fig. 12). Thick *Tr. lobatula*,  
 or, rather, *Pl. Ungeriana*, subvar.

PULVINULINA REPANDA (type).

"Auricula" group. *Pulvinulina Brongniartii* (*D'O.*).

ROTALIA BECCARII (type).

*Rotalia Parkinsoniana* (*D'O.*). *R. orbicularis*, *D'O.*

These types and subtypes are comprised also in the foregoing list of the Rotalines from the English Crag.

§ XI. *Conclusion.*—With reference to the Cretaceous Foraminifera, generally speaking, and as far as our observations lead us, we may say that, excepting *Discorbina Binkhorsti* (*Rss.*), of the Maestricht Chalk, there is no *Discorbina* known in this great series of formations; indeed that species seems to be the oldest of its genus. Of the other ROTALINÆ, there are numerous deep-sea forms of *Rotalia*, *Pulvinulina*, and *Planorbulina*. A rare *Calcarina* in our White Chalk, many in that of Maestricht, numerous *Orbitolinæ* (*Tinoporos* and *Patellina*) in some of the Cretaceous formations, and crowds of *Orbitoides* in some Chalk-strata of France and elsewhere, complete the Cretaceous Rotaline group.

With the closely allied *Globigerinæ*, on the one hand, and the *Nodosarinæ* (including *Cristellaria* &c.) on the other, the Rhizopodist has to deal largely when examining the Cretaceous rocks. In the former case, individuals, innumerable and variable, predominate, increasing in number upwards with the successive formations from the Neocomian to the Gault, Chalk-marl, and Chalk, in England. In the latter case the variations of all degrees and value become almost as numerous as the individuals; and these abound far more plentifully than the Rotalines. Such of the latter as we have more especially had to treat of in this memoir (namely, *Planorbulina*, *Pulvinulina*, and *Rotalia*) are more equally distributed all through this series of deposits.

Taking them in succession, we find that the typical *Planorbulina* is represented in all the columns of our Table. The subtype *Pl. Haidingerii*, taken as the leading form of the helicoid or conical Cretaceous forms, is represented in all the columns except 7, 10, 16, 18, and 21. The Nautiloid varieties, typified by *Pl. ammonoides*, occur in all except No. 14. The plano-convex or Truncatuline varieties, grouping around *Truncatulina lobatula*, fail only in Nos. 5, 11, 18, and 21. In all these cases the absence is probably not real; further search may supply such forms.

The *Pulvinulina* type of ROTALINÆ is also well represented in these Cretaceous deposits, as shown by our columns. Only No. 21

\* See also *Bullet. Acad. Roy. Sc. Belg.* vol. xv. p. 154; and further on, p. 127.

fails to present some variety or subvariety of *Pulv. repanda*. Of the *Pulv.-Menardii* group there are representatives in Nos. 1, 4, 5, 6, 7, 9, 10, 12, 13, 15, 16, 19, and 20. Of the *elegans* group there are abundant and strongly marked forms in relatively few strata; and all but one of them are very close to, indeed scarcely separable from, the typical *elegans*, except by the comparative richness of the shell-growth. Columns 1, 2, 3, 8, 11, and 18 (?) have *Pulv. elegans* or some of its subvarieties; and its greatest abundance is decidedly with the Lower Cretaceous rocks. A very few *Pulvinulinae* of the *Schreibersii* group are scattered here and there through the series—columns 4, 8, and 17.

*Rotalia* is represented by one variety of *R. Beccarii*, namely *R. exsculpta*, in columns 8 and 16, and far more persistently by the deep-sea variety *R. umbilicata* in Nos. 2, 8, 9, 10, 11; 12, 13, and 19.

All these typical species, and several of their varietal forms, have continued through the Tertiary period on to our own times, and are to be found in some existing sea or ocean. The chief distinction between the Cretaceous Rotalines and those of the present day is, that a vast number of varietal forms, which have sprung up during the intervening ages, indicate, by their multiplicity, the varying conditions of successive and changing marine areas, with differing limits, depths, and climates.

This is shown in Table II. (p. 123), by which we follow, though with unequal steps, the progressive development of the several types, as far as the materials before us will serve.

Thus the "conical" *Planorbulinae* began early; they are present in the Lower Cretaceous deposits; they abound in the White Chalk, the Tertiary beds, and the Atlantic. *Pl. Ungeriana* is the most persistent form. The "nautiloid" or Anomaline *Planorbulinae* abound in both the Lower and the Upper Cretaceous formations, and in the Tertiaries; but they are not so predominating in the Atlantic. *Pl. ammonoides* is the leading and lasting form. On the other hand, the "plano-convex" or Truncatuline *Planorbulinae* have flourished freely throughout and nearly everywhere, in some subvariety or other of *Truncatulina lobatula*. The orbicular, concentric, plano-convex *Pl. mediterranensis (vulgaris)* is a later form; and its annular growth indicates a morphological position higher than that of its simply coiled allies.

*Pulvinulina repanda* (proper) is represented in the Chalk of Maestricht, but in none of the other Cretaceous beds. It is rare in the Tertiaries of our Table (occurring only in the Pliocene), but is scattered throughout the Atlantic. *P. auricula* existed in the Nummulitic sea, abounded in the mid-Tertiary times, and, living now, is abundant in some places; but it is wanting in the Chalk. *P. Menardii*, however, was one of the early representatives of the genus. In New Jersey (North America) it occurs in the Greensand. With us it begins with the White Chalk, and has continued with increased prolificness till now. *P. Schreibersii* occurs sporadically in the Greensand of New Jersey, the Chalk-formations of Eastern Europe, the

Upper Chalk of Western Europe, the Tertiary beds, and at the present day in the Atlantic; but it has not been found in the Lower Cretaceous rocks of Europe, though representatives of it (*P. Karsteni*, &c.) are not wanting in some of the Secondary formations. *P. elegans*, another old (Secondary) form, reached a high stage of growth and abundance in the sea that deposited the Gault of England and Europe, and has continued since.

*Discorbina* has presented no fossil form older than the Upper Chalk (Maestricht). Since the Cretaceous period it has abounded profusely in the Paris Tertiaries, and in many other localities since; and it still flourishes.

*Rotalia* is found in the Gault; but it seems to have flourished more abundantly in seas of later periods, and is prolific now in the Atlantic and elsewhere.

Of the other *Rotalinæ*, we have not sufficient data for "correct observation in the line of research we have here pursued; except that we may note the isolated occurrence of *Cymbalopora* at Maestricht, and its apparent absence until the Miocene period, the absence of *Calcarina* and of *Orbitoides* before the Chalk, and, on the other hand, the persistence of *Tinoporos* and *Patellina* through the Cretaceous and Tertiary to the present age.

With the *ROTALINÆ*, as with *Globigerina* (of which we intend to treat before long), the chief distinction between the Cretaceous and existing groups is in the progressively increased number of modifications, and among them the incoming of important variations, though few of them are of generic, or even specific, value,—a distinction strong enough, when supported by other known geological and palæontological considerations, to mark the impropriety of calling the Atlantic ooze "Chalk," except in the sense of a calcareous rock of marine organic origin. That its geological status should not be spoken of in this vague halobiolithological \* sense, the painstaking and thoughtful Ehrenberg long ago warned us. He says:—"In consequence of the mass-building Infusoria and Polythalamia [Diatoms, Polycystines, and Foraminifers], the Secondary formations can now no longer be distinguished from the Tertiary; and, in accordance with what has been above stated, masses of rock might be formed even at the present time in the ocean, and be raised by volcanic power above the surface, the great mass of which would, as to its constituents, perfectly resemble the Chalk. Thus, then, the Chalk remains still to be distinguished as a geological formation, but no longer as a species of rock by its organic contents." 'Taylor's Scientific Memoirs,' vol. iii. 1843, p. 367, § 10; 'Edinb. New Phil. Journ.' vol. xxxiv. 1843, p. 260; Abhandl. Berl. Akad. für 1839, p. 164, 4to, 1841.

To render our synoptical study of the *ROTALINÆ* more complete, we propose to compare the oldest forms on some future occasion; and, for the present, we offer, in a Supplement to this paper, a critical examination and revised nomenclature of such Tertiary *ROTALINÆ* as have been figured and described by Reuss, Bornemann, Karrer, and other palæontologists, and are not included in the foregoing lists.

\* "Halobiolith" (Ehrenberg) is a stratum of marine organic origin.

TABLE II.

*The Range of Recent, Tertiary, and Cretaceous Rotalinae.*

	PACIFIC OCEAN.	ATLANTIC OCEAN.						TERTIARY.				CRETACEOUS.												
	South America.	South America.	Abrolhos Bank.	Tropical Atlantic.	Cuba.	Canaries.	North Atlantic.	Arcic.	Upper.	Middle.	Lower.	Upper Chalk.	White Chalk.	Chalk formations.	Westphalian Chalk formations.	Chalk-marl.	Gault.	Green-sand.	Green-sand.	Chalk.				
									Crag.	Vienna Basin.	London Clay.	Paris Tertiaries.	Kressenberg.	Maastricht, Rügen, Mœn, Mecklenburg.	England and France.	Eastern Europe.	Upper.	Middle.	Lower.	Kent.	Germany and Kent.	Warrminster and Haldon.	New Jersey.	North America.
PLANORBULINA ...	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Conical ...	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
Nautiloid ...	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
Plano-convex ...	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
PULVINULINA	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
repanda ...	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
auricula ...	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
Menardii ...	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
Schreibersii ...	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
elegans ...	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
SPHIRILLINA	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
DISCORBINA	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
CYMBALOPOEA	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
ROTALIA	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
CALCARINA	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
PATELLINA	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
TINOPORUS	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::
ORBITOIDES	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::	::

M = elsewhere in the Miocene.

N = in the Eocene from Normandy.

S = in the south of France.

## SUPPLEMENT.

In the foregoing paper we have compared side by side several described sets of *Rotalina* from the Cretaceous and Tertiary rocks, and from the present seas. We know how imperfect the materials for this critical collocation really are, and that the sketch view we get of them in the foregoing Tables is but a glimpse into a wide and unexhausted region. Numerous as the forms are that we have catalogued in their zoological order, for comparison by the naturalist, and fertile as they are in suggestions as to range and relative persistence, we do not forget the wholesome caution to Rhizopodists clearly and forcibly given by Prof. W. C. WILLIAMSON years ago, when treating of the then new and striking researches of Ehrenberg and D'Orbigny:—"We must not cloud the evidence afforded by the higher animals with that derivable from beings so much lower in the scale of organization, and which, as a whole, are so far removed from the influence of external agencies. The study is at once so novel and so fascinating that all who pursue it, impressed by its singular interest, are in danger of being allured by it beyond the bounds of caution,—a tendency which is ever promoted by the announcement of comprehensive hypotheses and splendid novelties."—'Microscop. Objects found in the Mud of the Levant,' p. 126. *Memoirs Manchester Lit. & Phil. Soc.* vol. viii. 1847.

To make our subject as clear as known facts can help us to make it, we here subjoin further lists of local groups of *Rotalinae*, both Recent and Tertiary, prepared, on the same system of nomenclature, for rigid comparison with those in the body of this paper. From a study of these additional catalogues it will be found, as with the others, that, for the most part, numerous slight varietal differences, local and mainly recognizable in the *facies* of the group—indeed, only to be brought out by good drawings, and scarcely describable,—are important elements in the successional diversity that really obtains among the Foraminifera. These slight, but important, shades of difference give rise to great multiplicity of names. This is a trouble which we have endeavoured to deal with judiciously in all our lists, basing our nomenclature on the principles laid down in our memoirs in the 'Ann. Nat. Hist.,' in the 'Phil. Trans.' vol. clv., and in Carpenter's 'Introd. Foram.' 1862.

## § 1.—RECENT FORAMINIFERA.

I. In further illustration of the Foraminiferal fauna of the Pacific Ocean (see list, p. 115), we here offer a corrected list of the Foraminifera found by Mr. G. D. MACDONALD among the Fiji Islands. See *Ann. Nat. Hist.* ser. 2, vol. xx. pp. 193 &c., 1857.

- |  |                      |
|--|----------------------|
| Pl. 5. f. 1 & 2. Doubtful.   | } From 1020 fathoms. |
| f. 3-5. Polycystina.   |                      |
| f. 6. <i>Uvigerina pygmæa</i> , D'Orb., dimorphous variety.          | } From 440 fathoms.  |
| f. 7-10. <i>Lagena globosa et marginata</i> (Montagu), Entosolenian. |                      |



Pl. 5. f. 11-14. <i>Globigerina bulloides</i> , <i>D'O.</i>	}	From 1020 fathoms.		
f. 15. <i>Planulina</i> * ?				
f. 16. <i>Cymbalopora</i> * <i>Poeyi</i> ( <i>D'O.</i> ).				
f. 17. <i>Discorbina</i> * <i>globularis</i> ? ( <i>D'O.</i> ), young.				
f. 18, 19. <i>Nonionina umbilicatula</i> ( <i>Montagu</i> ).				
f. 20. <i>Discorbina</i> * <i>globularis</i> ? ( <i>D'O.</i> ).				
Pl. 6. f. 21. <i>Uvigerina pygmæa</i> ( <i>D'O.</i> ), aculeate variety.				
f. 22. <i>Verneuilina pygmæa</i> ( <i>Hgger</i> ).				
f. 23. <i>Virgulina Schreibersii</i> . <i>Újžek</i> .				
f. 24. <i>V. Schreibersii</i> , irregular and dwarf.				
f. 25. <i>Discorbina</i> * <i>Berthelotiana</i> ( <i>D'O.</i> ).				
f. 26. <i>Textilaria pygmæa</i> ( <i>D'O.</i> ), vel <i>Bolivina punctata</i> , <i>D'O.</i>				
f. 27. <i>Bolivina punctata</i> , <i>D'O.</i> , with an aculeate base.	}	From 440 fathoms.		
f. 28. <i>Spiroloculina planulata</i> ( <i>Lamk.</i> ).				
f. 29. <i>Quinqueloculina seminulum</i> ( <i>Linn.</i> ), young.				
f. 30. <i>Triloculina oblonga</i> ( <i>Montagu</i> ).				
f. 31, 33. <i>Calcarina</i> * <i>Spengleri</i> ( <i>Gmel.</i> ), var.				
f. 32. Described as a lenticular body, like a <i>Nummulina</i> .				
				In shallow water.

II. As an example of a Rotaline group from the Indian Ocean, we produce the following from Dr. C. SCHWAGER'S Monograph "Foraminiferen von Kar-Nicobar," *Novara Expedition*, geol. Theil, vol. ii.:—

P. 258, pl. 7. f. 105, 107. <i>Anomalina Wüllerstorfi</i> , <i>Schw.</i>	}	<i>Planorbulina</i> between <i>Pl. Ungeriana</i> and <i>Pl. ariminensis</i> .
P. 260, f. 108. <i>Anomalina cicatricosa</i> , <i>Schw.</i>		
P. 257, f. 106. <i>Discorbina saccharina</i> , <i>Schw.</i>	}	<i>Planorbulina vulgaris</i> , young, with some exogenous ramified ornament.
P. 262, f. 109. <i>Rotalia flosculiformis</i> , <i>Schw.</i>		
P. 259, f. 111. <i>Anomalina bengalensis</i> , <i>Schw.</i>		
P. 263, f. 110. <i>Rotalia nitidula</i> , <i>Schw.</i>		
P. 261, f. 114. <i>Calcarina nicobarensis</i> , <i>Schw.</i>		

§ 2.—THE TERTIARY FAUNAS, as represented by *Rotalinæ* described and figured by our continental fellow-workmen, in addition to the few selected for Table II. (p. 123), are here given in the order of publication, with corrected nomenclature.

I. F. A. ROEMER. 'Die Cephalopoden des Nord-Deutschen tertiären Meersandes.' *Neues Jahrb. f. Min. &c.*, 1838, pp. 381-394.

P. 388, pl. 3. f. 45. <i>Rotalia subtortuosa</i> †, v. <i>Münst.</i>	<i>Discorbina.</i>
f. 46. <i>R. depressa</i> , v. <i>M.</i>	—.
f. 47. <i>R. trochus</i> , v. <i>M.</i>	— ?
f. 48. <i>R. mammillata</i> , v. <i>M.</i>	— ?
f. 49. <i>R. impressa</i> , <i>Rœm.</i>	— ?
f. 50. <i>R. intermedia</i> , v. <i>M.</i>	<i>Planorbulina.</i>
f. 51. <i>R. conica</i> , <i>R.</i>	—.
f. 52. <i>R. discus</i> , <i>R.</i>	—.
f. 53. <i>R. parvispira</i> , <i>R.</i>	—.
P. 389, f. 54. <i>R. propinqua</i> , v. <i>M.</i>	—.
f. 55. <i>Truncatulina punctata</i> , <i>R.</i>	— ( <i>Truncatulina</i> ).
f. 56. <i>T. communis</i> , <i>R.</i>	— ( <i>Truncatulina</i> ).
P. 390, f. 58. <i>Planulina osnaburgensis</i> , v. <i>M.</i>	— ( <i>Planulina</i> ).
f. 59. <i>Planorbulina difformis</i> , v. <i>M.</i>	— <i>mediterraneanensis</i> .
P. 391, f. 60. <i>Anomalina elliptica</i> , v. <i>M.</i>	— ( <i>Anomalina</i> ).

\* These are *Rotalinæ*.

† These figures are not sufficiently good to serve as exact criteria for species. Some, however, have been refigured by Reuss.

II. A. E. REUSS. 'Ueber die fossilen Foraminiferen und Entomostraceen der Septarienthone der Umgegend von Berlin.' *Zeitschr. deutsch. geol. Gesellsch.*, vol. iii. 1851, pp. 49-92, plates 3-7.

- Pl. 5. f. 34. *Rotalina Girardana*, Rss. *Rotalia Soldanii*, D'O.  
 f. 35. *R. umbonata*, Rss. *Pulvinulina* near *P. Menardii*.  
 f. 36. *R. granosa*, Rss. *Planorbulina Ungeriana* (D'O.).  
 f. 37. *R. contraria*, Rss. *Pulvinulina auricula* (F. & M.).  
 f. 38. *R. bulimoides*, Rss. (not *Rotaline*). *Bulimina elegantissima*, D'O.

III. A. E. REUSS. 'Beiträge zur Charakteristik der Tertiärschichten des nördlichen und mittleren Deutschlands.' *Sitzungsb. Akad. Wiss. Wien*, vol. xviii. pp. 197 &c., 1855.

- P. 240, pl. 4. f. 52. *Rotalia Rœmeri*, Rss. = *Planorbulina Ungeriana* (D'O.).  
 P. 241, f. 53. *R. propinqua*, Rss. = *Planorbulina Haidingerii* (D'O.).  
 P. 242, pl. 5. f. 54. *R. stellata*, Rss. = *Calcarina armata* (D'O.).  
 f. 55. *R. trochus*, v. M. = *Pulvinulina trochus* (v. M.).  
 f. 56. *Truncatulina communis*, Rœm. = *Truncatulina lobatula*.  
 P. 243, f. 57. *Rosalina crenata*, Rss. = *Planorbulina* (between *ammonoides* and *Ungeriana*).  
 f. 58. *R. osnabrugensis*, v. M. (? *Planulina Osnabrugensis*, v. M.) = *Pl. (Planulina) ariminensis*, varying towards *Pl. ammonoides*.  
 P. 244, f. 59. *Antomalina subæqualis*, Rss. = *Pl. ammonoides* (Rss.).  
 f. 60. *A. tenuissima*, Rss. = A thin subvariety of *A. complanata*, D'O.

IV. BORNEMANN. 'Die mikroskopische Fauna des Septarienthones von Hermsdorf bei Berlin.' *Zeitschr. deutsch. geol. Gesellsch.* vol. vii. 1855, pp. 307-371, plates 12-21.

- Pl. 16. f. 5. *Rotalina Ungeriana*, D'O. *Planorbulina*.  
 f. 6. *R. Partschiana*, D'O., var. *Pulvinulina*.  
 f. 7. *R. Akneriana*, D'O., var. *Planorbulina*.  
 f. 8. *R. tæniata*, Born. *Rotalia* near *R. Soldanii*.

V. J. G. EGGER. 'Die Foraminiferen der Miocæn-Schichten bei Ortenburg in Nieder-Bayern.' In *Neues Jahrb. für Min. &c.*, 1857.

PLANORBULINA FARCTA (type).

- |               |   |  |   |
|---------------|---|--|---|
| Conical.      | { | P. 13, pl. 3. f. 8-10. <i>Rotalina Dutemplei</i> , D'O.  | } <i>Planorbulina</i> , varying from <i>Pl. Dutemplei</i> to <i>Pl. Haidingerii</i> and <i>Pl. Akneriana</i> , D'O. |
|               |   | P. 12, pl. 5. f. 21-23. <i>R. kalebergensis</i> , D'O.   |   |
|               |   | P. 15, pl. 4. f. 8-10. <i>R. anomphala</i> , Egger.  |   |
|               |   | P. 14, pl. 6. f. 1-3. <i>R. orthorupha</i> , Egger.  |   |
|               |   | P. 15, pl. 3. f. 14-17. <i>R. propinqua</i> , Reuss.   |   |
|               |   | P. 16, pl. 4. f. 4-7. <i>R. discigera</i> , Egger.   |   |
| Nautiloid.    | { | P. 19, pl. 6. f. 12-14. <i>R. patella</i> , Egger.   | } Between <i>Pl. ammonoides</i> and <i>Tr. lobatula</i> .   |
|               |   | P. 17, pl. 5. f. 4-6. <i>Rotalina cryptomphala</i> , Rss.  |   |
|               |   | P. 18, pl. 6. f. 4-6. <i>Rosalina simplex</i> , D'O. <i>Anomalina</i> .                                  |   |
| Plano-convex. | { | P. 20, pl. 5. f. 14-16. <i>Truncatulina tumescens</i> , Egger. <i>Planorb. tuberosa</i> , depressed var. | } <i>Anomaline</i> , with irregular chambers.   |
|               |   | P. 20, pl. 5. f. 10-13. <i>Anomalina anomala</i> , Egger.  |   |
|               |   | P. 19, pl. 5. f. 1-3. <i>Truncatulina lobatula</i> (W. & J.).  |   |
|               |   | P. 21, pl. 6. f. 15-17. <i>Planorbulina truncata</i> , Egger. <i>Truncatulina variabilis</i> , D'O.      |   |

## PULVINULA REPANDA (type).

- P. 13, pl. 3. f. 5-7. } *Rotalina* Brongniartii, D'O. Subvariety of  
*Pulvinulina auricula* (F. & M.).

## SPIRILLINA VIVIPARA (type).

- P. 50, pl. 6. f. 7, 8. } ?*Cyclolina impressa*, Egger. = *Spirillina vi-*  
*vipara*, Ehr.

## DISCORBINA TURBO (type).

- P. 14, pl. 3. f. 11-13. } *Rotalina* Haidingerii, D'O. (Non *Pl. Hai-*  
*dingerii*.) *Discorbina* between *globularis*  
and *turbo*.  
P. 16, pl. 4. f. 1-3. } *R. semiporata*, Egger. = *Discorbina globularis*,  
D'O.  
P. 22, pl. 7, f. 8-10. } *Asterigerina planorbis*, D'O. = *Discorbina*  
*planorbis (rosacea)* (D'O.).

## ROTALIA BECCARI (type).

- P. 17, pl. 4. f. 11-13. } *Rosalina viennensis*, D'O. = *Rotalia Bec-*  
*carii*, var.

## CALCARINA SPENGLERI (type).

- P. 13, pl. 3. f. 1-4. } *Rotalina aculeata*, D'O. } *Calcarina Spengleri*,  
P. 18, pl. 4. f. 14-16. } *Rosalina horrida*, Egger. } var.

VI. A. E. REUSS. 'Beiträge zur Kenntniss der tertiären Foraminiferen-Fauna. Zweite Folge. I. Die Foraminiferen des Septarienthones von Offenbach.' *Sitzungsb. Acad. Wiss. Wien*, vol. xlviii. 1863, pp. 36-61.

- P. 59. *Rotalia Girardana*, Rss. = *Rotalia Soldanii*, D'O.  
*R. Partschiana*, D'O. = *Pulvinulina Partschiana* (D'O.).  
P. 60. *R. umbonata*, Rss. = *Pulv. umbonata* (Rss.).  
*R. Ungeriana*, D'O. } = *Planorbulina Ungeriana* (D'O.).  
*R. granosa*, Rss. }  
P. 61. *Truncatulina variabilis* (?), D'O. = *Pl. (Truncatulina) variabilis*, D'O.

— II. 'Die Foraminiferen des Septarienthones von Kreuznach.' *Op. cit.* pp. 61-71.

- P. 68. *Rotalia Girardana*, Rss. = *Rotalia Soldanii*, D'O.  
Pl. 8. f. 97. *Rosalina Weinkauffi*, Rss. = *Planorbulina (Anomalina)*  
*complanata* (D'O.).

VII. A. E. REUSS. 'Les Foraminifères du crag d'Anvers.' *Bullet. Acad. Roy. Sc. Belg.* vol. xv. 1863, pp. 137-162. (See above, p. 120.)

- P. 154. *Rotalia Brongniartii*, D'O. *Pulvinulina*.  
— *crstellaxoides*, Rss., pl. 3. f. 44. = *Pulv. Brongniartii*, subvar.  
P. 155. — *kalembergensis*, D'O. *Planorbulina*.  
— *orbicularis*, D'O. *Rotalia*.  
— *tenuimargo*, Rss. *Planorbulina*.  
*Truncatulina varians*, Rss. = *Pl. Ungeriana*, subvar.  
— *oblongata*, Rss., pl. 3. f. 45. Neat *Tr. lobatula*.  
*Rosalina*, sp. = ?

VIII. A. E. REUSS. 'Zur Fauna des deutschen Oberoligocäns.'

Erste Abtheilung. *Sitzungsb. Akad. Wiss. Wien*, vol. I. part 1, 1864. (A useful Table accompanies this memoir.)

- P. 41. *Rotalia Dutemplei*, D'O. *Planorbulina Dutemplei* (D'O.).  
*R. Ræmeri*, Rss. *Pl. Ungeriana* (D'O.).  
*R. umbonata*, Rss. *Pulvinulina umbonata* (Rss.).  
*R. propinqua*, Rss. *Planorbulina Haidingerii* (D'O.).  
*R. kalemburgensis*, D'O. *Pl. kalemburgensis* (D'O.).  
*R. Boueana*, D'O. *Pulvinulina Boueana* (D'O.), near *pulchella* (D'O.).
- P. 42. *R. Brongniartii*, D'O. *Pulv. Brongniartii* (D'O.).  
*R. Haueri*, D'O. *Pulv. Haueri* (D'O.), near *auricula* (F. & M.).  
*R. trochus*, v. M. *Pulv. trochus* (v. M.).  
*R. stellata*, Rss. *Calcarina armata* (D'O.).  
*Asterigerina planorbis*, D'O. *Discorbina*.  
*Rosalina obtusa*, D'O. *Discorbina*, near *globularis* (D'O.).
- P. 43. *R. osnabrugensis*, v. M. *Planorbulina osnabrugensis* (v. M.).  
*Anomalina tenuissima*, Rss. *Pl. (Anom.) tenuissima*, Rss.  
*A. subæqualis*, Rss. *Pl. ammonoides* (Rss.).  
*Truncatulina communis*, Ræm. *Pl. (Tr.) lobatula* (W. & J.).  
*T. lobatula*, D'O. *Pl. (Tr.) lobatula* (W. & J.).
- Pl. 5. f. 6. *T. tenella*, Rss. Subvariety of *T. lobatula* (W. & J.).

IX. A. E. REUSS. 'Die fossilen Foraminiferen, Anthozoen, und Bryozoen von Oberburg in Steiermark. Ein Beitrag zur Fauna der oberen Nummulitenschichten.' *Denkschr. Akad. Wiss. Wien*, vol. xxiii. 1864.

- P. 9, pl. 1. f. 14. *Rotalia formosa*, Rss. (Non *Rotalia*.) *Discorbina* ?  
 P. 10. *Rosalina obtusa*, D'O. *Discorbina obtusa* (D'O.).  
 f. 15. *Truncatulina variabilis*, D'O.

*Harriet & Stachet, New Zealand.*

X. A. E. REUSS. 'Die Foraminiferen, Anthozoen, und Bryozoen des deutschen Septarienthones. Ein Beitrag zur Fauna mitteloligo-cänen Tertiärschichten.' *Denkschr. Akad. Wiss. Wien*, vol. xxv. 1866.

- P. 159. *Truncatulina variabilis*, D'O. *Planorbulina (Truncatulina)*.  
*T. communis*, Ræm. *Pl. (Tr.) lobatula*.  
*T. Boueana*, D'O. *Pl. (Tr.) lobatula*; neat.  
*T. austriaca* (D'O.). *Pl. (Anomalina) austriaca*, D'O.
- P. 160. *T. Weinkauffi*, Rss. *Pl. (Anom.) complanata*, D'O.  
*T. Akneriana*, D'O. *Pl. Akneriana* (D'O.).
- Pl. 4. f. 15. *T. lucida*, Rss. *Pl. near Pl. Ungeriana* (D'O.).  
*T. Ræmeri*, Rss. *Pl. Ungeriana* (D'O.).
- f. 16. *T. Dutemplei* (D'O.). *Pl. Dutemplei* (D'O.).
- P. 161. *T. Ungeriana* (D'O.). *Pl. Ungeriana* (D'O.).  
*T. granosa*, Rss. *Pl. Ungeriana* (D'O.).  
*Discorbina marginata*, Rss. *Globigerina marginata* (Rss.).  
*D. planorbis* (D'O.). *D. rosacea* (D'O.).
- f. 14. *Pulvinulina Boueana* (D'O.). *Pulvinulina near P. pulchella*.  
*P. Partschiana* (D'O.). *Pulv. near P. elegans*.
- P. 162. *P. umbonata*, Rss. *Pulv. near P. Menardii*.  
*P. contraria*, Rss. *Pulv. near P. auricula*.  
*Siphonina reticulata* (Czjz.). *Planorbulina (Siphonina)*.  
*Rotalia bulimoides*, Rss. *Bulimina elegantissima*, D'O.
- P. 163. *R. Girardana*, Rss. *R. Soldanii*, D'O.  
*R. tæniata*, Born. *Rotalia near R. Soldanii*.
- f. 17. *R. grata*, Rss. *Planorbulina near Pl. Haidingerii*.  
 (Not figrd.) *R. polita*, Rss. Described as being near *R. Beccarii*.

XI. A. E. REUSS. 'Die fossile Fauna der Steinsalzablagerung von Wieliczka in Galizien.' *Sitzungsb. Akad. Wiss. Wien*, vol. lv. part 1, 1867. (This memoir contains a good Table of the distribution of the Oligocene and Miocene Foraminifera.)

- P. 83. *Truncatulina lobatula* (*W. & J.*).  
 P. 84. *T. Ungeriana* (*D'O.*).  
           *T. Dutemplei* (*D'O.*).  
           *T. Haidingerii* (*D'O.*). } *Planorbulinae*.  
 P. 85. *Discorbina planorbis* (*D'O.*). Near *D. rosacea* (*D'O.*).  
       Pl. 5. f. 1. *D. stellata*, *Rss.* } Near *D. valvulata* (*D'O.*).  
                   f. 2. *D. squamula*, *Rss.* }  
 P. 86. *D. obtusa* (*D'O.*). Near *D. globularis* (*D'O.*).  
       Pl. 4. f. 13. *D. platyomphala* (*Rss.*). Near *D. parisiensis* (*D'O.*).  
                   *D. complanata* (*D'O.*). Near *D. elegans* (*D'O.*).  
                   *D. cryptomphala*, *Rss.* *Planorbulina*, near *Pl. Akneriana* (*D'O.*).  
                   *D. arcuata*, *Rss.* *Discorbina* near *D. trochidiformis* (*Lamarck*).  
 P. 87. *Pulvinulina Haueri* (*D'O.*). Near *P. auricula* (*F. & M.*).  
       Pl. 5. f. 3. *P. cordiformis* (*Costa*). Near *P. auricula* (*F. & M.*).  
                   *P. Boueana* (*D'O.*). Near *P. pulchella* (*D'O.*).  
                   *P. kalembergensis* (*D'O.*) *Planorbulina kalembergensis* (*D'O.*).  
 P. 88. *P. nana* (*Rss.*). *Discorbina* near *D. trochidiformis* (*Lamarck*).  
           *P. Partschiana* (*D'O.*). Near *P. elegans* (*D'O.*).  
           *Rotalia Beccarii* (*Linn.*).  
 P. 89. *R. Soldanii*, *D'O.*

XII. F. KARRER. 'Die miocene Foraminiferen-Fauna von Kostež im Banat.' *Sitzungsb. Akad. Wiss. Wien*, vol. lviii. part 1, 1868.

- P. 60. *Truncatulina Schreibersii* (*D'O.*). *Pulvinulina*.  
       *T. Haidingerii* (*D'O.*). *Planorbulina*.  
       *T. Ungeriana* (*D'O.*). *Planorbulina*.  
 P. 61. *T. Dutemplei* (*D'O.*). *Planorbulina*.  
       *T. Brongniartii* (*D'O.*). *Pulvinulina*.  
       *T. lobatula* (*Walk.*). *Planorbulina* (*Truncatulina*).  
       *T. Boueana* *D'O.* *Planorbulina* (*Truncatulina*).  
       *T. variolata* (*D'O.*) *Planorbulina* (*Anomalina*).  
       *T. rotula* (*D'O.*). *Planorbulina* (*Planulina*).  
 P. 62, pl. 4. f. 13. *T. stella*, *Kar.* } *Planorbulina* (*Anomalina*) *ammonoides*  
                   f. 14. *T. inæqualis*, *Kar.* } (*Rss.*), subvar.  
                   f. 15. *T. flos*, *Kar.* *Discorbina*, near *D. rosacea* (*D'O.*).  
 P. 63, pl. 5. f. 1. *T. laciniata*, *Kar.* *Discorbina*.  
                   f. 2. *T. papillata*, *Kar.* *Discorbina*.  
 P. 64, pl. 5. f. 3. *T. regularis*, *Kar.* *Discorbina*.  
                   *Discorbina planorbis* (*D'O.*). *Discorbina*.  
                   *D. obtusa* (*D'O.*). *Discorbina*.  
 P. 65. *D. complanata* (*D'O.*). *Discorbina*.  
       *D. squamula*, *Rss.* *Discorbina*.  
       *D. platyomphala*, *Rss.* *Discorbina*.  
       Pl. 5. f. 4. *D. turris*, *Kar.* *Discorbina*.  
                   f. 5. *D. semiorbis*, *Kar.* *Discorbina*, near *D. turbo* (*D'O.*).  
 P. 66. *Pulvinulina Haueri* (*D'O.*). *Pulvinulina*.  
       *P. Boueana* (*D'O.*). *Pulvinulina*.  
       *P. kalembergensis* (*D'O.*). *Planorbulina*.  
       *P. Partschiana* (*D'O.*). *Pulvinulina*.

- P. 66. *P. perforata* \*, Kar. *Planorbulina* near to *Pl. Haidingerii* (D'O.).
- P. 67, pl. 5. f. 6. *P. erinacea*, Kar. *Pulvinulina* related to *P. excavata* (D'O.) of the *auricula* group.  
*Rotalia Beccarii* (Linn.). *Rotalia*.  
*R. simplex* (D'O.). *Planorbulina*.  
*R. aculeata*, D'O. *Calcarina*.
- P. 68. *R. Girardana*, Rss. *Rotalia Soldanii*, D'O.  
*R. spinimargo*, Rss. *Pulvinulina*.  
*R. tuberosa*, Kar. *Rotalia Schröteriana*, P. & J.  
*R. granulosa*, Kar. *Cymbalopora granulosa* (Kar.).
- P. 69, pl. 5. f. 7. *R. præincta*, Kar. *Planorbulina Haidingerii* (D'O.), subv.

XIII. A. E. REUSS. 'Zur fossilen Fauna der Oligocänschichten von Gaas bei Dax.' *Sitzungsb. Akad. Wiss. Wien*, vol. lix. 1 Abth. 1869.

- P. 15. *Planorbulina mediterranea*, D'O.  
 — *variabilis* (D'O.).
- P. 16. *Truncatulina falcata*, Rss., pl. 2. f. 1.  
 — *insignis*, Rss., pl. 2. f. 2.
- P. 17. — *Haidingerii* (D'O.). *Planorbulina*.  
*Discorbina obtusa* (D'O.).  
 — *crenulata*, Rss., pl. 2. f. 3.
- P. 18. — *stellata*, Rss., pl. 2. f. 4. *Calcarina armata* (D'O.).  
 — *Pulvinulina prominens*, Rss., pl. 3. f. 2. Near *P. elegans* (D'O.).
- P. 19. — *formosa*, Rss., pl. 3. f. 1. Near *P. Menardii* (D'O.).  
 — *grandis*, Rss., not figured. *pl. 3, fig. 1a-c*.  
 — *Rotalia rimosa*, Rss., pl. 2. f. 5. *Calcarina armata*, feeble var.

XIV. A. E. REUSS. 'Die Foraminiferen des Septarienthones von Pietzpuhl.' *Sitzungsb. Akad. Wiss. Wien*, vol. lxii. part 1, 1870. (This is avowedly not an exhaustive list.)

- P. 36. *Truncatulina variabilis*, D'O.  
*T. Akmeriana* (D'O.).  
*T. Ungeriana* (D'O.). } *Planorbulina*.  
*T. granosa*, Rss. }  
*Pulvinulina Partschiana* (D'O.). Of the *elegans* group.  
*P. umbonata*, Rss. Of the *Menardii* group.  
*P. contraria*, Rss. } Of the *auricula* group.  
*P. Haueri* (D'O.). }  
*Siphonina reticulata* (Czjžek). *Planorbulina* (*Siphonina*).
- P. 37. *Rotalia bulimoides*, Rss. (Non *Rotalia*.) *Bulimina elegantissima*, D'O.  
*R. Girardana*, Rss. = *R. Soldanii*, D'O.

#### DISCUSSION.

The PRESIDENT suggested the possibility of some of the minute Foraminifera being transported fossils derived from earlier beds than those in which they are now found.

Dr. CARPENTER observed that the mode of examination to be adopted with Foraminifera was different in character from that which was applicable to higher organisms. The range in variation was so great that a comparatively imperfect examination of Nummulites had sufficed to make M. d'Archiac reduce the number of species by one half; and all the speaker's subsequent studies had impressed upon him the variety in form and in sculpturing of surface on individuals of the

\* Found also in Tertiary sands at Orakei Bay, New Zealand. 'Novara-Expedition, Neu-Seeland; Abth: Paläontologie,' p. 81, pl. 16. See also, for Critical Notes, Geol. Mag. 1864, no. 2, p. 74.

same species. When out of some thousands of specimens of *Operculina*, say, a dozen pronounced forms had been selected, such as by themselves seemed well marked and distinct, it might turn out that after all there was but one species present, with intermediate varieties connecting all these different forms. He thought the same held good with *Rotalinae*, and that there were osculant forms which might connect, not only the species, but even the genera into which they had been subdivided. This fact had an important bearing on their genetic succession, especially as it appeared that some of the best-marked types were due to the conditions under which they lived.

The temperature in tropical seas differed in accordance with the depth so much, that when 2000 fathoms were reached a degree of cold was attained such as was to be found in high latitudes; and in consequence the deep-sea forms in tropical latitudes assumed the dwarfed character of those in shallower seas and nearer the Pole. He suggested caution in drawing inferences from forms so subject to modification, both spontaneous and due to the depth of the sea, especially as connected with abundance of food.

Prof. RAMSAY remarked that geologists would be pleased to find Foraminifera exhibiting, like other organisms, changes in some degree connected with the lapse of time. These low forms, however, could hardly afford criteria for judging of the age of geological formations, while at the same time such ample means were afforded by the higher organisms for coming to a conclusion. He cited, for instance, the Cephalopoda as proving how different were the more important forms of marine life in Cretaceous times from those of the present day. He thought that no one who had thoroughly studied the forms of ancient life would be led to ignore the differences they presented, as a whole, from those now existing.

Mr. SEELEY, Dr. MURIE, and Mr. HICKS also made some remarks on the paper.

Prof. JONES, in reply, observed that the question of whether the Foraminifera in a given bed were derived or not was to be solved partly by their condition and partly by their relative proportions, and that in most cases sufficient data existed on which to found a judgment. He agreed with Dr. Carpenter as to the existence of extreme modifications; and it had been his object to ignore such as seemed due to ordinary and local causes, and to group the forms in accordance with certain characteristics. Whether the classification was right or wrong, it was necessary, for the sake of increasing knowledge, that fossils of this kind should be arranged in groups; and whether these were to be regarded as truly generic was a minor consideration. In forming their types and subtypes the authors had carefully avoided minor differences; and they thought that the modifications which were capable of being substantiated were significant of a great lapse of time. A variation once established never returned completely to the original type. In *Globigerina*, he stated that there were in Cretaceous times 8 forms, in Tertiary 12, at the present time 14; and these modifications he regarded as equivalent to the specific changes in higher animals.