

## IV.—ON THE RECOGNITION OF TWO STAGES IN THE UPPER CHALK.

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(Concluded from the July Number, p. 313.)

THE next step is to see if the evidence of the Echinodermata coincides with and confirms that of the Cephalopoda. The Echinoderms will be tabulated in the same way as the Cephalopoda, beginning with those of Germany. The following table has been compiled from several sources, and may not be quite complete as regards the irregular forms, though it is practically so for the Regulares, this part being taken from Schlüter's monograph on that order:—

TABLE IV.  
ECHINODERMATA IN NORTH GERMANY.

SPECIES.	Curieri zone.	The Emischer.	Zone of Marsupites.	Zone of S. binodosus.	Zone of A. quadratus.	Zone of B. mucronata.
<i>Cidaris Merceyi</i> , Cott. . . . .	x	-	-	-	-	-
<i>C. sceptrifera</i> , Mant. . . . .	x	x	-	-	-	-
<i>C. hirudo</i> , Sorig . . . . .	-	-	-	x	-	-
<i>C. ? pistillum</i> , Quendst. . . . .	-	-	-	-	-	x
<i>C. pseudopistillum</i> , Cott. . . . .	-	-	-	x	-	-
<i>C. Hertha</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>C. mammillata</i> , Cott. . . . .	-	-	-	-	-	x
<i>C. gigas</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>C. darupensis</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>C. cometes</i> , Boll . . . . .	-	-	-	-	-	x
<i>C. striatula</i> , v. d. Marck . . . . .	-	-	-	-	-	x
<i>C. alata</i> , Boll . . . . .	-	-	-	-	-	x
<i>C. spinosa</i> , Boll . . . . .	-	-	-	-	-	x
<i>C. baltica</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>C. Faujasi</i> , Desor . . . . .	-	-	-	-	-	x
<i>C. cf. Hardouini</i> , Desor . . . . .	-	-	-	-	-	x
<i>C. Gosæ</i> , Schlüter (= <i>clavigera</i> , part) . . . . .	-	-	-	x	-	-
<i>C. vexillifera</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>Temnocidaris Baylei</i> , Cott. . . . .	-	-	-	-	-	x
<i>T. danica</i> , Cott. . . . .	-	-	-	-	-	x
<i>Porocidaris lingualis</i> , Desor . . . . .	-	-	-	-	-	x
<i>Pleurocidaris regalis</i> , Goldf. . . . .	-	-	-	-	-	x
<i>Salenia gehrdensis</i> , Schlüter . . . . .	-	-	-	x	-	-
<i>S. Quendstedti</i> , Schlüter . . . . .	-	-	-	x	-	-
<i>S. Heberti</i> , Cott. . . . .	-	-	-	-	x	-
<i>S. obnupta</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>S. anthophora</i> , Müll. (= <i>Bonissenti</i> , Cott.) . . . . .	-	-	-	-	-	x
<i>S. stellifera</i> , Hagen. . . . .	-	-	-	-	-	x
<i>S. pygmaea</i> , Hagen. . . . .	-	-	-	-	-	x
<i>S. maestrictensis</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>Peltastes heliophorus</i> , Ag. . . . .	-	-	-	-	-	x
<i>Cyphosoma radiatum</i> , Sorig . . . . .	x	x	x	-	-	-
<i>C. spathuliferum</i> , Forbes . . . . .	-	x	-	-	-	-
<i>C. gehrdense</i> , Schlüter . . . . .	-	-	-	x	-	-
<i>C. cf. magnificum</i> , Ag. . . . .	-	-	-	x	-	-
<i>C. ornatissimum</i> , Ag. . . . .	-	-	-	-	-	x

SPECIES.	Cuvieri zone.	The Emscher.	Zone of Marsupites.	Zone of S. binodosus.	Zone of A. quadratus.	Zone of B. mucronata.
<i>Cyphosoma princeps</i> , Hagen. . . . .	-	-	-	-	-	x
<i>C. teniatum</i> , Hagen. . . . .	-	-	-	-	-	x
<i>C. pseudoradiatum</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>C. polygophorum</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>Echinocyphus tenuistriatus</i> , Desor . . . . .	-	-	-	x	-	-
<i>Zeuglopleurus pusilla</i> , Röm. . . . .	-	-	-	x	-	-
<i>Goniopygus Heberti</i> , Cott. . . . .	-	-	-	-	-	x
<i>Phymechinus cretaceus</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>Diplotagma altum</i> , Schlüter . . . . .	-	-	-	-	-	x
<i>Catopygus obtusus</i> , Desor . . . . .	-	-	x	x	-	-
<i>Caratonus truncatus</i> , d'Orb. . . . .	-	-	-	-	x	-
<i>Micraster coranguinum</i> , Leske . . . . .	-	x	x	-	-	-
<i>M. cortestudinarium</i> , Goldf. . . . .	x	-	-	-	-	-
<i>M. gibbus</i> , Lam. ( <i>Epiaster</i> ) . . . . .	-	-	-	x	x	x
<i>M. glyphus</i> , Cott. . . . .	-	-	-	-	x	x
<i>M. Haasi</i> , Stolley . . . . .	-	-	-	-	x	-
<i>M. Gotschei</i> , Stolley . . . . .	-	-	-	-	x	-
<i>M. Schroderi</i> , Stolley . . . . .	-	-	-	-	x	-
<i>Epiaster brevis</i> , Desor . . . . .	x	-	-	-	-	-
<i>Ananchytes vulgaris</i> , var. <i>conica</i> . . . . .	-	-	-	-	x	x
<i>A. vulgaris</i> , var. <i>gibba</i> . . . . .	-	x	-	-	x	-
<i>A. vulgaris</i> , var. <i>ovata</i> . . . . .	-	-	x	x	x	x
<i>A. vulgaris</i> , var. <i>conoidea</i> . . . . .	-	-	-	-	x	x
<i>Galerites albogalerus</i> , Leske . . . . .	-	x	-	x	-	x
<i>G. Roemeri</i> (= <i>abbreviatus</i> , Desor) . . . . .	-	-	-	-	-	x
<i>Offaster pilula</i> , Lam. . . . .	-	-	-	-	x	-
<i>O. corculum</i> , Goldf. . . . .	-	-	-	-	-	x
<i>Cardiaster granulatus</i> , Goldf. . . . .	-	-	-	x	x	x
<i>C. jugatus</i> , Schlüter . . . . .	-	-	x	-	-	-
<i>C. Heberti</i> , Cott. (= <i>maximus</i> , Schlüter) . . . . .	-	-	-	-	x	x
<i>Hemiaster ligeriensis</i> , d'Orb. . . . .	-	-	-	x	-	-
<i>H. recklinghausensis</i> , Schlüter . . . . .	-	-	x	-	-	-
<i>Pygurus rostratus</i> , Röm. . . . .	-	-	x	-	-	-
<i>Marsupites testudinarium</i> , Schloth. . . . .	-	-	x	-	-	-
<i>Uritacrinus westfalicus</i> , Schlüter . . . . .	-	-	x	-	-	-
<i>Bourgetricrinus ellipticus</i> , Müll. . . . .	-	-	x	x	x	-

From this table it will be seen that there are two different Echinoderm faunas in Germany, just as there are two different Cephalopodan faunas, only two species passing from the lower three to the two highest zones. There is not, however, such a clearly marked line of separation; the fauna of the *S. binodosus* zone seems from the tabulated species to be linked as closely with the higher as with the lower zones, for it contains sixteen species, of which number ten appear to be restricted to the zone and three range both up and down, while one passes downward only and two range upward. This result, however, is deceptive, because the Emscher is so poor in Echinoderms that only six species have been recorded from it, and only eight have been found in the *Marsupites* zone. If these zones were as productive in Germany as they are in England and France it

is probable that the number of species ranging from them to the equivalent of the *Offaster pilula* zone would be very much larger.

In the Franco-Belgian region a much greater number of Echinoderms has been obtained from the corresponding series of beds. The following table has been compiled chiefly from the separate lists given by M. de Grossouvre in the work already mentioned, but the Belgian species have been corrected in accordance with Mr. Lambert's recent revision of them, as published in the Mém. Mus. Roy. Belg. for 1911. I have not, however, included all his new species. The Belgian occurrences are indicated by the letter B., and those in France by the letter F.; these latter include the records from Touraine and the Cotentin as well as the Paris Basin:—

TABLE V.

## ECHINODERMATA OF THE UPPER CHALK IN THE NORTH OF FRANCE AND BELGIUM.

SPECIES.	Zone of <i>M. decipiens</i> .	Zone of <i>M.</i> <i>coranginum</i> .	Zone of <i>Marsupites</i> .	Zone of <i>O. pilula</i> and <i>A. granulatus</i> .	Zone of <i>A. quadratus</i> .	Zone of <i>B. mucronata</i> .
<i>Cidaris hirudo</i> , Sorig . . . . .	x	x	x	x	x	x
<i>C. subhirudo</i> , Cott. . . . .	-	-	-	-	x	x
<i>C. pseudohirudo</i> , Cott. . . . .	-	-	-	-	-	x B.
<i>C. sceptrifera</i> , Mant. . . . .	x	x	x	x	x	x
<i>C. clavigera</i> , Koenig . . . . .	x	x	x	-	x	x
<i>C. Merceyi</i> , Cott. . . . .	x	-	-	-	-	-
<i>C. perlata</i> , Sorig . . . . .	x	-	-	-	-	-
<i>C. perornata</i> , Forbes . . . . .	x	x	-	-	-	-
<i>C. subvesiculosa</i> , d'Orb. . . . .	x	x	-	-	-	-
<i>C. serrifera</i> , Forbes . . . . .	x	-	-	-	-	-
<i>C. serrata</i> , Desor . . . . .	-	-	-	x	x	x B.
<i>C. turonensis</i> , Gauthier . . . . .	-	x	x	-	-	-
<i>C. Faujasi</i> , Desor . . . . .	-	-	-	-	-	x B.
<i>C. Hardouini</i> , Desor . . . . .	-	-	-	-	-	B.
<i>C. lingualis</i> , Desor ( <i>Porocidaris</i> ) . . . . .	-	-	-	-	-	B.
<i>Cyphosoma radiatum</i> , Sorig . . . . .	x	x	-	x	x	x B.
<i>C. granulosum</i> , Goldf. . . . .	-	x	-	-	-	x
<i>C. corollare</i> , Agas. . . . .	-	x	-	-	-	B.
<i>C. magnificum</i> , Cott. . . . .	-	x	x	-	-	-
<i>C. Koenigi</i> , Mant. . . . .	-	x	x	x	B.	-
<i>C. Delaunayi</i> , Cott. . . . .	-	-	x	-	-	-
<i>C. Corneti</i> , Cott. . . . .	-	-	-	-	-	B.
<i>C. elongatum</i> , Cott. . . . .	-	-	-	x	x	x
<i>C. remus</i> , Cott. . . . .	-	x	-	-	-	-
<i>C. spathuliferum</i> , Forbes . . . . .	-	-	-	-	-	B.
<i>Salenia incrustata</i> , Cott. . . . .	-	x	-	x	x	-
<i>S. Bourgeoisi</i> , Cott. . . . .	-	x	x	-	-	-
<i>S. geometrica</i> , Ag. . . . .	-	x	x	-	-	-
<i>S. anthophora</i> , Müller . . . . .	-	-	-	B.	B.	-
<i>S. Janeti</i> , Cott. . . . .	-	-	-	-	-	x
<i>S. Bonissenti</i> , Cott. . . . .	-	-	-	-	-	x
<i>S. Heberti</i> , Cott. . . . .	-	-	-	-	x	-
<i>S. maestrichtensis</i> , Schlüter . . . . .	-	-	-	-	-	x B.
<i>Peltastes heliophorus</i> , Cott. . . . .	-	-	-	-	-	x B.

SPECIES.	Zone of <i>M. decipiens</i> .	Zone of <i>M.</i> <i>coranguinum</i> .	Zone of <i>Marsupites</i> .	Zone of <i>O. pitula</i> and <i>A. granulatus</i> .	Zone of <i>A. quadratus</i> .	Zone of <i>B. macronata</i> .
<i>Pyrina Bourgeoisi</i> , Cott.	-	-	x	-	-	-
<i>P. ovulum</i> , Lam.	-	-	x	-	-	-
<i>Nucleolites analis</i> , Ag.	-	-	-	-	-	F., B.
<i>N. minimus</i> , Ag.	-	-	x	-	-	-
<i>N. coravium</i> , Ag.	-	-	-	-	-	F., B.
<i>Echinobrissus Guillieryi</i> , Cott.	x	-	-	-	-	-
<i>Catopygus elongatus</i> , Desor.	-	-	x	-	-	B.
<i>C. fenestratus</i> , Ag.	-	-	-	-	B.	B.
<i>Oolopygus Orbignyi</i> , Cott.	-	-	-	-	-	x
<i>O. pyriformis</i> , Ag.	-	-	-	-	B.	B.
<i>Trematopygus oblongus</i> , Desor.	-	-	x	-	-	-
<i>Hemiasiter nasutulus</i> , Sorig.	x	-	-	-	-	-
<i>H. nucleus</i> , Desor.	x	-	-	-	-	-
<i>H. ligeriensis</i> , d'Orb.	-	-	x	-	-	-
<i>H. angustipneustes</i> , Desor.	-	x	x	-	-	-
<i>H. prunella</i> , Lam.	-	-	-	-	-	F., B.
<i>H. Neustriæ</i> , Desor.	-	-	-	-	-	F.
<i>Linthia spienmesensis</i> , Schlüter	-	-	-	-	-	B.
<i>Cassidulus lapiscanceri</i> , Lam.	-	-	-	-	-	F., B.
<i>C. elongatus</i> , d'Orb.	-	-	-	-	-	B.
<i>C. Peroni</i> , Gautier.	x	-	-	-	-	-
<i>Clypeolampas orum</i> , Ag.	-	-	-	-	-	B.
<i>Heteropneustes tenuiporus</i> , Cott.	-	-	x	-	-	-
<i>Caratomus avellana</i> , Dubois.	-	-	-	-	-	F., B.
<i>C. ocellatus</i> , Cott.	-	-	-	-	-	B.
<i>C. hemisphericus</i>	-	-	-	-	-	B.
<i>C. peltiformis</i> , Wahl.	-	-	-	-	-	B.
<i>C. sulcatoradiatus</i> , Desor.	-	-	-	-	B.	B.
<i>Hemipneustes ocellatus</i> , Cott.	-	-	-	-	-	B.
<i>H. striatoradiatus</i> , d'Orb.	-	-	-	-	-	B.
<i>Rhynchopygus Marmini</i> , d'Orb.	-	-	-	-	-	F., B.
<i>Faujasia Faujasi</i> , d'Orb.	-	-	-	-	-	B.
<i>F. Delaunayi</i> , d'Orb.	-	x	-	-	-	-
<i>Peroniaster Cotteaui</i> , Gauthier	-	-	-	x	-	-
<i>Cardiaster granulosus</i> , Goldf.	x	x	-	x	B.	F., B.
<i>C. Heberti</i> , Cott. (= <i>maximus</i> , Schl.).	-	-	-	-	-	F., B.
<i>Plesiaster bucardium</i> , Goldf.	-	-	-	-	-	B.
<i>Galerites albogalerus</i> , Klein.	-	x	x	x	x	-
<i>G. circularis</i> , Buc.	-	x	x	-	-	-
<i>G. sulcatoradiatus</i> , Goldf.	-	-	-	-	-	B.
<i>Echinocorys scutatus</i> , var. <i>gibba</i>	x	x	-	-	-	B.
<i>E. scutatus</i> , var. <i>striata</i>	-	x	x	x	x	x B.
<i>E. scutatus</i> , var. <i>comica</i>	-	-	x	x	x	x B.
<i>E. scutatus</i> , var. <i>meudonensis</i>	-	-	-	-	-	x B.
<i>E. orbis</i> , Arnaud.	-	-	-	-	-	x B.
<i>Holaster placenta</i> , Ag.	x	-	-	-	-	-
<i>Offaster pilula</i> , Lam.	-	-	x	x	x	x B.
<i>O. Gauthieri</i> , Lamb.	-	-	-	-	-	x
<i>Orthopsis miliaris</i> , d'Arch.	-	-	x	-	-	-
<i>Holactypus turonensis</i> , Desor.	-	-	x	-	-	-
<i>Epiaster brevis</i> , Schlüter	x	-	-	-	-	-
<i>E. gibbus</i> , Schlüter	-	x	x	-	-	-
<i>Micraster decipiens</i> , Bayle	x	-	-	-	-	-

SPECIES.	Zone of <i>M. decipiens</i> .	Zone of <i>M.</i> <i>coranguinum</i> .	Zone of <i>Marsupites</i> .	Zone of <i>O. ptila</i> and <i>A. granulatus</i> .	Zone of <i>A. quadratus</i> .	Zone of <i>B. mucronata</i> .
<i>Micraster turonensis</i> , Bayle . . . . .	-	x	-	-	-	-
<i>M. senonensis</i> , Lamb. . . . .	x	x	-	-	-	-
<i>M. senonensis</i> , var. <i>belgica</i> , Lamb. . . . .	-	-	-	B.	-	-
<i>M. icaunensis</i> , Lamb. . . . .	x	-	-	-	-	-
<i>M. Cayeuxi</i> , Parent . . . . .	x	x	-	-	-	-
<i>M. coranguinum</i> , Leske . . . . .	-	x	x	B.	B.	-
<i>M. gibbus</i> , Lam., var. <i>fastigatus</i> . . . . .	-	-	-	x	-	-
<i>M. gibbus</i> , Lam., var. <i>Stolleyi</i> . . . . .	-	-	-	-	B.	B.
<i>M. Brongniarti</i> , Hébert . . . . .	-	-	-	-	x B.	F., B.
<i>M. Schroderi</i> , Stolley . . . . .	-	-	-	-	x	F., B.
<i>M. regularis</i> , Arnaud . . . . .	-	-	-	-	x	F.
<i>M. ciptlyensis</i> , Schlüter . . . . .	-	-	-	-	-	B.
<i>Leucaster remensis</i> , Gauthier . . . . .	-	-	-	-	x	-
<i>Marsupites testudinarius</i> , Schloth. . . . .	-	-	x	-	-	-
<i>Umtacrinus westfalicus</i> , Schlüter . . . . .	-	-	x	-	-	-
<i>Bourgetiacrinus ellipticus</i> , Müll. . . . .	x	x	x	x	x	-

In considering this table, if in the first place we leave the *Offaster* zone out of account we find that the three lower zones have yielded forty-eight species and that the two higher zones contain no fewer than fifty-six species. Of this large number only ten species and varieties are common to the two assemblages, which are thus very different, though, as might be expected, they are not so entirely distinct as those of the more highly organized Cephalopoda.

The line of division between the two stages is not, however, so clearly indicated by the Echinoderms, for the fauna of the *Offaster* zone seems to form a complete passage from the one to the other. This zone has yielded fifteen species, of which ten range both up and down, one ranges downward only, three range up but not down, and one is restricted to the zone. The fact is that the tabulated number of occurrences is hardly sufficient to give a reliable result, and we can only infer that the zone might be placed in either stage.

In passing to the South of France we come to a different area of deposition, inhabited by an assemblage of Echinoderms which differed considerably from that of the Anglo-Parisian basin. Some of the northern species do occur in it, but there are a large number of others. From the lists given by M. de Grossouvre, in the work already mentioned, I have compiled a table of the distribution of species in the Aquitanian and Pyrenean areas, in order to ascertain what evidence they afford. This list includes no fewer than one hundred species, and yet is probably not quite complete; the greater number (sixty-three species) occur in the two higher zones and only ten of these range down into the three lower zones. The equivalent of the *Offaster* zone has yielded twenty-four species, and of these ten range both upward and downward, three range down only, and six pass up, while five are restricted. Here again, therefore, the existence of two different faunas and consequently of two distinct

stages is very apparent, but there is a transition from one Echinoderm fauna to the other, and the zone might be placed in either stage.

Lastly, Table VI shows the distribution of the Echinoids and Crinoids through the same zones in England, and in compiling this I have received special assistance from Mr. A. W. Rowe, who has kindly sent me notes regarding the identification and range of all the species, so that this list is more correct than any that has previously been published.

In comparing this with the preceding lists it will be noticed that the number of species is less and that the proportion of them which ranges from the lower to the higher zones is greater. Both these peculiarities are doubtless owing to the fact that in England there is little variation in the lithological character of the Upper Chalk, the whole of it being a deep-water facies of the formation deposited under conditions which did not change greatly from beginning to end. There was, therefore, no sudden or rapid extinction of species, only the increasing rarity of some and the occasional introduction of new forms.

In spite of these conditions there are many species which do not range from the lower to the higher zones. The total number of species and varieties enumerated is fifty-one, and of these forty-four occur in the lower four zones and twenty-five in the two higher zones, nineteen species being common to the two assemblages. This is less than half of the larger fauna, so that there is still a considerable difference between them. The zone of *O. pilula* has yielded twenty-seven species, of which seventeen range both up and down, only two have an exclusively upward range, while eight do not range higher; it is therefore more closely connected with the lower than the higher zones.

TABLE VI.  
ECHINODERMS IN ENGLAND.

SPECIES.	Zone of <i>M. cortestudinarium</i> .	Zone of <i>M. coranginum</i> .	Zone of <i>Marsupites</i> .	Zone of <i>O. pilula</i> and <i>A. granulatus</i> .	Zone of <i>A. quadratus</i> .	Zone of <i>B. mucronata</i> .
<i>Cidaris hirudo</i> , Sorig . . . . .	x	x	x	x	x	x
<i>C. sceptrifera</i> , Mant. . . . .	x	x	x	x	-	-
<i>C. clavigera</i> , Koenig . . . . .	x	x	x	-	-	-
<i>C. perornata</i> , Forbes . . . . .	x	x	x	x	-	-
<i>C. subvesiculosa</i> , d'Orb. . . . .	x	x	x	x	x	x
<i>C. Merceyi</i> , Cotteau . . . . .	x	x	-	-	-	-
<i>C. serrifera</i> , Forbes . . . . .	x	x	-	-	-	-
<i>C. serrata</i> , Desor . . . . .	-	-	-	-	-	x
<i>C. pleracantha</i> , Ag. . . . .	-	x	-	x	x	x
<i>Cyphosoma Koenigi</i> , Mant. . . . .	x	x	x	x	-	x
<i>C. corollare</i> , Ag. . . . .	-	x	x	x	x	x
<i>C. granulosum</i> , Goldf. . . . .	x	-	-	-	-	-
<i>C. magnificum</i> , Cott. . . . .	-	-	-	x	x	x
<i>C. elongatum</i> , Cott. . . . .	-	-	x	-	-	-
<i>C. radiatum</i> , Sorig . . . . .	x	x	x ?	-	-	-
<i>C. spatuliferum</i> , Forbes . . . . .	x	x	x	x	-	-

SPECIES.	Zone of <i>M. cortestudinarium</i> .	Zone of <i>M.</i> <i>coranguinum</i> .	Zone of <i>Marsupites</i> .	Zone of <i>O. ptila</i> and <i>A. granulatus</i> .	Zone of <i>A. quadratus</i> .	Zone of <i>B. mucronata</i> .
<i>Salenia granulosa</i> , Forbes . . . . .	x	x	x	x	x	x
<i>S. geometrica</i> , Ag. . . . .	-	-	x	x	x	x
<i>S. magnifica</i> , Wright . . . . .	-	-	-	-	x	x
<i>Zeuglopleurus Rowei</i> , Gregory . . . . .	-	-	x	-	-	-
<i>Helicodiadema fragile</i> , Wilt. . . . .	-	x	x	x	x	x
<i>Echinocorys scutatus</i> , Leske ( <i>ovata</i> ) . . . . .	-	x	x	x	x	x
<i>E. scutatus</i> , a gibbous form . . . . .	-	-	x	x	-	-
<i>E. scutatus</i> , var. <i>gibba</i> , Lam. . . . .	x	-	-	-	x	-
<i>E. scutatus</i> , var. <i>depressa</i> , Bryd. . . . .	-	x	x	x	-	-
<i>E. scutatus</i> , var. <i>pyramidata</i> , Bryd. . . . .	-	-	x	x	-	-
<i>E. scutatus</i> , var. <i>subconica</i> , Bryd. . . . .	-	-	-	-	-	x
<i>Galerites albogalerus</i> , Leske . . . . .	x	x	x	x	-	x
<i>G. albogalerus</i> , var. <i>globulus</i> , Desor . . . . .	-	x	x	-	-	-
<i>Cardiaster anachyitis</i> , Goldf. . . . .	-	x	x	x	-	x
<i>C. Cotteauanus</i> , Schlüter . . . . .	x	-	-	-	-	-
<i>Offaster pilula</i> , Lam. (type) . . . . .	-	-	x	x	x	x
<i>O. pilula</i> (dwarf var.) . . . . .	-	-	-	-	x	x
<i>Holaster planus</i> , Mant. . . . .	x	-	-	-	-	-
<i>H. placenta</i> , Ag. . . . .	x	x	x	x	-	-
<i>Micraster cortestudinarium</i> , Goldf. . . . .	x	-	-	-	-	-
<i>M. præcursor</i> , Rowe . . . . .	x	x	-	-	-	-
<i>M. coranguinum</i> , Leske . . . . .	-	x	x	x	x	-
<i>M. glyphus</i> , Cott. . . . .	-	-	-	-	x	x
<i>Epiaster gibbus</i> , Lam. . . . .	x	x	x	-	-	x
<i>Infulaster excentricus</i> , Bosc. . . . .	x	x	x	-	-	-
<i>I. rostratus</i> , Forbes . . . . .	-	x	x	x	x	-
<i>Hemiaster minimus</i> , Ag. . . . .	x	x	x	x	x	x
<i>Marsupites testudinarius</i> , Schloth. . . . .	-	-	x	-	-	-
<i>Uintacrinus westfalicus</i> , Schlüter . . . . .	-	-	x	-	-	-
<i>Pentacrinus Bronni</i> , Hagenow . . . . .	-	-	-	-	-	x
<i>P. Agassizi</i> , Hagenow . . . . .	x	-	-	-	-	-
<i>Isocrinus Kloedeni</i> , Hagenow . . . . .	-	x	x	x	-	-
<i>Bourgetocrinus ellipticus</i> , Müller . . . . .	x	x	x	x	x	x
<i>Ophiura serrata</i> , Römer . . . . .	-	x	x	x	-	-
<i>Roveacrinus communis</i> , Douglas . . . . .	x	x	x	x	-	x

Another group of fossils which furnishes useful evidence of the distinctness of the two faunas is the genus *Inoceramus*. This was studied by Schlüter in Germany in 1876,<sup>1</sup> and a tabular view of this zonal distribution in that country is given at the end of his monograph. Recently the genus has been more thoroughly investigated, so far as the British species are concerned, by Mr. H. Woods, whose excellent monograph will henceforward be the chief book of reference for the European species generally.

The species which occur in France, Germany, and other countries now require re-examination in the light of Mr. Woods' researches and studies of the various type-specimens, but by the aid of some notes on foreign forms in Mr. Woods' monograph, I have been able to compile a list of those which occur in the Paris Basin.

<sup>1</sup> *Palæontographica*, Bd. xxiv, 1876-7.

The following tables, showing the zonal distribution of the species of *Inocerami*, have thus been prepared from the sources above mentioned, that for North Germany being taken from Schlüter, with some corrections and modifications:—

TABLE VII.  
INOCERAMI IN THE UPPER CHALK OF ENGLAND.

SPECIES.	Zone of <i>M. cortestudinarium</i> .	Zone of <i>M.</i> <i>corangulum</i> .	Zone of <i>Marsupites</i> .	Zone of <i>O. pilula</i> .	Zone of <i>A. quadratus</i> .	Zone of <i>B. macronata</i> .
<i>Inoceramus Lamarcki</i> , Park. (type) (= <i>I. Brongniarti</i> , Mant.)	x	x	-	-	-	-
<i>I. Lamarcki</i> , var. <i>Cuvieri</i> , Sow. . .	x	x	-	-	-	-
<i>I. Lamarcki</i> , var. <i>Websteri</i> , Mant. . .	x	-	-	-	-	-
<i>I. Lamarcki</i> , var. <i>undulatus</i> , Mant. . .	x	-	-	-	-	-
<i>I. cordiformis</i> , Sow. . . . .	x	x	x	-	-	-
<i>I. involutus</i> , Sow. . . . .	x	x	-	-	-	-
<i>I. inconstans</i> , Woods . . . . .	x	x	x	x	x	x
<i>I. inconstans</i> , var. <i>striatus</i> , Mant. .	?	x	-	-	-	-
<i>I. inconstans</i> , var. <i>sarumensis</i> , Woods	-	-	-	x	-	-
<i>I. digitatus</i> , Sow. . . . .	-	x	-	-	-	-
<i>I. undulato-plicatus</i> , Römer . . . .	-	x	-	-	-	-
<i>I. undulato-plicatus</i> , var. <i>digitatus</i> , Sch.	-	x	-	x	-	-
<i>I. cardissoides</i> , Goldf. . . . .	-	-	?	x	-	-
<i>I. subcardissoides</i> , Schlüter . . . .	-	?	-	-	-	-
<i>I. pinniformis</i> , Will. . . . .	-	-	-	x	-	-
<i>I. balticus</i> , Bohm . . . . .	-	-	x	x	x	x
<i>I. lingua</i> , Goldf. . . . .	-	-	x	x	?	x
<i>I. lobatus</i> , Goldf. . . . .	-	-	x	x	-	-
<i>I. tuberculatus</i> , Woods . . . . .	-	-	-	x	-	-

TABLE VIII.  
INOCERAMI IN THE UPPER CHALK OF NORTH GERMANY.

SPECIES.	<i>Cuvieri</i> zone.	The <i>Emscher</i> .	Zone of <i>Marsupites</i> .	Zone of <i>S. binodosus</i> .	Zone of <i>A. quadratus</i> .	Zone of <i>B. macronata</i> .
<i>Inoceramus Lamarcki</i> , Park. (= <i>Brongniarti</i> , Schlüter, etc.)	x	-	-	-	-	-
<i>I. Lamarcki</i> , var. <i>Cuvieri</i> , Sow. . .	x	x	-	-	-	-
<i>I. involutus</i> , Sow. . . . .	-	x	-	-	-	-
<i>I. involutus</i> , var. <i>exogyroides</i> , Meek .	-	x	-	-	-	-
<i>I. involutus</i> , var. <i>umbonatus</i> , Meek .	-	x	-	-	-	-
<i>I. digitatus</i> , Sow. . . . .	-	x	-	-	-	-
<i>I. subcardissoides</i> , Schlüter . . . .	-	x	-	-	-	-
<i>I. unduloplicatus</i> , Schlüter . . . .	-	x	-	-	-	-
<i>I. radians</i> , Schlüter . . . . .	-	x	-	-	-	-
<i>I. subquadratus</i> , Schlüter . . . .	-	x	-	-	-	-
<i>I. gibbosus</i> , Schlüter . . . . .	-	x	-	-	-	-
<i>I. cardissoides</i> , Goldf. . . . .	-	?	x	-	-	-
<i>I. cancellatus</i> , Goldf. . . . .	-	-	x	x	-	-
<i>I. balticus</i> , Bohm (= <i>Crippsi</i> , auct.)	-	-	x	x	x	x
<i>I. lingua</i> , Goldf. . . . .	-	-	x	x	-	-
<i>I. lobatus</i> , Goldf. . . . .	-	-	x	x	-	-

TABLE IX.  
INOCERAMI IN THE UPPER CHALK OF THE PARIS BASIN.

SPECIES.	Zone of <i>M. decipiens</i> .	Zone of <i>M.</i> <i>coranginum</i> .	Zone of <i>Marsupites</i> .	Zone of <i>O. pilula</i> and <i>A. granulatus</i> .	Zone of <i>A. quadratus</i> .	Zone of <i>B. mucronata</i> .
<i>Inoceramus Lamarcki</i> , Park. (type) . . .	x	x	-	-	-	-
<i>I. Lamarcki</i> , var. <i>Cuvieri</i> , Sow. . . .	x	x	-	-	-	-
<i>I. Lamarcki</i> , var. <i>Mantelli</i> , de Mercey . .	x	x	-	-	-	-
<i>I. Lamarcki</i> , var. <i>undulatus</i> , Sow. . . .	x	-	-	-	-	-
<i>I. inconstans</i> , Woods (= <i>Brongniarti</i> ). .	x	-	-	-	-	-
<i>I. involutus</i> , Sow. . . . .	x	x	-	-	-	-
<i>I. digitatus</i> , Sow. . . . .	-	x	-	-	-	-
<i>I. lezennensis</i> , Decocq . . . . .	-	x	-	-	-	-
<i>I. inæquivalvis</i> , Schlüter . . . . .	x	-	-	-	-	-
<i>I. unduloplicatus</i> , Röm. . . . .	-	x	-	-	-	-
<i>I. subcardissoides</i> , Schlüter . . . . .	-	x	-	-	-	-
<i>I. balticus</i> (= <i>Crippsi</i> , auct.) . . . . .	-	-	-	-	x	x
<i>I. lingua</i> , Goldf. . . . .	-	-	?	-	-	-

From these lists it will be seen that the English list is the most complete, and that the evidence of the *Inocerami* accords entirely with that of the Cephalopoda. The zone of *Offaster pilula* in England has yielded nine species, of which five, and probably six, range downward, while only three of them range upward. In Germany the same zone has yielded four species, all of which range down into the *Marsupites* zone and only one (*balticus*) passes up into the higher zones.

#### INFERENCES.

Reviewing the results which have been obtained from the tabulated distribution of Cephalopoda, Echinoderms, and *Inocerami* in the Upper Chalk, we arrive at the following conclusions:—

1. That the Upper Chalk, with its equivalent in France and Germany, contains two distinct assemblages or faunas, and consequently that it comprises two stages as distinct from one another as are the Albian, Cenomanian, and Turonian.

2. That the evidence of the Cephalopoda fixes the line of division between the zones of *Offaster pilula* and *Actinocamax quadratus*.

3. That the distribution of *Inocerami* in all three countries leads to the same conclusion as that of the Cephalopoda.

4. That the evidence of the Echinoderms is less definite, because the assemblage found in the *O. pilula* zone is everywhere a passage fauna with many species that range both up and down.

The exact position of the boundary-plane between the two stages is of course a mere matter of detail. The important point, which is so obvious from an inspection of the preceding tables, is the recognition of the fact that our Upper Chalk is not a single stage comparable with the Middle Chalk or Turonian, but comprises two such stages for which names must be adopted.

With regard to the plane of division between them, the weight of evidence indicates that it should be drawn at the top of the zone of *Offaster pilula* and *Scaphites binodosus*. This line seems to be clear enough in Germany, but has not yet been accurately determined in England or France.

#### NOMENCLATURE.

Having demonstrated the existence of two different faunas, and consequently of two different stages, in what we have hitherto been accustomed to call the Upper Chalk, it becomes necessary to consider by what names they should be called. The old-fashioned names Lower Middle and Upper Chalk may still be used for divisions which can be shown on geological maps, because they have usually well-marked lithological boundaries, but we cannot continue to employ them as stage-names, since the Chalk is really divisible into four stages, not three as was formerly supposed.

There can be little doubt that we must adopt the French method of nomenclature, and it will also be convenient to employ the actual French names for these stages as far as possible, because these names are in general use on the Continent. Unfortunately, however, the French geologists are not yet agreed on the question of simplifying their nomenclature and making it accord with the stratigraphical value of their divisions.

The French terminology originated with d'Orbigny in 1843, and at first he only recognized two divisions or stages in the Chalk, giving these the names of *Turonien* and *Sénonien*. Subsequently he became aware that his *Turonien* included two distinct faunas and also that there was another fauna above his *Sénonien* in Denmark. Consequently in 1852 he established four stages under the names of *Cénomanien*, *Turonien*, *Sénonien*, and *Danien*. These names have been in use ever since that date, and the definitions of them given by d'Orbigny in his *Géologie Stratigraphique* of 1852 show that the first three correspond very closely with our Lower, Middle, and Upper Chalk.

As time went on, however, French geologists found that the Senonian was divisible into two or more parts, which they regarded as stages or sub-stages. Thus the Senonian of the Paris Basin was divided by Lambert in 1876 into Lower and Upper divisions, while that of Aquitaine was divided by Coquand into four parts, to which he gave the names of *Coniacien*, *Santonien*, *Campanien*, and *Dordonnien*.<sup>1</sup>

In 1879 de Mercey pointed out that there were really only two separate stages in the Senonian of d'Orbigny, but that these ought to be recognized and that one of them should receive a new name while Senonian was retained for the other; just as d'Orbigny himself had given a new name to part of his original Turonian, but retained that name for a restricted Turonian. De Mercey advocated the retention of the name Senonian for the upper part and the adoption of Coquand's name *Santonian* for the lower part.<sup>2</sup>

The correlation of the successive zones was not, however, fully established in 1879. Coquand's stages were really sub-stages, but they

<sup>1</sup> Coquand, Bull. Soc. géol. France, ser. II, t. xiv, p. 746, 1857.

<sup>2</sup> Bull. Soc. géol. France, ser. III, t. vii, p. 355, 1879.

were definite stratigraphical units, and de Mercey was wrong in supposing that the *Coniacien* had no separate existence. The *Santonien* was not therefore the equivalent of the whole "Sénonien Inférieur" as he supposed. Moreover, French geologists were so accustomed to the use of the name Senonian in its wider and more comprehensive application that the idea of its restriction to a portion of the original stage did not commend itself to them. Hence a complicated system of stages and sub-stages was adopted, which included an unnecessary number of names and could not possibly be used with advantage in any other country. The following table shows the divisions recognized by de Grossouvre in 1901 :—<sup>1</sup>

STAGES.	SUB-STAGES.	ASSISES.
DANIEU		
SÉNONIEN	{ Campanien	{ Supérieur.
	{ Corbiérien	{ Inférieur.
		{ Santonien.
		{ Coniacien.
TURONIEN	{ Angoumien	
	{ Saumurien	
CÉNOMANIAN . .	(not divided).	

It is obvious that this scheme is illogical; the Corbiérien and Campanien have the same palæontological and stratigraphical value as the Turonian, and consequently the retention of a comprehensive Senonian can only produce confusion and misapprehension. This seems to have been perceived by de Lapparent, for in the latest edition of his *Traité de Géologie* he remarks (p. 1883) that "The old Sénonien of d'Orbigny really includes two very distinct faunas of Cephalopoda, *Mortoniceras* and *Placenticeras* prevailing in the one which is the fauna of the Emscher marls of Westphalia. The other fauna, in which *Pachydiscus* and *Baculites* are conspicuous, is that of the Chalk of Haldem and Lemberg and of the beds near Tercis. The beds which contain it form the Aturien stage, from the Adour on the banks of which this division is well developed".

De Lapparent therefore divides his Upper Cretaceous Series into six stages, for which he adopts the names Cénomanién, Turonien, Emschérien, Aturien, Danien, and Montien, thus excluding the Albien and including the Montien, which others regard as the base of the Eocene Series. The stages with which we are concerned he subdivides in the following manner:—

STAGES.	SUB-STAGES.	ZONES.
ATURIEN	{ Maestrichtien	{ Calcaire à <i>Baculites</i> .
	{ Campanien	{ Craie de Meudon.
		{ Craie de Reims.
EMSCHÉRIEN	{ Santonien	{ Craie à <i>Marsupites</i> .
	{ Coniacien	{ Craie à <i>M. coranguinum</i> .
		Craie à <i>N. cortestudinarium</i> .

From this it is evident that de Lapparent wished to abandon the term Senonian altogether instead of adopting the view advocated by

<sup>1</sup> "Recherches sur la Craie Supérieure": Mém. Carte Dét. de la France, fasc. ii, table after p. 700.

de Mercey; further, that he proposed two new stage-names when he might have adopted those used by de Grossouvre. On the other hand, it seems to me that de Mercey was right in principle and that he was quite justified in saying—"L'équité scientifique exige que les dénominations des étages de d'Orbigny subsistent dans la nomenclature, quels que soient les changements apportés dans la délimitation des étages, ou bien les démembrements opérés à leur dépens."

I am therefore strongly of opinion that the name Senonian should be used for one of these stages, and the only question is to which of them should it be applied. The name is taken from the tribe of the Senones who inhabited the country round Sens, and so far as this typical area is concerned it might be used equally well for either division, since the beds of the Lower Senonian crop out to the south-east of Sens and those of the Upper Senonian to the north-west.

We need therefore only consider to which stage the name can be most usefully and conveniently applied. Now de Grossouvre has shown that the 'Maestrichtien' is not a sub-stage, but only a part of the zone of *Pachydiscus neubergicus*, which is elsewhere included in the Campanian; in the same way its equivalent in Aquitaine (the Dordonien) is shown to be merely part of the Campanian.<sup>1</sup> Consequently he adopts the name *Campanian* (derived from the 'champagne' of the Charentes) to denominate the stage for which de Lapparent introduces the new name of *Aturian*. Campanian has the priority, and is now generally recognized by French geologists as a good name for this division of the Upper Chalk. There is, therefore, no need for *Aturian*, which should be dropped as a synonym.

On the other hand, all the names proposed for the 'Sénonien Inferieur' are open to objection. The application of Santonian to the whole stage is untenable, because the real and original Santonian was only a part of it, and Coquand was right in so regarding it. The name *Corbiérien* has not found favour in France because it is taken from a locality, Corbières in the Pyrenees, where the beds differ from those of the Anglo-Parisian Basin, both in their fauna and their lithological characters. '*Emschérien*' is open to the same objection, the Emscher marls being a local facies and their fauna a poor one, especially in Echinoderms, so that they do not form a suitable exemplar or type for reference.

These considerations make it clear that if the name Senonian is to be used at all it should be applied to the lower part of d'Orbigny's division, that of Campanian being adopted for the higher one. Further, there is not the slightest occasion for the use of sub-stages; a primary division of the series into stages and a subdivision of these stages into zones is all that is necessary, any kind of intermediate term is both cumbersome and useless.

In its complete development the Chalk of Northern Europe appears to be divisible into five stages, though the Danian is of smaller

<sup>1</sup> In both districts, however, it forms the highest portion of his zone of *P. neubergicus*, and is characterized by the presence of *Sphenodiscus Ubaghi* and a special set of Echinoderms, so that it seems to be separable as a distinct zone.

thickness and altogether of smaller importance than the rest. The following table sets forth the names which I would adopt for these stages, and the zones which they comprise:—

STAGES.	ZONES.
DANIAN	<i>Nautilus danicus.</i>
CAMPANIAN	<i>Belemnitella mucronata.</i>
	<i>Actinocamax quadratus.</i>
SENONIAN	<i>Offaster pilula.</i>
	<i>Marsupites.</i>
	<i>Micraster coranguinum.</i>
	<i>M. decipiens.</i>
TURONIAN	<i>Holaster planus.</i>
	<i>Terebratulina lata.</i>
	<i>Rhynchonella Cuvieri.</i>
CENOMANIAN	<i>Holaster subglobosus.</i>
	<i>Schloenbachia varians.</i>

#### V.—NOTE ON THE CHALK ROCK IN NORTH KENT.

By G. E. DIBLEY, F.G.S.

IN the early spring of 1910, while collecting in the Chalk quarry at Borstal,<sup>1</sup> I found in a loose piece of chalk an impression of a small Gasteropod shell which probably belongs to the genus *Lampusia*. Shortly afterwards, while at the Borstal Manor Quarry, a workman brought me another small Gasteropod, which has since been identified as *Turbo geinitzi*, Woods. Both specimens were preserved as casts, showing part of the external ornament from near the apex to the basal whorl. Part of the zone of *Holaster planus* is exposed in the quarry, but the locality is not included in my previous list of exposures in the neighbourhood. The occurrence of these Gasteropods at such an horizon was almost conclusive evidence of the presence of the *Reussianum* fauna, so I again visited the quarry, in company with my wife, with a view to discovering the exact position at which these fossils occurred.

The lithological character of a certain bed of Chalk at Borstal is exactly the same as that on the other side of the Medway, being exposed in Messrs. Martin & Earl's quarry at Wickham (No. 2)<sup>2</sup> and at Messrs. Trechmann's quarry at Cuxton (No. 4). A small block from this bed, about the size of a cubic foot, would be found to contain irregular patches deeply iron-stained and of a nodular and fibrous character, the remainder being soft and gritty. I had for some time been familiar with its distinctive lithological features, but until that time had never succeeded in obtaining any fossils from it. A more detailed search at Wickham yielded a small indeterminable Gasteropod cast, and a specimen of *Dentalium turoniense*, Woods.

In the spring of this year we again visited the Borstal Quarry, which had been unworked since December, and during five hours' search came across the rich molluscan fauna that characterizes the 'Chalk Rock'. This was in the bed of Chalk, about 5 feet in

<sup>1</sup> Proc. Geol. Assoc., vol. xvi, p. 484, 1900.

<sup>2</sup> These numbers refer to the list of exposures in (1).