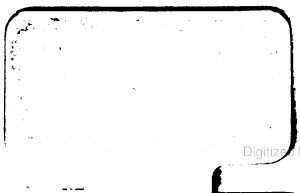

THE

COTTESWOLD HILLS.

HAND-BOOK

INTRODUCTORY TO THEIR GEOLOGY AND PALÆONTOLOGY:

BY

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INTRODUCTION.

THE physical features of the Cotteswold hills are distinctive in their character, strongly marked, and exhibit much picturesque beauty; their rock structure and fossil zoology are also replete with subjects of extensive and varied interest. The non-existence of any recent work illustrative of the Geology and organic remains of this region may be allowed to invite the present little treatise, in which it is endeavoured to render the language as free as possible from terms which are not in common use, and are therefore not intelligible to the general reader. The frequent appearance of elementary treatises on Geology by men whose names are guarantees for the value of their works afford a convincing proof that the number of their readers is considerable, and it may fairly be presumed that the public are now familiarized with the leading features of the science. Works of that description may therefore be considered to have prepared the way for Hand Books which have special reference to particular districts. The second edition of Sir R. Murchison's Geology of Cheltenham, edited by Messrs. Buckman and

Strickland, relates chiefly to the vicinity of that place, and has been published upwards of eleven years; its scope, therefore, is different from that of the present production. The time which has elapsed forms so considerable a period in the history of geological science, and the labours of local observers have been so unremitting during that period, that the combined effects of both causes have sufficed to impart almost a new aspect to the subject. In the proceedings of the Cotteswold Naturalists' Club are memoirs which bear upon portions of our subject; others will be found in the Journal of the Geological Society; and these, together with the Monograph on the Mollusca of the Great Oolite, published by the Palæontographical Society contain by far the greater portion of information to be found in English literature: other sources of information, both British and foreign, are duly considered and acknowledged. It is evident that elementary treatises on geology cannot satisfy the desire for information upon particular districts, and that the Monographs of the Palæontographical Society, however valuable they may be to the scientific naturalist, are not calculated to meet the wants of the general public whose reading will be directed rather to the hand-book, provided its contents are calculated to merit and repay the trouble of perusal. To meet these requirements, and at the same time to limit the size of the work by avoiding minuteness of details have been the chief aims of the author.

In the appendix will be found notes upon some subjects which are only briefly alluded to in the body of the work, and descriptions of such new species of testacea as are illustrated in the plates. The glossary of scientific terms contains concise descriptions of those fossil *genera* which

from their prominence or geological range characterize the region of the Cotteswolds. The reader is also referred to the list of authorities given at the end of the work, all of which have been consulted in the preparation of its materials. The small pretentions assumed in the present hand-book should not be regarded as a fair measure of the importance to which the subject may lay claim, but rather as a contribution which it is hoped may arrest the attention of the public, and possibly induce a portion of them to bestow increased notice upon the natural history features of the district in which they reside or to which they have access; to investigate with becoming diffidence and humility the works of the One Great Being whose thoughts we recognize in the varied operations of nature and in the records of the long past not less than in the present scheme of creation; evidenced in the application of means to ends through all the kingdoms of nature, in the minute Polype not less than in the collossal elephant; in a train of idea or pattern of design present continually throughout the great geological epochs and exhibited in the long chain of created beings forming the extinct races of our planet.

CHAPTER I.

THE OUTER CHAIN OF THE COTTESWOLD HILLS.

The region of the Cotteswolds may be described as an extensive and elevated tract, rising abruptly from the low plain through which the Severn takes its course. The traveller by railway from Bristol to Worcester passes in full view of and within an easy distance of the western face of the chain, a length of little less than fifty miles. Passing first through an undulating, thickly wooded, and rather elevated tract, the more southern portion of the range is intercepted from the view; the low plain bearing the names of the vales of Berkeley, Gloucester, and Evesham next succeed, affording some very striking and almost continuous views of the outer range, of its bold promontories and outlying masses, and of its deep, receding bay-like hills, until finally the mountainous chain of the Malverns upon the opposite boundary of the plain and the rounded quick succeeding eminences of the Worcestershire red ground announce that he has quitted the fine vale-like expanse which stretches along the front of the Cotteswolds their whole extent.

For richness, fertility, and varied scenery few portions of England of like extent can compare with this favoured

tract, little elevated above the sea, screened from easterly winds by the abrupt, elevated and continuous line of the Cotteswolds, open to the warm south and to the breezes of the Bristol Channel, with abundant foliage everywhere intercepting strong winds, the climate is remarkably mild without partaking of that superabundant moisture which characterises South Devon. Overlooking this low plain the Cotteswold Hills, commencing near Bath, form at first an inconsiderable though abrupt line of heights at some miles distance eastward from the railway, until they suddenly sweep round to the westward, increase in altitude and form a great bay-like expanse in which is situated the cloth manufacturing district of Wooton and Charfield. A little further the conspicuous headland of Stinchcomb Hill stretches far westward into the vale, its head bare, its flanks precipitous and wooded, around its base white villas and smaller houses peep out from the general foliage, and so free is this clothing district generally from dirt and blackness that it detracts nothing from the country-like freshness around, and produces a pleasing impression of population and comfort. To the north of Stinchcomb Hill is a deep bay-like recess, almost enclosed by high wooded hills, in which nestles the town of Dursley. Singular are the outlines of the several projecting promontories which next present themselves, one of these being the deeply scarped Roman Camp of Uley Bury. For the few miles next succeeding the heights are more wall-like, affording on their summits a pleasing variety of bare ground, of oolite quarries and of beech woods. Frocester Hill, Buckholt Wood, Long Wood and Selsley Hill are their names. We have now before us a great inlet which passes eastwards some miles into the mass of

the Cotteswolds, the approach to various tortuous gorge-like vallies in the bottoms of which, and fed by their streams, is the Stroud clothing district. The town of Stroud may be described as standing at the head of the great inlet or vale of Stonehouse at the point where the inlet branches into several narrow vallies. The town conveys but an inadequate idea of the extent and importance of the cloth manufacture or of the population which are concerned in it. To appreciate these the stranger should explore the numerous vallies where the white houses scattered upon the hill sides and the mills upon the streams make up an aggregate of houses which several times exceed those of the town. The wide and populous vale of Stonehouse, with its large clothing mills and villages, is the only great inlet which divides the western escarpement of the Cotteswold hills, their extension northwards from the inlet being about equal to that towards the south. The vale of Stonehouse, therefore, divides the northern from the southern Cotteswolds. The height of the range, although it presents an undulating outline, gradually increases in its course northwards. Whiteshill forms the northern boundary of the vale; Haresfield Beacon, the next height, is more precipitous, its head wooded and stretching to the northward far in advance of the general line; Robin's Wood Hill, a little northward from the latter eminence, is a complete outlier, and one of the most picturesque objects which adorn the vale of Gloucester. It is destitute of wood, its green but very irregular surface telling of ancient landslips. The chain then trends more to the north-east, greatly denuded, and depressed at the Horsepools Hill, it rises again to the old Roman Camp of Painswick Beacon; Cooper's Hill, Birdlip

Hill, Crickley Hill and Shurdington Hill are the next succeeding heights; all these have much general similarity in their aspects, for the most part barren and steep, their summits jagged and broken by oolite quarries, with their attendant mounds of debris. The escarpement as it approaches Leckhampton Hill becomes more precipitous and elevated, at a point called the Devil's Chimney it is suddenly deflected eastwards at right angles to its former course, forming another great bay-like expanse, and here, enclosed by a great semicircle of the most lofty hills of the range, is the beautiful town of Cheltenham. Cleeve Hill to the north-east of Cheltenham attains the greatest elevation of the whole range, terminating northwards in the headland of Notting Hill, near to which are the two picturesque outliers of Oxenton Hill and Stanley Hill; these, however, appear inconsiderable when placed in juxta-position with the much larger and more lofty Breedon Hill, a little beyond them, and which is the most northern and very much the larger of the Cotteswold outliers. The great outlying mass of Breedon Hill has its escarpment facing northwards, and may be considered to divide the vales of Gloucester and Evesham. From Notting Hill, passing eastwards across the vale of Winchcomb and following the main range northwards, it will be found to front the vale with a slope less steep but still lofty, Broadway Beacon being the next distinctive eminence; from thence northwards it declines in height somewhat, terminating in the bold promontory of Ebrington Hill.

Upon the whole the Northern Cotteswolds have a much greater elevation than the Southern, but their slopes towards the western vales are more gentle, the difference of outline being chiefly due to the greater elevation

which the soft beds of the Lias attain in the Northern Cotteswolds and the greater amount of denudation to which that formation has there been subjected; so that the Inferior oolite which everywhere crowns the summit of the escarpment constitutes a much smaller proportion of the mass in the Northern than in the Southern Cotteswolds. The general aspect of the hills, therefore, throughout the entire course of the escarpment is rocky and steep towards the crest, and sloping gently in the middle and lower portion, melting insensibly into the plain. There are no natural sections, every exposure of rock having been produced either by quarrying for stone, or by road and railway cuttings; the stone quarries more especially are scattered so generally over the hill region that no considerable area of rock structure is altogether hidden from view. Upon the outer escarpment indeed the quarries are so numerous and conspicuous that a stranger would in many places readily mistake them for natural cliffs.

CHAPTER II.

PHYSICAL FEATURES.

The Physical conformation of the Cotteswolds is upon the whole very simple, and has much general uniformity. Over the southern and middle region the surface dips gently, and almost insensibly, at the small angle of three or four degrees to the south-east, until it blends with the plain of Wiltshire. This general uniformity is disturbed only by small lines of faults, and by undulations which form anticlinal and synclinal axes, usually perceptible only within a short distance of the western escarpment. It seems, indeed, most probable that all the transverse vallies have had their origin in small anticlinal axes which have produced lines of weakness, and thus yielded to the denuding forces; the numerous small vallies of the Stroud district exhibit many indications of such an arrangement. In like manner the projecting headlands are probably due to a synclinal arrangement of their beds which have in consequence been enabled to resist the beating of the waves upon the outer cliffs. Mr. Hull, of the Geological Ordnance Survey has in an able memoir on the Physical Geography and Pleistocene phenomena of the Cotteswold Hills demonstrated the existence of several

gentle domes of elevation or places in which the beds dip in every direction from the centre; the valley of Painswick affords the most striking example of this kind; the road from Stroud to Painswick in the course of four miles rises not less than 300 feet, but as this ascent proceeds at a smaller angle than the rise of the beds of Lias, it will be found that the foot of the last ascent near Painswick is at an inferior geological position than the lower level at Stroud. The surface of the northern portion of the Cotteswolds is much less uniform in its character, it is traversed by the longitudinal vallies of Moreton, of the Windrush, and the Evenlode, in all of which a considerable portion of the upper rock masses of the district have been removed by denudation; in these instances there would appear to have existed several great anticlinal and synclinal lines, and that the elevatory forces which in the Southern Cotteswolds only acted towards the outer escarpment, in the northern affected the whole area of the region, producing great and gentle rolling undulations in a direction for the most part parallel to the outer escarpment or at right angles to the dip. The outer escarpment for its whole extent consists of only two geological formations, the Lias, which everywhere forms the western vale region and also the more considerable portion of the mass of the hills, and the Inferior oolite which as constantly forms the higher portion of the chain, and from its superior hardness has resisted the denuding forces. The Great oolite and its subordinate stages occupies a higher position in the geological scale; it does not extend to the outward escarpment but throughout the southern Cotteswolds it forms in the rear of the escarpment at some little distance, another step-like elevation which is quite removed from view in

the western vales. It is only by following the course of the transverse vallies into the mass of the hills, as by the great Stonehouse inlet and its deep gorge-like branches, that steep slopes are found crowned by the Great oolite; and the relative mass of that formation and of the Inferior oolite may then be compared. The junction line of the Lias and Inferior oolite upon the outer face of the range by no means forms a regular and unbroken line, or occupies a particular position which may be determined with accuracy upon theoretical grounds alone, on the contrary it is frequently disturbed by faults or displacements, or there may be a series of undulations, or the junction may be masked by another and very frequent occurrence in which a large portion of the Inferior oolite has slided forwards over the yielding clay beds of the Lias, and presents itself at some exposed section at a level which had previously been occupied by the Lias. The position, therefore at which the junction of the two formations may be looked for upon the hill slope will depend chiefly upon the relative position of the masses at contiguous situations; when no rock sections are visible the junction can usually be determined by the outburst of springs which are unable to penetrate the clays of the Lias. The vale region at the foot of the Cotteswolds does not differ very considerably in its elevation above the sea, the vales of Berkeley, Gloucester, and Evesham being traversed by the Severn and Avon whose gentle currents indicate the small rise of the land towards the interior; but as the Lias of the northern Cotteswolds rises upwards of 900 feet above the sea as at Breedon Hill and Cleeve Hill the denudation of the Lias has been much greater over the northern than the southern region, in which it very rarely attains an elevation of 500

feet. The denudation of the Lias, therefore, sufficed to bring the sea bottom of the vale region nearly to the same general level, and the observations of Sir R. Murchison have shown the high probability that at one and not a remote geological period it formed a gulf of the sea separating England from Wales. It needs only a superficial acquaintance with the general features of the district or to view the low region from any part of the outward line of the Cotteswold range to see the high probability of the fact; the observer then standing upon a lofty cliff of an extended coast line, traces the ancient boundaries of the gulf, and at once realizes in idea how large a portion of the vale would be again submerged were a subsidence of the whole to take place to the amount of only 100 feet; in such a case the lateral vale of Stonehouse would again form an inlet of the sea and the sites of the towns of Gloucester and Tewkesbury would again become beneath the level of the gulf. The vale itself, rich, wide spread, and thickly wooded, is but little laid open except by railway cuttings and these display superficial deposits of sand, oolitic gravel, and marl covering the greater portion of the surface; it is to these superficial diluvial drift beds that the vale owes its fertility, a subsoil composed of the clays and shales of the Lias is by no means favourable to vegetation, and is difficult to drain; the marine currents, therefore which traversed and modified the bed of the ancient strait left behind them a salutary and fertilizing deposit eminently fitted to support that rich pasturage for which this tract is celebrated.

The following table, which gives the altitudes of some of the more remarkable of the Cotteswold Hills, is taken from a communication by W. H. Hyett, Esq., to the

Cotteswold Naturalists' Club, and will be found in the first volume of its proceedings.

	By Ordnance Survey.
Robins Wood Hill	652 feet
Standish Hill	715 „
Stinchcomb Hill	725 „
Oxenton Hill	733 „
Uley Hill	823 „
Painswick Hill	929 „
Birdlip Hill	969 „
Leckhampton Hill	978 „
Base of Breedon Hill Tower	979 „
Cleeve Hill or Cleeve Cloud	1081 „
To these may be added,	
Broadway Beacon	1000 „
Symonds Hall Down	802 „
Finger Post on Top of Frocester Hill	780 „

The last measurement having been made by Mr. Hyett with the aid of the Aneroid Barometer.

CHAPTER III.

THE ROCK MASSES OF THE COTTESWOLDS.

The three formations already indicated, viz., Lias, Inferior oolite, and Great oolite, constitute the *Lower Jurassic Rocks;* the term Jurassic is now universally employed by continental geologists, and is preferable to *oolite* from the more comprehensive signification of the former term, and more especially so when applied to the Cotteswold Hills, for these are in effect the English representatives of the lower subdivision of the Swiss Jura system, and present the nearest approach which Britain affords to a typical or full exemplification of those rocks. In no other part of our island are the Inferior and Great oolites developed to so great a thickness, and so complete in all their stages; in every other direction one or other of these formations will be found to lose a portion of those deposits which characterize them in their integrity. The Lias, both in its southern and northern extension, has from the very infancy of geology presented a most rich and varied field for the Palæontologist, and has accordingly found illustrators in men whose names are linked with the history of the science, and whose labours are known and appreciated over the civilized world, and as the

Gloucestershire Lias has not recently yielded any features of novelty, either in its rock structure or in its organic remains, it is purposed to limit this treatise to illustrate the two formations which occur next above it in order of superposition; an arrangement which will appear the more legitimate, when it is explained that the several quarries and sections which illustrate the Lias are not strictly within the limits of the Cotteswolds; the only expositions of that formation within the region being extremely partial in their nature, and limited to foundations for buildings, drain cuttings, well sinking, brick yards, &c.

THE CYNOCEPHALA STAGE.

Our examinations may fitly commence with a group of beds forming a very remarkable zoological stage, and possessing some features both petrographic and zoological, which seem to claim for it a position intermediate and connecting the Lias with the Inferior oolite. Our name for this stage has been chosen from the *Rhynchonella cynocephala*, a remarkable shell, whose geological range is limited to this stage; as the full significance of this group of beds is not yet generally appreciated, it is proposed to give a full and careful description of its features, and to note any variability in its conditions which may be induced by difference of locality. Wotton-under-Edge affords the most southern section of this group which we propose to examine; the road to London from the town first passes over the Lias and soon begins to ascend Wotton Hill, which it continues to do until it has attained the lofty platform of Symonds Hall Down. Leaving the road as it ascends the hill, we follow a lane

to the left, which was the ancient post road, and which ascends the hill by a deep cutting; some small exposures of blue Lias clay are first seen, and soon after we reach a section upon our left hand; the lower portion consists of compact laminated brown marly rock, with blueish patches, passing upwards insensibly into loose micacious yellowish brown sand, the summit of the section having some thin beds of brownish slightly compacted argillaceous rock.

The full thickness of sands exposed is nearly 40 feet, but probably 15 or 20 feet would require to be added to the lower portion ere we could affirm that we are looking upon the Lias. Owing to the compact structure of the lower portion of these laminated marly sands, they become in some localities retentive of water, and well sinkings in such instances are not continued downwards to the clay of the Lias. These sands contain much silica, are used for polishing, and sold by Gypsies and others. The sand is everywhere altogether destitute of organic remains, it constitutes a subsoil well suited for pasturage, and even orchards thrive moderately well upon it, the soil covering it is therefore of more than an average value when compared with other Jurassic soils, aud when unmixed with superficial drift. The brown rubbly rock immediately above the sands is only imperfectly exposed in this section, and from its position is difficult to examine, but it is charged full of fossils, chiefly Ammonites and Belemnites, so that scarcely a portion the size of a hand can be examined without finding fragments of these shells; there are also some few univalve and bivalve testacea. Passing northwards round the flanks of Stinchcombe Hill the same beds are exposed, but imperfectly,

and the whole slope of the hill is so much covered up with fragments detached from higher beds, that we prefer to return and visit a much better section situated at a greater elevation. On quitting the Frocester Station of the Gloucester and Bristol Railway, and taking the road to Nymphsfield, the quarried brow of Frocester Hill, and of the neighbouring Buckholt Wood, are conspicuous; a long ascent over the slope of the Lias leads to an exposure of the same marly sand bed as at Wotton, surmounted by thick and well marked beds of stone; fragments of Ammonites scattered upon the slope indicate the bed to be examined, and as the Ammonite bed has been partially excavated in the search for fossils, the hard sandstone above it stands out in relief upon the face of the cliff. The section afforded by this spot is as follows in descending order:—

Inferior oolite.

1 Freestone quarry worked for building stones; thick bedded oolitic limestone with occasional layers of fine shelly detritus but no shells entire.

2 Band of brownish sandy, concretionary marl, with badly preserved casts of pholadomya. 4 inches.

3 Hard brown sandstone in three divisions, with concretionary nodules at the lines of partition; few fossils; the lower portion has some belemnites and a few specimens of rhynchonella cynocephala. 4 feet.

Cynocephala Stage.

4 Ammonite bed consisting of many irregular layers of brownish or ochery and sometimes dark grey slightly compacted marly sandstone, variable in its hardness and colour; charged with ammonites and belemnites, more sparingly with conchifera, and rarely with gasteropoda; the only brachiopoda are rhynchonella cynocephala and terebratula punctata. Near the base is a yellow marl seam three inches thick, full of belemnites, beneath which is a hard band of concretionary rock without fossils; in all about 4 feet 6 inches.

5 Marly sands, yellow in the upper part, more brown in their lower, with occasional concretionary nodules. The greater portion of this bed is covered by a steep grassy bank, but the lower portion is partially exposed in a deep lane beneath the turnpike road. The entire thickness may be estimated at about 60 feet.

6 Grey Liassic marls with a thin layer of white concretionary Lias.*

The mineral character of the ammonite bed is very inconstant both in its extension and in its layers, occasional argillacious dark grey or black patches remind us of the Lias, but the more frequent condition consists of small oval dark brown grains in a paler coloured cement. The passage both in mineral character and in fossil contents from the ammonite bed to the hard brown sandstone bed above is by no means uniformly abrupt, and in some places the divisional line which separates them is very indistinct. The upper two or three feet of the hard ferruginous bed is nearly destitute of fossils, but the mineral character is persistent, and the change to the white freestone above with its oblique lamination is very strongly defined. This hard ferruginous bed will subsequently be shown to be the reduced representative of the brownish yellow ferruginous oolite which acquires so great a development near Cheltenham.

The magnificent picture of vale scenery together with the broad tidal expanse of the Severn and the foreground of bold Cotteswold capes and headlands to the right and left will not be lost upon the stranger, rarely can there be found such a combination of the best features of English landscape. The adjoining wood of Buckholt and the continuation of it called Long Wood contain in their slopes and deep lane cuttings several small exposures of the ammonite bed and the marly sands; the collector of fossils should explore these, and will probably find himself rewarded by the acquisition of specimens which cannot

* In this band of white lias my friend Dr. Wright discovered specimens of ammonites bifrons, a shell which is recorded both in the marlstone and upper lias; as the marls both above and beneath this bed are decidedly liassic they cannot be considered as forming any part of the cynocephala stage.

now be obtained at Frocester Hill without the laborious operation of the pick axe. Three other localities only a few miles distant afford good sections of the cynocephala stage. At Haresfield Beacon, a mile and a half from the Haresfield railway station, and elevated nearly 700 feet above the sea, a deep wall-like section on either side of the road affords a very perfect and interesting exposure of the same beds; as the road rises in a south-easterly direction which nearly accords in direction with the dip of the beds, they are passed over successively in ascending order. The junction of the sands with the Lias is concealed by some Inferior oolite freestone beds which have been displaced and fallen forwards, but the junction of the sands with the ammonite bed above and the succession of beds upwards from that horizon are finely developed. The upper boundary of the sands becomes compact and concretionary for half-a-yard in thickness. The ammonite bed above is very slightly compacted, so that the passage from the one to the other is somewhat gradual, and the belemnites which everywhere crowd the ammonite bed are also found in the concretionary layer of the sand bed. A comparison of the ammonite bed with the Frocester Hill section exhbits a considerable diminution in the thickness of that remarkable deposit, its thickness at Haresfield Hill is not more than two feet, its colour is dark or chocolate like and it is so little compacted that it may be broken up by the hands alone. Belemnites are peculiarly abundant, Ammonites only moderately numerous, of small size and indifferently preserved, there are also numerous casts of small Myacites, of *Gresslya, Area, Trigonia striata, Pholadomya fidicula* and of *Modiola Sowerbii.* The *Brachiopoda* are represented by *Terebratula punctata,* which is com-

mon, and by *Rhynchonella cynocephala*, which is rare, excepting in one thin layer. This small list contains nearly the whole of the testacea, and here as at Frocester Hill some few Belemnites and Terebratulæ pass upwards into the hard and comparatively unfossiliferous bed above. At Frocester Hill the hard ferruginous sandstone which immediately overlies the ammonite bed consists of a single bed four feet in thickness; here the thickness is not less than ten feet divided into several beds.

SECTION AT HARESFIELD HILL.

	ft.	in.
Freestone forming the summit of the cutting.....		
Ferruginous concretionary marl.....	1	6
Ferruginous brown hard sandstone	8	0
Oolitic ferruginous bed	2	6
Brown ferruginous bed, with a few Belemnites and Terebratulæ	1	0
Cynocephala layer of red marl.....	0	2
Ammonite bed	1	2
Sands, concretionary at the top.....		

From this spot an old woodland lane leads to another and similar quarry less than a mile distant situated upon the opposite or north-eastern slope of the hill; where the cepholopoda bed and sands are exposed upon a steep bank, the beds of ferruginous oolite having been removed in quarrying; the more exposed position, together with atmospheric action has rendered the bed extremely friable; In its organic remains, thickness, and general features it exactly resembles the former section and exhibits the same thin bed of soft red marl with *Rhynchonella cynocephala* dividing the bed into two equal portions. Upon the lane side is a large gravel pit, a stratified deposit of angular gravel and sand situated at about 600 feet above the sea and indicating a former sea beach at that elevation. Following a great bay-like curvature upon the crest of the ridge to the Horsepools Hill, three miles to the north-east

is another exposure of the ammonite bed overlying the yellow sands and having the same soft fragmentary character and general dark colour as at Haresfield Hill; the Ammonites are small, but *Rhynchonella cynocephala* here reappears in considerable numbers. The ferruginous beds above are largely quarried and agree with the Haresfield section; the denudation of the crest of the hill has been so considerable that no portion of the Inferior oolite higher than the ferruginous beds remains. At Painswick Hill the denudation has been much less, and the old Roman camp at the Beacon is capped by the upper stage of the formation; the sands are here also exposed beneath the ferruginous beds. This appears to be the most northern point at which the Cynocephala stage has been observed, a fact which will appear the more worthy to be recorded when it is stated that the stage extends southwards through the counties of Somerset and Dorset, that it reappears in France, occupying the same position at the base of the Inferior oolite and that under the names of *Gres supra Liassique*, or marly sandstone, it has been traced by French geologists through the Departments of the Sarthe, of the Mozelle and the adjoining province of the Luxembourg, and has been referred by them to the upper Lias. M. Terquem in his memoir on the Palæontology of the Department of the Mozelle has given ample lists of the fossils of the several beds and in those of the *Gres supra Liassique* there will be perceived a similar *facies*, a great resemblance and even identity in some instances with the testacea of our Cynocephala stage. In the dawn of modern geological science, and long ere the study of Palæontology had acquired any claim to the position which it now holds as the only solid foundation upon all geolo-

gical generalizations are based, William Smith, upon considerations of mineral character only, placed this stage with the Inferior oolite; it therefore becomes a point of much interest to attempt by a careful examination of its organic remains to determine the particular zoological assemblage to which it should be referred and the true relation which it bears to each of the fauna bordering upon it. Previously, however to entering upon this investigation it will be necessary to examine another horizon of the same stage which is not without its peculiar share of interest.

A deep lane cutting adjoining Nailsworth, on the way to the hamlet of Shortwood, discloses about 25 feet of the yellow sands, but the section does not extend upwards to their junction with the ammonite bed; immediately at the base of the sands is a bed of brown or chocolate coloured argillaceous sandstone, somewhat rubbly in its structure, and from 14 to 16 inches in thickness. One stratum of this bed, 4 or 5 inches in thickness, is full of fossils which, from the general softness of the rock, are easily separated. Ammonites occur only sparingly, *Conchifera* and *Gasteropoda* are abundant, these latter it will be found are decidedly oolitic in their character, and agree for the most part with those of the ammonite bed. Beneath the Nailsworth bed are a few feet of the brownish partially compacted laminated marls, agreeing with that at other sections, and these are seen to overlie the blue unctuous marls of the upper Lias. A landslip on the eastern side of the Woodchester valley, one mile from Nailsworth, exposed the chocolate coloured sandstone charged with *Lima Electra*, *Gervillia fornicata*, *Trigonia Ramseyii*, *Perna rugosa*, and *Turbo capitaneus*. Some shaly bands of the blue Lias marl beneath contained many

specimens of *Posidonia Bronnii*, a shell which is invariably found in the same position in France and Germany. The general absence of quarries, which expose the junction of the sands with the upper Lias, prevents our affirming with any certainty either the local or general character of this fossiliferous basement stratum of the Cynocephala stage. One other example of the stratum in question has been observed in the vale of Chalford, near to the Brimscomb railway station, and on the southern side of the valley. Some drain cuttings exposed the upper boundary of the Lias, upon which was the usual bed of brown compact marl, about 4 feet in thickness, upon this reposed a thin stratum of brownish ochery concretionary rock, slightly compacted and a few inches in thickness. *Rhynchonella cynocephala* occurred clustered in great numbers, and a dwarfed variety of *R. plicatella* very sparingly, there were also some specimens of small *Myacites*, (species undetermined.) There were neither Ammonites nor Belemnites.

Here then is a fossiliferous stratum upon the horizon of the Nailsworth bed, but containing the *Rhynchonella* which occurs so abundantly in the upper part of the stage. The amount of information upon this basement stratum is therefore much more scanty than could be desired, but as the Nailsworth locality is very fossiliferous, our list of testacea from the basement bed is considerable, and has been kept separate from those of the ammonite bed, in order that the true character and connexion of each assemblage may be properly appreciated.

TESTACEA OF THE BASEMENT BED OF THE CYNOCEPHALA STAGE, AT NAILSWORTH.

* *Ammonites Jurensis*, D'Orb.
L ——— *Raquenianus*, D'Orb.
——— *variabilis*, D'Orb.

L *Belemnites compressus (young)*, Voltz.
——— *tripartitus*, Schlot.
* *Turbo capitaneus*, Munst.
Pleurotomaria
Trochus duplicatus, Sow.
* *Chemnitzia lineata*, Sow. sp.
——— *species undetermined.*
L & * *Pecten textorius*, Schlot.
* ——— *svbcomatus*, Muntz.
* *Lima Electra*, D'Orb.
* ——— *bellula*, Mor. & Lyc.
——— *ornata*, n. sp.
* *Perna rugosa*, Munst.
* *Trigonia striata*, Sow.
* *Gervillia Hartmani*, Goldf.
——— *fornicata*, n. sp.
* *Modiola Sowerbii*, Sow. sp.
Unicardium, sp.
* *Cardium Buckmani*, Mor. & Lyc. (var.)
* *Myoconcha crassa*, Sow.
Arca (cucullœa) ferruginea, n. sp.
—— *olivœformis*, n. sp.
Nucula ovalis, Goldf.
L *Astarte complanata*, Roem.
——— *rugulosa*, n. sp.
lurida, Sow. ?
Pholadomya, n. sp.
* *Pholadomya ovulum*, Ag.
* ——— *fidicula*, Sow.
* *Myacites tenuistria*, Ag, sp.
Cypricardia brevis, Wright
* ——— *cordiformis*, Desh.
L *Terebratula punctata*, (var.) Dav.
Rhynchonella cynocephala, Rich.
* ——— *plicatella.*

The star placed opposite a species indicates that it is known to pass upwards into the Inferior oolite of the Cotteswolds.
The letter L denotes that the species is found in the Lias.

The ammonite bed at Frocester Hill has produced the following testacea:—

L *Ammonites variabilis*, D'Orb.
L ——— *radians*, Schlot. *Striatulus*, Sow.
——— *radians*, Orbigny.
L ——— *radians*, Dewalque.
——— *Thouarsensis*, D'Orb.
L ——— *insignis*, Schubler.
——— *jurensis*, Zeit.
——— *discoides*, Zeit.
L ——— *concavus*, Sow.

Ammonites Mooreü, n. sp. Lyc.
——— *torulosus*, Schub.
——— *Leckenbyü*, Lyc. n. sp.
——— *Levesqaei*, D'Orb.
——— *opalinus*. Haresfield Hlll.
L *Belemnites iripartitus*, Schlot.
L ——— *irregularis*, Schlot.
L ——— *compressus*, Voltz.
Gryphæa plicata, Lyc. n. sp.
* *Hinnites abjectus*, Phil. sp.
Lima Electra, D'Orb.
* ——— *bellula*, Mor. & Lyc.
* *Modiola Sowerbü*, Sow. sp.
* *Gervillia Hartmani*, Goldf.
* *Cypricardia cordiformis*, Desh.
——— *brevis*, Wright.
Arca (cucullæa) ferruginea.
* *Cardium Buckmani*, Mor. & Lyc. (var.)
* *Opis lunulatus*, Sow. sp. (var.)
——— *carinatus*, Wright.
Trigonia Ramseyii, Wright, n. sp.
* ——— *striata*, Sow.
*? ——— *costata ?*
* *Aslarte excavata*, Sow.
* ——— *modiolaris*, Desh.
* ——— *lurida*, Sow.
* *Macrodon Hirsonensis.* d'Arch. sp. Haresfield.
* *Goniomya angulifera*, Sow. sp.
* *Pholadomya fidicula*, Sow.
——— sp. undetermined.
* *Gresslya abducta*, Phil. sp.
* ——— *conformis*, Ag.
* *Myacites tenuistriatus*, Ag. sp.
* *Pinna fissa*, Goldf.

L *Terebratula punctata*, Dav. (var).
Rhynchonella cynocephala, Rich.
L ——— *furcillata*, Theod. Haresfield Hill

A comparison of the foregoing lists of testacea will be sufficient to establish between them a general zoological identity of character, the paucity of ammonites in the bed at Nailsworth being probably only a local peculiarity.

The ammonites which predominate to so great an extent in the upper portion of the stage belong to the group of the *Falciferi;* ammonites with compressed forms, sharp edged backs, and flexuose ribs, a group which like-

wise occurs both in the upper Lias and Inferior oolite, but is more especially prominent in the stage in question. The most abundant ammonite is *A variabilis*, which displays fully as much variability in its ornamentation as its name implies; *A. radians striatulus*, and *A. radians-orbignianus*, are likewise abundant, the second name being appended to these species owing to an unfortunate confusion into which Palæontologists have fallen in giving the name *radians* to no less than three different shells, all of which are associated at Frocester Hill, in the same bed. Next in point of numbers is *A. Jurensis*, the more rare of the series being *A. Leckenbyi*, *A. torulosus*, *A. Levesquei*, and *A. Thouarsensis*. The belemnites are liable to be mistaken for other forms excepting *B. irregularis*, of which its synonym and more appropriate name "*digitalis*" has a very remarkable finger-like figure, it appears to be proper to this stage. (Pl. 1, fig. 1.)

The evidence of geological position afforded by the ammonites of this stage will be found to be somewhat transitive in its character.

The greater number of them appear to be proper to this stage, for although two species have actually been found in a higher stage of the Inferior oolite, it is possible that in such rare instances the shells may really have been transported from the older stage. It is certain that *A. Jurensis*, *A. variabilis*, *A. radians-striatulus* and *A. insignis* occur in the upper portion of the upper Lias both of England and France, and of the other species there is now sufficient evidence to be found in the memoirs of M. Sœman, O. Fraas, M. Terquem, and Messrs. Chapuis, and Dewalque to prove that these (so called) highest Liassic beds in France are upon the same horizon as our

Cynocephala beds. In the counties of Somerset and Dorset the altered marine conditions have induced considerable difference in the beds of this stage, and as sufficient care has not hitherto been taken to keep their testacea distinct from those of other neighbouring deposits no useful comparison can at present be made between them and those of the Cotteswolds. On the coast of Yorkshire the lower portion of the Inferior oolite appears to constitute a continuation of the same stage under somewhat altered conditions; in ascending order occur beds of dark grey sandstone, of yellow sandstone, and of iron-shot sandstone, altogether 70 feet thick, containing several fossiliferous bands with *Belemnites compressus*, *Ammonites radians-striatulus* and *A. concavus*. The upper portion, or Dogger, likewise presents a resemblance to the Cotteswold Inferior oolite in its abundance of *conchifera* and *gasteropoda* and absence of *cephalopoda*.

The upper Lias of England in its ammonites contains upon the whole a very different association of species. The Yorkshire exposition of the upper Lias surpasses in extent and development that of any other portion of England, and in the very careful memoir of M. Louis Hunton, on the cephalopoda of that stage, Geol. Trans. 2d Series, vol. 5, p. 215, we find them to consist of the following testacea:—

Ammonites annulatus, Sow.
——— *Boulbiensis*, Y. and B.
——— *angulatus*, Sow.
——— *communis*, Sow.
——— *concavus*.
——— *crassus*.
——— *elegantulus*.
——— *exaratus*.
——— *fibulatus*.
——— *fimbriatus*.
——— *Heterophyllus*.

Ammonites Lythensis.
——— *Mulgravius.*
——— *ovatus.*
——— *sigmifer* (*elegantulus*).
——— *subarmatus.*
——— *subcarinatus.*
——— *Walcotii* (*Bifrous*).
——— *Clevelandicus* (*Margaritatus*).
——— *Belemnites compressus.*
——— *elongatus.*
——— *trifidus.*

To these may be added in Gloucestershire *A. serpentinus*, *A. variabilis* and *A. radians Dewalqueanns*. *A. insignis*, and *A. variabilis*, occur in the upper Lias of Somerset, together with a considerable number of those enumerated in the Yorkshire Lias. It is evident that although a portion of the Frocester Hill ammonites occur in the upper Lias of England, a very much larger number of upper Lias species including the more abundant forms of that genus, are not known in the Cynocephala stage, and that, taken as a whole, the latter contains a group of species which differ very materially from the Upper Liassic fauna. There is a total absence of the more common Liassic forms as—*A. annulatus*, *serpentinus*, *communis*, and *bifrous*. On the other hand the three belemnites are all found in the English Lias. The few *Gasteropoda* are oolitic, the specimens of *Turbo capitaneus* from the Nailsworth bed being more distinct in their ornamentation than others from newer deposits. The *Conchifera* are also very decidedly oolitic, so that of 40 species obtained from this stage in the Cotteswolds, one only *(Astarte complanata)* can be referred to the Lias, and this occurs only at the base of the stage; of the remainder, 17 have not been observed in any other position, and the following have so considerable a range in the oolites, both stratigraphical and horizontal, that their extension downwards to the base of the Cynocephala

stage adds little to the extent of their previously ascertained limits; such are *L. bellula*, *Perna rugosa*, *Astarte excavata*, and *Modiola Sowerbii;* the occurrence also of *Pholodomya fidicula*, *Gervillia Hartmani*, and *Trigonia striata*, leave no doubt that the Inferior oolite is the formation to which they must be referred. The *Brachiopoda* furnish evidence of a much less decisive character, *Rhynchonella plicatella* is an Inferior oolite, and *R. furcillata* a Lias species; both are equally rare in this stage, and the other two more abundant species of *Brachiopoda* are perhaps only derivatives or varieties of middle and upper Lias forms, a note illustrating this point, and relating to *Rhynchonella cynocephala*, will be found in the appendix, and with respect to the *Terebratulæ*, if we examine a large number of specimens, it will be difficult to regard them otherwise than as constituting a dwarfed variety of *T. punctata*, Dav., and *T. subovoides Oppel*, which perhaps are not distinct species; there is much variability in the convexity of the perforate valve, and occasionally the anterior border is somewhat flexuose or raised like to *T. Buckmanni*, and when this feature coincides with one of the more depressed forms, it is difficult to distinguish it from the latter shell. In the Conchifera, the first appearance of a considerable number of Inferior oolite forms is accompanied by a simultaneous disappearance of the usual Liassic genera, of these, *Cardinia* and *Hippopodium*, which hold the most prominent position in the Liassic Conchifera, have altogether disappeared, to be replaced by *Opis*, *Cypricardia* and *Myoconcha*, genera which now first appear together with a varied development of form in the genus *Astarte*. Upon a view of the general *facies* of this assemblage, we observe that the Liassic Molluscous tribes,

which possessed the smaller power of locomotion, and were unable to withstand sudden changes of marine conditions, perished; but that certain of the Cephalopoda which, as swimming mollusks, were possessed with the utmost freedom of movement, were probably enabled to migrate to a sea already tenanted with an assemblage of the Inferior oolite, Gasteropoda and Conchifera. The migratory species, notwithstanding their numbers, were not, however, able to survive for any lengthened period the new influences to which they were subjected, for no sooner had the deposition of the ferruginous oolite commenced, than they suddenly disappeared. It is this curious character of the assemblage, half Liassic, half Oolitic, which constitutes its transitive character, viewed as a zoological assemblage, for in general mineral character the stage very much resembles the Marlstone; the brown ferruginous grains, which impart a distinctive character to the ammonite bed, and which might be supposed to identify it with that of Dundry, is now well known to characterise more than one bed in the Jurassic district of northern France, the lower one of which is referred to the Lias.

In the lingering, or rather, perhaps, migration of Liassic cephalopoda into the Cynocephala stage there would appear to be a close analogy to that curious and more ancient transitive fauna disclosed by the beds of St. Cassian (Voralberg) referred long and doubtfully, alternately to the Trias and Lias; in this instance the Triassic ancient forms of cephalopoda, the *Orthocerata* and *Goniatites* lived side by side with the newer forms of cephalopoda, with Ammonites which are altogether Liassic in their character. These beds have recently been placed by

M. Merian as an independent group or formation between the Trias and Lias.

It may be concluded from the foregoing facts that the fauna of the Cynocephala stage is upon the whole sufficiently distinguished from that of the Upper Lias, and more especially from the English expositions of that well marked stage, so much so that in adopting the theory of its Liassic character it would be necessary to erect it into a higher and additional stage of that formation, or to a position intermediate, the Inferior oolite and Lias; any other arrangement would appear to be inconsistent with a consideration of *the entire facies of the fauna*, of the presence of a numerous assemblage of oolitic sedentary mollusks together with the absence of a similar series of Liassic forms.

The following striking remarks, by the President of the Geological Society in his anniversary address (1855) refer to the St. Casciano beds and contain an exposition of a truth which is scarcely even yet fully recognized in Geological nomenclatures. "Wherever we find the strata "conformable we have a confirmation of the well-known "saying, *Natura non facit saltum.* In fact all natural "changes are gradual under these circumstances. The "conditions of life gradually change and the organic "forms are modified to meet these changes; certain "species disappear, while others, adapted to the altered "circumstances, are called into existence, and continue to "flourish side by side with some of the pre-existing forms; "thus confirming the view already stated, that where the "strata are conformable, no line can be drawn between "successive formations, the gradual change is not marked "by sudden breaks in the series of animal life. Nature

"ever acts on one long unbroken plan, and knows as little "of sharp limits between Trias, Lias, and Jurassic, as "between the families and genera of existing animal life. "These terms are at best but temporary shifts to assist "our memories, and to enable us to register our facts and "our knowledge, and we must be careful not to give too "much importance to nomenclatures, which deserve at "the best but a secondary consideration."

In concluding the subject of the Cynocephala stage, as it is developed in the Cotteswolds, the possible and even probable contingency must not be unnoticed, that a more extensive acquaintance with the group of organic forms derived from a continuation of the same stage through the counties of Somerset and Dorset may, by a comparison of a larger series of testacea, lead to some modification of the results arrived at by an examination of the Cotteswold fauna alone, and that the facts here stated should be regarded as contributions to our local Geology, rather than as affording any full or sufficient history of this stage in its more extended or European aspect.

CHAPTER IV.

THE FIMBRIA STAGE.

We have now to investigate the petrographic features and zoology of a great series of oolitic freestones, with subordinate beds of ferruginous pisolite and calcareous marls, which come next in order of superposition, and have their chief development towards the western verge of the Cotteswold Hills; their entire thickness upon the outward range appears to vary from 120 to 190 feet, their maximum of thickness being found in the hills which are situated immediately to the east and south of Cheltenham. In the counties of Somerset and Dorset these calcareous freestones are present in much diminished importance, and even in Gloucestershire, upon tracing them to the south-east, in the direction of the general dip of the oolites, they will be found to have lost very much of their mass, that on the boundary of Oxfordshire they are reduced to very insignificant dimensions, and that in the further course of the Inferior oolite through the counties of Northampton and Lincoln, the formation is represented by a deposit of ferruginous rock. Upon this subject the reader is referred to an interesting memoir by Professor Morris in the Journal of the Geological Society, who has

shewn that the Inferior oolite in those counties is characterized by an extension of that intensely ferruginous rock, which at Wellingborough has been largely quarried for iron ore.

The freestones are, therefore, for the most part a Gloucestershire group of beds or subformation, which rapidly diminishes in its extension both to the north-east, and south-west, beyond the limits of the county. The finest and most comprehensive example afforded by any one section of the freestone, is that of the precipitous lofty headland of Leckhampton Hill, so long and largely quarried for building stone. Of this section an accurate measurement, taken by the late Mr. Strickland, was published in the Journal of the Geological Society, and is here reproduced, as it forms a type section with which it will be convenient to make comparisons when examining the freestone group of any other portion of the Cotteswolds.

The name of the stage has been chosen from the *Terebratula fimbria*, a shell which, together with its ally, *T. plicata*, occurs throughout the stage in the Cotteswolds, and more especially in the bed of marl above the building freestones where it is abundant.

SECTION OF LECKHAMPTON HILL, MEASURED BY H. E. STRICKLAND, ESQ., F.G.S.

		ft.	in.
Inferior oolite, 230 ft.	1. Trigonia grit	7	6
	2. Gryphite grit	7	0
	3. Rubbly oolite with many fossils	24	0
	4. Fragmentary oolitic freestone, apparently unfossiliferous	26	0
	5. Oolite marl with *Terebratula fimbria*	17	0
	6. Freestone quarried for building, with shelly layers at irregular intervals; the thickest and most fossiliferous portions at the base	106	6
	7. Pisolite ("Pea grit") and ferruginous oolite ("Belemnite bed") and sand	42	0

		ft.	in.
Lias, 749 ft.	8. Upper Lias, about	180	0
	9. Marlstone, about	50	0
	10. Lower Lias (probably 600 feet thick	519	0

A small portion of blue Upper Lias shale is exposed at the lowest part of the quarry, and reposing immediately upon it is a hard semisiliceous grey stone, 1 foot in thickness, in which are numerous fragments of belemnites, upon this band is a brownish oolitic stone 3 feet thick, with dark brown shining grains in a calcareous paste, resembling the ammonite bed at Frocester Hill; this bed also contains some few belemnites. If the Frocester Hill beds have not altogether thinned out, they must be represented by this portion of the Leckhampton section; but we have seen that the bed which overlies the ammonite bed at Frocester Hill contains in its lower part belemnites, perhaps washed from the bed beneath, and as the belemnites in the basement beds at Leckhampton are fragmentary, it is not improbable that they had a similar origin. Immediately reposing upon these transitive beds is the ferruginous or *pisolitic* portion of the Cheltenham freestone series consisting altogether of about 40 feet of rubbly yellowish brown or ferruginous oolite with layers of concretionary, rounded or flattened masses, about the size of peas. It is divisible into three portions, the upper and lower of which consist of ferruginous beds, the middle portion, 8 feet thick, is a hard whitish oolite with shelly detritus, and some flattened pisolitic concretions; it constitutes a useful building stone. Small corals are abundant, occurring at intervals throughout the ferruginous beds, together with fragments of *Pentacrinites*, plates of *Echinoderms*, &c. Cephalopoda are few both in species

and individuals, *Ammonites Parkinsoni* and *Murchissonæ* occur very sparingly, the latter shell acquiring large dimensions, and exhibiting much variability both in its general form and in the prominence of its costa, but the test is not preserved. Certain pisolitic layers have also shells of Conchifera well preserved, consisting chiefly of *Lima*, *Pecten*, *Avicula*, *Hinnites*, *Ostrea*, (plicated forms of) *Trigonia*, *Arca*, *&c.*, also several small *Brachiopoda* of the genera *Terebratula* and *Thecidium;* other ferruginous layers, which are neither very shelly nor pisolitic, contain beautifully preserved specimens of Sea Urchins or Echinodermata, *Pygaster semisulcatus*, *Hyboclypus agariciformis*, *Echinus perlatus*, *Diadema depressum*, *Acrosalenia Lycettii*, *&c.* Perhaps no British fossiliferous deposit has yielded Echinoderms in such variety, and so beautifully preserved, as the Cotteswolds in the vicinity of Cheltenham, it is therefore a subject for congratulation that the Palæontographical Society will shortly publish an extensive Monograph upon this subject from the pen of Dr. Wright, whose collection of Jurassic Echinodermata is unrivalled in this country. The turnpike road from Leckhampton to Birdlip passes successively the long quarried escarpments of Leckhampton Hill, of Shurdington Hill, and of Crickley Hill, passing in review many and extensive sections of the ferruginous pisolite; some variability will be observed in the thickness and number of the ferruginous beds, but the general features of the deposit remain the same; perfect shells become more rare, fragments of Echinoderms are still abundant; thin marly or sandy bands dividing the beds contain specimens of those two large Brachiopoda, *Terebratula simplex*, and *T. plicata*, species which also occur sparingly in the ferruginous

oolite itself. From Cleeve Hill to Birdlip Hill, an extent of about 8 miles, would seem to include the limits of the pisolite upon the western face of the Cotteswolds, and it has not been detected at any point far within the range eastward of a line connecting those two hills, Whatever causes may have sufficed to produce the small concretionary grains called oolites, may be presumed to have been capable, under certain modifying influences, of forming also the larger pisolites, without endeavouring to account for a phenomenon which is, as yet, only very insufficiently understood, one little fact which bears upon the subject may be mentioned :—it is not uncommon to find flattened pisolites with small Bryozoa adhering to their upper surfaces; we may therefore conclude that the change of the deposit to the concretionary structure must have occurred upon the floor of the sea prior to the deposition of the next layer, and that the pisolites remained uncovered long enough for the growth of the Bryozoa, and that in all probability the flattening of the concretions resulted from the superincumbent aqueous pressure; so that the ferruginous beds in the aggregate, represent in all probability a long continued action of marine deposition, that the fauna of this great group of beds attained to maturity each assemblage upon its own pisolitic floor, and that during this epoch many successive repetitions of similar marine conditions, both animal and mineral, took place. The ferruginous beds, when no longer pisolitic, extend southwards in the Cotteswolds in reduced and constantly diminishing importance; at Haresfield Hill they consist of about 12 feet of hard ferruginous sandstone in four or five beds, having a tendency to concretionary structure at the junctions of the beds. The wide hiatus of the vale of

Stonehouse next succeeds, but at Frocester Hill the hard brown bed, which overlies the ammonite bed, 4 feet in thickness, is the sole representative of the ferruginous oolite. The middle, or white freestone, subdivision of the Cynocephala stage, has for the most part the oolitic structure, and is locally shelly, its total thickness at Leckhampton being 106 feet. The lower beds have very many layers of shelly detritus, including some in which the shells are unbroken, and these, from their general good state of preservation and great number, both of species and individuals, present a very attractive deposit to the collector. Some of the more common are the following:—

Ostrea Marshii, Sow. sp.
Placunopsis Jurensis, Roemer sp.
Hinnites velatus, Goldf. sp.
Limea duplicata, Goldf.
Lima punctata, Phil.
Pecten subcomatus, Munst.
——— *lens*, Sow.
Mytilus furcatus, Munst.
——— *stritatulus*, Goldf.
Avicula complicata, Buck.
Corbula involata, Goldf.
Tavcredia axini formis, Phil. sp.
Arca Pratii, Mor. Lyc.
—— *pulchra*, Sow.
—— *cancellata*, Phil.
—— *lata*, Dunker,
Trigonia costata (var pulla.)
——— *exigua*, Lyc.
Astarte interlineata, Lyc.
Myoconcha crassa, Sow.
Opis gibbosus, Lyc.
Cypricardia cordiformis, Desh.
Sphæra Madridi, D'Arch. s.p.
Cyprina trapeziformis. Roem. s.p.
Unicardium, s.p.
Patella rugosa, Sow.
——— *inornata*, Lyc.
Pileolus lavis, Sow.
Nerita minuta, Sow.
——— *costata*, Sow.
Monodonta lævigata, Sow. sp.

Monodonta Lyelli, D'Arch.
——— *Sulcosa.*
Turbo capitaneas, Goldf.
Trochus monilitectus, Phil. sp.
Solarium Cotswoldiæ, Lyc.

In addition to the above, are a considerable number of testacea which have not been figured. The upper beds of the freestones are extensively quarried, both at Leckhampton and at many other localities, for building stones; owing to the great thickness of these beds, and the considerable distance between the vertical partings (joints), the quarries have a wide, flattened, floor-like roof, and are worked by level galleries piercing the hill sides; the blocks afford masses of all possible dimensions; their nearly homogeneous structure, pale uniform colour, and absence of shells, are qualities of great advantage to the architect, and the stone is capable of receiving any kind of form from the chisel of the sculptor; but as it is very porous and absorbs a large proportion of water, its use upon the exterior of buildings should be restricted to situations in which water cannot remain upon the surface of the stone; for cornices, parapets, window-sills, and similar purposes, it is unfitted, or can only be employed with some risk of disintegration. The oolitic freestone of Caen (Great oolite) is of very similar structure, hardness and aspect, so that each kind is of nearly equal value in the metropolis; there is, however, one disadvantageous circumstance attending the Cotteswold freestone from which the other is exempt; it not unfrequently happens that a thin exudation or spathose layer of carbonate of lime will form upon, and extend over the surface upon particular stones, which gives an unsightly aspect to buildings where it occurs. A comparison of the ferruginous pisolite with that of the

shelly freestones of Leckhampton Hill proves that they form portions of one zoological assemblage, characterised for the most part by the small dimensions of the shells; Univalves are comparatively few, and the valves of Conchifera disunited; small Echinoderms, and portions of them are common, but there is a total absence of the great family of the fossil *Anatinidæ*, so abundant in other stages of the formation; also of Ammonites, of Belemnites, and of Fishes' teeth and palates. The general association of testacea affords a striking resemblance to that of the shelly Great oolite of Minchinhampton, a resemblance which is confirmed by an identity of species in very many instances; this resemblance becomes the more remarkable upon a review of the shells of the upper stage of the Inferior oolite in the Cotteswolds, which contains upon the whole a very different assemblage of species. The freestone series in the southern Cotteswolds may now be noticed. The neighbourhood of Stroud, with its deep ramifying vallies and numerous mural sections, affords ample illustrations of this group and its peculiarities; there is, indeed, no single exposition of the freestones, which can be compared with that of Leckhampton for extent and completeness, but this inferiority is amply compensated for by the great number of examples, and by the linear extent of country which they serve to connect. Selsley Hill is a promontary, dividing the vales of Stonehouse and Woodchester; two miles from Stroud, and upon the slope of the hill facing that town, are several quarries which expose in the aggregate the whole of the Inferior oolite above the Cynocephala stage. The lower quarry exhibits the lower portion of the freestone group to the thickness of about 45 feet, the summit of the section

exposing a band of marl. The whole face of the quarry beneath the marl band exhibits a series of beds of stone, without any division lines of softer material; thick bedded towards the lower part with fine shelly detritus and imperfect shells, mingled with spines of Echinoderms, crystalline carbonate of lime and sandy drift, constituting a coarse hard rock, variable in its mineral character, and consequently of little commercial value; the marly band at the summit of the section has produced a large number of the fine *Terebratula plicata*, which is its sole fossil; this association of a colony of a particular species of *Rhynchonella* or *Terebratula* in a marly stratum, is a feature very common in the Cotteswolds, and of which other instances will be noticed. The second quarry, higher upon the hill and now disused, discloses the upper or building stone portion of the freestones, of which Leckhampton has already afforded a sufficient illustration. Quitting Selsley Hill, and following the course of the Woodchester valley through Nailsworth, the road to Avening exposes upon the right hand a long range of deep cuttings, ascending nearly in the line of the general dip of the beds, we pass over the lower freestones upwards in succession; neglecting the first cutting opposite Longford's Mill (in which the whole mass of the beds has slid downwards from its original position, and is therefore useless for our purpose) we soon after pass an indefinite series of pale, sandy fragmentary freestones, divided by many seams of brown marl or of sandy marl, producing by the alternation of colours a ribband-like appearance; these freestones have been quarried in several places, but with little success, owing to the blocks of stone being small and of indifferent quality; they contain shells rather sparingly

distributed through their mass, and some occasional layers of shelly dentritus. Very similar sections, exhibiting the lower portion of the freestone series, may be examined in other vallies of the Stroud district—two or three localities will suffice :—the road from Nailsworth to Horsley passes upwards over the whole group, including some partial disclosures of the Cynocephala stage at their base. The road formed upon the hill side or eastern flank of the valley from Nailsworth to Minchinhampton affords another extensive exposition. The vale of Chalford has many smaller sections very similar in their character. Upon comparing the lower or shelly freestones of Leckhampton with the examples just cited, the most striking distinction between them consists in the universal absence of shelly beds in the latter; this, indeed, is a very general feature in the mass of the Cotteswold freestones, so that very many and extensive sections of this portion of the stage may be examined without a single shell being detected. The shelly deposit at Leckhampton, therefore, is local only, and appears to be confined to a very limited area; neither is the Stroud district without some very similar local examples; a quarry near to Brimscombe Church has two thick beds of coarse shelly oolite in which many of the testacea are entire, mingled with shelly drift and fragments of sea urchins. A quarry in Woodchester Park from a similar position has afforded many Conchifera, including specimens of *Tancredia compressa*, a shell which under the name of *Hettangia compressa*, has been figured and described by M. Terquem from the *gres supraliassique* of the Moselle, a position upon the horizon of our Cynocephala stage. The uppermost bed of the building freestones in the Nailsworth valley has produced some

large testacea including *Trichites nodosus*, Lyc., and *Perna quadrata*, Sow., both very inequivalve forms of their respective genera, and among the more rare fossils of the formation.

THE OOLITE MARL SERIES.

The third or highest subdivision of the Fimbria stage, known by the name of *oolite marl*, and its associated freestones, is well known to all persons who possess even a cursory knowledge of the rock features of the Cotteswolds, owing to the great abundance of the Brachiopoda which it contains. The position of the bed overlying the building freestone ensures its exposure at every freestone quarry, and affords ample opportunities of noting and comparing its natural history features, so that a greater certainty attaches to our knowledge of this bed than perhaps to any other fossiliferous horizon in the Cotteswolds. The marl bed will be found associated with, and forming a portion of, a more considerable mass of deposits, including a bed of compact limestone, and of soft sandy oolites; the entire thickness of the group is exemplified in the Leckhampton hill section, commencing with the uppermost of the beds of building freestone, including the marl and sandy oolite above, in all 57 feet thick. This group will be found developed over the whole of the northern and middle Cotteswolds, the southern portion of the district being altogether destitute of them. The passage of the oolite freestone into the bed of pale buff coloured marl is somewhat gradual, the calcareous oolite become more compact and argillaceous, the uppermost layers of which acquire more nearly a marly and concretionary structure. Mr. Strickland has assigned 17 feet to the thickness of the marl, but its limits upwards are, at Leckhampton, extremely

arbitrary, the upper portion of the marl gradually becoming sandy and compact, ultimately forming a whitish sandy freestone, irregular in its joints and bedding, constituting the *bastard freestone* of the quarrymen to distinguish it from the true or *building freestone*, situated beneath the marl. It is only at very few localities that the bastard freestone occurs in blocks sufficiently large, or of a quality sufficiently good, for economic purposes. At Leckhampton the Rev. P. B. Brodie obtained some masses of corals in the lower portion of the marl bed, and was led to infer that the marly deposit resulted from the destruction of a more considerable reef at that spot, (Journal of the Geological Society, vol. 6, part 1, 1850,) a theory founded upon the presence of corals at a single locality only, but which has received much support and corroboration from subsequent researches over larger areas. Immediately above the lower or more compact deposit is the zone of *Brachiopoda*, abounding with *Terebratula fimbria* in all stages of growth, and usually forming two well marked varieties. *(See note in the Appendix.)* *Rhynchonella subobsoleta*, Dav., is in tolerable abundance, together with another form of the same genus, and with *Terebratula submaxillata*, a shell whose numerous phases of form exemplify the difficulty of separating it, even as a *variety* from the cornbrash *T. maxillata*. More rarely are found specimens of the broad variety of *Terebratula carinata* with deeply waved borders, a variety readily distinguished from that which occurs in the upper stage of the formation. The *Brachiopoda* have their tests preserved, other testacea are usually in the condition of casts, often compressed, and consisting more commonly of *Lucina Orbigniana*, *Cypricardia cordiformis*, *Mytilus furcatus*

Natica adducta, with distorted and doubtful forms of *Natica*, *Phasianella*, *Nerinœa*, and *Chemnitzia*. These are the more common fossils of the soft marl, the more rare testacea would make a much larger but scarcely more satisfactory list, owing to their imperfect condition. It is only within a thickness of three or four feet that testacea are abundant, the upper or more sandy portion of the marl being altogether destitute of fossils, and a similar barrenness continues throughout the superincumbent bastard freestone, an occasional single valve of *Terebratula fimbria*, (probaly washed from the lower stratum,) serving occasionally to exemplify the general absence of organic life.

At Leckhampton scarcely any portion of the marl bed can be considered as uncompacted, and the term *marly nodular limestone* more nearly expresses its mineral character. The association of organisms, and their limitation to the more argillaceous portion of the deposit, will be found to obtain over the Cotteswolds wherever this group of beds is developed. The ancient freestone quarries near to Painswick, and an extensive section of a disused quarry at Whites Hill, near Stroud, afford examples of this sandy and unfossiliferous character of the beds which overlie the oolite marl, their thickness being very considerable, and apparently equal to that at Leckhampton. The narrow picturesque valley which passes southwards from Sheepscombe to Stroud has several rock sections, which exhibit an interesting change in the zoology of the oolite marl. The soft marl with *Brachiopoda* is of inconsiderable thickness, passing downwards gradually into hard pale argillaceous limestone, about half a yard in thickness, destitute of *Brachiopoda*, but abounding with

corals, chiefly of the genera *Thamnastrea* and *Isastrea*. Swifts Hill, 2 miles from Stroud, on the eastern side of the valley, has an extensive section of the marl, and a fault which traverses the cliff causes a considerable displacement of the beds, and the concretionary limestone abounds with corals and detached valves of *Lima Pontonis*, a shell which occurs in the same position at other localities of the Stroud district.

At Watts's quarry, north-east of Stroud, and also at a section in the neighbouring cemetary, the same concretionary hard bed abounds with corals and with minute or young *Terebratula*, which, however, acquire their full dimensions in the soft marly layers above; the great diminution in thickness which the whole group has undergone will be understood from the following sections :—

WALLS'S QUARRY.

		ft.	in.
1 & 2	Upper ragstones, which cap the section ..	8	0
3 & 4	Bastard freestone	10	0
5 —	Oolite marl and concretionary limestone ..	4	0
6 —	Building freestone (upper portion exposed)	15	0

WALLS'S QUARRY, NEAR BRIMSCOMBE.

		ft.	in.
1 & 2	Upper ragstones	10	0
3 & 4	Rubbly freestone	7	0
5 —	Oolite marl	2	6
5*a* —	Pale argillaceous limestone	2	6
5 —	Building freestones (portions exposed) ..	15	0

Walls's quarry exemplifies the general conditions of this group throughout the vale of Chalford, and its lateral smaller vallies; in these there is a portion of soft marl with *Brachiopoda*, also a more compact bed beneath with various *Gasteropoda* and *Conchifera*, corals are rare, and the entire thickness of the group is only from eight to eleven feet. *Terebratula simplex*, and *T. plicata*, which in

the northern Cotteswolds occupy, the Ferruginous oolite near to the base of the Fimbria stage, here pass upwards into the oolite marl; *T. plicata* never assumes the large dimensions and deeply plicated borders, common to specimens from the older deposit, and *T. simplex* is dwarfed to a small species not exceeding nine lines in diameter, but exhibiting in its rugose plications all the indications of adult growth. Passing across the Stroud valley southwards two miles, the Selsley Hill section exhibits the continual thinning out of the upper or bastard freestones; the marl is nearly consolidated, *Brachiopoda* abound in a zone only a few inches thick, the nodular limestone beneath containing a few corals, associated with a numerous assemblage of slender univalves of the fossil genus *Nerinæa*, but owing to the friable nature of the rock, perfect specimens can rarely be obtained. Other Gasteropoda and Conchifera are less numerous, *Trochotoma calix*, *Nerita tumidula*, *N. costata*, *Natica adducta*, *Chemnitzia procera*, *Ceromya concentrica*, *Mytilus furcatus*, *Lima Pontonis*, *Gervillia tortuosa*, and others have been collected at this spot. At Rodborough Hill, which forms another great terminal headland facing Stroud, the soft marly zone with *Brachiopoda* has altogether disappeared, a single bed of hard buff-coloured argillaceous limestone is the only representative of the marly deposit, it appears to contain but few fossils of any kind, and is overlaid by a small thickness of bastard freestone; upon exposure to the action of frost it resumes its marly condition.

These two sections of Selsley and Rodborough Hills are upon the opposite sides of a large valley, which from thence passes southwards, containing the villages of

Woodchester and Nailsworth, with many smaller lateral offsets, and abounding with rock sections, in which we are enabled to trace the thinning out and eventual disappearance of the whole group. Numerous sections all disclose a thick bed of hard argillaceous limestone overlying the building freestone, usually not constituting a distinct bed, but only the upper portion of a more considerable mass of oolite, the passage from the one condition to the other being gradual, and indicating a very tranquil and almost insensible continuation of the same kind of marine action; pitchstone or pitchingstone is the quarryman's name for this bed, its superior hardness having recommended its use for stable floors, outhouses, &c.; upon this bed usually reposes a small thickness of flaggy oolite, (bastard freestone) in other instances the pitchstone is covered immediately by the upper ragstone (1 and 2 of the Leckhampton section). At Scar Hill, near Nailsworth, is the following section:—

		ft.	in.
1 & 2	Upper ragstones in several beds partially fossiliferous, in other layers concretionary and barren; the portion exposed 12 to 14 feet thick.		
3 & 4	Bed of compact oolite, bored everywhere by small vertical tubes of marine Annellida	1	6
	Sandy oolite.....	1	6
5 & 6	Thick bed of oolite, the upper or argillaceous portion abounding with sections of *Nerinæa*, and with small brown ferruginous grains in a paler paste.....	1	0

Here we find the entire marl group reduced to a thickness of 4 feet, destitute both of corals and Brachiopoda, but containing Gasteropoda and Conchifera generally of small size. At Ball's Green, a mile higher up the valley, is the following section:—

		ft.	in.
1 & 2	Ragstone as at Scar Hill	13	0
5 —	Thin band of concretionary marl, with a few specimens of *Terebratula fimbria*	0	4
5 *a*	Hard limestone, slightly marly in the upper part	5	0
6 —	Oolitic freestone, three beds worked, each about 6 feet thick		

The trace of oolite marl with its characteristic fossil becomes an interesting feature, indicating the approaching southern limit of the marl group. Several small sections of the same series of beds, scarcely differing in their general features, are exposed in a further extension of the same valley towards the village of Avening. The great quarry upon the summit of Wotton Hill displays the upper stage of the Inferior oolite, or upper ragstones, immediately overlying the building freestones, the oolite marl therefore, and the rubbly freestones above it, have altogether thinned out and disappeared. One remarkable feature relating to the uppermost bed of the rubbly or bastard freestone remains to be noticed; throughout the Stroud district, and more especially in the Nailsworth valley, including an area of several square miles, the bed in question has been perforated by vertical tubes, extending downwards from 9 to 18 inches, and so closely arranged that numerous tubes may often be included within a hand specimen, few tubes exceeding the diameter of a crow quill. These become more conspicuous from the entire absence of other fossils, or even of shelly detritus, throughout the freestone bed, they were the work of marine *Annellida*, and belonged to the fauna of the next stage; the distinctness of these tubes, filled with dark-coloured carbonate of lime, sufficiently attests that the bed of oolite had become to some extent consolidated ere the tubes were formed, indicating a pause in the

marine deposits, followed by a change both physical and zoological, which will subsequently be adverted to.

Upon a general review of the oolite marl group, we find it of great thickness in the northern Cotteswolds, and that the Leckhampton Hill section exemplifies its full development; the base of the marl bed has there some masses of *(Thamnastrea Mettensis)*, apparently disconnected from any larger group; in the Sheepscomb valley and the district of Stroud, the same stratum assumes the character of a small coral reef of more importance in its extent than in its thickness; passing southwards to Selsley and Rodborough Hills, the corals will be found to have almost disappeared, so that in the Nailsworth valley they are only recognised as trifling disconnected portions, and most commonly they are absent altogether. The rock sections to the south-east of Stroud in the Chalford valley, exhibit this group of beds in like manner, almost, and usually destitute of corals, so that the limits of the reef to the south and east are known and defined.

It will be observed that throughout the long course of the Nailsworth valley southwards, the bed of argillaceous compact limestone, contains a considerable assemblage of *Gasteropoda* and *Conchifera*, which replace the *Corals* and *Brachiopoda* of the north Cotteswold marl, and more especially is characterized by a multitude of slender univalves of the genus *Nerinœa;* the usual connection of this genus with coralline limestone has been fully illustrated by Mr. Sharpe in his memoir on *Nerinœa; (see Appendix.)* The predominance of these remarkable shells upon the skirts of, and upon the ultimate extensions of the coralline mud in the Cotteswolds, is one of the most interesting of the natural history features of the region,

for in other portions of the Inferior oolite the genus is of extremely rare occurrence.

Perhaps the genus *Nerinæa* has not been found in any deposit older than the oolite marl; the aspect of the five species which characterize this position is sufficiently distinctive when compared with those of the Coralline oolite and of the cretaceous rocks; they are nearly destitute of ornament, have an imperforate columella, have an acute apex, consist of a great number of volutions, and are so attenuated that their figure may be described as cylindrical or even acicular.

That the stratum of the argillaceous limestone, and overlying bed of marl, were the products of the degradation of a coral reef, may be considered as sufficiently probable, but to infer that the muddy current resulted from the abrasion of the present coralline stratum, would be to seek for an origin altogether inadequate to produce so considerable a result, the layer of corals, considerable as may be its horizontal extension, nowhere exceeds a few inches in thickness. The general character of the marl, altogether free from detached or water-worn fragments of a coralline bed, would seem rather to indicate that its origin was more distant; that only the more comminuted particles were carried forward by the current, and that probably the present coralline layer was analogous to one of those detached growths of the smaller corals, so many of which stud coralline seas, and of which the shallow sea between the coast and the great outer barrier reef of New South Wales supplies an innumerable number of examples. Judging from the great mass of the marl group in the Northern Cotteswolds, and the extreme attenuation of the beds towards the south and south-east, it may be

inferred that the source of the deposit was situated to the north and west of the present chain of the Cotteswolds, a theory which has the additional advantage of explaining the source of the multitude of corals which everywhere accompany the beds of oolite gravel spread over the vale of Gloucester, and over the lower levels of the vale of Stonehouse, and of the vallies of the Stroud district.

The mind thus reverts to the fact capable of the clearest demonstration, that the Inferior oolite, once extended in mass across the vale of Gloucester, and by estimating the proportion of corals to that of the whole amount of oolitic gravel and sand, it may fairly be presumed that the coralline deposit was neither inconsiderable in its extent or thickness.

The organic remains of the upper portion of the Fimbria stage have been in a general manner already indicated; *Cephalopoda* are extremely rare, two species of *Ammonites* have occurred belonging to undetermined species; oysters are scarcely less rare, and consist only of the plicated forms of that genus, and of the great family of the *Myadæ* or *Anatinidæ*, which so strongly characterizes the Inferior oolite, scarcely a vestige can be found throughout the group. My cabinet has two small specimens of *Anatina (Cercomya) pinguis*, Ag., and two of *Goniomya angulifera*, Sow., from these beds; species which range upwards from the lower beds of the Inferior oolite, and tend to support this observation by the very nature of the exception. It is evident that in these calcareous oolites, argillaceous limestones, and marls, we contemplate a marine deposit of the open sea quite unconnected with tranquil bays, estuarine waters or littoral banks, which appear to have been the favourite habitats

both of the Cephalopoda, of the long siphoned Myadœ, and of the banks of oysters. The coralline character of the oolite marl tends to illustrate the truth of a remark made by M. Oscar Fraas, in his comparison of the English, French, and German Jura formations, viz., that any portion of the Jurassic rocks may locally put on the aspect of a Coral rag; the upper stage of the Cotteswold Inferior oolite contains locally many Corals; other indications of a similar character are afforded by certain beds of the Great oolite in the vicinity of Bath, and in a less degree by an approximation to a coral bank in the same formation of the Minchinhampton district. At the base of the Cornbrash, near Fairford, is a stratum of marl which has also yielded a profusion of Corals in a fine state of preservation.*

In the following list of fossils from the argillaceous portion of the Fimbria stage, care has been taken to include only such as actually occur within the narrow vertical limits of that deposit:—

FOSSILS OF THE OOLITE MARL.

Ammonites ..... species undetermined.
———— *Murchisonæ*, Sow. (*young*)
Nautilus clausus, D'Orb. (young)

Chemnitzia procera, Desh.
Nerinœa gracilis, Lyc. sp.
———— *Cotteswoldiæ*, Lyc. n. sp.
———— *Jonesii*, Lyc. n sp.
———— *Oppelensis*, Lyc. n. sp.
———— *pseudocylindrica*, Desl. sp.
Cylindrites tabulatus, Lyc.
———— *gradus*, Lyc.
———— *attenuatus*, Lyc.
Natica canaliculata, Mor. & Lyc.
———— *macrostoma*, Roem.
———— *adducta*, Phil.

* The position of this coralline stratum has been determined by my friend Mr. Jones, of Gloucester.

Natica tumidula, Phil.
Trochotoma calix, Phil. sp.
——— *tabulata*, Lyc.
——— *depressiuscula*, Lyc.
Trochus monilitectus, Phil.
——— *pyramidalis*, Phil.
——— *gemmatus*, Lyc.
——— *ornatissimus*, D'Orb.
Monodonta levigata, Sow. sp.
——— *heliciformis*, Lyc.
Cirrus nodosus, Sow. (var.)
Solarium Cotswoldiæ, Lyc.
Neritopsis sulcosa, D'Archiac. sp.
——— *varicosa*, Mor. & Lyc.
Nerita costata, Sow.
Delphinula funata, Goldf.
——— *quaterno-cingillata*, Lyc.
——— *Buckmani*, Mor. & Lyc.
Turbo elaboratus, Lyc.
Phasianella subangulata, Lyc.
Pileolus lævis, Sow.
——— *plicatus*, Sow.
Patella inornata, Lyc.
Pleuotomaria funata, Lyc.
——— *lævigata*, Lyc.
——— *sulcata*, Sow.
Cerithium quadricinctum, Goldf.
——— species undetermined.
——— species undetermined.
——— species undetermined.
Fusus, species undetermined.
Alaria unicornis, Lyc.
——— *spinigera*, Lyc.
——— *lævigata*, Lyc.

Ostrea gregarea, Sow.
Placunopsis.
Hinnites abjectus, Phil. sp.
Mytilus (Modiola) imbricata, Sow.
——— *furcatus*, Sow.
Plicatula.
Pecten subcomatus, Munst.
——— species undetermined.
——— species undetermined.
——— species undetermined.
Lima punctata, Phil.
——— n. sp.
——— n. sp.
——— *Pontonis*, Lyc.
——— *pectiniformis*, Schl. (young.)
Myoconcha striatula, (Mytilus Goldf.)
——— *elongata*, Mor. & Lyc.

Perna quadrata, Sow.
Trichites nodosus, Lyc.
Pteroperna costatula, Desl. sp.
——— *gibbosa*, Lyc.
——— *lata*, (*Gervillia*, Phil.)
Gervillia lanceolata, Goldf.
——— *aurita*, Lyc.
——— *tortuosa*, Phil. sp.
Arca cancellata, Phil.
—— *carinata*, Koch. & Dunker.
—— *Prattii*, Mor. & Lyc.
Cucullæa cucullata, Goldf.
Macrodon Hirsonensis, D'Arch. sp.
Pinna cuneata, Phil.
——— *hastata*, Lyc.
Unicardium gibbosum, Lyc.
——— n. sp.
——— n. sp.
Opis Moreausus, Buvig.
—— *gibbosus*, Lyc.
—— *elongatus*, Lyc.
Trigonia costata (var. *pullus*) Sow.
——— *costatula*, Lyc.
——— *angulata*, Sow.
——— *striata*, Sow.
——— *subglobosa*, Mor. & Lyc.
Cypricardia cordiformis, Desh.
Cyprina curvirostra, Lyc.
——— *nuciformis*, Lyc.
——— *Suevica*, Goldf.
——— *picta*, Lyc.
Lucina Orbigniana, D'Arch.
Astarte depressa, Gold.
——— *bullata*, Lyc.
——— *transversa*, Lyc.
——— *excavata*, Sow. (young.)
——— *var*, *compressiuscula*.
——— n. sp.
Myacites punctatus, Buck. sp.
——— *compressus*, Lyc. n. sp.
Goniomya angulifera, Sow. sp.
Anatina pinguis, Ag. sp.
Ceromya concentrica, Sow. sp.

Serpula socialis, Goldf.

Terebratula submaxillata, Dav.
——— *fimbria*, Sow.
——— *carinata*, Lam. (var.)
——— *galeiformis*, Dav.
——— *plicata*, Buck.
——— *simplex*, Buck.

Rhynchonella subobsoleta, Dav.
——— *concinua*, Sow.
——— *subtetahedra*, Dav.
——— *Lycettii*, Dav.

Cladophyllia, sp., at Birdlip.
Comoseris vermicularis, McCoy, sp.
Convexastrea Waltoni, Edw. & Haime.
Isastrea limitata, Lamx. sp.
——— *Davidsoni*, Edw. & Haime.
Thamnastrea Defranceii, Mich. sp.
——— *concinua*, Goldf. sp.
——— *Mettensis*, Edw. & Haime.
Thecosmilia gregaria, McCoy, sp.
Stylina solida, McCoy, sp.

For the determination of the corals I am indebted to my friend Mr. Jones, of Gloucester, who collected them at Birdlip and Sheepscombe; several of the same species have been also obtained near Stroud. Notwithstanding that the genus *Nerinæa* is so abundant, it is rare that a specimen can be obtained to exhibit the internal character of the volutions by which chiefly the species are distinguished; usually the entire specimen consists of crystalline lime, in which all structure is lost; it is only when some opake limestone has penetrated a volution that the internal characters can be distinguished.

Small specimens of *Cerithium* are common in the hard limestone, but their surfaces cannot usually be sufficiently exposed to enable us to determine the species with any certainty.

CHAPTER V.

THE SPINOSA STAGE.

The above designation for the upper division of the Inferior oolite has been chosen from the position and stratigraphical range of the *Rynchonella spinosa*, an abundant and well-known fossil, which occurs only in this stage; the geographical distribution of the fossil is also extensive both Continental and British.

The thickness of this group of beds in the Cotteswolds is inconsiderable, varying from 30 to 40 feet; strongly characterized by its features, both petrographic and zoological; recognized by its great horizontal extension, it is upon this stage chiefly that the Geologist will rely in making comparisons between widely separated deposits of the Inferior oolite. This general persistency of character, and more successful resistence to denuding forces, is no doubt due to its superior hardness; throughout the western escarpments of the Cotteswolds more especially, its presence may usually be detected in an abruptness of outline which it imparts to the hills, which are capped by it. Consisting for the most part of coarse calcareous sandstones, with varying additions of iron or of alumina, it assumes sometimes the aspect of an argillaceous

limestone, or of a ferruginous concretionary sandstone, in the latter condition it is usually only very sparingly fossiliferous, the organisms then occurring mostly at the junctions of the beds, and associated with some partial and temporary change in the character of the deposit. The argillaceous limestone on the other hand will locally become a soft argillaceous shale, or a hard crystalline limestone, according to the predominance of alumina or lime, but in either case usually abounding with fossils; or should a calcareo-ferruginous sandstone prevail, the fossils will be fewer in number, and very indifferently preserved. All, or the greater number of these rock features, may commonly be observed in the different beds of a single section, so that upon the whole there is a much greater diversity of aspect and structure in the Spinosa Stage, than in any lower portions of the Inferior oolite, and it is impossible by any single term to express its physical aspect or composition. Ragstone is the quarryman's name for a bed when it assumes an irregular hard and rubbly composition, and not unfrequently the same name is applied to the whole of this stage. The authors of Murchison's Geology of the Vicinity of Cheltenham, 2nd Edition, divided this stage into two beds or series of beds, the lower of which they designated Gryphite grit, and the upper Trigonia grit, from the prevalence of *Gryphæa Buckmani* in the one, and of *Trigonia costata* in the other, and also from distinctions in their mineral character. This arrangement, founded upon the sections of Leckhampton Hill chiefly, is found to be applicable, with local modifications, to the whole of the northern Cotteswolds; in the southern Cotteswolds, however, the stage does not present such clearly separated

features, and any arrangement of the beds in accordance with such a subdivision would be purely arbitrary. A third series of beds (No. 3 of the Leckhampton section), agree with the two superior beds in their general features, and should be included in the same stage, their thickness at Leckhampton being 24 feet; this lower series of beds is generally present throughout the northern Cotteswolds in greater or less importance. There is also a fourth and higher series of beds overlying the Trigonia bed, and but little developed in the hills near to Cheltenham, so that the Spinosa stage of the Cotteswolds, in its intireity, consists of the following series of beds in descending order:—

A.—*Pholadomya grit;* thin bedded rubbly brown calcareous sandstones, abounding with *Brachiopoda* and with *Pholadomya* and *Homomya.*

B.—*Trigonia grit;* hard argillo-siliceous limestone, abounding with *Trigonia* and other *Conchifera,* having their tests preserved, converted into crystalline lime; in other localities it consists of brownish hard sandstones, with *Conchifera* in the form of casts.

C.—*Gryphite grit;* two or three beds with a profusion of *Cryphœa Buckmani* in one or more layers; other layers abound with *Trigonia* and a large assemblage of *Conchifera.*

D.—*Rubbly ragstone;* many beds of brownish ragstone, shelly in certain layers, chiefly developed in the northern Cotteswolds.

Probably in no single locality are the whole of the above subdivisions exhibited; thus in the northern Cotteswolds the series A is of inconsiderable thickness, and the series D constitutes the greater portion of the stage; in the southern Cotteswolds the series D seems to have thinned out altogether; the series B and C cannot always be clearly separated; the series A being very persistent, and of considerable importance. The Trigonia grit and Gryphite grit, therefore, which in the northern Cottes-

wolds so strongly mark the Spinosa stage, are situated near to the middle portion; the *Rhynchonella spinosa*, which occurs throughout the stage, is found chiefly in the Trigonia grit in certain layers, almost exclusively occupied by the *Brachiopoda*.

Such are the leading features of the Spinosa stage in the Cotteswolds, tending to the inference that its local subdivisions are only of very subordinate importance, that the different horizons, characterized by certain assemblages of testacea, however distinct over certain areas, are not applicable to others, and that the lists of fossils derived from particular horizons must not be expected to recur in all their distinctness at distant geographical positions; the *stage* has nevertheless a very considerable extension, modified by local influences. In the *calcaire à polypiers* of Terquem, it is recognized in the department of the Mozelle; in the *calcaire de Longwy* of Dewalque, in the province of the Luxembourg; that it extends into Swabia, may be concluded from the description of M. Oscar Fraas.* That it occurs in the Swiss Jura may also be stated on the authority of M. Alphonse Favre, the eminent geologist of Geneva, who, upon visiting the Rodborough Hill quarries, at once recognized the stage in its rock features and organic remains. For the most part the Spinosa stage is very fossiliferous, not, however, without some very striking local exceptions; it frequently happens that certain beds assume a concretionary structure, forming hard concretionary brown sandstones, which are usually destitute of testacea, but such variations are only local.

* Comparison of the German Jura formation with those of France and England.

The lower series (D) is not usually worked for economic purposes, its fossils are, therefore, not ascertained, excepting several Conchifera, identical with species found also in the Gryphite grit.

The Gryphite grit series (C), next in order of superposition, varies in thickness from 3 to 8 feet, but at Rodborough Hill it is reduced to 2 feet, and is there one compact mass of fossils; the grit at that locality has produced a large assemblage of Conchifera in an excellent state of preservation, it is a coarse greyish blue or brown argillaceous limestone, very uncertain in its hardness; the shells are confined to the lower foot, the upper portion is more siliceous and somewhat concretionary, it abounds with the valves of *Gryphœa Buckmani*, from which the name of the bed has been derived; at Rodborough, and throughout the Cotteswolds southwards, in consequence of the absence of the lower subdivision (D), the Gryphite grit rests upon the freestone of the Fimbria stage, which is everywhere bored by *Annellida* of the Gryphite grit bed.

In the whole geology of the Cotteswolds, no more striking contrast can be found than the change in rock structure and organic remains, which suddenly takes place upon passing from the pale barren freestone, or uppermost member of the Fimbria stage to the Gryphite grit, the base of which must have been absolutely crowded with marine life; the bored bed, together with the change in the organisms, indicates a pause in the marine deposits during which a series of beds, 24 feet thick, were accumulated in the northern Cotteswolds. The upper surface of the freestone bed presents a level floor, literally covered and grooved with impressions and remains of animal life; valves of oysters clustering and adherent, a labyrinth of

grooves and tracks of *Annellida* and *Mollusca*, crossing each other in all directions.

The *Gryphæa* is a subgenus of oysters, and in its general habits resembled the typical group of that genus; *Gryphæa Buckmani* was attached by the extremity of the beak, where a small flattened area is perceptible, and this flattening continued throughout the life of the *mollusk* unlike the well-known *Gryphæa arcuata* of the lias, which was attached only in its young state; upon the upper surface of the bed, more especially *G. Buckmani*, is often found clustered together to the exclusion of all other fossils. At Leckhampton, at Rodborough, and over the whole of the intervening tract, this Gryphite is found wherever the grit is exposed, forming a vast oyster bank, distributed in moderate abundance throughout one or two beds, associated with other Conchifera, and in great and almost exclusive abundance over the uppermost stratum of the deposit. It would appear that Rodborough is situated at the extreme southern limit of this oyster bank, and that over the southern Cotteswolds it is altogether absent; as this remarkable shell does not occur higher in the stage, its presence affords a useful guide to the position of the bed where it occurs. Under the name of the *Gryphæa, with a large ear*, it is mentioned by M. Oscar Fraas, and is stated to be common in the Swiss Jura, and in Swabia, a fact which confirms its importance as a stratigraphical guide.

As many testacea of the Gryphite grit have not been described, it will be more convenient to mention such only as are the more abundant; these are the following:—

Ostrea Marshii, Sow.
—— *gregarea*, Sow.

Ostrea (Gryphœa), Buckmani, Lyc.
—— *acuminata*, Sow.
—— *rugosa*, Goldf.
Perna rugosa, Goldf.
Pecten lens, Sow.
——— *demissus*, Sow.
——— *articulatus*, Schlot.
——— *personatus*, Goldf.
Mytilus curtansatus, n. sp.
——— *tumidous*, Mor. & Lyc.
——— (*Modiola*) *Sowerbii*, Sow. sp.
——— *gibbosa*, Sow.
Pinna cuneata, Phil.
Trichites undulatus, Lyc.
Gervillia Hartmani, Goldf.
——— *tortuosa*, Phil. sp.
——— *prælonga*, n. sp.
Lima pectiniformis, Schlot. sp.
—— *bellula*, Mor. & Lyc.
—— *gibbosa*, Sow.
—— *punctata*, Phil.
Cucullæa oblonga, Goldf.
Macrodon Hirsonensis, D'Arch. sp.
Tancredia donaciformis, Lyc.
Quenstedtia oblita, Mor. & Lyc.
Corbis (Corbicella) compressiuscula, n. sp. Lyc.
—— (*Corbicella*) *tumidula*, n. sp. Lyc.
Astarte excavata, Sow.
——— *elegans*, Sow.
Myoconcha crassa, Sow.
Opis cordiformis, Lyc. n. sp.
Cypricardia cordiformis, Desh.
Unicardium depressum, Phil. sp.
Trigonia costata (var sculpta), Lyc.
——— *tenuicosta*, Lyc.
——— *hemispherica*, Lyc.
——— *angulata*, Sow.
——— *striata*, Sow.
Myacites compressiusculus, n. sp.
——— *dilatus*, Phil. sp.
——— *tenuistriatus*, Ag. sp.
——— *elongatus*, Ag. sp.
Homomya crassiuscula, Mor. & Lyc. sp.
Gresslya latirostris, Ag.
——— *abducta*, Phil. sp.
——— *conformis*, Ag.
Ceromya Bajociana D'Orb.
Pholadomya media, Ag.
——— *ovulum*, Ag.
——— *carinata*, Ag.
——— *fidicula*, Sow.
Trochotoma carinata, Lyc.

Natica adducta, Phil.
Monodonta lævigata, Sow. sp.

From this list of the more common species, it will be perceived that the Conchifera constitute the great majority of the testacea, the family of the *Anatinidæ* are represented by a considerable number of species, and by a great profusion of individuals; it is rare to find the test of *Pholadomya* or of *Ceromya* preserved in the Inferior oolite, and it is only under conditions unusually favourable that the delicate outer granulated tegument of *Myacites*, *Gresslya*, or of *Goniomya*, can be procured, but in the Gryphite grit at Rodborough Hill, the tests of these shells are usually preserved, the only difficulty consisting in separating the delicate test from the matrix, an operation which is often impracticable without much injury to the specimen.

The *Trigonia costata* of this bed (var sculpta) is clearly distinguished from the typical form, by the more elongated and depressed figure, by the roundness of the anterior border, the greater size and flatness of the area, the less recurved umbones, and also by the large pattern of the ornamentation upon the area, and the smaller curvature of the costa upon the sides of the shell. M. d'Orbigny considers it to be a distinct species, and has named it *T. scuticulata*.*

It is remarkable that the typical form occurs both in the freestone beneath and in the Trigonia grit above this variety. The lower portion of the Gryphite grit at Rodborough is so fully charged with the valves of Conchifera, that nearly the whole of the species enumerated in the above list occur in considerable numbers, and it is scarcely possible to disengage a specimen without destroying others. The species of the *Gasteropoda* are comparatively few, and are represented by very few specimens; Belem-

* Prodrome de Paléontologie: 10 ét. Bajocien, No. 314.

nites are very few, and Ammonites and Nautili are almost absent. Echinoderms, or even fragments of them, are rare. *Serpulæ* are abundant, attached to the valves of Conchifera. Brachiopoda are few, consisting only of two species of *Rhynchonella; Thecidium triangularis* is not uncommon, attached to dead valves of *Gryphæa Buckmani.* The total number of testacea ascertained in this bed are as follows:—

	Species.
Cephalopoda	5
Brachiopoda	3
Annellida	3
Gasteropoda	30
Conchifera	84
	125

TRIGONIA GRIT.

The Trigonia grit next in succession is of greater thickness than the Gryphite grit, harder, equally extended in its range, it is also equally characterized by its fossils. The bed usually admits of subdivision into several portions; at Rodborough its thickness is about 8 feet, and more frequently it is of less thickness throughout the Cotteswolds. Its mineral character varies greatly within short distances, or even through its mass at the same locality; the most frequent condition is that of a pale brown, coarse, hard, sandy limestone, the greater mass of which exhibits casts and impressions of Conchifera and Brachiopoda, irregularly and sparingly distributed; there are also usually one or two bands from half a foot to a foot in thickness, which are almost made up of the valves of Conchifera or of their casts, the Brachiopoda always retaining their tests. In other instances, from an increase in the proportion of argillaceous lime, these shelly bands

consist of coarse blue limestone, so hard as to strike fire with the blows of the hammer; the tests of Conchifera are then preserved of a pearly aspect, the most delicate features of their surfaces being retained, but as this spathose material is less indurated than the matrix, the attempt to separate the shells is frequently futile, and the collector experiences the disappointment of seeing the more delicate and beautiful specimens crumble from the concussion of blows directed upon the hard matrix. From the effect of one or other of these adverse conditions, it usually happens that the crowded shells of the Trigonia grit are seen in the rock more abundantly than in the cabinet, and it is only after prolonged and persevering efforts that a small series of fossils which fairly represent the bed can be obtained. From the general superior hardness of the rock, and its intractable character, it is solely employed for rough walls and for road mending, so that, to obtain a good knowledge of its testacea and of their impressions, the tops of the low rough walls which divide the fields may be advantageously studied in preference to the masses in quarries. The shells consist almost entirely of Conchifera and Brachiopoda, of the former the two most abundant are *Trigonia costata*, and *Gervillia pernoides;* of the latter *Rynchonella spinosa*, *R. angulata* and *Terebratula carinata.* The two prevailing conchifers, grouped in every position, occupy one layer, the Brachiopoda another, the latter more commonly occupying some marly floor, or parting of a bed or of its layers. Other shells, but in much less abundance, are *Trigonia signata* (a large beautiful tuberculated species.

Trigonia duplicata, Sow.
——— *v. costata*, Lyc.

Avicula digitata, Deslong.
——— *ornata*, Goldf.
Lima gibbosa, Sow.
—— *bellula*, Mor. & Lyc.
Pecten demissus, Sow.
——— *articulatus*, Schlot.
Trichites undulatus, Lyc., usually in fragments.
Macrodon Hirsonensis, D'Arch. sp.
Quenstedtia lævigata, Phil. sp.
Cardium Buckmani, Mor. & Lyc.
Opis similis, Sow. sp.
Unicardium depressum, Phil. sp.
Perna rugosa, Goldf.
Gervillia pernoides, Deslong.
Astarte rugulosa, n. sp.
——— *subtrigona*, Goldf.
——— *rhomboidalis*, (var.) Phil. sp.
Ceromya striata, Sow. sp.
Myacites subelongatus, Ag. sp. (casts)
Gresslya abducta, Phil. sp. (casts)
Goniomya, sp.
Pholadomya (several species of)
Holectypus depressus, Desor.
Pedina, sp.
Ammonites Parkinsoni, Sow.
——— *Martinsii*, D'Orb.

PHOLADOMYA GRIT.

Under this name it is intended to designate the beds of the Spinosa stage higher than the Trigonia grit, from the occurrence in them of the well known *Homomya gibbosa, (Mactra*, Sow.) a form which is never found in a lower position, neither has the test ever been discovered preserved in this conntry; associated with it are *Pholadomya Heraulti*, Ag., from which perhaps *P. carinata*, Ag., is not really distinct, and *P. Dewalquei (media* Dew. non Ag.) *Ceromya plicata*, a more rare shell also occurs, and *C. striata (Cardita*, Sow.,) which is probably only the young condition of the former species. Of the Brachiopoda, *Terebratula globata* is in immense abundance, exhibiting several varieties of form, and occupying certain thin layers of rock, together with the smaller and more

elongated variety of *T. carinata* and *Rynchonella angulata; Nuclcolites sinuatus* and *Holectypus depressus*, are the prevailing Echinoderms. The quarries near to the Bear Inn, Rodborough common, exhibit the Pholadomya grit under the aspect of several beds of hard brown sandy limestone, with few fossils, and occasional concretionary masses at the junctions of the beds, the upper portion of the grit being occupied by clusters of *Terebratula globata*. The higher quarry at Culver Hill, on the western declivity of Minchinhampton common exhibits a similar section; altogether the Pholadomya grit is about 15 feet in thickness, divided into several beds of hard rubbly brown limestone, the Brachiopoda alone having their tests preserved.

The following sections illustrate the varied features of the Spinosa stage:—

Section in a Pit at the summit of Whites Hill, near to Randwick.

	ft.	in.
1. Trigonia grit, consisting of hard flaggy bands, with *T. costata*, and valves of *Ostrea*	4	6
2. Gryphite grit; thinly laminated argillaceous limestone, and shale with a profusion of the *Gryphœa Buckmani*	4	6
3. Compact brown stone in three layers, with *Trigonia costata*	2	0
3*a*. Concretionary brown rock in several layers, the base not exposed	3	0

Numbers 3 and 3*a*, probably are the equivalents of No. 3 of the Leckhampton Hill section.

Section at Scar Hill, near Nailsworth.

	ft.	in.
1. Brown oolite, partially disintegrated by atmospheric action	4	0
1*a*. Sandy, concretionary oolite abounding with *Terebratula globata*	1	0
1*b*. Four beds, the upper portion of each consisting of brown concretionary rock, with *Myacites subelongatus*,		

	Gresslya abducta, and *G. conformis* in the state of casts	7	0
1c.	Trigonia grit in two beds, the upper stratum, one foot thick, is loaded with casts of *Trigonia costata*, *Rynchnella spinosa*, *R. angulata*, *Myacites tenuistriatus*, together the Gresslyas above mentioned	3	6
2.	Sandy grit, shelly, in two beds, but without the characteristic Gryphite	3	6
4.	Highest bed of the Fimbria stage consisting of hard cream-coloured fine grained limestone, bored with small vertical tubes in vast profusion. (No fossils.)	2	0
6.	Thick bedded oolite freestones, quarried for building purposes, of which the second bed is very compact and shelly, with numerous sections of *Nerinæa;* portion exposed	15	0

CHAPTER VI.

THE INFERIOR OOLITE; GENERAL REMARKS.

Comparison of the Cotteswold Inferior oolite, with the same formation at other British localities.

The Cotteswold region, in its oolitic deposits and fauna, constitutes a distinct marine area or province in the ancient Jura sea of England, the result, it would appear, chiefly of bounding hydrographic conditions: in its north-eastern extension, towards the midland and northern counties, the change of deposits and of the fauna is gradual, but in its opposite extension, towards Somerset-shire, the transition is abrupt; the Carboniferous rocks of the Bristol coal field nearly sever the connection between the Cotteswoldian and the more southern area, and it is to such a physical barrier existing at the oolitic period, and bounding the southern limit of the Cotteswoldian marine province, that may be ascribed the very different physical conditions of the two seas. In their minor sub-divisions, the two series of deposits are essentially distinct; the fauna likewise, both of *Mollusca* and *Radiaria*, present upon the whole some remarkable differences, which extend not only to varieties in the aspect of species,

but to distinctions in species, and even to the proportions of the higher divisions of genera and familics, so that on passing southwards across the small area of the Bristol coal field, there is found at Dundry a succession of oolitic beds, and an assemblage of testacea remarkably unlike those of the neighbouring Cotteswolds. It will be perceived, therefore, that in confining this hand-book to the region of the Cotteswolds, it embraces the natural history limits of a distinct ancient marine province of the lower oolitic sea, and the consideration of this fact should induce collectors to keep the fossils of the southern or Mendip area distinct from those of the Cotteswoldian, in order that a correct appreciation may be formed of the association of species, or general *facies* of the fauna over both regions.

At Dundry the quarries are capped with ragstone, which seem to belong to the Spinosa stage; this is underlaid by useful building freestones and by sandy oolite, in all nearly 50 feet thick, which probably represent the Fimbria stage; beneath is the celerated fossiliferous bed, so remarkable for the large number of testacea, embracing all the great subdivisions of the Sub Kingdom Mollusca preserved with great delicacy. The Cynocephala stage is here represented by only half a yard of sands overlying the upper lias clay. Considering the position of the Mollusca bed beneath the freestones, and overlying the Cynocephala stage, it may approximately be placed upon the parallel of the Cheltenham ferruginous pisolite. From the lower portion of the sandy oolite near to this spot, Mr. Moore*, of Bath, obtained and described

* Proceedings of the Somersetshire Archæological and Natural History Society, 1856.

a curious series of minute Brachiopoda of the genera *Thecidium*, *Spirifer*, and of a new genus *Zellania*, the greater number of which have not been found at any other locality.

In Northamptonshire, near Wellingborough, the Inferior oolite (red rock) is worked for iron ore, the proportion of iron in the deposit much exceeds that of the ferruginous pisolite; shells are few, and Ammonites appear to be altogether absent. In Lincolnshire this red rock, and the deposits which overlie it, have been illustrated by my friend, Professor Morris,* in an interesting communication to the Geological Society. The evidence presented in this memoir demonstrates the general local character of these deposits, and their distinctness from those of the Cotteswold region on the one hand, and of Yorkshire on the other; they have been placed provisionally upon the horizon of the Great oolite, but their marine fauna would seem rather to connect them with the Inferior oolite, and this remark will also apply to the fossils of the Collyweston states. In these local and uncertain succession of clays, shales, and argillaceous limestones, we do not recognize the pelagic deposits of the Cotteswolds, but rather sediments accumulated in a gulf or *sub-estuarine* marine province, characterized by an entire absence of Cephalopoda and paucity of *Brachiopoda;* the *Gasteropoda* and *Conchifera* presenting a multitude of individuals, and only a moderate number of species and genera; the presence of a few land plants in the shales tend to connect these deposits with those great estuarine series on the Yorkshire coast, which must next be adverted to. The lofty cliffs between Scarborough and Whitby, present

* Quarterly Journal of the Geological Society for November, 1853.

a succession of dark-coloured sandstones and shales, with land plants, placed between the Cornbrash and the Upper Lias, upwards of 600 feet in thickness; certain smaller calcareous deposits occur, containing strata of marine shells.

The lower shelly group which immediately overlies the Upper Lias is termed Dogger or Inferior oolite; it consists of dark-coloured coarse sandstones, and rubbly argillaceous limestone, the seams of testacea occupying only a very small portion of the mass; the lower beds appear to represent the Cynocephala stage of the Cotteswolds, and has produced several of the well-known Ammonites of that stage; the upper portion has a stratum, charged with testacea in such profusion, that it is impossible to expose specimens without destroying others; this crowd of Gasteropoda and Conchifera contains a large proportion of species identical with Cotteswold Inferior oolite forms, together with others proper to the locality, the Cotteswold species being such as pertain for the most part to the Fimbria stage, or are not known to occur higher than the oolite marl; *Trochotoma calix*, *Trochus monilitectus*, *Gervillia tortuosa*, *Gervillia lata*, *Opis gibbosus*, and *Acteonina glabra* are examples. From the Dogger upwards a vast series of estuarine beds, with seams of coal and land plants occur even to the Cornbrash. An intercalated bed of grey limestone, referred by Phillips to the Great oolite, contains a considerable series of testacea, including many forms which in the Cotteswolds characterize the Spinosa stage; *Rhynchonella spinosa*, *Hinnites abjectus*, *Unicardium depressum*, *Perna rugosa*, *Ostrea Marshii*, *Isocardia cordata*, *Pecten demissus*, occur in this bed, other forms pass upwards into the Cornbrash, so that upon the Yorkshire coast the lower Jurassic rocks present an uninterrupted

series from the Lias to the Cornbrash, in which the Fuller's earth, Great oolite, and Forest marble of the south and west of England, are altogether absent, and are not represented by any equivalent deposits.

PALÆONTOLOGY, GENERAL REMARKS.

Every portion of the formation exhibits marine conditions, unmixed with estuary or fluviatile deposits, there is also an entire absence of those finely laminated shales which preserved in so perfect a manner the Liassic marine reptiles and fishes; even detached bones are rarely met with, and palatal teeth are almost eqnally rare. No great coral bed occurs, but detached corals are not uncommon, more especially in the Spinosa stage; *Echinodermata* are often found associated with the larger coralline deposits, but they do not accompany the thin coralline stratum which underlies the oolite marl, neither does the Spinosa stage contain any *Calcaire a Polypiers* as it does in France.

Judging from the general character of the oolitic freestones, and of their including shells, it is probable that these beds whether ferruginous or otherwise, were formed in an open sea of considerable depth; the beds of building freestones, each of which is 5 or 6 feet in thickness, and homogeneous in structure strongly corroborate this view; a single valve of a *Terebratula* or *Lima* disclosed by a section of one of these thick masses. in its solitary and drifted condition, illustrates the pelagic aspect; the Leckhampton Hill shelly beds appear to have originated in a local and very different condition in which the numerous shells are dwarfed in a remarkable manner. A general comparison of the Inferior oolite testacea with

that of the formation which immediately preceded it, affords some curious results. Of the classes of Mollusca, *Conchifera* is that which more especially commends itself to the Geologist, from the mere force of their numbers and their very general distribution, scarcely a shelly bed can be found, whatever its mineral character, in which the valves of *Conchifera* do not constitute the greater portion of the organic contents; even in the *Ammonite* beds their valves are abundant, and very frequently they have entire possession of the floor of the sea. The *Gasteropoda* are far less common in the number of individuals, and their distribution is also to a great extent localized. The *Brachiopoda*, whose tests are everywhere better preserved than the other Molluscous tubes are also eminently local in their distribution, so that a collector well acquainted with these local peculiarities of form, dimensions, and general aspect, will be able to declare not only the horizon but also the locality of very many of the Cotteswold *Brachiopoda*, when they may be heedlessly thrown together; these testacea have the further peculiarity, that they commonly occupy exclusively some particularly thin stratum of sandy or concretionary marl, and in such instances the *Brachiopoda* are usually co-extensive with the stratum. *Ammonites*, which by general consent have been regarded as the organic forms peculiar to certain horizons, and whose species have probably a smaller vertical range than other genera of Mollusca, are nevertheless so far localized that the mere presence of a particular bed will not insure their occurrence, and, moreover, the number of these ammonite beds is exceedingly few in the Jurassic rocks. The *Echinodermata* can scarcely be expected anywhere to characterize a particular stage or formation;

they are never sufficiently numerous in the Jurassic beds, very commonly they are found only in fragments, or if the entire test is present, the delicate features which in their aggregate, form distinctions, are too freqnently only partially seen or disengaged from the matrix, so that even the genus in such instances cannot be determined. It follows, therefore, from a consideration of these circumstances, that the *Conchifera* constitute the most general and useful guides to the position of beds, and that although certain species have a very considerable stratigraphical range, there are many others which are only found within very small vertical limits; it also rarely happens that a species passes upwards from one formation to another without undergoing a certain amount of change in its figure or aspect, by which its geological position may be recognized. Take as an instance *Astarte excavata*, found in the Frocester Hill beds; in the freestones; in the argillaceous limestone bed which underlies the oolite marl, and in the Gryphite grit; in each of these four positions it acquires a very striking difference of aspect, the third variety being repeated, very slightly modified in the Great oolite; it would be easy to select a single specimen from each position, from inspection of which any person unacquainted with the history of the shell might be induced to regard as so many species, but the use of terms employed in conchology would fail to convey any sufficient idea of these variations of form and surface markings, unless accompanied by numerous figures. The *Trigonia striata* of the Cynocephala stage, with its few and widely separated varices, is at once distinguished from the shell of the Spinosa stage, and still more so from that of the freestones in which the shell is dwarfed, and the

varices crowded upon a figure unusually flattened. That interesting and varied genus, *Cardinia*, so conspicuous in the Liassic fauna, finds no representative in the Cynocephala stage; the singular and massive form *Hippopodium* has also disappeared, to be replaced by a certain modification of the genus *Astarte*, which has all the attributes of *Hippopodium*, excepting the hinge teeth, which are large and well defined; *Astarte rhomboidalis*, and two other allied species, have the *Hippopodium* like figure. The *Ostreidæ* will be found to have undergone some changes, *Placunopsis* a form intermediate *Placuna* and *Hinnites* is here first seen sparingly distributed. *Hinnites* acquires from its numbers much importance, the flattened valve, more delicate than the other, was attached to other bodies, and is, therefore rarely detected. The *Aviculidæ* have the addition of *Pteroperna*, a form with small anterior teeth and posterior longitudinal grooves. *Gervillia* has several additional species, including the two very inequivalve forms, *G. Hartmani*, and *G. tortuosa*. *Trichites*, a genus not recognized lower than the Inferior oolite, acquired large dimensions and was abundant in the Spinosa stage; inequivalve, with the test thick and fibrous, it had close filling valves, but the absence of the inner or nacreous layer of the test, prevents our acquiring any sufficient knowledge of the inner surface. The *Arcadæ* have an addition in *Macrodon*, which appears to have the same relation to *Arca* that *Pteroperna* has to *Avicula*. *Trigonia*, altogether absent in the lias of the middle and south of England, is represented by no less than 16 species in the Inferior oolite of the Cotteswolds; the student should acquire a knowledge of these interesting forms, nearly the whole of which characterize this formation.

Opis occurs in moderate abundance, both in the Cynocephala stage and in the Inferior oolite. Rodborough Hill has produced a stout and well marked species *(O. cordiformis)* very abundantly. *Corbis*, which is unknown in the English lias, occurs in the Inferior oolite, both in the typical form, and in that of the two subgenera *Sphæra* and *Corbicella;* the former has a subglobose figure, the latter is more flattened and elongated, both are destitute of the sculptured surface which is always seen in *Corbis*. Rodborough Hill has produced two species of *Corbicella* in great numbers. *Tancredia (Hettangia Terq.,)* of which the Lias in France has produced upwards of 12 specics, has not been found lower than the Cynocephala stage in this country, a single example from that stage is in the cabinet of the author. The freestones have produced two species, one of which, *T. axiniformis*, is common at Leckhampton, some of the more flattened forms of this genus are only slightly separated from *Corbicella;* Rodborough Hill has produced the typical shell *T. donaciformis* in great numbers. *Cyprinidæ*, this extensive family, which in the Lias is represented almost entirely by *Cardinia* and *Hippopodium*, undergoes in the Inferior oolite a total change; these Liassic genera are replaced by *Astarte*, *Opis*, *Myoconcha*, and *Isocardia*. In the "*Tellinidæ*" should probably be placed the genus *Quenstedtia*, which approaches *Psammobia* in its general figure, but the siphonal flexure is smaller, the dentition is distinct, and it has not the elevated nymphal callosity of that genus (see note in the Appendix). Rodborough Hill has produced it somewhat rarely. The *Anatinidæ*, of which the lias had a moderate number of forms, acquired a much greater development in the Inferior oolite, probably in no other

part of the Jurassic rocks are they so largely represented as in the Spinosa stage. *Pholadomya*, *Gresslya*, and the smaller *Myacites*, are the prevailing fossils, these were eminently gregareous; *Ceromya*, *Goniomya*, and *Anatina*, were not grouped together, and are much more rare. The *Gasteropoda*, compared with those of the lias, present a general increase in the genera; in the Department of Calvados, and in Somersetshire, the Inferior oolite has a beautiful and varied assemblage of the genus *Pleurotomaria*, a form which is comparatively rare in the Cotteswolds, and exemplified by few species; in fact the Gasteropoda generally are rare in the Cotteswolds, the genera and species presenting only a very limited number of specimens, *Alaria*, *Acteonina*, *Bulla*, *Cylindrites*, and *Pileolus*, may be thus designated; some of these forms present a near approximation to the numerous Gasteropoda of the Great oolite, but their local and rare occurrence detracts from their value as Geological guides. The Brachiopoda in their general features are but little distinguished from those of the Lias, and with one minute exception, the genus *Spirifer* is no longer found. In the Cephalopoda the *Ammonites*, if we exclude those of the Cynocephala stage, (which, from their exceptional position, cannot be included with the Inferior oolite testacea,) are comparatively rare, so that above the boundary of the Cynocephala stage we nearly take leave of them altogether; the freestones, and more especially the lower ferruginous beds, produce a few isolated specimens of *A. Murchisonæ*, of *A. Garantianus*, and of another undescribed species; in the Spinosa stage a few specimens may be obtained of *A. Parkinsoni*, *A. Martinsii*, and *A. Tessonianus?* a *Nautilus* is also one of the more

rare forms. The *Echinodermata*, notwithstanding the considerable number of genera and species which have been obtained, are by no means common in the Cotteswolds, always excepting the small *Cidaridæ*, which crowd the ferruginous Cheltenham pisolite, but of these few are well preserved.

CHAPTER VII.

THE GREAT OOLITE.

SOUTH WEST. NORTH EAST.

CORNBRASH.

Flaggy limestone, with bands of brown or blue marl and clay.

FOREST MARBLE. *Obliquely laminated oolite, and bands of marl.*	FOREST MARBLE.	FOREST MARBLE *Obliquely laminated oolite, and bands of marl.*
	Bradford Clay.	
FOREST MARBLE.	FOREST MARBLE.	FOREST MARBLE.
Thick bedded pale oolite.	*Shelly oolite or weatherstone.*	*Flaggy oolite and marls, at the base is the useful*
BATH STONE.	MINCHINHAMPTON STONE.	STONESFIELD SLATE.
	FULLERS EARTH.	
150 *feet thick.*	70 *feet thick.*	3 *feet thick.*

The diagram on the preceding page represents the subdivisions of the Great oolite, arranged in their order of parallelism and of superposition, as they occur over the region of the Cotteswolds. These several masses present distinctive petrographic features, which are of importance both to the Geologist and the Agriculturist. The zoological features of these several subdivisions, however, have a much greater affinity for each other than the stages of the Inferior oolite have been shewn to possess, so that a series of testacea, procured from any one of the subdivisions, will be found to be separated from the others by distinctions of very subordinate value, and to contain only those few additional forms of animal life which any distinct bed of the same stage may be expected to possess. From the foregoing conditions, both mineral and zoological, it may be inferred that these several subdivisions are really of less stratigraphical importance than the amount of their masses alone might lead us to suppose, that they represent only the varying local conditions of the bed of the Great oolite sea, and that the variations of the marine fauna which they disclose are to be attributed to the varying mineral character of the beds, to the depth of the sea, to the action of currents, to sub-estuarine deposits, and to all or either of those causes of local change, which a shallow sea not distant from the embrochures of rivers may be supposed to have been subjected to. It is only when the Great oolite acquires the character of a massive oolitic formation, nearly uniform in mineral character, almost destitute of testacea and of beds of clay, that we recognize a purely pelagic deposit, which may be expected to extend over a large area without much change. The only valid exception to the foregoing

remarks will be found in passing from the Forest Marble to the Cornbrash, when we at once meet with a profusion of forms of marine testacea, differing so materially from those of the Forest Marble and of the other subdivisions, that we at once recognize it as a distinct stage or sub-formation of the Great oolite. Basing our generalizations, therefore, upon the zoological characters of the deposits, we are led to the conclusion that the Great oolite should be arranged into two stages or fauna, and that all the subordinate groups of deposits older than the Cornbrash, constitute a single and lower stage of the formation.

THE FULLERS EARTH.

Of the rock masses of the Cotteswolds, that which is the most imperfectly known is the Fullers earth; destitute of useful beds of stone it is never quarried, and is only slightly and partially exposed in drains, well sinkings, small road cuttings, or by the mounds of detritus derived from railway tunnels. Constituting a wet tenaceous subsoil, it is well fitted for grass land, and is consequently very generally concealed beneath the green sod. Upon several accounts it is desirable that some knowledge of its mineral character, its position and boundaries should be acquired not only by the scientific naturalist, but also by the owner and occupier of land. Its presence will be found to influence to a great extent the character of the vegetation, and its composition determine the value of the land, and the kind of cultivation which is best suited to it. The supply of water also over the greater portion of the hill district of the Cotteswolds depends upon its presence and the character of its beds, for without it the high lands of the middle and southern Cotteswolds, like the great

central table land of Spain, would be a waterless desert, almost without trees or population. Composed almost entirely of beds of marl and clay, it has been preserved from denudation by its position, intermediate the two great porous rock masses of the Great and Inferior oolite. The term Fullers earth was chosen by William Smith to designate the entire deposit, from its having yielded at several localities the useful Fullers earth of commerce, but throughout the Cotteswolds it is very rare that any good Fullers earth can be obtained from it. The two great tunnel sections of Box, near Bath, and of Sapperton near Stroud, afford in their mounds of debris, the only considerable examples of the rock structure of the Fullers earth which are exposed to view. At the Box tunnel the Fullers earth is 148 feet in thickness, but throughout the southern Cotteswolds its thickness is certainly less than 100 feet, at the Sapperton tunnel it is 70 feet, and this latter amount will represent its thickness throughout the escarpments of the vallies in the Stroud district. Northwards from Stroud it decreases rapidly, so that in the hills to the east of Cheltenham it is believed to be reduced to an inconsiderable band of clay, forming a retentive stratum. It rarely happens that the Fullers earth approaches to the outer verge of the Cotteswolds, it forms usually a kind of terrace some distance in the rear of the outward range, forming a broken irregular surface, surmounted by the rock mass of the Great oolite; in the southern Cotteswolds more especially it assumes this position, and it is only by following inwards the transverse vallies, and more especially the interior vallies of the Stroud district, as the Chalford valley or the Woodchester valley, that we find a single great slope upon either side

of the vale, comprising all the rocks from the Lias to the Great oolite inclusive.

Composition. The Fullers earth consists of beds of brown, blue, or yellow clay, or of marls more or less compacted of similar colours, sometimes the marls become shaley, and there are usually several thin beds of very hard brown or chocolate-coloured coarse siliceous sandstone, or of hard rubbly argillaceous limestone, locally called "clay rag." The whole stage is free from ferruginous concretions, which so commonly deteriorate the clays of the Lias, and the water which percolates it with more or less difficulty, is free from that most common source of mineral impregnation and impurity. In the populous clothing district to the south east of Stroud, the course of the Fullers earth upon the flanks of the vallies is indicated by a zone of cottages, gardens, and orchards, which often afford a striking contrast to the barren slope of the Inferior oolite beneath. This association of population and fertility is due chiefly to the springs of water which are emitted from the junction of the Fullers earth with the Great oolite, and to the composition of the beds of the Fullers earth, which in such instances are usually marly. Land with a subsoil of this kind is less wet and cold than mere clay land, it more readily forms vegetable mould, and is more easily penetrated by the roots of trees and plants. Upon these marls the elm sometimes acquires a good size, and apple trees flourish to a considerable extent, but orchards upon the Cotteswold marls are never comparable to those upon the red, deep ground to the west of the Severn *(marls of the old red sandstone)*, even under the most favourable circumstances, and in other instances in which the substratum consists more

decidedly of blue shaley marls, or of yellow ochraceous clays, the results are very unfavorable; the soil is difficult to drain, it is very tenaceous of moisture, the fruit trees are dwarfed, moss covered and stag headed, the produce becomes uncertain and inferior in size and quality, nor is there ever seen the fine Prume Damson which is so productive in the hedge rows in the counties of Worcester, Stafford, and Warwick upon the marls of those districts *(marls of the new red sandstones)*. The broken and irregular surface, which is so conspicuous upon the slopes of the vallies of Chalford and Woodchester, with their lateral ramifying dells, is produced by landslips from the undermining action of water, and the sliding forward of the clay and marl over the steep slope of the Inferior oolite. These natural movements, elsewhere usually so disastrous in their consequences, are in the Cotteswolds on the contrary more commonly beneficial, in some instances eminently so. A layer of these marls spread over the porous barren slope of the Inferior oolite produces fertile ground; the porous rock beneath prevents the accumulation of water, and the stratum itself in its transit has been so much loosened in compactness as readily to be penetrated by the roots of trees; in such instances the surface which, without the landslip, would be almost destitute of soil, and fitted only for a beech thicket, is thus often tripled in value and becomes grass land, supporting orchards and trees of large growth. This sliding downwards of the Fullers earth in the Cotteswold vallies has occurred much more commonly and extensively than has commonly been supposed; the beauty and fertility of the vallies in the vicinity of Stroud, and of Wotton, are in a great measure due to this cause, for

beyond the limits of the Fullers earth the slopes of the Inferior oolite are usually very barren, and their aspects are fairly represented in the hills between Cheltenham and Birdlip, upon the flanks of Rodborough Common, or upon Stinchcomb Hill, where the surface of the Inferior oolite has not been subjected to any ameliorating influencies. In describing the Fullers earth as a water bearing deposit, it should be understood as only comparatively so when compared with the porous rock masses between which it is placed, for were it an impermeable clay, and capable of arresting all the water which flows through the Great oolite, the springs thrown out by the Fullers earth would be so general along its escarpments, and the quantity of water so great, that the valleys of the Cotteswolds would be amongst the best watered districts of the kingdom; that the contrary is the fact will be seen upon following the course of the Fullers earth at its boundary, and noting at how few places springs are discharged, and how insignificant is the quantity of water. The experience of well sinking fully illustrates the same fact, for it sometimes happens that after passing through the Great oolite, when the clay is reached. the *pound* as it is termed by the operatives destined to retain the water is permeable, rendering further sinking necessary until a more compact bed is attained, and it has occasionally been necessary to penetrate the marls 30 or 40 feet ere this has been accomplished. The Fullers earth has been recognized by its geological position and mineral character over some extensive districts of France, Switzerland, and Germany, under the name *Marmes des Ostrea Acuminata*, *Marmes Vesulienses*, and *Marmes à foulon.*

The organic remains are abundant locally, and in

certain layers; they are for the most part only indifferently preserved, and do not afford much variety. With the exception of numerous branching bodies impressed upon beds of stone. and which, probably, belonged to marine vegetation, they are confined to testacea. Banks of marl and clay are believed to have been formed near to the land, and such deposits are tenanted by certain genera of Mollusca; oysters more especially flourish upon such surfaces, and accordingly these beds have two species of that genus in enormous profusion, a single species only being found in the same bed and locality. A little crescentric shaped oyster, rather pointed at the extremities *(O. acuminata)*, is the prevailing fossil, and is equally abundant in the same deposit in Switzerland, there also, as in the Cotteswolds, certain laminated marls, and bands of hard limestone, are almost made up with its valves. Amberley, on the western border of Minchinhampton Common, exhibits a small bank loaded with the valves of this shell, and the mounds of blue laminated marls above the Sapperton railway tunnel abound with a larger and more irregular oyster, *O. rugulosa*, and also casts of *Homomya Vezelayi*, *Myacites calceiformis*, *Ceromya plicata*, *Avicula echinata*, *Pecten vagans*, *Sphœra Madridi*, and *Arca lata*. A variety of *Terebratula perovalis*, and *Rhynchonella concinna*, are the prevailing Brachiopoda.

CHAPTER VIII.

BATH STONE; MINCHINHAMPTON STONE; STONESFIELD SLATE.

This group of beds, or subdivision of the Great oolite, exhibits very dissimilar petrographic conditions upon the same horizon. The Bath group, which for the most part resembles the general character of the formation through France, may be described as a pale yellow oolite, nearly destitute of testacea, except upon a few horizons. The second or Minchinhampton group abounds with shelly detritus or with entire testacea, with much crystalline lime diffused through the beds. The third or Stonesfield slate group, which pervades the northern Cotteswolds, consists of an interpolation of clays, laminated marls and shales, either sandy or flaggy, between the more purely marine deposits. These very different geognostic features appear to be the result of different local conditions of the old Jura sea; extensive limestone deposits are usually regarded as affording evidence of pelagic conditions; clays and marls, on the contrary, appear to indicate the proximity of a shore or of an estuary, they are also usually less continuous and more variable than the limestones. The Great oolite limestone forms an elevated great plateau, which dips to south east with an inclination of 3 or 4

degrees, and gradually sinks down into the plain of Wiltshire; it is waterless, except at its junction with the Fullers earth which underlies it in every part of the Cotteswolds, the extension of the one deposit appearing to coincide nearly with that of the other. At the base of the Great oolite is usually found an inconsiderable bed of flaggy calcareous sandstone, or of shale, grey or blue, forming a kind of transition to the Fullers earth, and characterized in like manner by an abundance of the valves of *Ostrea acuminata*. On the western verge of Minchinhampton Common is a greater thickness of these flaggy beds, which have produced several species of the Anatinidœ, including the well known Fullers earth shells, *Homomya Vezelayi* and *Ceromya plicata*. This basement bed has sometimes been regarded as the equivalent of the Stonesfield slate, and it appears to agree with that bed in its geological position, but in its general features, both petrographic and zoological, are altogether distinct; in no instance has it been found capable of being divided into laminated tiles for roofing purposes, and the few testacea found in it are different from those of the Stonesfield slate. *Trigonia impressa* and *Gervillia acuta* are usually profusely scattered over the slabs of Stonesfield slate, remains of land plants and of fishes are also not uncommon, but at the base of the Great oolite, when a *Trigonia* occurs, it is the *T. Moretonis*, a common Great oolite species; these distinctions are such as would result from difference of marine conditions, the laminated flags of the Stonesfield slate being an estuarine, the other a more purely marine deposit, placed by its position beyond the area of mixed or fluviatile remains. The foregoing statement, that the Great oolite limestone is for the most

part destitute of fossils, correctly represents its *general* condition. To select one example. A large quarry, upon the summit of Wotton Hill, yields stones fitted for rough walls and for road mending, shells are absent, but there are not wanting many occasional layers of fine shelly detritus, together with single plates and spines of Echinoderms, joints of Pentacrinites, and, rarely, teeth of fishes. Sections, very similar in character, are met with commonly over the plateau of the Great oolite between Bath and Minchinhampton; oolitic limestones, forming beds of no great thickness, destitute of clay or marl partings, and without a trace of organic life, are commonly met with.

In other instances quarries, from which not a single perfect shell can be obtained, produce good thick beds of weatherstone fitted for building purposes, owing to the amount of shelly detritus, and of crystalline carbonate of lime disseminated through them; quarries of this kind have been worked near to the villages of Avening and Cherrington.

The shelly weatherstones which contain the well known Minchinhampton fossils, appear to extend over very limited areas in large useful blocks, and with testacea entire; thus it has happened that nearly the whole series of beds in one quarry are shelly, and produce large blocks of stone, and in another neighbouring quarry a large portion of the whole mass wanting these features is useless for economic purposes. The quarries upon Minchinhampton Common have been worked from ancient times, and afford extensive sections, their base commencing at the bed which immediately overlies the Fullers earth, and their vertical height is about 36 feet. It

should, however, be understood that the order of succession of the beds, and their petrographic features, will only be found to apply partially to other Great oolite sections of the same district. Even in the larger of the two quarries now used upon Minchinhampton Common, the uppermost or planking bed changes its condition very materially between the two extreme ends of the section, losing all its testacea towards its southern extension, and in the larger of the two quarries at Burley, little more than half a mile distant, the planking can no longer be recognized.

SECTION OF THE LARGER QUARRY AT MINCHINHAMPTON COMMON.

	ft.	in.
A.—Planking, consisting usually of several beds or divisions, a shelly coarse oolitic limestone; thin bedded in the larger, and thick bedded in the smaller quarry, the oolitic grains being only sparingly distributed. A tendency in the larger quarry for the beds to separate into thin divisions, which have a lengthened horizontal extension, accounts for the name of the bed. In the smaller quarry the lower planking bed is a very coarse deposit, containing *Purpuroidea*, *Pteroperna*, *Macrodon*, and other large shells; these disappear towards the southern end of the larger quarry, when the stone acquires a finer harder grain, and exhibits oblique lamination. Throughout both quarries the upper layers for a thickness of several feet become rubbly from atmospheric influences; at the base is usually a sandy parting	10	0
B.—Soft, pale yellowish thin bedded rubbly calcareous oolite, with occasional sandy partings. The absence of shells, and of crystalline carbonate of lime, throughout the greater portion of these thin beds, render them worthless for economic purposes, as they quickly disintegrate upon exposure to frost; the stone is therefore piled up, forming the refuse of the quarries. The lower portion has numerous laminated surfaces, strewed over with small valves of *Ostrea*, *Tancredia*, &c., passing gradually into the more compact and shelly bed beneath....	10 to 14	0
C.—Soft yellowish oolite, shelly, the testacea being arranged in layers which assume every kind of inclination, even within a short distance; numerous holes, bored by *Litho domi*, prevade it; the softness enables it to be sawed		

	ft.	in.
into ridge tiles and coping for walls, *oven stone* is the workman's term for this bed	6	0
D.—Weatherstone in two or three beds; greyish brown oolitic limestone full of shells, crystalline lime and shelly detritus, towards the bottom the stone acquires great hardness from the increased amount of the valves of oysters in the mass	6	0
E.—Basement bed, coarse grey or brown and blue hard argillaceous limestone, full of the valves of small oysters ..... 4 in. to	0	9

Upwards of 300 species of testacea have been procured from the quarries at this single locality; the greater number of these are found both in the lower and upper beds, others abound at particular horizons. The profusion of shells in certain layers towards the base of the soft oolite B, and occasionally in the planking A is excessive, the surfaces of some thin beds of the latter (a coarse rock) are strewed over with small spiral univalves of the genera *Nerinæa* and *Cerithium;* other univalve genera are *Nerita, Patella, Pileolus, Ceritella, Cylindrites, Trochus, Turbo, Trochotoma, Natica, &c.*, the bivalves most abundant are *Tancredia, Gervillia, Sphæra, Pecten, Lima, Arca, Limopsis, Ostrea, &c.* With these are found spines and plates of Echinoderms, fragments of Coral, crabs' claws, fishes' palates, fragments of wood, &c. Throughout the section generally, however, Conchifera constitute by very much the greater portion of the shelly mass, although in number of species they do not materially predominate over the Gasteropoda. Cephalopoda are rare, and consist chiefly of two specimens of Belemnites; the few Ammonites are usually broken, but the two species of Nautilus having been provided with stronger shells, have more frequently escaped injury. This paucity of the Cephalopoda throughout the Great oolite of the Cotteswolds, appears to be a

feature which obtains throughout the formation generally, both in England and on the Continent, there having never been discovered within it a bed of Ammonites, the few examples of this genus found in the shelly beds have evidently suffered from the rolling and attrition incident to the floor of a shallow sea, exposed to currents and to sudden changes in the direction of the moving forces. A large portion of the other testacea, both univalve and bivalve, have been rendered imperfect by the same causes, or their surfaces have been worn to such a degree as materially to obscure their distinctive features; the coarse portion of the planking more especially is characterized by these abraded shells; in univalves the preservation of the central pillar only; the imperfect outer lip, the rounded extremity of the broken apex of the columella, and the surface deprived of costœ, tubercles and striations are of constant occurrence; in bivalves, the valves of which are usually disunited, the amount of injury is usually less, being chiefly confined to the destruction of the surface ornaments. Echinoderms, entire in this kind of deposit, are rarely met with, and their general state of preservation is very bad; they are also dwarfed in size; star fishes are extremely rare, except in the condition of detached ossiculœ. Some layers of the softer beds B and C are strewn with a profusion of valves of the little *Tancredia brevis*, which is perhaps the most abundant bivalve in the formation; other layers abound with *Ostrea acuminata* or *Placunopsis socialis*. Those fine shells of the genus *Purpuroidea* do not occur at a lower horizon than the coarse planking in which they abound, associated with large examples of the Great oolite compressed variety of *Astarte rhomboidalis*, *Pteroperna costatula*, *Macrodon Hir-*

sonensis, Trigonia Goldfussii, Lima cardiiformis, Nerinæa Voltzii, N. funiculus, Trochotoma obtusa, Natica Michelini, N. intermedia, &c. In pursuance of our plan, the following list comprises those testacea only which are most abundant in the shelly limestones of this stage :—

Gasteropoda.

Alaria armata, Mor. & Lyc.
——— *hamulus*, Desl. sp.
——— *paradoxa*, Desl. sp.
——— *trifida*, Phil. sp.
Ceritella acuta, Mor. & Lyc.
——— *unilineata*, Sow. sp.
Cerithium quadricinctum, Goldf.
Cylindrites acutus, Sow. sp.
——— *altus*, Mor. & Lyc.
——— *cuspidatus*, Sow. sp.
Delphinula alta, Mor. & Lyc.
Eulima communis, Mor. & Lyc.
Monodonta formosa, Mor. & Lyc.
——— *Lyellii*, D'Arch.
——— *Labadyei*, D'Arch.
Natica Michelini, D'Arch.
Nerinæa Voltzii, Desl.
——— *funiculus*, Desl.
——— *Dufrenoyi*, D'Arch.
Nerita rugosa, Mor. & Lyc.
——— *cancellata*, Mor. & Lyc.
——— (*Neridomus*) *hemispherica*, Roem.
——— ——— *minuta*, Sow. sp.
Patella Aubentonensis, D'Arch.
——— *inornata*, Mor. & Lyc.
——— *cingulata*, Roem.
——— *rugosa*, Sow.
Phasianella elegans, Sow.
——— *Leymerieri*, D'Arch.
——— *conica*, Mor. & Lyc.
Pileolus lævis, Sow.
——— *plicatus*, Sow.
Purpuroidea glabra, Mor. & Lyc.
——— *Morrissii*, Buvig.
——— *nodulata*, Sow.
Trochotoma obtusa, Mor. & Lyc.
——— *conuloides*, Desl.
Trochus obsoletus, Roem.
——— *spiratus*, D'Arch.

Conchifera.

Arca æmula, Phil.

Arca Prattii, Mor. & Lyc.
—— *(cucullœa) cucullata*, Roem.
—— *(Macrodon) Hirsonensis*, D'Arch.
Astarte excavata, Sow. (var.)
——— *excentrica*, Mor. & Lyc.
——— *rhomboidalis*, Phil. sp.
——— *squamula*, D'Arch.
Avicula echinata, Sow.
——— *Pteroperna, costatula*, Desl. sp.
Cardium Stricklandi, Mor & Lyc.
Corbis (Sphœra) Madridi, D'Arch.
——— *(corbicella) Bathonica*, Mor. & Lyc.
Corbula involuta, Goldf.
Cypricardia cordiformis, Desh. var. Bathonica, Mor. & Lyc.
Cyprina Loweana, Mov. & Lyc.
——— *nuciformis*, Mor. & Lyc.
——— *trapeziformis*, Goldf. sp.
Gervillia monotis, Desl.
———— *ovata*, Sow. sp.
———— *socialis*, Mor. & Lyc.
Hinnites velatus, Goldf. sp.
Lima cardiiformis, Sow. sp.
—— *duplicata*, Sow. sp.
—— *impressa*, Mor. & Lyc.
—— *ovalis*, Sow. sp.
Limopsis ooliticus, Desl. sp.
Lithodomus inclusus, Desl. sp.
Lucina despecta, Phil.
——— *Bellona*, var. *depressa*, Mor. & Lyc.
——— *rotundata*, Roem.
Mytilus furcatus, Goldf.
——— *sublœvis*, Sow. sp.
——— *(Modiola) imbricata*, Sow.
Nucula variabilis, Sow.
Opis lunulatus, Sow. sp.
—— *similis*, Sow. sp.
Ostrea acuminata, Sow.
——— *gregarea*, Sow.
——— *rugulosa*, Mor. & Lyc.
Pecten clathratus, Roem.
——— *lens*, Sow.
——— *retiferus*, Mor. & Lyc.
——— *vagans*, Sow.
Placunopsis, Jurensis, Roem, sp.
———— *socialis*, Mor. & Lyc.
Tancredia axiniformis, Phll. sp.
———— *brevis*, Lyc.
———— *subcurtansata*, Mor. & Lyc.
———— *planata*, Lyc.
Trigonia costata, var. *pulla*, Sow.
———— *Goldfussii*, Munst.
———— *Moretonis*, Mor. & Lyc.

Brachiopoda.
Terebratula perovalis, (var.)
Rhynchonella concinna.

Echinodermata.
Hyboclypus caudatus, Wright.
Nucleolites. clunicularis, Llhwyd.
Pygaster semisulcatus ? (young) Phil.?
Acrosalenia hemicidaroides, Wright.
Diadema depressum, Ag.

Considerable as this list may appear, it little exceeds one-fourth of the entire number of species which have been figured and described* from the shelly weather-stones, and includes only such as, from their numbers, may be expected to occur at other and distant localities. The examples given in this work represent a few of the more special forms. At Bussage, a hamlet on the western verge of Bisley Common, the bed which represents the planking consists of white fine grained limestone, only slightly oolitic, in which testacea are preserved with great delicacy, but it is far from containing the large and varied assemblage found at our typical locality; the larger shells more especially are absent, including *Purpuroidea*. Certain layers of the white stone contain disunited valves of a short subglobose variety of *Terebratula perovalis* in great numbers, and almost to the exclusion of every other fossil; *Gervillia socialis* is another gregareous species, which occupies certain layers of the white stone in the same exclusive manner; very many species of the smaller testacea are preserved in this stone with great delicacy, more especially such whose ornamentation is minute, and in the bivalves certain forms, which have prominent rugose plications at Minchinhampton Common, are here smooth, delicate, and often dwarfed in size; *Patella rugosa* is no

* Morris & Lycett, Oolite, Mollusca. Polœont Soc. 1850-4.

longer rugose, and the greater number perished in the young state; *Trigonia costata* seldom measures more than 6 or 8 lines across, the *Arcas* are of similar dimensions, the specimens of *Opis*, *Macrodon*, *Pteroperna*, *Mytilus*, and *Astarte*, have a similar immature character. In these zoological features, and in the fine granular limestone which constitutes their matrix, may be recognized a tranquil marine deposit of some depth, and unaffected by those varying currents and sudden changes in the deposit which the Minchinhampton beds exhibit; an interesting fact, and in conformity with the observations of the late Professor E. Forbes, on the varieties of species which are induced by certain marine conditions, and exemplified by the fauna of the Ægean Sea. Other quarries of the shelly limestones may be examined at Brown's Hill, where the Conchifera are of unusually large size, but the stone is hard, and at Chalford Hill, which presents similar features; other localities are Cowcombe Hill, upon the opposite side of the vale of Chalford; Quarhouse, upon the hill north of Brimscombe; Burley, and at the Box, both in the parish of Minchinhampton. At the Box quarry (now disused) the hard thick bedded weatherstone has produced many fine specimens of large *Naticas*, and it may be stated, as a general rule throughout the district, that the larger shells of the Great Oolite are found only in the harder beds of rock; the superior size of the testacea having apparently been the result of an unusually large deposit of carbonate of lime upon the floor of the sea around them. It is a common occurrence to find isolated pebbles of hard calcareous freestone in the shelly beds of the formation, but at the Hyde, a hamlet one mile from Minchinhampton, a small road side section discloses a

conglomerate of the Great Oolite; the rolled calcareous hard pebbles having a matrix of pale fine grained limestone.

The Minchinhampton district of the Great Oolite consists, as will be perceived from the foregoing description of an uncertain series of oolitic and shelly limestones, variable in their petrographic features to a great degree, both in their horizontal and vertical extension, and altogether undivided by beds of clay or marl. Northwards, towards Bisley, the formation will be found to have undergone another and considerable alteration, and that the series of beds which overlie the Fullers Earth have, for the most part, acquired an argillaceous character, a large proportion of their mass consisting of beds of grey or brown marls, the beds of stone having a more sandy character, the whole constituting that third or North Cotteswold example of the Great Oolite, usually known by the name of the Stonesfield Slate.

A line, drawn eastwards from the ancient village of Bisley, will nearly represent the boundary between the argillaceous or Stonesfield Slate series to the north, and the limestone to the south; the absolute passage of the one into the other is nowhere fully exposed, but in one instance, much to the south of the line indicated, a state of transition may be noticed. At Quarhouse, to the north of the vale of Brimscombe, is an ancient quarry long disused, and now partially filled up, which exposes in its upper part a thick deposit of grey marls and sandy shales, about 15 feet in thickness, which reposes upon several beds of hard weatherstone. The Stonesfield Slate series of the Bisley district is exposed in quarries which are worked for roofing tiles, at Througham, two miles north

of Bisley, and also about one mile to the westward of that spot. It consists of an indefinite series of grey and brownish thin bedded flaggy oolite, alternating with thicker beds of marls and shales of similar colours; the bed which is raised for roofing tiles is about two feet in thickness; when first raised it is compact, but upon exposure to frost it readily divides into thin laminæ. The surfaces thus exposed are not very fossiliferous in the Bisley district, small valves of *Oysters* and of *Rhynchonella concinna* are common, and more rarely the characteristic *Trigonia impressa*. The roofing tile thus obtained is lighter and neater than that of the Forest Marble, but is much less durable; in some instances the tile continues to separate layers after having been placed upon the building, and the aspect of roofs thus composed is often that of exfoliation and decay; the darker colour, finer grain, together with the greater thinness and flatness, distinguishes its aspect from that of the heavy flags of the Forest Marble; both kinds being extensively used in their respective neighbourhoods. Similar quarries at Sevenhampton and Eyeford have been described by Messrs. Buckman and Strickland, in their edition of the Geology of Cheltenham, and since the publication of that work other sections similar in character have been exposed on the road from Cheltenham to Stow. The most striking feature in these sections is the variability in the succession of the beds, so that scarcely any two sections are exactly alike in this respect. The shales and flags are very fossiliferous, *Trigonia impressa* and *Gervillia acuta* are nearly equally abundant, the large *Lima cardiiformis*, *Pecten vagans*, *P. lens*, *Arca Prattii*, *Cerithium quadricinctum*, *Nerita rugosa*, and *N. minuta*, are the forms

which most commonly occur, but only a small number of species can be procured sufficiently well preserved for comparison.

Alternating with this marine fauna, are shales which have more of an estuary character; remains of plants are common, and the researches of the Rev. P. B. Brodie have resulted in the curious discovery of well preserved remains of insects of the following families; *Blapsidæ*, *Buprestidæ*, *Coccinellidæ*, *Pimpelliidæ*, and *Prioniidæ*. The occurrence of the fragile portions of insects in these shales afford an unerring proof of the tranquil nature of the deposit, and of its sub-estuary character. The perfect preservation of beautiful specimens of star fishes *(Astro pecten Cotteswoldiæ)* tend forcibly to the same conclusion. Under the general aspect of the Stonesfield Slate series, and overlaid by Forest Marble, the Great Oolite extends eastwards, across Oxfordshire, following the general line of the outcrop of the Lias, through a district full of Geological interest, but beyond our assigned limits.

CHAPTER IX.

THE UPPER PORTION OF THE GREAT OOLITE. THE BRADFORD CLAY. THE FOREST MARBLE.

At a position apparently varying from about 60 to 80 feet above the Fullers Earth, and extending over a large portion of the Great Oolite district of the Cotteswolds, there occurs a remarkable change in the lithological character of the formation, comprising a series of beds so persistent in their aspect and extension, that they can readily be recognized wherever they are present. The variable oolitic beds, with oblique lamination, or in other localities marls and flaggy bands of stone, are succeeded by a thick bed of hard white or cream-coloured limestone; in a district nearly destitute of any good road stone, the superior hardness of this bed has caused it to be extensively employed for that purpose, consequently its fossil contents can readily be studied by examining the heaps of road stone wherever it is found. As a limestone it is more homogeneous in its structure, and less impure than any bed in the Cotteswolds, constituting a good material for the lime kiln. At its western escarpment, which passes through the village of Avening northwards to Minchinhampton, and upon the western border of Bisley Common,

its position may frequently be detected by an abrupt step like ledge which it presents upon the surface of roads; at Bussage it has been largely quarried for lime, also at Cowcombe, and near to Cirencester on the Stroud road; the deep cutting at the eastern extremity of the Sapperton railway tunnel exposes it about the middle of the section. The white limestone is the basement bed of a series of limestones which, in passing upwards, become browner, less compact, and generally less distinctive in their aspect; at Sapperton tunnel they are at least twenty feet in thickness, and, judging from several well sinkings, it would appear that some additional beds of a similar character were super-imposed ere there occurred a repetition of the marine conditions which obtained over the lower Great Oolite series. At about 100 feet above the Fullers earth, there re-appears irregular bands of marls and sandy partings, the beds of stone become very irregular in thickness and lamination; shelly detritus reappears occasionally, *Brachiopoda* and *Echinodermata*, or fragments of the latter are common; the former represented by *Terebratula maxillata* or *Rhynchonella obsoleta*, the latter by *Nucleolitrs Solodurinus* or *N. clunicularis*, and the entire aspect agrees with that of the Forest Marble. The white limestones are upon the whole remarkably destitute of organic remains, at Bussage and at Cowcombe, a small area of the hard basement bed is crowded with the fine *Pachyrisma grande*, Mor. & Lyc., associated with *Natica Michelini*, *Natica grandis*, *Purpuroidea Morissii* and *P. nodulata*. The shells have their tests preserved, converted into crystalline lime much softer than the hard investing granular limestone, and therefore very difficult, and frequently impossible, to separate from the matrix; disintegration by the action of

frost affording the only possible means of obtaining them. The persistency in the range and mineral character of these limestones, the absence of oblique lamination, of shelly drift, and of seams of marl, indicate that they were formed in a sea deeper and more tranquil than that of the shelly weatherstones and of the Forest Marble, the general condition being that of an entire absence of organic remains.

An exception to this general barrenness occurred in a quarry now disused, two miles east of Minchinhampton, and worked for road stone; the uppermost bed of limestone, sandy and buff coloured, produced the following shells stated in their order of abundance. *Phalodomya socialis*, *Lucina Bellona*, (a shell often mistaken for *L. lyrata*, Phil.) *Ceromya concentrica*, *C. Symondsii*, *Cyprina Loweana*, *Purpuroidea Morrissii*, *P. nodulata*, *Nerita rugosa*, *Nerinæa funiculus*, *Alaria armata*, *A. paradoxa*, *Ceromya undulata*, *Cardium pes-bovis*, *Goniomya litterata*.

The extreme variability and absence of continuity in the marl and clay beds which divide the flaggy beds of the Forest Marble, has recently induced the officers of the Geological Ordnance Survey to select a boundary between that rock and the Great Oolite, more persistent in its character than that of the Bradford Clay, and for this purpose they propose to regard the uppermost of the limestone beds as the termination of the Great Oolite; a change of base line will extend the Forest Marble downwards to a lower horizon than that of the bed which is regarded as the equivalent of the Bradford Clay. This proposed arrangement, it should be understood, is one of convenience only, and is altogether independent of zoological considerations. The most extensive sections of

the beds which overlie the limestones, are those upon the Great Western Railway, near to the Tetbury-road station, these disclose a considerable series of thin bedded oolite and marls, characterized by the usual features of oblique lamination and occasionally shelly detritus, the marly bands containing Serpulœ and Brachiopoda; a road side section adjoining the same station discloses the Bradford Clay with the characteristic, *Terebratula digona*, *T. orbicularis*, *T. maxillata*, *T. coarctata*, *Avicula echinata*, *Pecten hemicostatus*, *Serpulæ*, *small smooth Terebratulæ*, dwarfed specimens of *Trigonia costata*, two species of small *Cidaridæ*, casts of *Cypricardia rostrata*, and a number of other small testacea, Gasteropoda being almost entirely absent, nor are there any remains of *Apiocrinites*, which are so characteristic of the clay at Bradford. Organic remains are for the most part only sparingly distributed throughout the Forest Marble, stems of *Apiocrinites* badly preserved and decapitated are not uncommon. At Chavenage, near Tetbury, are pits from which roofing tiles are raised; unlike the Stonesfield Slate, the hard flaggy stone does not split into thin laminœ by the action of frost and only requires to be dressed with a hammer. The surfaces of these flags abound with valves of small *Oysters*, *Pectens*, *Rhynchonellæ*, *Limæ*, &c., all much compressed and distorted. The increasing use of slate has much lessened the demand for this heavy kind of covering, its weight being fully three times that of slate; the tile, however, possesses much advantage in point of comfort compared with slate, as it is a much worse conductor of heat, the upper parts of houses covered with the stone tiles are much less exposed to the vicissitudes of the external temperature. Various quarries in the vicinity of Cirencester, Tetbury, and Avening afford

sections of the Forest Marble, the large impressions upon the flaggy beds called ripple mark is of very general occurrence. The several fossiliferous horizons of the Great Oolite and Forest Marble are ascertained with tolerable precision by the aid of well sinkings, all of which pass down to the Fullers Earth, but in the upper portion of the Forest Marble the wells sometimes only reach the first retentive bed of clay, and as the position and extension of these is variable, they afford no certain guide to the thickness of the entire stage. From the foregoing sketch of the organisms of the upper portion of the Great Oolite, and of the Forest Marble, it will be perceived that they do not constitute an assemblage distinct from that of the Minchinhampton stone, and that there are only a small minority of species which are not found at the lower horizon of Minchinhampton Common.

CHAPTER X.

THE CORNBRASH.

The Cornbrash, strictly speaking, does not occur within the hilly region of the Cotteswolds, it is only when the Forest Marble sinks down into the plain of Wiltshire, that the general boundary line of the Cornbrash is attained. In Gloucestershire it is only recognized as an outlying portion of a larger mass, and much denuded, 2½ miles south east of Cirencester, on the road to Cricklade, only a few feet in depth is quarried to obtain the thin bedded, hard, flaggy, coarse brown stone, for rough walls and for road mending; several limestone beds of this description, alternate with bands of brown or grey marls. Here, as in Wiltshire, the whole series abounds with fossils, more especially with Brachiopoda and with the fossil Anatinidœ, the latter are usually badly preserved, and have undergone so much compression and distortion, that the discrimination of species (often very difficult with the Anatinidœ) can only be attempted in a small number of examples; the number of species in this family may, therefore, possibly be more considerable than is indicated by the following list, in which all undetermined or doubtful species are excluded. Species, with a * affixed to them,

are likewise found in the lower stage of the Great Oolite in the Cotteswolds,—

Very abundant.

- **Terebratula intermedia.*
- *———— *maxillata.*
- ———— *obovata.*
- *Gresslya peregrina*, Phil. sp.
- *Myacites securiformis*, Phil. sp.

Less abundant.

- ———— (*Homomya*) *gibbosa*, Sow. sp.
- *———— *calceiformis*, Phil. sp.
- **Ceromya concentrica*, Sow. sp.
- **Pholadomya Heraulti*, Ag.
- **Lima duplicata*, Sow sp.
- *—— *cardiiformis*, Sow. sp.
- *—— *pectiniformis*, Schlot. sp.
- **Modiola Sowerbii*, D'Orb.
- **Avicula echinata*, Sow.
- **Nucleolites clunicularis*, Ag.

Comparatively rare.

- **Trigonia costata* (var.)
- **Astarte excavata*, Sow.
- **Goniomya litterata*, Phil. sp.
- **Gervillia crassicosta*, Mor. & Lyc.
- *Modiola bipartita*, Sow.
- **Avicula costata*, Sow.
- **Cardium Buckmani*, Mor. & Lyc.
- **Pecten lens*, Sow.
- *———— *vagans*, Sow.
- **Nucleolites sinuatus.*
- *———— *orbicularis.*
- **Holectypus depressus.*
- **Acrosalenia hemicidaroides*, Wright.
- **Diadema depressum.*

An examination of the foregoing list will render it evident that the Cornbrash testacea are by no means disunited from those of the Great Oolite, and that they clearly form a portion of that assemblage. The marine conditions of this stage appear very much to have resembled those under which the upper stage of the Inferior Oolite was formed, and accordingly there will be found to exist a very similar association of *genera* in both cases, there are also a considerable number of *species* common to

both formations, but in the very great majority of such instances the identity will be found to be confined to species which are known to pass upwards through the Great Oolite of the Cotteswolds. The great resemblance, therefore, between the Cornbrash and the Inferior Oolite testaceous assemblages, depends upon the fact that the Cornbrash series consists *for the most part of a portion of those Cotteswold forms which have a great stratigraphical range, and pass upwards through the Great Oolite.*

PALÆONTOLOGY OF THE GREAT OOLITE.

General remarks. The several rock masses of the Great Oolite have been shewn to consist of deposits which were formed under very different conditions of the old Jura sea, and each has accordingly been tenanted by certain families and genera of testacea, which have been found associated with particular petrographic conditions. Thus the great family of the fossil *Anatinidæ* are found almost exclusively in argillaceous deposits, as in the argillaceous limestone of the Spinosa stage in the Inferior oolite; in the clays and marls of the Fullers earth; in the argillaceous beds of the Cornbrash; in the clays and shales of the Oxford Clay. The occurrence of this family in the Great Oolite limestone is local only, and limited to an occasional seam of sandy marl or marly limestone, which is usually occupied by a single species of *Phalodomya*, such situations being quite distinct from, and usually distant from the shelly weather-stones of the Great Oolite. These shelly deposits have produced in the Minchinhampton district upwards of 80 genera of Gasteropoda and Conchifera, and it is remarkable that in so large a number only 9 genera occur, which are not also found in the Inferior Oolite of the Cotteswolds,

and only 2 of the 9 genera are represented in the Great Oolite by more than a single species. These genera are—

Purpuroidea.	*Umbrella.*	*Limopsis.*
Pteroceras.	*Stomatia.*	*Thracia.*
Deslongchamsia.	*Pachyrisma.*	*Pholas.*

But although the genera of Mollusca in the two formations are nearly all alike, the comparison, when applied to the species, produces very different results. The Great Oolite of the Minchinhampton district has produced—

	Species.		Species.
Gasteropoda	165		20
Conchifera	171	Of which are found in the Inferior Oolite.	45
	336		65

So that 22 per cent. are common to both formations in the Cotteswolds. Possibly some few additional species may eventually be ascertained to occur in both formations, but their numbers cannot materially affect the conclusion, that the same genera are represented for the most part by different species in the Inferior and Great Oolite. Even of the 65 species which pass upwards into the newer formation, there are some which re-appeared as *varieties*, whose aspect is sufficiently distinguished from those of the Inferior Oolite; *Trigonia costata*, *Astarte excavata*, *A. elegans*, *Cypricardia Bathonica*, *Trichites nodosus*, *Modiola Sowerbii*, *Lima gibbosa*, *Myacites calceiformis*, *M. dilatus*, *Lucina Bellona*, *Turbo capitaneus*, *Pteroperna costatula*, *Astarte rhomboidalis*. The Cephalopoda and Brachiopoda are too few in number of species to form good elements for comparison, and the Echinodermata, although affording some species identical with Inferior Oolite forms, are greatly dwarfed, and their usual state of preservation is but indifferent.

CHAPTER XI.

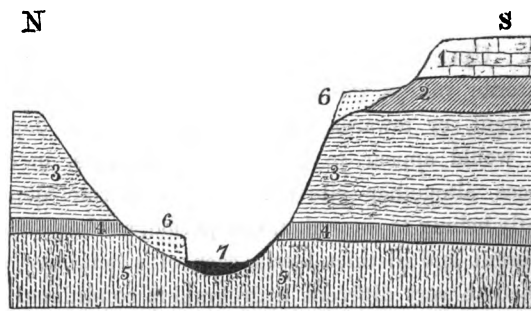
FLUVIATILE, ESTUARY AND MARINE DRIFTS.

The surface of the high table land of the Cotteswold Hills is entirely destitute of water worn deposits, which have resulted from the destructed of older rocks. A small thickness of loam usually overlies fragmentary oolite, which gradually becomes more compact and regularly arranged downwards, until it forms laminœ or portions of a bed divided into cubical masses. In this structure there may be recognized the effect of atmospheric causes, acting uniformly over the whole district, without respect to inequalities of ground or height. It is only when the hill country gradually dips down to the plain of Wilts, or in the Northern Cotteswolds to the vale of Moreton, that the surface becomes masked by thick deposits of marine water worn materials. In the vale of Moreton these deposits consist of what is termed *Northern drift*, a series of beds of quartzore pebbles and siliceous sand, which covers a large portion of the surface over the counties of Chester, Stafford, Salop, Worcester and Warwick; lessening in importance southwards, and finding its extreme limit in that direction, in the vale of Moreton. This great deposit is not uniform in its character; in Staffordshire

and Shropshire the gravel is chiefly granitic, mixed with trappean rocks, and occasional large granite boulders; over Worcestershire and Gloucestershire the granites have disappeared, the pebbles being quartoze, and both these and the sand are identical in character with the conglomeritic portions of the new red sandstone of the midland counties, from which the drift has evidently been derived. Over the plain of Wilts the drift is oolitic, mixed with chalk flints, deposits which everywhere cover the lower districts which slope towards the Thames and its tributaries, but is altogether absent in the higher region. Upon the outer flanks of the Cotteswolds, and in the interior valleys which have their exit at the western escarpment, or towards the Severn, are other deposits which would appear to be in part estuarine, in other instances altogether alluvial. The estuarine deposits evidently belong to more than one period, and are situated at different and distinct levels, each of which must have pertained to very different hydrographic conditions. To the more ancient and higher of these estuarine deposits may be referred that upon the flank of Leckhampton Hill, about 700 feet above the sea, and described by Mr. Hull in his able memoir on the Pleistocene deposits of the Cotteswolds, published in the Journal of the Geological Society. This drift consists of oolitic water-worn materials, stratified, and clearly marks a period when the Cotteswolds at that locality were placed at least 700 feet beneath their present elevation; other localities, with similar deposits, have been discovered by Mr. Hull in the neighbourhood of Painswick, Whitcomb Wood, and Lyreford, near Whittington, at the north end of Cleeve Cloud. The Box, near Minchinhampton, about 550 feet

above the sea, has one of these deposits consisting of small partially rounded oolitic gravel, situated upon a kind of platform which overlies the Fullers earth. At the Hyde, on the southern side of the vale of Brimscombe, and upon a similar platform overlying the Fullers earth, and at about 500 feet above the sea, is a similar mass of rounded and stratified gravel, upward of 16 feet in thickness.

VALE OF BRIMSCOMBE.



1.—Great Oolite. 2.—Fullers Earth. 3.—Inferior Oolite. 4.—Cynocephala Stage. 5.—Upper Lias Clay. 6.—Estuary Drift. 7.—Alluvial Drift.

The above section across the vale of Brimscombe shews clearly that the estuary deposits of the Cotteswolds are the products of more than one period, the higher of the two estuary beaches (6) being situated not less than 280 feet higher than the other which occurs upon the northern face of the valley, and near to the Brimscombe railway station. The bank of gravel in the latter position is situated at the angle formed by the junction of two valleys; deposits similarly placed are at Gannicox, near Stroud, and in the village of Nailsworth, where a cutting, made to

form a site for the new Subscription Room, disclosed beds of gravel, sand, and marl, the gravel being in layers alternately rounded and angular. In these instances of Stroud, Nailsworth and Brimscombe, the position of the gravel bank appears to have been directed by the figure of the valleys, and to have been formed in the eddy between the tidal currents which rushed up each bifurcating valley. The Stroud gravel has produced numerous fine teeth and tusks of the fossil elephant, a fine collection of which has been made by Mr. Carpenter, of that place; no shells have been preserved, and even bones or portions of them are rare; it is only the enamel and dentine of the teeth, the hardest and most indestructible of animal substances, which has escaped decomposition. No marine shells have been discovered in these estuarine deposits; oolitic water-worn fossils and oolitic corals are abundant, the entire deposit having been partially silicified.

FLUVIATILE DEPOSITS.

(Recent or Pleistocene.)

The interior valleys of the Cotteswolds have, for the most part, too great an inclination in their beds to allow of the accumulation of any very considerable Fluviatile beds, nevertheless the level floor-like bottom of many of the narrow valleys affords unmistakable evidence of the presence of such deposits. The course of the streams in these valleys has so generally been subjected to the controlling power of man, that it is only when some new direction has been given to a stream, by the construction of a new channel or by other works connected with mill power, that we can expect to meet with undisturbed deposits. Fortunately, an example of this kind has

recently occurred so perfect in all its details, that it will serve to convey a sufficient and accurate idea of these kind of deposits. At Dunkirk Mills, near Nailsworth, the construction of a new channel for the mill stream disclosed the subjoined section, for which I am indebted to Mr. G. F. Playne, who, from a just appreciation of its value to science, has preserved this record, together with the organic remains which were procured. The section follows the course of the new cutting, 46 feet in length and 12 in height; the soil higher than the section had been disturbed, and therefore is not noticed.

1. Brownish yellow clay	1 to 2 ft.
2. Dark blue clay	2 to 5 ft.
3. White small oolitic gravel 6 inches to 2 ft.	
4. Black peaty clay, bed alternating with white gravel	2 to 5 ft.
5. Large angular oolitic gravel	3 ft.
6. Upper Lias marl	

The white rounded gravel (3) appears to have been derived from the freestones of the Inferior oolite; the lower bed of gravel (5) is larger, browner, and generally more angular: it reposes upon the blue clay of the upper Lias; the bones and branches of trees occurred chiefly in the black peaty bed (4), and also in the white gravel (3). The vegetable remains, which were in immense abundance, consisted of trunks and branches of Scotch Fir, Birch, Beech, Ash, White Thorn? Alder? Hazel nuts, Fir cones, portions of Rushes and Equisetacea, shells of the fresh-water genera *Lymnea*, *Valvata*, and *Cyclas*. Bones, which must have belonged to many individuals of a very large species of Deer, nearly allied to the Rein Deer, of these the ponderous broken antlers are very striking objects; portion of the skull and horns of the Red Deer; teeth of the Ox and Horse; jaw of a Pig; tusk of a Boar, and the

left ramus of the lower jaw of the European Beaver; bones of the latter animal are very rarely found in this country, its presence in the streams of the Cotteswolds is therefore of interest, and proves the great antiquity of the deposit.* It is deserving also of notice that this varied and remarkable exemplification of the ancient fauna and flora of the Cotteswolds, occurred within the area of a few square yards. Landslips, which are numerous in the Nailsworth valley, and in the immediate vicinity of the foregoing section, have been justly referred to by Mr. Playne as a probable cause of alluvial accumulations; a mass of the Fullers earth, clay, and marl having descended the hill slope, might readily be expected to produce an obstruction to the usual course of the stream in the valley, and might even form a kind of pool or dam into which the spoils of the land would be transported in times of floods; a marsh with rushes, horsetails, and a peaty subsoil, would be concomitant with such conditions.

* There can be no doubt that the Beaver formerly lived in the British Islands; the absence of any record of the existence of the animal in England, may be admitted to prove the remoteness of the period at which it disappeared; in Wales it had become very rare in 1188, when Giraldus Cambrensis travelled in that country, it was then found only in the river Teify; that it must have been very scarce, even in earlier times, may be inferred from the laws of *Howel dda*, in which the price of a Beaver's skin is fixed at a hundred-and-twenty pence, which was a considerable sum in those days.

APPENDIX.

DESCRIPTIONS OF NEW SPECIES OF TESTACEA FIGURED OR CITED IN THIS WORK.

Tancredia gibbosa, Lyc. sp. nov.

Pl. 7, Fig. 4.

Shell subtrigonal, tumid, umbones elevated, pointed, placed a little anterior to the middle of the valves; the surface has a posterior obtuse angle; anterior side rather attenuated, posterior border curved elliptically. A few rugose plications are visible towards the lower border. Height, 10 lines; length, 13 lines; diameter through both the valves, 6 lines. It is distinguished from all other species of this genus by the combination of a trigonal outline and tumid figure. Rare.

Position and locality; the shelly weatherstone of Minchinhampton Common.

Gervillia fornicata, Lyc. sp. nov.

Shell ovate, hinge line straight, oblique, lengthened; umbones acute, elevated, anterior auricle short, sloping somewhat downwards, dorsal surface very much elevated, and narrow, lines of growth numerous and faintly marked; antero-inferior border slightly sinuated; hinge plate narrow, sulcations numerous, irregular. The right or more flattened valve is unknown.

Gervillia glabrata, Koch and Dunker, approximates to this species in figure, but that shell is more elongated, less convex, has a shorter hinge line, and much larger folds of growth. It is rare.

Position.—The Cynocephala Stage.

Locality.—Buckholt Wood.

Astarte rugulosa, Lyc. sp. nov.

Shell small, suborbicular, moderately convex, umbones depressed, antero-mesial, no lunule, internal margins of the valves crenulated. The surface has a few large longitudinal rugose irregular plications, and fine regular closely arranged concentric striations, which are suddenly deflected upwards upon the posterior side, and form a kind of angle. The hinge differs from the typical examples of the genus in possessing a very distinct rounded anterior lateral tooth. Rare.

Position, the thin band of indurated marly rock which underlies the Ammonite bed of the Cynocephala Stage.

Locality, Frocester Hill.

AMMONITES MOOREI, Lyc. sp. nov.

Pl. 1, fig. 2, 2 a.

Shell discoidal, the sides much depressed, back acute, carina not elevated nor distinct, inner border of the whirls not truncated, number of whirls 4 or 5, enveloped to the extent of two-fifths of their diameter; flexuose lines simple, rather unequal, very fine and densely arranged, so that their number can hardly be counted upon the last volution; they are much inflected forwards towards the carina passing over it to the other side. In the young state the flexuose lines or costa are much larger, more unequal, but are always simple; the back is more obtuse and the carina more distinct, so that the change which takes place in the last volution is considerable. When only 3 whirls have been formed, the longer diameter of the aperture is equal to that of the umbilicus, but in the ultimate stage of growth it is much less and the general form is more depressed. The flexose lines are impressed upon the casts. The septa have much general resemblance to those of A. radians, but both the supero-lateral and infero-lateral lobes are less produced, and the latter is separated into two branches, of which the inner branch is the most produced.

A. radians is the species which approaches most nearly to the present form, but our shell is more compressed, the back more acute, it has not any elevated carina, and the fine flexuose lines pass over the back. In A. radians the flexuose costæ are always equal, in our species they are very unequal in the young slate, and retain somewhat of this inequality throughout the growth of the species. The change from the large costa of the young state to the fine lines of the last whirl is very sudden, and affords a strong contrast within the umbilicus. A. radians has nothing of this character, its whirls are more convex, the costa are very much fewer, and are symetrical throughout all stages of growth.

The test is very thin, but is usually preserved over the greater portion of the specimens.

Diameter across the largest specimen	$3\frac{1}{2}$ in.
——— of the aperture longitudinally.....	$1\frac{1}{4}$ in.
——— of the umbilicus	$1\frac{1}{8}$ in.
——— across the aperture	$\frac{6}{10}$ in.

The name from Charles Moore, Esq., whose researches in the more minute forms of Brachiopoda have enlarged the boundaries of science.

Position and locality.—Frocester Hill, in the Ammonite bed, where it is not uncommon.

GRYPHÆA PLICATA, Lyc. sp. nov.

Shell small, elongated, slightly oblique, apex of the larger valve, pointed and curved forwards, with a small subterminal surface of attachment; the surface has rugose plications, and there are several longitudinal sulcations towards the lower portion of the valve; there

is also a posterior longitudinal groove near to the posterior margin. Length 7 lines, breadth 5 lines; convexity of the larger valve 3 lines. A small species distinguished by the longitudinal plications, lengthened figure, and beak like apex.

Position and locality.—Rare in the Ammonite bed at Haresfield Hill.

NATICA OPPELENSIS, Lyc. sp. nov.

Pl. 1, fig. 4.

Shell subhemispherical, ventricose; spire moderately elevated consisting of five volutions, narrow and rounded at their upper borders; aperture ovate, columella large, rounded, and imperforate; the surface of the last volution has several (5-6) slightly elevated encircling lines. The general figure resembles the young shell of N. adducta, but it has one more volution, the aperture is more contracted, the encircling lines is likewise a good distinguishing feature.

Position and locality; the Nailsworth bed at the base of the Cynocephala Stage, where it is rare.

AMMONITES LECKENBYI, Lyc. nov. sp.

Pl. 2, fig. 7.

Shell sub-discoidal, compressed, not carinated; whirls rounded and transversely sulcated; sulcations placed at unequal intervals, large and deep, becoming more nearly approximated towards the aperture, the last volution having 12 sulcations. Aperture elliptical, the whirls being only slightly embraced. Umbilicus large, and exhibiting all the volutions. Test not preserved.

A remarkable species, nearly allied in the general figure and sulcations to A. Germaini, d'Orb. ter. jurr.; pl. 101, but it has less convexity, and the sulcations unlike d'Orbigny's species, are placed irregularly and are more numerous, so that the latter portion of the last volution much resembles A. torulosus for which it might be mistaken in the absence of other portions of the specimen. The absence of the test renders the description incomplete. Longer diameter of the aperture 7-8 inch.; opposite diameter $\frac{3}{4}$ inch.; diameter of the last volution $2\frac{1}{4}$ inches, of the umbilicus $\frac{3}{4}$ inch.

Locality, Frocester Hill. Ammonite bed.

NERINCEA OPPELENSIS, Lyc. sp. nov.

Pl. 2, fig. 6, 6a.

Shell much elongated, cylindrical, volutions regular, slightly tumid at their junctions and narrow, so that their height is about one fourth less than their transverse diameter; columella large, imperforate, aperture very narrow and tortuous, with two folds upon the pillar which have a wide base; and one upon the posterior wall; the outer wall has three folds, which are expanded at the base, the posterior fold projecting but slightly. The absence of bifurcations in the outer folds separates it from N. trachea, Desl.; the figure of the shell is likewise more lengthened. Oolite marl, Selsley Hill.

NERINCEA COTTESWOLDIÆ, Lyc. sp. nov.

Pl. 2, fig. 2, 2a.

Shell conico-cylindrical, volutions narrow, numerous, increasing in height with advance of growth, tumid at their junctions, excepting in the later volutions which have their junctions linear and flattened; columella large imperforate; aperture narrow, tortuous, with three narrow straight contiguous folds upon the columella; one large curved fold upon the posterior wall; two upon the outer wall, the anterior one of which is very large. Abundant in the marly limestone of the Nailsworth valley and also at Selsley Hill.

NERINCEA GRACILIS, Lyc.

Pl. 2, fig. 3, 3a.

Syn. Chemnitzia gracilis, Lycett, Ann. & Mag. of Nat. Hist., 1850.

Volutions smooth, not elevated, shell cylindrical, columella imperforate, destitute of folds; outer wall with a single large mesial fold, acute at its extremity. All the examples consist of crystalline carbonate of lime, in which the internal characters are obliterated; fortunately a single volution contains opake limestone, and exhibits the figure of the interior cavity. This is the least complicated form of the genus constituting the subgenus *Nerinella* of Sharpe. Rare, in marly limestone, Nailsworth Hill.

NERINCEA JONESII, Lyc. sp. nov.

Pl. 2, fig. 4.

Shell elongated subcylindrical, volutions very numerous, the smaller ones narrow and tumid, projecting at their posterior borders; the larger volutions increase in height, and the figure of the shell becomes somewhat more conical, and the junctions of the volutions only slightly projecting. As all the specimens consist of crystalline lime, the internal characters are doubtful; the rapidly increasing height of the volutions, together with the narrow cylindrical figure sufficiently distinguish it. Rare, marly limestone, Nailsworth Hill.

PURPUROIDEA INSIGNIS, Lyc. nov. sp.

Pl. 7, fig. 8, 8a.

Ventricose, spire short, angulated, aperture large, columella with an umbilical groove, basal notch obsolete.

Spire short, volutions 5-6 with tubercles at the angles, 9-10 to a volution; the tubercles are depressed and disappear upon the last volution, so that the latter portion is not angulated, there are some large transverse plications, but the shell is destitute of other ornament. The columellar lip is much depressed and curved near to the base behind which is a strongly marked umbilical groove; the basal notch is very slightly defined, the junction of the columellar and outer lips forming a gentle curvature.

The absence of a basal notch, the ventricose figure and short spire will distinguish it from P. nodulata, the species which it most nearly resembles.

Position and locality.—Minchinhampton Common, in the bed of planking, associated with other examples of the genus. Rare.

ACTEONINA ANTIQUA, Lyc. sp. nov.

Pl. 4, fig. 8.

Shell oblong turrited, spire produced, small, consisting of five depressed volutions, rounded upon their upper borders, apex rather obtuse; aperture large, narrow above and much expanded beneath; columella curved and emarginated at its base.

Position and locality; the Spinosa Stage at Rodborough Hill.

ACTEONINA CONVOLUTA, Lyc. sp. nov.

Pl. 4, fig. 7.

Shell oblong, rather compressed at the sides; spire depressed scarcely produced, consisting of five volutions which embrace each other and rise but little above the body whirl, apex obtuse; aperture lengthened, very narrow above, more expanded towards the base; columella curved at the base, emarginated and slightly twisted. The shorter spire narrower aperture and more cylindrical figure distinguish it from Bulla? primœva, Desl.

Position and locality; the Spinosa Stage at Rodborough Hill.

BULLA FAVREI, Lyc. sp. nov.

Pl. 4, fig. 7.

Shell ovate, ventricose, or pyriform, summit contracted and nearly concealing the inner volutions, the first of which is slightly elevated; the columella at the base is slightly twisted: the aperture is large, ovate anteriorly, and moderately contracted posteriorly. The general figure is shorter and more tumid than is seen in other Lower Jurassic species.

Position and locality.—The Spinosa Stage, near to the village of Avening, collected in the same bed with Homomya gibbosa and Pholadomya Dewalquea.

TURBO ETHERIDGII, Lyc. sp. nov.

Pl. 6, fig. 3.

Shell turrited, conical, apex acute, umbilicus contracted; spire sinistral, whirls (6) flattened and ornamented with numerous rows of encircling granules, regular, equal, distinct and connected by as many fine encircling lines; the last volution is ventricose, the base is rounded, has numerous densely encircling lines, the narrow umbilicus having a distinct row of granules encircling its edge; the aperture is rounded and moderately large.

Position and locality.—A rare and remarkable species found in the Gryphite grit of Rodborough Hill, Mr. Etheridge has also a specimen, procured I believe, from Dundry.

CUCULLÆA FERRUGINEA, Lyc. sp. nov.

Shell elongated, umbones large elevated, rather compressed, nearly mesial, separated by a large area; hinge line much lengthened,

angular at both the extremities, the anterior, forms a right angle with the anterior, the other an obtuse angle with the posterior border; a posterior obtuse ridge separates an excavated area from the other portion of the surface; the base curves gently; the surface is ornamented with very numerous rather irregular radiating costa; which cover its entire surface, excepting the posterior slope upon which they are very faintly traced; the costa are impressed by numerous fine lines of growth, rendering the surface rather rugose.

In common with other examples of this genus, the radiating costa are more conspicuous in young than in adult shells, they are also in some instances indistinct or absent upon the middle of the surface. The lengthened hinge line, together with the large submesial compressed umbones, and nearly equal radiating costa, will serve to distinguish it from other species of the Lower Jurassic rocks.

Length, 21 lines; height, 13 lines; diameter through the valves, 15 lines.

Position, the Ammonite bed of the Cynocephala Stage.

Locality, Frocester Hill.

LIMA OOLITICA, Lyc. sp. nov.

Shell subhemispherical, umbones anterior, elevated, pointed, equally and widely divergent; hinge line very short, the anterior auricle being only very slightly produced, anterior aperture large lanceolate; anterior side very steep and straight, the other borders gracefully rounded; the whole shell except upon the anterior side being compressed; lines of growth usually few, irregular and strongly marked; radiating costa (about 50) flattened, wider than the interstitial spaces and somewhat waved; perfect only in young specimens.

With advance of growth the costa became obliterated, except that usually some traces of them may be discerned upon the anterior slope.

The lengthened figure, steep anterior slope, pointed, elevated umbones, short mon-aurited hinge line and compression of the posterior side, are the characteristic features.

Position and locality.—It occurs abundantly in the freestone beds at Nailsworth Hill.

Height 3¼, breadth 2¼, through both valves 1½ inches.

CORBIS (CORBICELLA) SUBŒQUILATERA, Lyc. sp. nov.

Shell ovate, moderately tumid near to the umbones; which are small, pointed and nearly mesial, hinge margin curved, no posterior angle; the surface smooth with fine irregular plications.

Length, 2 inches; height, 1⅝ inches; diameter through both the valves, ¾ inch.

Nearly allied to Corbis lœvis, Sow., but more tumid.

Position, the Spinosa Stage in the Gryphite grit.

Locality, Rodborough Hill.

ASTARTE CORDIFORMIS, Lyc. sp. nov.

Shell subcordiform, tumid at the middle, compressed at the two extremities of the valves; umbones anterior compressed, no lunule; hinge border lengthened, slightly curved and nearly horizontal.

The greatest convexity is about the middle of the valve, the anterior side being much compressed.

The surface has fine regular longitudinal striations, the lines of growth are inconspicuous. Length, 2 inches; height, 1¼ inches; diameter through both the valves, ¾ inch. It is allied to Astarte rhomboidalis, but is shorter, the anterior side more compressed, the general figure more tumid, and it is destitute of the large plications which characterize that species.

Position; the Gryphite grit bed of the Spinosa Stage.

Locality, Rodborough Hill.

Turbo Oppelensis, Lyc. nov. sp.

Pl. 3, fig. 8.

Shell conical, turrited, imperforate, spire sinistral, whirls flattened, carinated and angulated at their lower borders, furnished with a a single encircling row of depressed tubercles, about 16 in a volution; from each tubercle a small rib or elevation proceeds obliquely upwards and forwards, aperture ronnd, moderately large.

A remarkable species, resembling T. Bertholeti, d'Orb., in its general figure and sinistral spire, but the latter species has a double row of tubercles. and is destitute of the transverse rib.

Position and locality.—The bed of hard cream-coloured limestone with Nerinœas. Nailsworth Hill.

Gervillia prœlonga, Lyc. sp. nov.

Pl. 6, fig. 6.

Shell greatly elongated, slightly curved, subcylindrical in the middle and attenuated towards the extremities. Valves unequal in their convexity, umbones small, oblique, pointed, separated by a very lengthened hinge area, anterior auricle produced and pointed, posterior auricle much compressed, lengthened, and produced only slightly from the body of the valves, so that the posterior side of the shell is nearly straight throughout its length; hinge plate, lengthened with eight or nine irregular pits; inner teeth, three, lengthened, very oblique; anterior margin of the valves tortuous; the surfaces of the valves with large irregular rugose plications.

A species more oblique, more tumid in the middle portion, more lengthened in the hinge line than G. lanceolata or G. Siliqua, it has also eight or nine hinge pits, the other species having only three or four. The hinge border is upwards of three-fifths the entire length of the shell.

Position, the Spinosa Stage of the Inferior oolite, in the Gryphite grit.

Locality.—Rodborough Hill.

Lima ornata, Lyc. sp. nov.

Pl. 1, fig. 5.

Shell tumid, oblique, umbones pointed, auricles costated, small, nearly equal, anterior slope straight and steep; costa radiating over the whole shell, regular, rounded, moderately elevated and rather

distantly arranged; about 32 in number. The entire surface of the shell is covered with a delicate net work of radiating and concentric lines, knotted at their junctions; both the kinds of lines being of equal size, and more readily distinguishable upon the sides of the costa, and in the interstitial spaces. Height, 12 lines; opposite diameter, 9 lines; diameter through both the valves, 7 lines.

Position, the Ammonite bed of the Cynocephala Stage.

Locality.—Frocester Hill.

OPIS CORDIFORMIS, Lyc. sp. nov.

Pl. 4, fig. 2, 2 a.

Shell ovately trigonal, very convex, umbones large, incurved, lunule large, cordiform moderately or not much excavated, its margin rounded; posterior angle obtuse and not prominent, posterior surface moderately large and convex; plications of growth few and large; concentric striations regular, closely arranged and deeply impressed, excepting upon the surface posterior to the dorsal angle. The test is of great thickness, the hinge large, the teeth massive, and the inner margins of the valves strongly crenulated.

Height, 16 lines; opposite diameter, 14 lines; diameter through both the valves, 12 lines.

The ovate figure without angularity, the slight excavation of the lunule, and the convexity of the posterior surface will readily distinguish it from other Lower Jurassic examples.

Position, the Spinosa Stage of the Inferior oolite.

Locality, Rodborough Hill in the Gryphite grit bed, where it is abundant.

MYTILUS LUNULARIS, Lyc. sp. nov.

Shell with the apex acute, convex anteriorly, compressed posteriorly, the anterior side is steep, slightly excavated, having an acute ridge at its superior margin its whole length; the surface is smooth, and shining with fine irregular concentric lines of growth. The steep anterior side, slightly curved form and acute anterior margin, serve to distinguish it readily from other contemporary species.

It has been omitted in the list of shells from the Nailsworth bed at the base of the Cynocephala stage, at which place I procured specimens, in company with my friend Mr. Moore, of Bath. It also occurs in the Spinosa stage of the Inferior oolite at Rodborough Hill, in the Gryphite grit; the latter bed having yielded many specimens; my cabinet contains likewise a single specimen from the Nerinœa limestone of the Fimbria Stage.

CORBIS (CORBICELLA) COMPLANATA, Lyc. sp. nov.

Pl. 6, fig. 1.

Shell elongated, rather compressed, ovate, umbones small, anteromesial, pointed, hinge border lengthened, nearly straight, and almost horizontal, posterior surface with a faintly marked angle, concentric plications, irregular, and not very prominent. Hinge, with two cardinal triangular teeth, and one distant lateral tooth in each valve, inner margins of the valves smooth. The surface destitute of orna-

ment, the superior size of the posterior side, the absence of an anterior lateral tooth, are features which distinguish this subgenus from the typical forms of Corbis; the present is the most lengthened and compressed Inferior Oolite example of the subgenus.

Length, $2\frac{3}{4}$ inches; height, $1\frac{3}{4}$; diameter, through both the valves, $\frac{3}{4}$ of an inch.

Position, the Spinosa Stage of the Inferior Oolite.

Locality, Rodborongh Hill.

MYACITES COMPRESSIUSCULUS, Lyc.

Pl. 5, fig. 1.

Shell elongated, compressed, umbones small, contiguous, submesial, and very little elevated above the superior border; anterior slope, lengthened, oblique, the extremity rounded, posterior and superior or hinge margin lengthened and horizontal, or slightly concave, its extremity rather attenuated and slightly reflected; lower border curved, and nearly parallel to the superior border; both the extremities have an opening, of which the posterior is the larger; longitudinal plications fine and densely arranged. The rows of radiating granules upon the outer tegument are regular, and arranged at moderate distances, the granules are elevated, and rather distantly arranged in the rows.

Height, 14 lines; length, 29 lines; thickness through the valves, 7 lines.

The very compressed form and smooth surface will readily distinguish it from contemporaneous species of this genus; it is rare.

Position.—The Spinosa Stage of the Inferior Oolite.

Locality.—Rodborough Hill, in the Gryphite grit bed.

NOTES.

Ferruginous oolite near Cheltenham. — The remarkable mineral character of this deposit so nearly resembles the Northamptonshire iron-ore, that the probable synchronism of both may be predicated; in Switzerland and Swabia similar beds occur, and in the latter country they are also quarried for iron-ore.

Homomya gibbosa.—The tests of Conchifera are not preserved in the Pholadomya grit, and casts of this large species, however well they may be preserved, never shew any traces of muscular impressions, unlike the casts of Myacites generally, which often exhibit both the adductor and siphonal scars; the same observation will also apply to the fine Homomya! crassiuscula of the Gryphite grit, which at Rodborough Hill is so often procured with the test entire, or only fractured in separating it from the matrix; in this latter instance, so favourable for the examination of the muscular impressions, no such traces are present, although the test is of considerable thickness; the absence of distinct impressions coincides with Pholadomya rather than with Myacites. In the Homomyæ some few faintly marked radiating lines may sometimes be detected upon the umbones, but these never pass over the sides of the shell, as in Pholadomya; H. crassiuscula sometimes exhibits these. The absence of this feature, together with the absence of muscular scars, and of an outer granulated tegument, tend to approximate the Homomyæ to Pholadomyæ rather than to Myacites, and should this view be adopted, Homomya will form a very distinct subgenus of Pholadomya. The Gryphite grit shell is distinguished from the other by the smaller, more compressed, less elevated umbones, and by a general compression of the anterior side, which on the contrary is very tumid in H. gibbosa; the species figured by Ajassiz under this name, it should be mentioned, is altogether distinct, and is a shell very characteristic of the Fuller's Earth.

Ancient Strait or Gulf of the Sea separating England from Wales. —The diluvial beaches and shingle beds of the Cotteswolds have not preserved any marine shells, but they have been collected from several localities in the counties of Salop, Stafford, and Worcester. The following list of these shells, which were obtained chiefly at Kempsey, near Worcester, will be found in the Silurian system of Sir R. Murchison, p. 553 :—

Turritella unguilina	*Littorina littorea*
——— *terebra*	*Cypræa pediculus*

Purpura lapillus	*Murex erinaceous*
Buccinum reticulatum	*Bulla ampulla*
Tellina solidula	*Dentallium entalis*
Cardium tuberculatum	*Astarte*
Cyprina Islandica	*Dorax*

Others imperfect.

In an interesting little memoir by my friend Professor Buckman, entitled "*The Ancient Straits of Malvern*," will be found a list of marine plants, discovered by the author, now growing in the valley of the Severn in Worcestershire.

Scripus maritimus	*Bupleurum tenuissimum*
Gastridium lendigerum	*Œnanthe pimpinelloides*
Poa distans	*Smyrnium Olusatrum*
Triticum juncaum	*Glaux maritima*
Iris fœtidissima	*Samolus Valerandi*
Lepidum ruderale	*Plantago maritima*
Erodium maritimum	*Atriplex rosea*
Rosa spinosissima	*Rumex maritimus*
Apium graveolens	*Arenaria marina*

It is observed that "the plants in this list, though not all perfectly marine, are yet such as *elect to grow by the sea side*, hence their prevalence in the district under review affords good evidence that marine conditions once prevailed along the greater part of the valley of the Severn, and that the marine waters were far wider than the reach of even the floods of our days."

Ostrea acuminata and O. rugosa.—It is uot uncommon to meet with specimens of the former shell, which have towards their lower borders the radiating or perpendicular sulcations which distinguish O. rugosa, it is therefore not improbable that the latter may be only a variety of the other abundant and well known form.

The Cgnocephala stage.—During the progress of these pages through the press two memoirs have been published, one by my friend Dr. Wright, on the "*So called sands of the Inferior Oolite*," the other by Dr. Albert Oppel, of Stuttgard, on "*The Jura formation of England in comparison with that of France and Germany.*" In both of these works the Cynocephala stage has been referred to the Upper Lias. The perusal of these memoirs has not tended to alter the views, stated in a former part of this work, in which a position is claimed for the stage distinct from the Upper Lias. My friend Mr. Moore, of Bath, whose researches in the Upper Lias of Somerset have resulted in varied and important discoveries, only a small portion of which are as yet before the public, and whose acquaintance with that stage extends to great minuteness of detail, forwarded to me for comparison an extensive series of testacea, amounting to not less than 130 species. In this fauna so varied and comprehensive, two species only could be identified with those of the Cynocephala stage of the Cotteswolds, viz., *Ammonites striatulus* and *A. variabilis*, shells which occur only in the highest bed of the Somerset Upper Lias. The fossils in question have been collected with great care, so that Mr. Moore is able to assign all the species to their true position in the stage. It may be

predicted that the publication of this fauna, the greater portion of which is new to science, will tend materially to establish its distinctness from the Middle Lias on the one hand, and from the Cynocephala stage on the other, notwithstanding the gradual approximation in mineral character and distinctness of the boundary line at the base of the Cynocephala Stage.

Beds of Ammonites and Belemnites.— The occurrence of shells of Cephalopoda of all ages crowded together in the same bed, and in an unbroken condition, can readily be accounted for upon the hypothesis that their place of sepulture was selected by them, and that they perished in the retreat which they had chosen for their place of repose during that seasonal period of torpidity, which would appear to be a law in their economy. For a full and interesting account of this law as exemplified in the Cephalopod which inhabits the *Orgonanta Argo*, the reader is referred to the description of Madame Jeannette Power, who observed its habits in the bay of Messina. It will be readily understood that should a deposit of any kind cover the spot in question during the season of torpidity, in consequence of a shift of currents, of estuarine action or from other causes, that the Cephalopoda would be at once entombed in their place of retreat, and become denizens of the fossil kingdom. In no other manner does it seem probable that we should find an aggregation of a single species of swimming mollusks, having nearly exclusive possession of any given spot, occurring in a perfect condition, and including individuals of every stage of growth. Occurrences of this kind would take place at very uncertain intervals, and would be more or less partial in their operation, so that in certain instances shells in juxta position may have owed their extinction to very different causes.

Rhynchonella acuta and R. Cynocephala.—That the latter is probably only a smaller variety of the former species induced by altered marine conditions, may be inferred from an examination of their distinctive characters. The general figure of each is alike, the only essential difference between them consists in the number of the anterior elevated plaits and of the lateral folds. The learned author of the British Brachiopoda (Davidson, Ool. and Lias Brach., p. 3, 1852) relies upon the number of these plaits and folds as forming specific distinctions, *R. acuta* having one, and *R. cynocephala* usually two plaits; but the latter shell has occasionally only one plait as in *R. acuta*, and occasionally three plaits. Even in *R. acuta* my friend Mr. Jones, of Gloucester, has a specimen with two plaits. In the lateral folds the distinction again fails; *R. acuta* is stated to have three; the other four folds, but my specimens shew great uncertainty and irregularity in the folds, for R. cynocephala has indifferently two, three or four folds, and the number of folds are not always alike upon both sides of the same specimen, the latter observation applies equally to R. acuta. I conclude, therefore, that no distinction of *specific* value can be established between these remarkable Rhynchonella, and that the distinction of size and of the *usual* number of plaits is due to locality and position. The student should bear in mind this instructive example of the care required in forming species of Brachiopoda.

Astarte complanata Roemer.—The small shell assigned to this species may possibly be only a dwarfed variety of Astarte excavata, Sow., a species which varies so much even in the same bed, that it is not easy to define the amount of its variations of form. Roemer's shell belongs to the Upper Lias marl, a little lower than the position of our specimens; these seem to want the clearly defined excavated lumule of the typical A. excavata, and there is also a flattening upon the posterior side which seems to be a constant character in our complanata form.

Avicula complicata, Buckman.—Although upwards of eleven years have elapsed since the larger valve of this remarkable species was described in the Geology of Cheltenham, and specimens are abundant, the smaller valve remains unknown.

Terebratula globata, Sow.—The Cotteswold variety of this shell differs materially from the typical or Dundry type, and as it occurs in immense abundance through the upper beds of the Inferior Oolite, extending the whole range of the Cotteswolds, the difference is worthy of notice; the figure of the Cotteswold variety is more elongated, the anterior folds being very strongly defined; between this form and T. Phillipsi the transition is so gradual, that after the inspection of a good connecting series of specimens, confidence in the specific valve of T. Phillipsi is much lessened. Fine typical examples of T. Phillipsi do not occur higher than the Fimbria Stage of the Inferior Oolite, where it is rare. Another constant companion of T. globata, and nearly resembling it, is a form usually attributed to a small variety of T. perovalis; equally abundant with T. globata, its only distinction consists in a more depressed form and smaller anterior folds; in this instance, not less than in T. Phillipsi, we find the same gradual transition of form.

Cynocephala Stage in the Department of the Mozelle.—The Gres Supraliassique, and the Hydroxide oolitique of M. Terquem, probably in their aggregate are the equivalents of our Cynocephala Stage; the Mozelle beds have a larger assemblage of the Anatinidæ and two species of Tancredia (Hettangia) Dionvillensis and depressa, both occur in the Cotteswolds, but in higher stages—T. depressa having been procured in the freestones, and T. Dionvillensis, which is only a synonym of T. donaciformis, in the Gryphite Grit of the Inferior Oolite.

Testacea figured in this Work.—Plate 1 and plate 2, fig. 7, consist of a few shells proper to the Cynocephala Stage, and with two exceptions have not heretofore been figured; the Ammonites which pass downwards into the Upper Lias, and the Conchifera which are found likewise in the Inferior Oolite, have no place here. Plates 2 and 3 consist of species proper to the Fimbria Stage; 4, 5 and 6 of species proper to the Spinosa Stage. It may be objected that these plates are not occupied with the more common shells characteristic of the Inferior Oolite, as Ammonites Parkinsoni, Nucleolites sinuatus, Holectypus depressus, Lima pectiniformis, Trigonia costata, Modiola Sowerbii, Terebratula fimbria, Rhynchonella spinosa, &c. These are, indeed, very well known forms, and have been so repeatedly figured in

general treatises on Geology as examples of Inferior Oolite fossils, that their aspects are probably familiar even to the general reader; it has been deemed preferable to select fossils which, though less abundant, are equally characteristic of the formation, and of which a portion are altogether new to science. It would have been easy to make additions to the number of these new forms by means of additional plates, but as this would necessarily have enhanced the price of the work, and as it is not intended to present a *monograph* of Inferior Oolite fossils, the present plan has appeared to be the one best calculated to fulfil the intentions of the author. With respect to the Great Oolite fossils, these have so recently been figured and published by the Palæontographical Society, that it may be considered as superfluous to occupy much space with their forms, accordingly a single plate only (7) has been assigned to them. The specimens selected are intended to illustrate *genera* as well as *species*, and include two (Purpuroidea insignis and Tancredia gibbosa) which are now for the first time figured and described.

Study of the Natural History Characters of Ammonites.—The very limited vertical range of the species of Ammonites, renders them guides of a superior value in determining the stratigraphical position of the beds which contain them. In this the most varied, most extensive, and most interesting genus of fossil mollusca, the discrimination of species is sometimes only to be effected by an amount of study and research applied to the subject, that few persons, excepting naturalists, would be inclined to undertake. The change of the general form, and of the ornaments which were continuously in progress during the life of the animal, together with the final degeneration and vanishing of those distinguishing features in old age, would inevitably produce much confusion and perplexity were it not for the assistance derived from certain internal characters, which are of superior constancy and importance. These consist in the figure and arrangement of the internal foliated septa, or borders of the plates which divide the chambers, and although these foliated figures underwent certain minor modifications during the growth of the Mollusk, still by comparing Ammonites of nearly equal size, or the corresponding portions of different specimens, it is easy to discriminate differences in the foliations without having acquired any further scientific knowledge upon the subject, so as to enable the observer to determine that any too well preserved specimens belong to the same species or otherwise. The absence of a portion of the external test exposes the foliated septa; but when the test covers the whole surface, or when the cast only of the external mould remains, we can only study the figure and ornaments; internal casts on the other hand are usually altogether worthless, inasmuch as both the foliated septa and exterior ornaments are absent. However, to acquire a sufficiently discriminating knowledge of the leading forms of Ammonite which characterize the different formations, it is only necessary to regard the more obvious characters of form and external ornaments. The importance of the septa in assisting the discrimination of Ammonites was first pointed out by Leopold Von Buck, and subsequently has been very fully exemplified and extended by Aleide d'Orbigny both in

his Cours élémentaire de Paléontogic, and in his more important work Paléontologic Francaise, to which the reader is referred for ample information upon this subject.

Ammonites radians.—Four Ammonites, which have passed under the name of *Radians*, and are nearly allied to each other, occur together and abundantly in the Frocester Hill bed, and may be studied in all their stages of growth; these consist of A. radians Dewalqueanus, A. radians Orbignianus, A. radians striatulus, and A. Thouarsensis or Comensis. Of these striatulus and Thouarsensis may possibly be only varieties of the same species, the latter form having the more tumid figure, elevated keel and compressed dorsal surface. M. D'Orbigny has considered them distinct species. Between striatulus and Orbignianus the distinctions are more clearly marked, in striatulus the dorsal keel is more conspicuous, the costa are larger, more curved, and much more distant, so that taking a specimen of medium size the number in a volution is 40, in radians Orbignianus it is 95. The foliated septa afford another distinction in the lateral saddle, more especially the figure is quite distinct, being very wide in striatulus, divided upon the summit, and less festooned than in the other shell, there are also other distinctions of less value, and unnecessary to recite. In radians Dewalqueanus, which is a much smaller form, the costa become so many narrow, acute, closely arranged, and scarcely curved lines, about 120 in the last volution; the dorsal keel is but little produced. The Upper Lias examples of these Ammonites present similar distinctions equally clearly marked. A specimen labelled radians by Dr. A. Fraas is A. striatulus; the description of radians given by D'Orbigny, Terr. Jur., is that of striatulus, but the specimen figured by him represents our second shell radians Orbignianus. Between striatulas, Thonarsensis, and radians Amalthei, of Oppel, there exists in some instances so near an approximation, that it is difficult to regard them otherwise than as varieties; the latter form with very distant and curved costa (about 34 in the last volution), belongs to the Middle Lias. A. radians Orbignianus attains to much larger dimensions than the other forms, and presents a much greater variability in its figure and ornaments, so that a minute description of any one specimen will apply only more or less remotely to others of similar dimensions.

Granulated surface of the Anatinidæ.—The delicate outer granulated tegument of Anatina, Gresslya, Myacites and Goniomya may also be discovered in certain examples of the recent Panopœa; M. Terquem has mentioned its presence in P. Fanjassi, and my friend Mr. S. P. Woodward, in answer to my enquiries, states that he has discovered the granulated tegument in a young specimen of P. Anstralis, only two inches in length in the British Museum, but that with advance of growth it is altogether effaced; this interesting fact leads to the inference that all the species of that genus are furnished with this kind of tegument, which usually disappears during the life of the Mollusk; we may in like manner explain the absence of granulations upon specimens of the fossil genera above cited, whose state of preservation is in other respects very perfect; it also tends very materially to assimilate the recent Panopœa with the ancient Myacites.

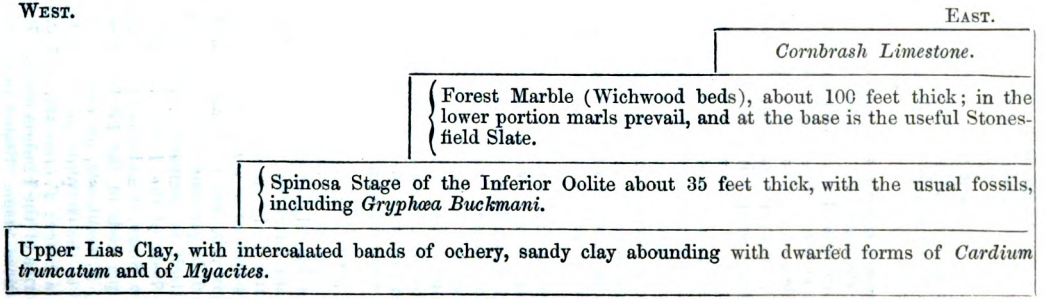
Ceromya striata, Sow.—It seems probable that this shell is only the young condition of *C. abrupta* (Cardita, Sow.), and of the large *Ceromya plicata, Ag.*, a shell which acquired radiating lines when of mature growth, and also experienced a sudden change in the direction of the grooves, which in the young shell are oblique or eccentric, subsequently they became longitudinal; the test had never been found preserved.

Trigonia costata, var., sculpta.—Judging from the brief description in the Prodome of D'Orbigny, it is probable that the *T. scuticulata* of that author is identical with this form which I regard as a variety only of *T. costata.* The difference in the figure and the size of the tubercles, or denticulations upon the area, do not, according to my views, justify the separation of these forms into distinct species, but as the variety *sculpta* is limited to the Gryphite grit, and is sufficiently distinguished in its aspect from the typical form, the student should not fail to acquaint himself with their distinctive features. The typical species occurs somewhat rarely in the white oolitic limestone of the Nailsworth valley, which passes upwards into the stratum with Nerinœas, these specimens attain large dimensions, but are difficult to separate from the matrix; the same form reappears in the Trigonia grit, sometimes in immense profusion; in the higher Jurassic stages the species is only recognised as varieties of the Inferior Oolite type.

Trigonia Hemispherica, Lyc., pl. 4, *fig.* 4.—This figure represents the adult form of a shell described by the author in the Ann. & Mag. of Nat. Hist., Sept., 1853, and figured as a very small example in the plate accompanying that memoir; larger specimens have since been procured, but hitherto the area has not been very distinctly exposed; the figure of the adult form is less hemispherical than in the younger state, but the densely arranged regular longitudinal costa continue to present the same character; it ranks as one of the more rare testacea of the Gryphite grit.

The genus Trigonia in the Inferior Oolite.—Although upwards of fifteen species of this genus occur in the Inferior Oolite of the Cotteswolds, higher than the Cynocephala Stage, there are only four abundant forms, viz., *T. costata, T. signata, T. striata,* and *T. exigua* the latter little species being common only at Leckhampton Hill. Impressions of *T. duplicata* are frequently seen in the hard bed of Trigonia grit, and these afford facilities for reproducing a model of the shell by pressing warmed gutta percha into the concavity, but the shell itself is comparatively rare; *T. angulata* occurs both in the upper beds of the Fimbria Stage, and in the shelly beds of the Spinosa Stage, this also is rare; *T. costatula* has been found only in the upper beds of the Fimbria Stage; *T. v. costata* in the Spinosa Stage; *T. tenuicosta,* an elegant gibbose form with a large area, is special to the Gryphite grit; *T. subglobosa,* in the upper beds of the Fimbria Stage; *T. gemmata, T. Tuberculosa,* and *T. clavo-costata,* are rare forms of the Fimbria Stage; *T. Phillipsi* and *T. hemispherica* of the Spinosa Stage. Stated in the foregoing order, the species represent a constantly decreasing number of specimens, the four or five latter species being known each by only two or three examples.

Thinning out of the Lower Jurassic rocks of the Cotteswolds in their extension Eastwards, beneath the superior formation.—The subjoined diagram represents the order of succession of the Jurassic rocks at the eastern boundary of Gloucestershire, and corresponding portion of Oxfordshire; the thinning out of the Inferior Oolite is there so considerable, as to lead to the inference that no portion of the series may exist beneath the Cretaceous System of the eastern portion of England.



Ammonite bed of the Cynocephala Stage at Longfords.—Since the description of this Stage went to the press, an opportunity has occurred of examining an additional section of the Ammonite bed in a bank at Longfords, near Nailsworth, upon the southern border of the lake. A fossiliferous thin bed of marly rock, with hard concretionary nodules, is overlaid by ferruginous, coarse, thin bedded oolite, the sands are here partially consolidated, are marly, and of a brownish hue. In the concretionary bed, testacea are moderately numerous, but for the most part badly preserved, so that few species have been determined, the mineral character of the fossils agrees nearly with that of the Frocester Hill bed, and contains grains of hydrate of iron; the following have been determined :—

Ammonites radians, striatulus.
——— *variabilis.*
Belemnites, apparently of two species.
Rhynchonella cynocephala.
Cerithium papillosum, Desl.
Opis carinatus, Wright.
Pecten textorius.
Myacites, sp.
Homomya crassiusculus, Mor. & Lyc.
Lima electra, D'Orb.

Of these Homomya crassiusculus occurs in the Spinosa Stage of the Inferior Oolite, and the Cerithium is recorded by M. Deslongchamps in the same formation at Bayeux, Normandy. There are indications that the valley at Longfords is traversed by a fault in the direction of its axis, as the beds upon the southern side are much lower than those upon the northern, the sands upon the latter side of the lake, at the distance of only a furlong, are seen considerably elevated. The several sections in this valley are inconsiderable and at no place disclose the whole of the sands, so that it is difficult to estimate their thickness with any approach to exactness.

Myacites Goldfussii, explanation to plate 6, fig. 2.—This shell has been unfortunate in its nomenclature; it is the *Lutraria elongata* of Munster, figured in the Petrefacta of Goldfuss; also the *Pleuromya elongata* of Agassiz, the *Panopœa subelongata* of D'Orbigny, and the *Myacites Goldfussii* of Morris, Catal. 1854, the latter new specific name distinguishes it from another shell, a Liassic Myacites, which will retain the specific name *elongatus*, and confusion between the two species will thus in future be avoided; the Liassic shell is the *Panopœa elongata* of Roemer, and of Portlock, the *Arcomya elongata*, of Agassiz, the *Panopœa petrea* of Buvignier, and the *Myacites longissimus* of Quenstedt. Morris's catalogue gives the Inferior Oolite of the Cotteswold Hills as the position and locality of *Myacites elongatus*, but this is an error, the shell is proper to the Lower Lias, in which it is not uncommon. *Myacites Goldfussii* occurs very abundantly over the Spinosa Stage of the Cotteswolds in the form of casts, the test is very rarely preserved.

At page 25, line 28, *Pholadomya ovulum* is stated to occur in the Nailsworth bed of the Cynocephala Stage; this is an erroneous identification, additional examples prove it to be an undescribed species,

approaching in figure to P. pelagica and P. siliqua, Ag. It has very large imbricated longitudinal folds, crossed by about 9 or 10 faintly marked diverging and very oblique ribs, the posterior border gapes but very slightly; the antero-inferior border being compressed, the umbones are large and moderately elevated; the ribs can scarcely be traced to the lower border; specimens occur of all stages of growth, but few have escaped distortion; *Pholadomya arenacea* is the name proposed for this form, which appears to be proper to the Stage.

There yet remains to be noticed an Ammonite found both at Frocester Hill and Nailsworth, resembling A. insignis, but which is probably a distinct species. Compared with A. insignis it is much more depressed, the costa are more numerous, less curved and less conspicuous; the lobes differ materially, they are much more simple and without the branched extremities; specimens hitherto obtained do not permit of a more rigorous comparison. Possibly it may be the *A. subinsignis* Oppel, Jura p. 367, but the description of the latter shell has not yet been given with sufficient precision.

The Cynocephala Stage in Yorkshire.—The lofty iron-bound coast between Scarborough and Whitby, at Blue Wick and the Peak, presents a most remarkable and extensive exposition of the Cynocephala Stage, in connexion with the superior and inferior groups of rocks. In a visit which I recently made to this spot, in company with my friend Professor Morris, the identity of the stage exemplified both in the sequence of beds, their mineral features, and included fossils was strongly impressed upon my mind, the whole forming a near approximation to the Gloucestershire sections. The Inferior Oolite or Dogger is seen to rise from the beach into the face of the mural cliff, forming thick bedded ferruginous sandstones about 40 feet in thickness, and containing about 10 feet beneath the top a stratum loaded with the shells which indicate the lower of the two stages into which I have divided the formation. Advancing northwards, the Cynocephala Stage rises from beneath, about 40 feet in thickness, and consisting for the most part of thick brownish yellow micaceous sandstones passing downwards into others of a darker and grey colour. The uppermost bed, from 12 to 15 inches thick, is a slightly compacted dark-coloured concretionary rock, the prevailing fossil of which is *Terebratula ovoides, Sow.*, (*trilineata, Y. & B.*) more rarely occurs *Belemnites compressus, B. irregularis, Pentacrinal joints, &c.*, these latter resting upon the floor of the micaceous sandstones next in order. The upper floor of the bed has a profusion of rounded argillaceous nodules, which adhere to the lower surface of the superincumbent Dogger. Lower in position is *Vermetus concinnus* disposed in clustering masses, and very rarely solitary specimens of *Ammonites striatulus, A. variabilis, A. concavus*, and fragments of other Ammonites. In the lowest bed, which is dark grey in colour and argillaceous, are groups of *Lingula Beanii, A. inequivalvis* and *Orbicula reflexa*. The Upper Lias or Alum Shale, 200 feet in thickness, is the next deposit which rises into the grand section of the Peak, the whole forming a *coup d'œil* of the Lower Jurassic rocks, unequalled for its extent and comprehensiveness. The Inferior Oolite, in the course of three miles, attains the summit of the scar, 400 feet above the beach, and in tracing this

lengthened section we note the gradual thinning out and final disappearance of the Cynocephala Stage, the Dogger being also reduced to less than half its former thickness, and reposing immediately upon the Alum Shale. At a section a little inland, and at a still greater elevation, formed by quarrying the Alum Shale for the works on Peak Hill, the Dogger is still further reduced, consisting of only two beds, which are nearly destitute of fossils.

The highest bed of the Cynocephala Stage with *Terebratula ovoides*, is undoubtedly the northern representative of the Ammonite bed of the Cotteswolds, and in the general aspect it nearly resembles the same bed at Haresfield Hill; the *Terebratula ovoides* of the former representing the *T. subpunctata* of the latter place. A series of specimens collected indiscriminately from each locality, present upon the whole so near an approximation to each other that it is not easy to distinguish them, or to regard them otherwise than *varieties* of the same form. Ammonites are nearly absent in the northern locality, but the same remark will also apply to some of the south Cotteswold sections. The micaceous character of these sandstones serves readily to distinguish them from those of the Dogger, and to assimilate them to the Gloucestershire sands, which underlie the Ammonite bed, and from which they are only distinguished by their greater degree of induration. The concretionary *Terebratula* bed forms a strong line of demarcation, separating the stage from the Dogger, and the basement or grey *Lingula* bed is as clearly distinguished from the highest bed of the Alum Shale, so that there is much less of that gradual melting of the one deposit into the other which obtains in the Cotteswolds.

Rhynchonella Cynocephala has not been observed, and *R. bidens* is so rare that only a single specimen has been shown me from this stage, a circumstance which induces a doubt as to the real habitat of the specimen. *Ammonites* are likewise very rare, one of them in the collection of Mr. Leckenby appears to be *A. Aalensis* Zeit. *Belemnites* are not uncommon, including that unmistakable species *B. irregularis*; another Belemnite seems to be undistinguishable from *B. giganteus*. Gasteropoda and Conchifera are represented by very few species; *Pleurotomaria subdecorata*, D'Orb, occurs in the Terebratula bed; in the *Lingula* bed is a small smooth undetermined *Pecten* and *Avicula inæquivalvis*, the two latter being abundant. The *Pleurotomaria* has occurred in the Cynocephala Stage at Nailsworth, and the *Avicula* at a similar position in the Brimscombe valley, associated with *Ammonites Raquinianus*, *Pholadomya arenacea*, *Goniomya*, &c.

Memoirs of the Geological Survey of Great Britain; the Geology of the Country around Cheltenham, by Edward Hull, Esq., A.B., F.G.S. Longman and Co., 1857.—The present little work had nearly passed through the press prior to the publication of Mr. Hull's valuable memoir on the Cheltenham district. One or two of that gentleman's statements appear to demand some notice from me. He adopts the views expressed by Dr. Wright with respect to Cynocephala Stage, by uniting it to the Upper Lias, and at page 31, in alluding to an estimate which I had made of the thickness of these sands in the Stroud district (Tabular view), he expresses his opinion that 40 feet is much

too low an estimate. To this I would remark that, with the exception of the Frocester Hill section, there are at present no means afforded of obtaining a knowledge of the thickness of the stage in question with an approach to accuracy; partial exposures of the sands are very numerous in the interior valleys of the district, and these embrace in the aggregate every portion of the stage, but in each instance there occurs some imperfection in the data tending to invalidate any estimate of the entire thickness of the stage. A deep lane section which passes upwards from the Bourne valley to Bisley common (that is, from the Lias to the Great Oolite), affords the means of ascertaining somewhat imperfectly the actual thickness, by tracing upwards the beds, and it was this and similar means of information that led me to assign a thickness of 40 feet to the stage throughout the Stroud district. I am still inclined to think that this estimate presents an approximation to the truth as far as relates to these valleys, but that upon the outward escarpment of the Cotteswolds the thickness of the stage is more considerable. In confirmation of the latter fact I have been favoured with the following observation by G. F. Playne, Esq., taken with great care by the aid of the Aneroid Barometer, and which may be relied upon as presenting a near approach to accuracy.

FROCESTER HILL.

	Therm.	Barom.	Feet.
At the base of the Sands	43°	29,175	
At the upper margin of the Ammonite bed	44°	29,095	71¾
For change of temperature	1	add	5
The thickness of the Stage			76¾

At pages 55-6 Mr. Hull alludes to my statement, that "no positive line of separation can be drawn between the Forest Marble and the Great Oolite," and objects that over the northern Cotteswolds, and at the Sapperton Tunnel, a line of separation can be traced. My remark applied only to the limits of the Great Oolite and Forest Marble, as accepted at that period by Geologists, the Bradford Clay being regarded as the stratum which divided those formations, and could not, of course, apply to any subsequent proposed division, chosen at a different geological horizon, and founded upon mineral characters only; a boundary line which, however clearly defined, as it is not accompanied by any remarkable zoological change, can only be regarded as of subordinate value. Probably the terms Forest Marble and Bradford Clay might be omitted altogether without any detriment to science.

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* Several Works inserted in this List, although not special to the Jurassic system, contain much important information upon that subject.

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INDEX TO SCIENTIC TERMS, AND TO THE MORE CHARACTERISTIC GENERA OF JURASSIC TESTACEA FOUND IN THE COTTESWOLD HILLS.

Acrosalenia, *Echinodermata;* suborbicular, small, depressed, anal opening on one side of the supra anal plate, base flat, mouth large, decagonal and notched.

Acteonina, D'Orb.—*Gasteropoda*, cylindrical, smooth, spire elevated, aperture entire, linear above, columella rounded. Jurassic and Cretaceous. Cotteswold specimens are rare. (See plate 4, fig. 8.)

Alaria, Lyc.—*Gasteropoda*, winged shells. The outer lip in the young state is without any digitation or spine; in the adult form, the last volution which is always angular, formed a spine at three distinct stages of the growth, the ultimate stage having sometimes two or three digitations; the anterior canal is long, the posterior canal is not produced upon the spire as in *Rostellaria*. From *Spinigera*, D'Orb., it is distinguished by the absence of spines upon all excepting the last volution. Jurassic species are numerous. (See plate 7, fig. 2.)

Alluvium, a deposit of water-worn materials transported by river action.

Ammonite.—*Ammon, a name of Jupiter.* An extinct genus of shells which are rolled up upon themselves, and are divided into chambers by sinuous partitions having an external siphon. They belong to the class of cuttle fishes (Cephalapoda), and have been arranged by M. D'Orbigny into 21 groups or subordinate sections; as the stratigraphical range of species is limited, they afford useful guides to the position of rocks.

Amphidesma, for Jurassic testacea formerly assigned to this genus see *Myacites.*

Anatina, subgenus Cercomya, Ag., *Conchifera;* the elongated posterior side, the longitudinal folds, and the mesial vertical depression distinguishes *Cercomya* from the typical *Anatina.* Jurassic species are few. (See plate 3, fig. 2.)

Annellides, animals whose external tegument is formed of rings, as the earth worm.

Arcomya, Ag., *Conchifera;* see *Myacites.*

Astarte, a name for Venus, *Conchifera;* species are numerous, but few are older than the Inferior Oolite.

Belemnite, *Belemnos dart*, Cephalopoda; a genus of cylindrical pointed bodies; the dorsal bone of an extinct kind of cuttle fish. Jurassic and Cretaceous. Species appear to be numerous, but the actual limits of variation in these forms which may be referred to sex, the period of growth, &c., are not yet sufficiently understood.

Brachiopoda, *arm-footed;* a class of Mollusca; the organs of locomotion consist of arm like processes. In rocks of all ages.

Bryozoa, *moss like animals*, Polypes which incrust other bodies.

Bulla, *Gasteropoda;* species and individuals few in the Jurassic rocks. (See plate 4, fig. 7.)

Cardinia, Ag., *Conchifera;* oblong or ovate, compressed, valves thick, close fitting, umbones anterior depressed, ligament external, cardinal plate lengthened and large, teeth obscure, lateral teeth distant, large, muscular scars deep. Species all Triassic and Liassic.

Cardium, *Conchifera;* one of the Jurassic forms of this genus has a dorsal angle, and a single tooth in each valve; by some authors this section of the genus has been assigned to *Cardita*.

Cephalopoda, a class of Mollusca which have the principal locomotive organs attached to the head in the form of muscular arms or tentacles; they are divided into two orders, whose names are derived from the number of Branchiæ, viz., Dibranchiata and Tetrabranchiata, each of which are again subdivided into sections and numerous families. In the Lower Jurassic rocks this class consists of the following genera:—*Ammonites*, *Belemnites*, *Ancyloceras*, *Helicoceras*, *Teudopsis* and *Geoteuthis;* the two latter genera having only been found in the Lias. The Cephalopoda occur in rocks of all æras, the maximum in number of genera occur in the Palæozoic series; the few genera in the Lias being compensated for by a large number of species of *Ammonites*. In the Great Oolite the Cephalopoda exhibit their minimum both of genera and species.

Certilla, Mor. & Lyc., *Gasteropoda*.—Small subulate shells of many whirls, columella rather twisted at the base, aperture lengthened, entire, outer lip simple. Jurassic.

Ceromya, Ag., *Conchifera;* Anatinidæ: ventricose, umbones, large anterior, contiguous, ligament external, there is a posterior hinge fold in the right valve visible upon the shell; the surface has grooves or striations sometimes unsymetrical, hinge without teeth; test very thin. Distinguished from *Gresslya* by the more ventricose figure, larger umbones, by the posterior fold visible upon the *shell*, and by the absence of a granulated outer surface. Jurassic. (See plate 5, fig. 4.)

Chemnitzia, *Gasteropoda*; a turrited or subcylindrical lengthened univalve not umbilicated, the spire consisting of many volutions; the mouth is oval or angular, large at its anterior part, and contracted posteriorly; the outer lip is thin and nearly straight, the columella straight, rounded, and without teeth or folds. A genus confounded by the older conchologists with the *Melanias*, which are fluviatile. *Chemnitzia* occurs in rocks of all ages; it is

very sparingly distributed in the Cotteswold Hills. (See plate 2, fig. 1.)

Cirrus, Sow., *Gasteropoda;* turbinated, turrited, or depressed, whirls for the most part enveloping each other, umbilicated; the last volution provided with respiratory tubes; the species are usually sinistral. M. D'Orbigny has recorded two species from the Lias of France, and Sowerby two from the Inferior Oolite of Dundry, but as the latter forms are destitute of respiratory tubes, it would appear that they have been incorrectly assigned to this genus.

Conchifera, shells composed of two valves or pieces as the cockle, muscle, oyster, &c.

Corbicella, Mor. & Lyc., *Conchifera;* a subgenus of *Corbis* distinguished by the plain surface, compressed figure, absence of anterior lateral teeth, by the different form of the cardinal teeth, and also by the superior size of the posterior side, contrary to the typical form. This subgenus in its general figure and dental characters form a connecting link between *Corbis* and *Tancredia.* Several Jurassic species are known, two of which are abundant in the Spinosa Stage at Rodborough Hill. (See plate 6, fig. 1.)

Corimya, Ag.; see Thracia.

Corbis *(a basket), Conchifera;* species and individuals few, two species in the Inferior, and three in the Great Oolite of the Cotteswolds.

Cylindrites, Mor. & Lyc., *Gasteropoda;* cylindrical, smooth, spire of many volutions produced or sunk, the upper edges of the whirls being always visible; aperture entire, linear above, rounded below, base of the columella twisted; the latter character will serve to distinguish it from *Acteonina,* D'Orbigny. The genus occurs very sparingly in the Inferior Oolite, and rather abundantly in the Great Oolite of the Cotteswolds. (See plate 7, fig. 3.)

Cyprina, *Conchifera;* species and individuals numerous.

Cypricardia, *Conchifera;* a genus of Cyprinidœ, represented in the Cotteswolds by several species. (See plate 1, fig. 3)

Deslongchampsia, McCoy, *Gasteropoda;* Limpet like shells, with a prominent hook like apex, a grooved spatulate process beneath it extending beyond the general border of the shell; surface ornamented; Jurassic; rare. Example, *D. Eugenii,* Great Oolite, Minchinhampton. Sec. Mor. & Lyc., Ool. Mollusca, p. 94.

Dentine.—Elephants' teeth are constructed of three substances, Enamel, Dentine or Ivory, and crusta petrosa, stated in their order of hardness, the layers of these substances are presented at the upper surface of the tooth, and as they wear unequally, the grinding surface is not destroyed by the attrition of mastication.

Discohelix, Dunker, *Gasteropoda;* shell usually flat or concave above, aperture quadrangular; spire usually sinistral; a genus proposed to include the depressed species of Solarium in the Lower Oolites.

Diadema, *Echinodermata;* depressed surface, with perforated tubercles raised, on mamillary eminences, with slightly crenulated summits. Mouth large, and 10 sided. The spines are long, slender, and subulate.

Echinus, *Echinodermata;* globular, mouth large, circular, or pentagonal; primary tubercles of nearly equal size in both areæ forming vertical ranges, imperforated and smooth.

Falciferi, a group of Ammonites which are found chiefly in the upper stage of the Lias; the external form is compressed, furnished laterally with folds curved forwards, frequently forming an inflection or angle about the centre of their length, without tubercles. Back sharp, salient, keel narrow containing the siphon. For Jurassic Ammonites consult D'Orb. Paleont. Fran. terr. jurass., vol. 1-2. Chapuis and Dewalque, foss. terr. second, Prov. de Luxembourg. Quenstedt Cephalopoda. Sowerby's Mineral Conchology of Great Britain contains likewise a considerable number of these forms.

Fauna, the animals of a region.

Gasteropoda, shells of one piece as the Whelk and Perriwinkle. The foot, by means of which progression is performed, is placed beneath the belly.

Gervillia, *Conchifera* (a proper name), an extinct genus of the Aviculidæ; the lengthened straight and oblique hinge plate has some irregular pits to receive a multiple ligament; it has also some internal oblique teeth beneath the hinge plate; the left valve is usually the larger. The great majority of the species are Jurassic. (See plate 6, fig. 6.)

Goniomya, Ag., *Conchifera*, a genus of fossil Anatinidæ characterized by the presence of large ribs, which are directed obliquely downwards upon the sides of the valves, and meet others directed the opposite way at an angle more or less acute; the umbones are depressed; the valves gape at both extremities, the test is very thin, with a granulated surface. Several species are known, all of which are Jurassic. Some authors have united this genus with Pholodomya. (See plate 5, fig. 3.)

Granitic, composed of the three ingredients of granite, viz., Quartz, Feldspar, and Mica.

Gresslya, Ag., *Conchifera* (a proper name), a genus of fossil Anatinidæ; figure ovate and rather compressed, umbones anterior, that of the right valve being a little higher than the other, sides of the valves with irregular plications, and a granulated test; ligament external, there is also an internal posterior rib in the right valve, which is only seen upon the casts. Some authors have arranged this genus with *Ceromya*, others regard it as a subgenus of *Ceromya*. *Gresslya* is abundant in the Lower Jurassic rocks, more especially in the Inferior Oolite. (See plate 5, fig. 2.)

Grit, a coarse-grained sandstone.

Gryphœa, *Conchifera;* a subgenus of *oysters*, which has the beak of the lower valve prominent and incurved; there is also a lateral lobe more or less prominent, separated by a groove; the shell was usually attached by the extremity of the beak; it was gregareous in its habits. Some species in their immature states are true oysters; the entire genus is very abundant. The smooth forms

of oysters are usually gregareous, those with longitudinal folds are solitary; large specimens are only found in argillaceous deposits.

Hemicidaris, *Echinodermata*, subglobose, flattened at the poles; mouth large, with decagonal indentations; anus central, surrounded by a circle of 10 plates. Spines of two kinds, primaries long, cylindrical large, secondaries small. Jurassic and Cretaceous.

Hemipedina, Wright, *Echinodermata*, small highly ornamented urchins, much depressed on their upper surface with a flat or slightly concave base. Apicial disk large, genital and ocular plaits expanded and foliated; spines long, slender, needle shaped, and their surface sculptured with longitudinal lines. It is related to Pedina in its perforated and uncrenulated tubercles, but distinguished by having the pores in the zones in single pairs. Jurassic, 16 species known, of which 7 are found in the Cotteswolds.

Hinnites, *Conchifera*, a genus distinguished from Pecten by the irregularity of the valves, one of which in the adult state is attached to the ground or to another substance, and thinner than the other; the surfaces are highly ornamented. Young specimens are not irregular. (See plate 5, fig. 5.)

Hippopodium (horse's foot), *Conchifera;* shell oblong, very thick, with rugose longitudinal plications, and a large oblique dorsal ridge; hinge without teeth, but with a lengthened and thick plate to support the ligament. Muscular scars, 2 in each valve, oval, the anterior one deeply impressed, there is also a small pedal pit. The genus is only known by one (a Liassic) species.

Holectypus, Desor., *Echinodermata*, tumid, anal opening inframarginal, mouth central, tubercles perforated and crenulated. Jurassic and Cretaceous.

Homomya, Ag., *Conchifera;* a proposed genus or rather subgenus of *Pholadomya*, resembling in figure the more elongated forms of that genus; *Homomya* is distinguished by the thick test; absence of radiating ribs upon the sides of the valves, and by the presence of a mesial oblique depression, which extends from the umbones to the lower border. The ligament is short, the hinge edentulous, but with a stout cardinal lamina, and some fine radiating lines may occasionally be seen upon the umbones. The surface is destitute of granulations; and the muscular scars are very faintly traced. Casts cannot be distinguished from those of *Myacites*, and some uncertainty will even occasionally exist when the test is preserved, the larger umbones being the usual characteristic of *Homomya*, *H. gibbosa*, *H. crassicuscula* and *H. Vezelayi* are the more common Cotteswold species of the subgenus.

Hyboclypus, Ag., *Echinodermata*, shell much depressed, anus in a valley of the dorsal surface, mouth excentral, surface with perforated tubercles raised on eminences with crenulated summits. Jurassic.

Isoarca, *Conchifera;* a ventricose Arca like shell, with large anterior umbones and external ligament; D'Orbigny has recorded two

species in the Inferior Oolite of France, but the genus has not been recognized in the Cotteswolds.

Isocardia, (etym., *isos* like, and *cardia* heart,) *Conchifera;* two species occur in the Cotteswold Inferior Oolite, but fossils attributed to the genus are numerous, certain of these belong to the genus *Ceromya.*

Jurassic rocks, so named from the mountainous region which divides France from Switzerland.

Lima, *Conchifera;* an oblique equivalve shell, with unequal auricles; the umbones being either in contact or diverging. Jurassic species are numerous, more especially in the Cotteswold Hills. *Lima pectiniformis*, a remarkable species of the Inferior Oolite, acquired with advance of growth the aspect of a *Spondylus*, with irregular tubular spines; ultimately, owing to shell deposit upon the interior of the valves, it acquired a thickness of upwards of $2\frac{1}{2}$ inches, and the umbones widely diverged; this feature is not observable in other Limæ. (See plate 1, fig. 5.)

Limopsis, Sassi, *Conchifera;* small, smooth, subquadrate, compressed shells, with pointed mesial umbones; the hinge consists of a broad curved plate, with a diverging row of raised teeth upon each side of a central fossa. *L. ooliticus* is abundant in the Great Oolite of Minchinhampton.

Limea, Goldf., *Conchifera;* a subgenus of *Lima*, distinguished by the presence of a parallel series of teeth upon the hinge plate on each side of the umbo, and beneate the auricles; the figure is without the obliquity of *Lima*, and the auricles are of equal size, well preserved specimens exhibit external grooves upon the auricles corresponding to the dental elevations beneath. Two species in the Cotteswold Inferior Oolite.

Lutraria, *Conchifera;* the numerous Jurassic species, formerly known under this generic name, are now arranged under *Myacites*, *Homomya*, *Pholadomya*, *Unicardium*, and *Goniomya.*

Macrodon, Lyc., *Conchifera.* Figure resembling that of *Byssoarca*, with a similar basal aperture; teeth anterior, one or two being elongated posteriorly upon the hinge plate. Carboniferous, Triassic, and Jurassic.

Mactromya, Ag., *Conchifera;* for M. globosa, M. æqualis, &c., see *Unicardium;* for M. mactroides see *Quenstedtia.*

Myacidœ, Myadœ, or Myariœ; a family of Conchifera which usually gape at both extremities, and have large folds upon the sides; ligament external or internal, test thin, hinge usually edentulous, but having a thickened hinge lamina; several genera as *Myacites*, *Goniomya*, and *Gresslya*, have an external granulated tegument. Anatinidœ would be the more correct designation for this family, which includes the following genera of Jurassic forms, *Myacites*, *Pholadomya*, (with its subgenus *Homomya*,) *Ceromya*, *Gresslya*, *Anatina*, *Thracia*, and *Goniomya.*

Myacites, Schlot., a proposed genus of fossil *Anatinidæ*, which ranges throughout all the secondary rocks, and is represented by

a great variety of forms, certain of which resemble the more elongated species of *Pholadomya*, others with compressed sides have an expanded posterior aperture, another series have the valves almost close fitting, and lastly, others have a rhomboidal figure approaching to that of the more elongated *Arcas*. These distinctions of form, together with some minor differences of the hinge, and supposed distinctions in the test, induced Agassiz to arrange them under the following genera: *Pleuromya*, *Arcomya*, *Myopsis*, and perhaps *Platymya*. These forms have a thin test, granulated outer tegument, large folds upon the sides of the valves, no hinge teeth properly so called, but sometimes the hinge lamina assumes the shape of a dentiform process, the ligament is short and external, the siphonal scar is deeply retracted. The foregoing proposed genera, which were for the most part founded upon casts (Etudes Critiques), cannot be sustained, and the whole probably should be arranged under the single genus Myacites, Schl., the proposed genera remaining as groups or sectional divisions. The Cotteswold species are numerous, more especially in the Spinosa Stage of the Inferior Oolite. (See plate 5, fig. 1, and plate 6, fig. 2.)

Myoconcha, Sow., *Conchifera;* elongated, shaped like a Modiola, but more pointed at the extremities; the hinge has an obtuse tooth in one valve, which is received into a pit in the other; the anterior muscular scar is supported by a prominent ledge, and is deeply impressed. Jurassic. (See plate 3, fig. 1.)

Myopsis, Ag., *Conchifera;* see Myacites.

Natica, *Gasteropoda;* Jurassic species are numerous, they consist chiefly of the more elongated forms, which are nearly destitute of an umbilicus, these approach to the genus *Phasianella*. The fossil species are often difficult to distinguish from each other, and with casts should scarcely be attempted. For Cotteswold species see Phillips's Geology of Yorkshire, vol. 1, also the Monograph of the Great Oolite Mollusca, by Morris and Lycett, in which numerous species are figured and described. (See plate 3, fig. 10.)

Nerinœa, Defr., *Gasteropoda;* a genus of extinct, turrited, or cylindrical spiral shells, with numerous whirls; both the pillar and outward or upper walls of the interior, have usually one or more strong folds, which are continued throughout the whirls; these folds are sometimes simple, or they have great complexity and contract the aperture so much, that its section has the aspect of an Egyptian hieroglyphic figure; (see the sections in plate 2) the columella is umbilicated in the turrited and solid in the more cylindrical species, and occasionally both the kinds of columella are seen in the same species, the folds likewise sometimes vary during the progress of growth; the aperture is subquadrate with a short channel at each extremity. Mr. D. Sharpe, in an interesting memoir on this genus, proposed to arrange the numerous species into four subgenera, founded upon distinctions which are supplied chiefly by the number and character of the folds upon the walls of the aperture; but so varied are the aspects which the

interior of these shells assume, that the value or advantage of such a subdivision is questionable; the folds, however, afford the most certain characters for the discrimination of the species. The examples in plate 2 illustrate the primal forms of the genus, and shew that both the more simple and complex forms of the interiors appeared simultaneously. Nerinœa acquired its maximum of development in the Coralline Oolite, and became extinct before the close of the cretaceous epoch. Five species are ascertained in the Inferior Oolite, and six in the Great Oolite of the Cotteswolds. (See plate 2.)

Nerita, *Gasteropoda.* The Jurassic species may be arranged under the following three subgenera:—

1. *Nerita*, shell thick, hemispherical, whirls carinated, aperture semilunar; outer lip thick and smooth, inner lip flat and smooth, without notch or striœ, surface ornamented.
2. *Neridomus*, shell smooth, aperture ovate or semilunar, outer lip thick, inner lip thick, convex, and smooth.
3. *Neritopsis*, inner lip concave, with a wide notch upon its inner border, surface sculptured. Jurassic and cretaceous; species numerous.

Nucleolites, Lam., *Echinodermata*, covered with small imperforate tubercles, mouth opening subcentral; anal opening situated in a valley of the dorsal surface, vertex excentral, ambulacra pettalloid. Jurassic.

Oolite *(egg stone)*, resembling the roe of fishes; a kind of concretionary limestone, which abounds in the Jurassic system of rocks.

Opis, Defr., *Conchifera*, figure subtrigonal, test thick, umbones curved subspirally inwards, ligament external, usually there is a dorsal keel, and the lunule is large and excavated; the hinge has one large projecting tooth in the left valve, the other valve has a cavity between two smaller teeth; Jurassic. (See plate 4, fig. 2.)

Pachyrisma, Mor. & Lyc.—*Conchifera* (Etym. *pachus* thick, *ereisma* support). Shell cordiform, with large subspiral umbones; valves anteriorly very thick; keeled obliquely, hinge with a thick conical tooth behind the pit in the right valve, a small anterior lateral tooth, a thickened and projecting hinge lamina in each valve; anterior adductor scar large and oval, ligamental plates short and strongly defined. A single species only known; it occurs in a bed of white limestone, situated a little higher than the shelly Oolite of Minchinhampton. (See plate 7, fig. 1.)

Palœontology; the science of fossil animals.

Panopœa, *Conchifera;* an equivalve elongated, inequilateral shell gaping at the extremities, the hinge having a single conical projecting tooth in each valve. The recent species are few and distributed over distant seas. Numerous Jurassic testacea have been assigned to *Panopœa* by some authors, including nearly the whole of those arranged as *Myacites* in this Hand-book, the distinction consisting in the absence of a hinge tooth (properly so called) in *Myacites*. Terquem has affirmed the presence of true Panopœas in the Jurassic rocks, but casts alone are insufficient to determine the question.

Patella (Limpet), *Gasteropoda ;* the Great Oolite of Minchinhampton contains numerous species; in the Inferior Oolite they occur very sparingly.

Pholadomya, *Conchifera ;* a genus of Anatinidœ which is peculiarly abundant in the Jurassic rocks, distinguished by their tumid figure, large rounded umbomes and radiating ribs upon the sides of the valves which gape at both the extremities ; the test, which is rarely preserved, is thin and translucent; the hinge has only a delicate longitudinal lamina in each valve. An important Jurassic genus, the study of which is rendered difficult by variations of figure, and of the ribs produced apparently by accidental circumstances of position, rendering great care necessary in the discrimination of species. When the shells are found in their normal position, it frequently happens that the antero-inferior border upon which they rested is compressed, producing a change in the direction of the ribs and of the general figure, a condition which sometimes existed even from an early period of the growth. and was probably produced by supercumbent pressure when the shell rested upon a bed already consolidated. *Homomya* is a subgenus. Consult the elaborate monograph on this genus by Agassiz in his "Etudes Critiques sur les Mollusques fossiles." *Pholadomya* occurs in oolitic sandy limestones, in argillaceous limestones, and still more frequently in clays and marls, it is not found in beds which abound with shelly detritus, and is therefore absent in the freestones of Leckhampton and in the shelly weatherstones of Minchinhampton; owing to its buried habitat it has more commonly escaped compression during fossilization than other and stouter shells. (See plate 6, fig. 4.)

Pentacrinite, *Radiaria*, a genus of sea lillies, the stems of which are five sided.

Phytiphagous, plant eating.

Perna, *Conchifera*, equivalve or inequivalve, usually compressed, subquadrate, squamous, beaks terminal, hinge plate with numerous parallel ligamentary pits. *P. rugosa* represents the flattened and equivalve, *P. quadrata* the Inoceramus like, inequivalve form. (For the latter see plate 3 fig. 11.)

Pileolus *(a little cap)*, Gasteropoda, a genus of small extinct shells, which have much the aspect of a depressed limpet, but the mouth nearly resembles that of *Nerita*, to which it is evidently allied; it is represented by two species in the Cotteswolds, which occur in the Inferior and Great Oolite.

Pisolite (*pea stone*), a rock with large oolitic concretions which often resemble peas, more frequently flattened.

Placunopsis, Mor. & Lyc., *Conchifera*, distinguished from Placuna by the absence of the diverging hinge teeth. It was attached in some instances by the flat valve to valves of Trigonia, Lima, &c., whose sculpture is then transferred through the lower valve, body of the animal and upper or convex valve, but specimens of the lower valve, destitute of such impressions are common. *P. socialis* frequently has the colours preserved. Jurassic. (See plate 7, fig. 10.)

Pleuromya, Ag., *Conchifera ;* see Myacites.

Pleurotomaria, *Gasteropoda*, an extinct genus of conical or trochus shaped shells, which have a fissure upon the outer lip; a thickened spiral band marks the position of the fissure during the growth of the shell; the surface is sculptured, in certain localities the number of species are considerable, but in the Cotteswolds the genus is comparatively rare.

Plicatula, *Conchifera;* a subgenus of *Spondylus* destitute of lateral auricles, several Cotteswold species occur sparingly distributed.

Psammobia (living in sand) Conchifera; recent species are numerous, and several Jurassic shells have been assigned to it from a general resemblance of external form; one of these is the *Quenstedtia lævigata*, found in the Cotteswold Inferior Oolite.

Pteroceras, *Gasteropoda;* a genus of winged shells, which differ from Strombus chiefly in the outer lip, having upon that border of the aperture several large tubular spines. The spines are only formed at the ultimate stage of growth; this latter feature, together with their number, will serve to distinguish it from *Alaria* and *Spinigera; Rostellaria* is destitute of the spines, and does not occur in the Jurassic rocks. *Pteroceras* occurs rarely in the Great Oolite of Minchinhampton, and also in the Slate of Collyweston.

Pteroperna, Lyc., *Conchifera;* a subgenus of *Avicula*, distinguished by the presence of a series of small parallel teeth at the anterior extremity of a lengthened hinge plate, upon which one or two folds extend backwards. Several Jurassic species. (See plate 7, fig. 9.)

Purpuroidea, Lyc., *Gasteropoda*, figure resembling *Purpura*, spire produced, aperture large with a very wide but not deep basal notch; columella rounded, outer lip thin, surface sculptured with a circle of spines or tubercles upon their angle. Four large species are known in the Great Oolite of the Cotteswolds. (See plate 7, fig. 8.)

Pygaster, Ag., *Echinodermata*, pentagonal, surface with perforated tubercles, raised on mamillated and crenulated eminences and surrounded by areolœ, with encircling granules; mouth opening central, anal-opening large, occupying the upper half of the single interambulacral area. Jurassic and cretaceous.

Quenstedtia, Mor. & Lyc., *Conchifera;* figure oblong, compressed, slightly gaping at the extremities, surface smooth, with an obtuse oblique posterior angle; umbones submesial depressed, ligament external, placed within an elongated groove; hinge lamina, lengthened, with a small projecting obtuse, slightly spatulate tooth in the left valve, received into a corresponding pit in the other valve. Siphonal flexure short, muscular scars rounded, faintly marked. Two species in the Cotteswold Inferior Oolite. (See plate 4, fig. 6.)

Rhynchonella, *Brachiopoda;* occurs abundantly in the Cotteswolds. (See plate 1, fig. 7.)

Rissoina, D'Orb, *Gasteropoda;* a minute turrited thick shell, differing from *Rissoa* by possessing a slight basal notch. Five species have been obtained in the Great Oolite of Minchinhampton, but specimens are rarely found, probably owing to their minute size.

Ragstone, a hard rubbly stone, which breaks into irregular masses.

Shale, laminated clay hardened.

Sphœra, Sow., *Conchifera*, a subgenus of Corbis, characterized by its plain surface, globose figure, and by the absence of the posterior lateral tooth of the typical form. Jurassic and cretaceous.

Spirorbis, *Annellides*; specimens are found attached to *Terebratula* and *Gryphœa*. One Inferior Oolite species is not uncommon in the Cotteswolds.

Spondylus, *Conchifera;* some species of *Hinnites* have erroneously been assigned to this genus.

Stage, from *etage;* a series of beds enclosing a fauna distinguished from others, constitutes a stage.

Stomatia, *Gasteropoda*, rare in the Great Oolite.

Tancredia, Lyc., Hettangia, Terq., *Conchifera*, transverse, smooth, ovately trigonal, rather compressed, with a posterior angle, ligament external. Hinge with one obtuse cardinal tooth in each valve and a pit, also an approximale posterior lateral tooth, which is large in the typical species. Twelve species in the Lias of France; nine in the Inferior and Great Oolite of the Cotteswolds; some species approximate to *Corbicella*. (See plate 4, fig. 3.)

Tellina, *Conchifera;* was formerly believed to be abundant in the Jurassic rocks, and various species of *Thracia*, *Corbicella*, *Quenstedtia*, *Tancredia*, and *Myacites*, have been assigned to it; D'Orbigny still retains it in his list of Jurassic testacea, but in none of the doubtful instances does it appear that the hinge has been fully exposed; further researches are required to establish it as a Jurassic genus.

Terebratula, *Brachiopoda;* (Etym. terebratus perforated.) Species and varieties are abundant in the Cotteswolds, requiring great care in their discrimination.

Trigonia, Brug., *Conchifera;* shell subtrigonal or crescentic, with two strong diverging crenulated teeth in each valve; the sides have rows of longitudinal ribs or varices, and there is a flattened posterior slope or area which is also ornamented. The Jurassic and cretaceous species are numerous; it is unknown in the Tertiary rocks, and is represented in our present seas by a single species from the sea of New South Wales. A genus of importance in the study of Jurassic Mollusca, as individuals are numerous, and species have a small stratigraphical range, excepting when they occur as *varieties* in a newer stage. For extensive information upon this genus, refer to the Memoir on Trigonia in the Etudes Critiques of Agassix; for Great Oolite species, to the Monograph on Great Oolite Mollusca, by Morris and Lycett; and for Inferior Oolite species to a Memoir by the last-named author in the Annals and Mag. of Nat. Hist. for Sept., 1853. (See plate 1, fig. 8.)

Trochotoma, Lyc., Desl., *Gasteropoda;* resembles *Pleurotomaria* in figure, but the fissure, which in the latter genus divides the outer lip, is in *Trochotoma* placed at same distance backwards, forming a separate apertnre as in *Haliotis*. Refer to an interesting

memoir on this genus by M. Eudes Deslongchamps, in the Transactions of the Linnean Society of Normandy, vol. 7. The known species occur chiefly in the Lower Jurassic rocks. (See plate 4, fig. 5.)

Umbrella, *Gasteropoda;* shells ascribed to this genus have been found in the Great Oolite, both of Normandy and the Cotteswolds; a thin test, depressed circular figure, and mesial apex are their characteristics, they are also radiately ornamented.

Unicardium, D'Orb., *Conchifera;* shell thin, tumid, oblong or ovate; umbones depressed, antero mesial, the hinge is ligamentary and destitute of teeth, but there is a lengthened posterior internal lamina beneath the ligament. Surface plain, with longitudinal rugose plications, palleal line simple. Many species occur in the Jurassic rocks. (See plate 4, fig. 1.)

Unio, *Conchifera;* Certain Jurassic marine testacea, formerly assigned to this fluviatile genus, are now distributed under *Cardinia* and *Gresslya; Unio* has, however, been procured in the estuarine plant-bearing beds of the Yorkshire coast.

Venus, also Pullustra, *Conchifera;* an examination of the internal characters of Jurassic shells formerly attributed to these genera, has resulted in their being placed with *Cyprina, Astarte, Lucina, Cypricardia,* and *Quenstedtia.*

Zoophaga, flesh eaters.

POSTSCRIPT.

During the period which has elapsed since the List of Fossils from the Cynocephala Stage was written, some additional testacea have been obtained, and in other instances the acquisition of better examples has led to the detection of errors of identification; these circumstances, together with the discussion which has recently been excited amongst Geologists respecting the formation to which the stage should be assigned, will be a sufficient apology for rendering the following amended list of testacea, arranged into two distinct zones. In each of these zones the fossils have been obtained at different localities, but the names of localities are added, only when the species has not been found at Frocester Hill in the upper, or at Nailsworth in the lower zone, the two places which have yielded the most considerable assemblages of these fossils.

CYNOCEPHALA STAGE, UPPER ZONE.

Ammonites variabilis, D'Orb. var. Beanii.
——— *variabilis*, var. dispansus.
——— *striatulus*, Sow.
——— *comensis*, De Buch.
——— *insignis*, Schub.
——— *insignis*, var., with compressed back.
——— *subinsignis*, Op.
——— *Jurensis*, Zeit.
——— *discoides*, Ziet.
——— *Boulbiensis*, Y. & B.
——— *Levesquei*, D'Orb.
——— *torulosus*, Schub.
——— *Moorei*, Lyc.
——— *Leckenbyi*, Lyc.
——— *radians Dewalqueanus*, Rein.
——— *radians Orbignianus*, Schlot.
Belemnites tripartitus, Schl.
——— *irregularis*, Schl.
——— *compressus*, Voltz.
Nautilus latidorsatus, D'Orb.
Turbo capitaneous, Munst.
Cerithium papillosum, Desl., Longfords.
Cypricardia cordiformis, Desl.
——— *brevis*, Wright.
Cucullæa ferruginea, Lyc.
Tancredia, n. sp.
Cardium Hullii, Wright.

Opis lunulatus, Sow. var.
—— *carinatus*, Wright.
Trigonia Ramsayi, Wright.
———— *striata*, Sow.
———— *costata ?* Haresfield Hill.
Astarte complanata, Roem.
———— *excavata*, var. Sow.
———— *detrita*, Goldf.
———— *lurida*, Sow., a short gibbose var.
Macrodon Hirsonensis, D'Arch.
Gryphæa plicata, Lyc., Haresfield Hill.
Hinnites abjectus, Phil., sp.
Lima Electra, D'Orb.
—— *bellula*, M. & L., var.
Modiola Sowerbyi, Sow.
Pecten textorius, Schl.
Gervillia Hartmani, Goldf.
Pinna fissa, Goldf.
Goniomya angulifera, Sow. sp.
Pholadomya fidicula, Sow.
———— *arenacea*, Lyc.
Gresslya abducta, Phil., sp.
———— *conformis*, Ag.
Myacites arenacea, Ag., sp.
———— *species*, undet.
Homomya crassiuscula, M. & L., Longfords.
Terebratula subpunctata, Dav.
Rhynchonella cynocephala, Rich.
———— *Jurensis*, var., Haresfield Hill.

LOWER ZONE.

Ammonites variabilis, var., dispansus.
———— *Raquinianus*, D'Orb.
———— *species allied to Raquinianus.*
———— *Jurensis*, Ziet.
———— *radians Orbignianus.*
———— *striatulus.*
———— *subinsignis ?* Op.
———— *Bonibiensis*, Y. & B.
Belemnites compressus.
———— *tripartitus.*
Nantilus latidorsatus.
Turbo capitaneus.
Trochus duplicatus.
Pleurotomaria subdecorata, D'Orb.
Chemnitzia lineata, Sow. sp.
———— *species*, undet.
Natica adducta, Phil.
———— *Oppelensis*, Lyc.
Astarte lurida, Sow.
———— *complanata.*
———— *rugulosa.*

Trigonia striata.
Cypricardia brevis.
——— *cordiformis.*
Cucullœa ferruginea.
Nucula jurensis, Quenst.
Cardium Hullii.
Unicardium, sp. undet.
Myoconcha crassa, Sow.
Perna rugosa, Munst.
Goniomya angulifera.
Gervillia Hartmani.
——— *fornicata*, Lyc.
Avicula inæquivalvis ? Sow., Brimscombe.
——— *substriata*, Goldf.
Modiola cuneata, Sow.
——— *Sowerbii.*
——— *compressa*, Goldf.
——— *ungulina*, G. & B., Brimscombe.
Mytilus lunularis, Lyc.
——— sp. undet.
Lima electra.
——— *bellula.*
——— *Galathea*, D'Orb.
——— *ornata*, Lyc.
——— n. sp.
Pholadomya arenacea, Lyc.
——— *fidicula.*
——— sp. undet.
Myacites arenacea.
——— sp. undet.
Rhynchonella cynocephala, Brimscombe.
——— *plicatella*, var. Brimscombe.
Orbicula reflexa, Phil.

Ammonites opalinus has purposely been omitted in the above list, as it is probable that the sole specimen found upon the ground at Haresfield Hill, was derived from the calcareous sandstones which overlie the Ammonite bed, and with which the mineral character of the specimen agrees: this is the position assigned to the species both by Quenstedt and Oppel; *viz.:* the Br. Jura *a*, of the former author. A. opalinus Rein. has been confounded with the A. primordialis of Schlotheim and of D'Orbigny, but the latter is a different shell of the Upper Lias. A. opalinus Pusch is again a third species.

Ammonites variabilis *var Beanii*, from the Upper Lias of York and Somerset, occurs likewise very rarely at Frocester Hill, my cabinet contains a single example. The very abundant Cotteswold form of the species *var dispansus*, is more compressed, the volutions are more enveloped; the fasciated tubercles and the ribs are less prominent and more numerous, the ribs are likewise much more curved.

CORRIGENDA.

At page 22, it is stated that Painswick Beacon is the most northern point at which the Cynocephala Stage has been observed in the Cotteswolds; for this read the most northern point at which *the Ammonite bed* has been observed in the Cotteswolds; the sands destitute of fossils are exposed at other and more northern points of the district.

Pages 25 and 26. For the fossils of the Cynocephala Stage see the corrected lists in the Postscript.

At page 27 it is stated that two Ammonites of the Cynocephala Stage have been found in the Inferior Oolite; this is given upon the authority of Quenstedt and of Oppel, who mention the lowest bed of the Inferior Oolite (Brown Jura *a*) as the position of A. torulosus and A. opalinus. The species in question cannot as yet be admitted into the list of the *British* Inferior Oolite fauna.

Page 39, line 5, for Cynocephala Stage, read Fimbria Stage.

Page 43, line 2, for dentritus, read detritus.

Page 47, line 16, for Walls quarry, read Watts's quarry.

Page 45, Terebratula fimbria (Note omitted). This species is usually separable into two forms or varieties which may be distinguished during their entire growth. The first or larger form is the more rounded, the anterior border is destitute of plications; the adult condition has marginal folds which pass backwards only a short distance from the border. The second or smaller form is more oblong and compressed laterally, the young condition has marginal folds, which in the adult state become deep and lengthened, extending backwards almost to the beak; the concentric folds of growth are likewise strongly marked. It is probable that these differences are referable to distinctions of sex.

Page 159. (Omitted in the list of characteristic genera.) Trichites Lhwyd., *Conchifera*. Shell inequivalve, ham shaped, sometimes gryphoidal; valves close fitting all round, except at the terminal beak; the anterior border is steep and excavated, the superior border thin and irregular, the posterior border has a considerable flexure; the surface has irregular longitudinal folds and sometimes radiating depressions; the structure of the test is fibrous as in Pinna and Avicula; the inner or nacreous layer is never preserved, but judging from the strongly marked muscular scar, it must have been thin; the scar is large and resembles that of Pinna. T. undulatus a large and massive shell occurs in the Spinosa Stage of the Inferior Oolite; T. nodosus a smaller and more gryphoidal species occurs in the Fimbria Stage of the same formation, and a presumed variety of it in the Great Oolite of Minchinhampton.

Page 138, line 2, for formation, read formations.

Page 140, line 44, for Ammonites concavus, read A. Boulbiensis, Y and B, this latter Liassic species has sometimes been considered as a Synonym of the former, but it appears to be sufficiently distinct.

Page 140, line 46, after Avicula inæquivalvis add a ? additional specimens are required.

Page 144, line 18, for Lecondaires, read Secondaires.

Page 136, line 29, for Thomarsensis read Thouarsensis.

Page 150 for Certilla read Ceritella.

EXPLANATION OF THE PLATES.

PLATE 1.

FOSSILS OF THE CYNOCEPHALA STAGE.

Fig. 1, *a*. Belemnites irregularis Schloth. *Syn. B. digitalis Blainv.*
1, *b*. Belemnites irregularis, transverse section at the summit of the alveolus.
2, *a*. Ammonites Moorei, Lyc., small specimen, see p. 122.
2, *b*. Ammonites Moorei, the sinuous septa magnified.
3, *a*. Cypricardia brevis, Wright.
3, *b*. Cypricardia brevis, the hinge.
4. Natica Oppelensis, Lyc., see p. 123.
5. Lima ornata, Lyc., see p. 127.
6. Opis carinata, Wright.
7, *a*. 7, *b*. Rhynchonella cynocephala, Rich., the ultimate stage of growth, front and lateral views, see p. 133.

PLATE 2.

Fig. 7. Ammonites Leckenbyi, Lyc., internal cast, see p. 123.

FOSSILS OF THE FIMBRIA STAGE.

Fig. 1. Chemnitzia procera, Desl., see p. 150.
2, *a*. Nerinœa Cotteswoldiœ, Lyc., see p. 124.
2, *b*. Nerinœa Cotteswoldiœ, section exhibiting the folds upon the walls of the interior, magnified two diameters.
3, *a*. Nerinœa gracilis, Lyc., p. 124.
3, *b*. Nerinœa gracilis, section of the interior.
4. Nerinœa Jonesii, Lyc., see p. 124.
5. Nerinœa pseudocylindrica, D'Orb.
6, *a*. Nerinœa Oppelensis, Lyc., see p. 123.
6, *b*. Nerinœa Oppelensis, section of the interior twice magnified, exhibiting the complicated folds.

PLATE 3.

FOSSILS OF THE FIMBRIA STAGE.

Fig. 1. Myoconcha striatula, Goldf. sp., see p. 155.
2. Cercomya (Anatina) pinguis, Ag., see p. 149.
3. Opis elongatus, Lyc.
4. Trigonia tuberculosa, Lyc.
5. Opis gibbosus, Lyc.
6. Trochotoma calix, Phil. sp.

Fig. 7. Tancredia compressa. *Syn. Hettangia compressa, Terq. Pullastra opalina Quenst.*
8. Turbo Oppelensis, Lyc., a sinistral species, see p. 127.
9, *a*. Trichites nodosus, Lyc., the convex valve reduced three diameters, see p. 146, also the Corrigenda.
9, *b*. Trichites nodosus, the dotted figure shews the convexity.
10. Gervillia tortuosa, Phil. sp. the convex valve.
11. Perna quadrata, Sow., the convex valve reduced two diameters. The figure scarcely represents the steep concavity of the anterior side; a portion of the thin shell has been detached, disclosing fine radiating striations upon the cast.

PLATE 4.

FOSSILS OF THE SPINOSA STAGE.

Fig. 1. Unicardium depressum, Phil. sp., see p. 160.
2, *a*. Opis cordiformis, Lyc., slightly reduced, see p. 128.
2, *b*. 2, c. Opis cordiformis, the hinge slightly magnified.
3. Tancredia donaciformis, Lyc., *Syn. Hettangia Dionvillensis Terq.*, slightly reduced, see p. 159.
3, *a*. 3, *b*. Tancredia donaciformis, the hinge.
4. Trigonia hemispherica, Lyc., slightly reduced, see p. 137.
5. Trochotoma carinata, Lyc. The fissure upon the angulated border of the last volution is not distinctly seen, see p. 159.
6, *a*. Quenstedtia oblita. *Syn. Pullastra oblita, Phil. Mactromya mactroides, Ag. Psammobia mactroides, Terq.*, see p. 158.
6, *b*. 6, *c*. Quenstedtia oblita, the hinge.
7. Bulla Favrei, Lyc., see p. 125.
8. Acteonina antigua, Lyc., see p. 125.
9. Acteonina convoluta, Lyc., see p. 125.
10. Avicula digitata, Desl., the convex valve.

PLATE 5.

FOSSILS OF THE SPINOSA STAGE.

Fig. 1, *a*. Myacites compressiusculus, Lyc., see p. 129.
1, *b*. Myacites compressiusculus, the upper surface.
1, *c*. Myacites compressiusculus, portion of the surface magnified.
2, *a*. Gresslya abducta, Phil. sp., slightly reduced.
2, *b*. Gresslya abducta, the anterior side.
3, *a*. Goniomya angulifera, Sow. sp., *Syn. G. proboscidea, Ag.*
3, *b*. Goniomya angulifera, a portion of the surface magnified.
4, *a*. Ceromya Bajociana, D'Orb., reduced one diameter.
4, *b*. Ceromya Bajociana, the upper surface of the left valve shewing the projecting hinge lamina.
5. Hinnites abjectus, Phil. sp., *Syn. Spondylus tuberculosus, Goldf. Pecten tuberculosus, Quenst.*, an example of the convex valve, small size.

PLATE 6.

FOSSILS OF THE SPINOSA STAGE.

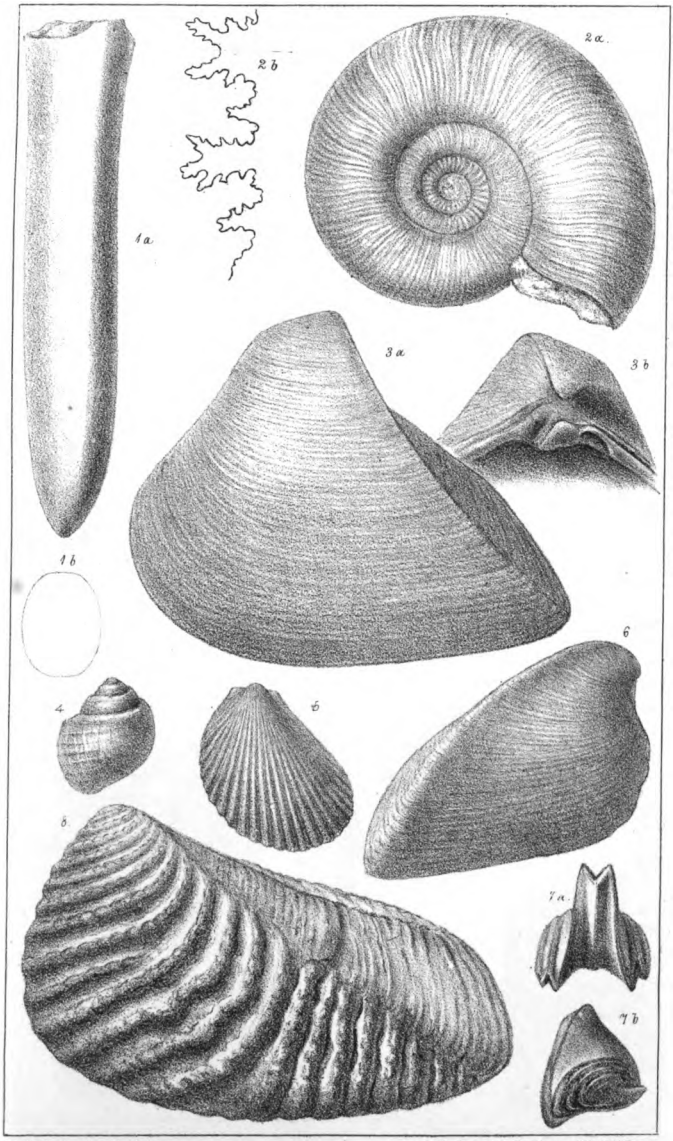
Fig. 1, *a*. Corbicella complanata, Lyc., reduced one-third, see p. 128.

Fig. 1, *b*. Corbicella complanata, the hinge.
2. Myacites Goldfussii, sp., an internal cast, shewing the adductor scars and the siphonal flexure. See note in the Appendix, p. 139.
3. Turbo Etheridgii, Lyc., a sinistral species, p. 125.
4. Pholadomya Dewalquea. *Syn. P. media, Ch. & Dew. non. Ag.*
5. Trigonia V. costata, Lyc., slightly reduced.
6. Gervillia prælonga, Lyc., slightly reduced, the more convex valve, see p. 127.

PLATE 7.

Fossils of the Great Oolite.

Fig. 1, *a*. Pachyrisma grande, Mor. & Lyc., reduced two-thirds, see p. 156.
1, *b*. 1, *c*. Pachyrisma grande, hinge, reduced one half.
2. Alaria lœvigata, Mor. & Lyc.; showing the production of a single tubular spine at two positions upon the last volution, and ultimately of two spines, see p. 149.
3. Tancredia brevis, Lyc.
4. Tancredia gibbosa, Lyc., p. 121.
5. Trigonia impressa, Sow., see p. 159.
6, *a*. Nerinœa Voltzii, Desl.
6, *b*. Nerinœa Voltzii, section of the interior.
7. Cylindrites acutus, Sow. sp., see p. 151.
8, *a*. 8, *b*. Purpuroidea insignis, Lyc., reduced one-third; specimen at the ultimate stage of growth in which the coronary tubercles cease to be formed, and the basal notch is obliterated; p. 124.
9. Pteroperna costatula, Desl. sp., young specimen; at a more advanced stage of growth the sculptured surface ornaments disappear, see p. 158.
10. Placunopsis Jurensis, Roemer sp., specimen of the flat valve, see p. 157.



W. H. Baily, del. et lith.

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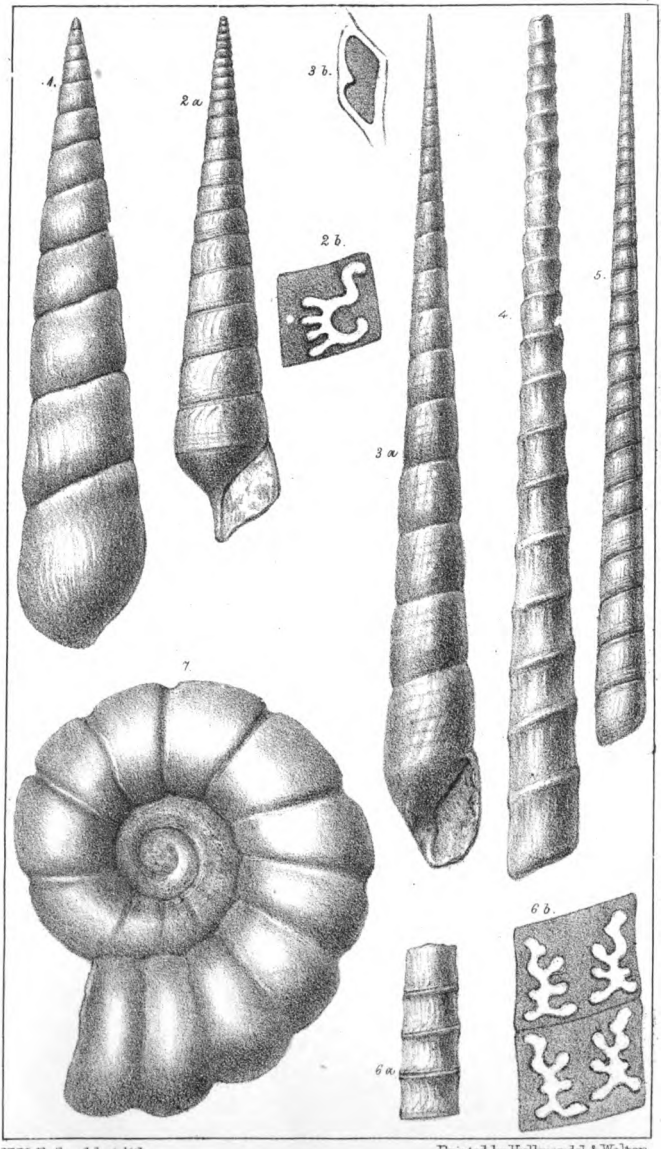

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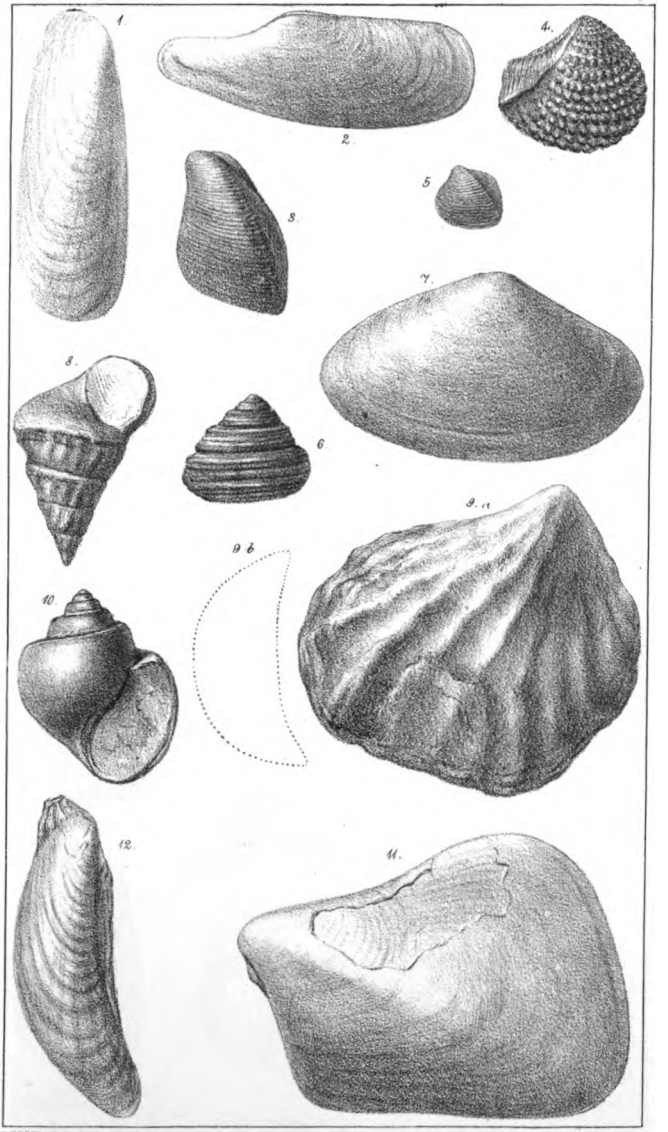

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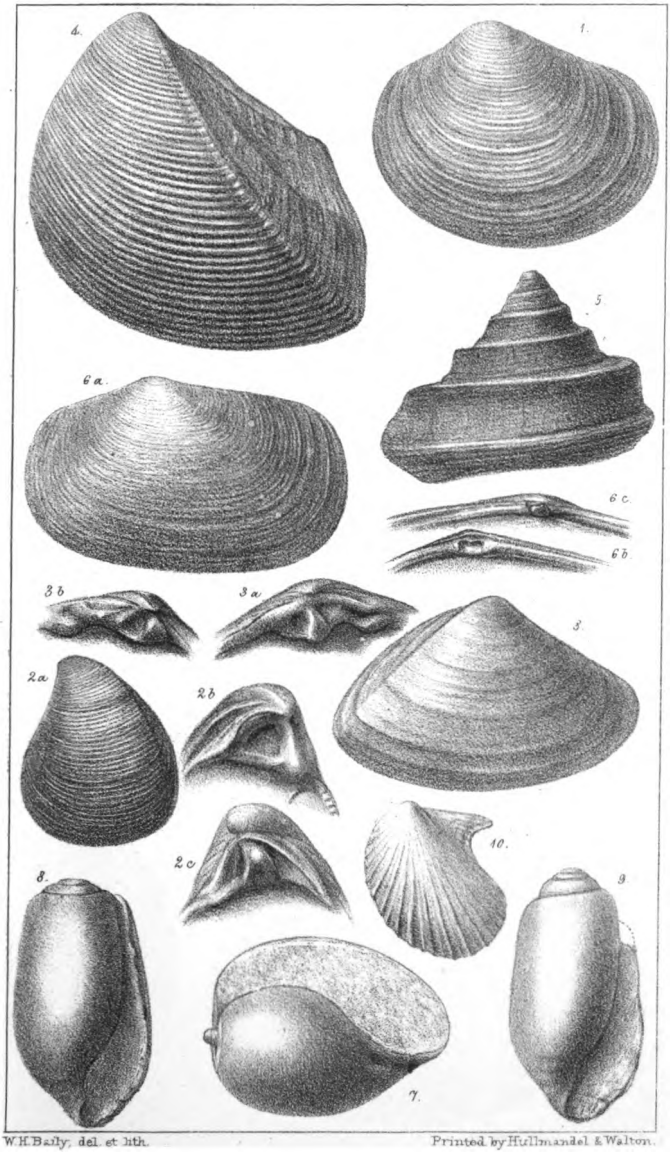

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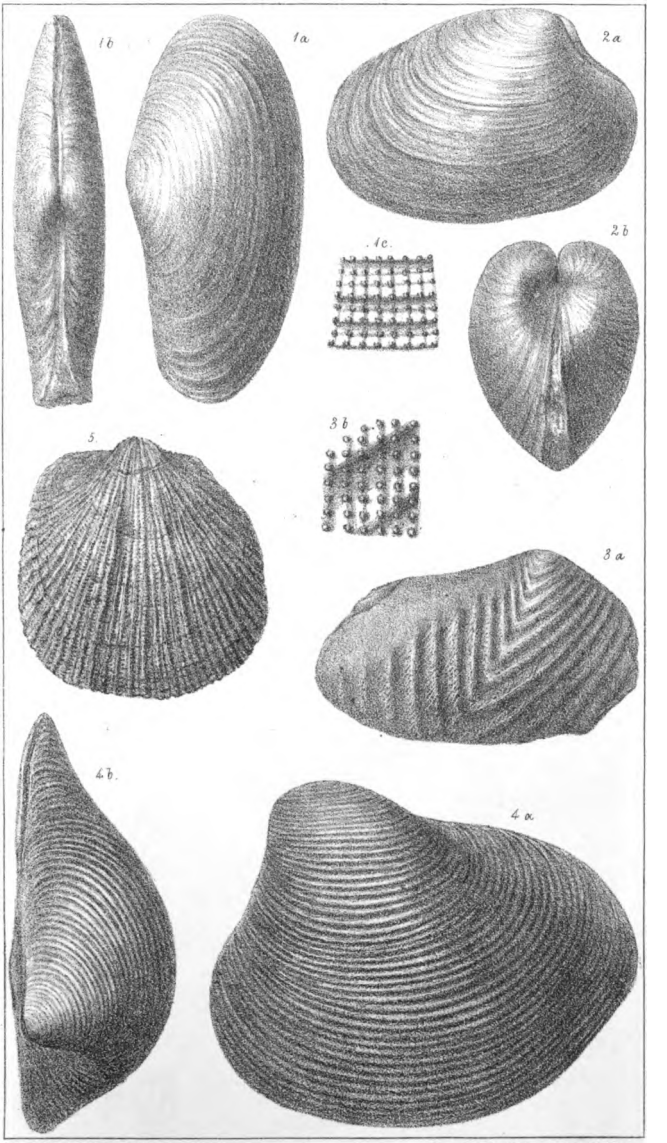

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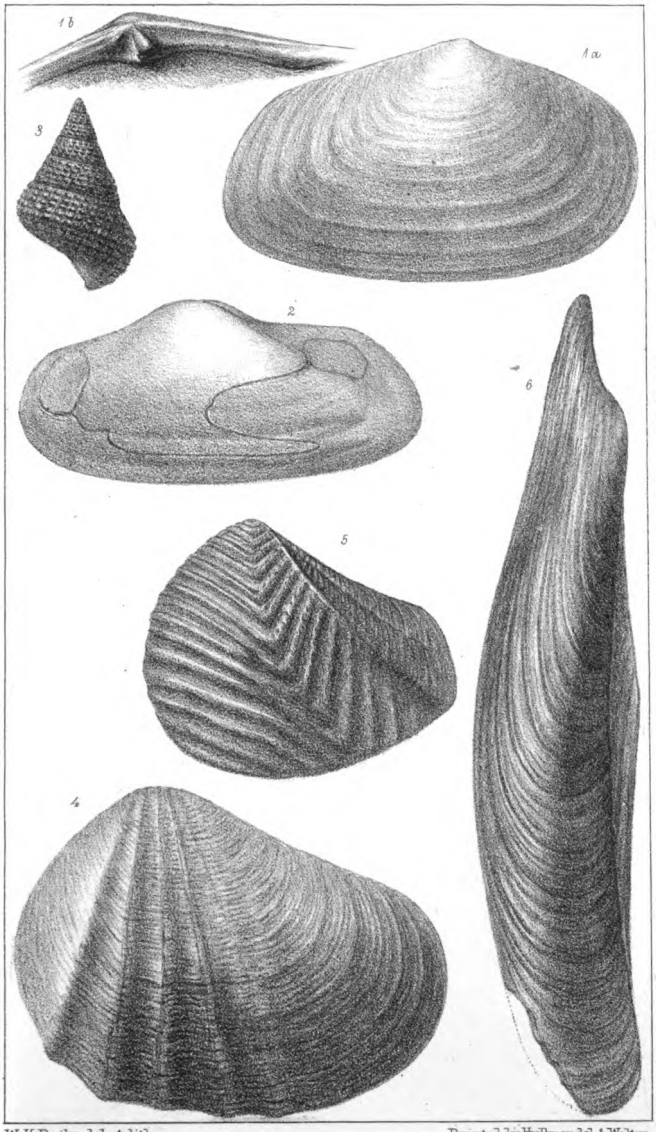

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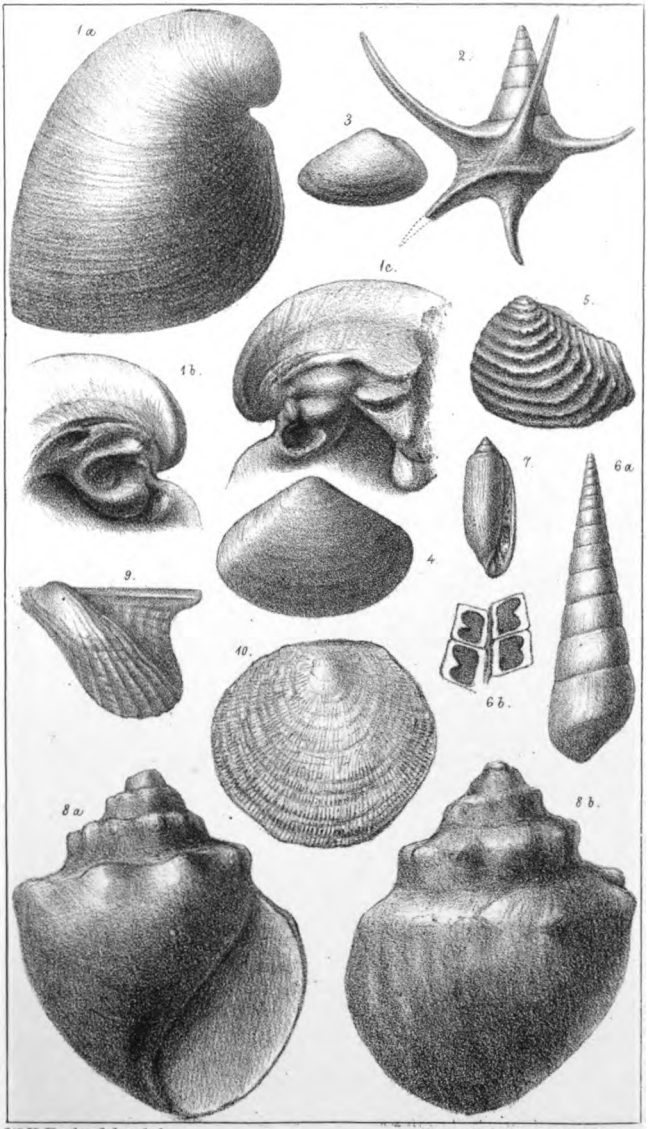

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MUSEUMS, BOTH PUBLIC AND PRIVATE, WHICH CONTAIN COLLECTIONS OF ORGANIC REMAINS FROM THE COTTESWOLD HILLS.

The British Museum is particularly rich in the Inferior Oolite fossils of Dundry, and of the Lias of Somerset, which may advantageously be studied in connexion with the Cotteswold fossils.

The Museum of Practical Geology, Jermyn street, London, contains a considerable and increasing series from the Lias, Inferior Oolite and Great Oolite.

The Woodwardian Museum, Cambridge, has a very extensive collection of Great Oolite testacea from the Minchinhampton district.

The British Museum is rich in Cotteswold fossils, and likewise in those of the same formations at other British localities, with which they may be compared.

The Museum of the Royal Agricultural College, Cirencester, has a small but instructive series of Cotteswold forms.

Private Collections.—Dr. Wright, of Cheltenham; Mr. Jones, of Gloucester; Professor Buckman, of Cirencester; the collection made by the late Mr. C. Pearce, of Bath; that of Mr. Walton at the same place; Professor Morris, Kensington; Mr. Tennant, Strand; Rev. P. B. Brodie, Rowington, near Warwick; the Collection of the Author at Minchinhampton.

INDEX TO NAMES OF AUTHORS ABBREVIATED.

Ag.	Agassiz.
Buck.	Buckman.
Brug.	Bruguiere.
Dav.	Davidson.
Defr.	Defrance.
Desh.	Deshayes.
D'Arch.	D'Archiac.
Desl.	Deslongchamps.
D'Orb.	D'Orbigny.
Edw.	Edwardes Milne.
Goldf.	Goldfuss.
Lyc.	Lycett.
Mor. & Lyc.	Morris and Lycett.
Munst.	Munster.
Op.	Oppel.
Phil.	Phillips.
Rein.	Reinecke.
Quenst.	Quenstedt.
Rich.	Richard.
Roem.	Roemer.
Schlot.	Schlotheim.
Shub.	Shubler.
Sow.	Sowerby.
Terq.	Terquem.
Y. & B.	Young & Bird.
Zeit.	Zeiten.