THE

MEDALS OF CREATION;

OR,

FIRST LESSONS IN GEOLOGY,

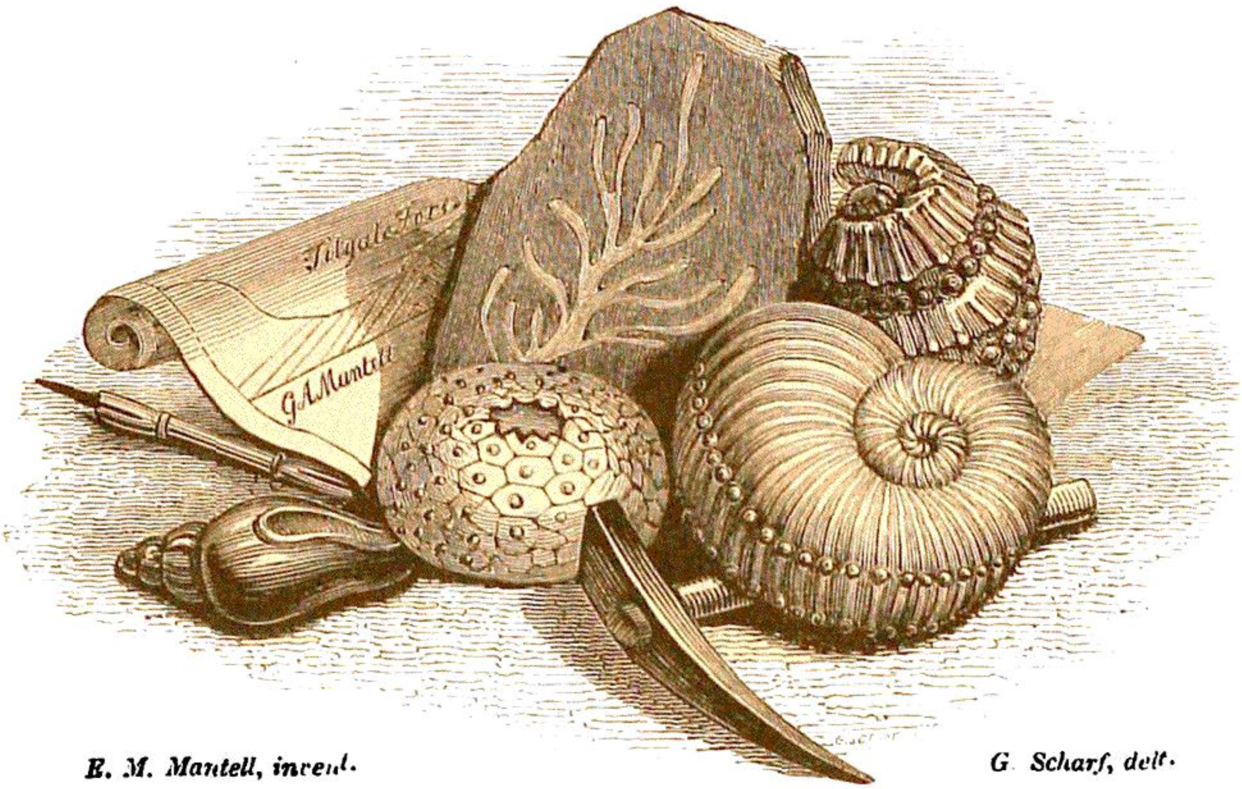
AND IN THE STUDY OF

Organic Remains.

BY

GIDEON ALGERNON MANTELL, LL.D. F.R.S.

AUTHOR OF THE WONDERS OF GEOLOGY,
ETC.



E. M. Mantell, invent. *G. Scharf, delt.*

"Voilà! une nouvelle espèce de médailles, beaucoup plus importantes, et incomparablement plus anciennes, que toutes celles des Grecs et des Romains!"—Knorr, *Monumens des Catastrophes.*

IN TWO VOLS.—VOL. I.

CONTAINING

FOSSIL VEGETABLES, INFUSORIA, ZOOPHYTES, ECHINODERMS, AND MOLLUSCA.

LONDON:

HENRY G. BOHN, YORK STREET, COVENT GARDEN.

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Pl. I.

J. Dinkel del. G. Scharf lithog.

MEDALS OF CREATION.

DESCRIPTION

OF THE

FRONTISPIECE OF VOL. I.

PLATE I.

Fig. 1.—A FERN in Coal-shale, from Leicestershire.

2.—A CRUSTACEAN in Limestone, from Solenhofen; in the cabinet of the Marquess of Northampton, Pres. R. S.

3.—A FISH (*Pycnodus rhombus*) in Limestone; from near Castel-a-mare; collected by Sir Woodbine Parish, F.R.S.

4.—Half the Lower Jaw of an HYENA, from a fissure in a sandstone rock, near Maidstone; in the collection of the Rev. Dr. Buckland.

5.—An AMMONITE, from the Isle of Portland.

DESCRIPTION OF THE VIGNETTE OF VOL. I.

A Group of Fossils, containing—

AMMONITES MANTELLI, from the *Chalk-marl*, Sussex.
TURRILITES COSTATUS, from the *Lower Chalk*, Rouen.
FUCOIDES TARGIONII, from the *Firestone*, Sussex.
ECHINUS and FUSUS, from *Tertiary strata*, Palermo.

TO

CHARLES LYELL, ESQ., D.C.L. F.R.S.

VICE-PRESIDENT OF THE GEOLOGICAL SOCIETY OF LONDON,

AUTHOR OF THE PRINCIPLES OF GEOLOGY;

ETC.

MY DEAR FRIEND,

IN commemoration of the happy hours which we have spent together in the investigation of the geological phenomena of my native County—in grateful remembrance of the warm encouragement which you bestowed on my first attempts to demonstrate the fluviatile origin of the Wealden deposits of the South-East of England—in acknowledgment of the kind interest you have always taken in the success of my scientific researches—and in testimony of the highest respect for your profound attainments in science, and of affectionate regard for the friendship which you have allowed me the privilege of enjoying for nearly a quarter of a century—I inscribe these unpretending volumes with your distinguished name.

Believe me, my dear friend,

Ever most faithfully yours,

GIDEON ALGERNON MANTELL.

CRESCENT LODGE,
CLAPHAM COMMON,
May, 1844.

PREFACE.

In the Wonders of Geology, an intention was expressed of immediately publishing, as a sequel to those volumes, "First Lessons," or an Introduction for persons wholly unacquainted with the science; but the appearance of the contemplated work was unavoidably postponed, from year to year, by the long and severe indisposition of the Author.

In the meanwhile several works professing the same object have issued from the press; among them a volume by a writer, whom a sense of honour, if not of gratitude, should have deterred from interfering, in any manner, with the literary labours of the individual to whom he was mainly indebted for whatever acquaintance with Geology he may possess; and who, in the unrestricted and unsuspecting confidence of personal intercourse, was made fully acquainted with the plan and scope of the intended publication of the Author.

An enlarged edition of Mr. Lyell's "ELEMENTS" has also appeared, in which that eminent philosopher has fully illustrated the elementary principles of physical Geology, and has given numerous figures of the characteristic fossils of the several formations, or groups of strata. But that most interesting department of the science which treats of Organic Remains, is necessarily considered in a cursory manner; and a work upon the plan originally proposed by the Author seems still to be required, to initiate the young, and uninstructed, in the study of those MEDALS of CREATION—those electrotypes of nature—the mineralized remains of the plants and animals which successively flourished in the earlier ages of our planet, in periods incalculably remote, and long antecedent to all human history and tradition.

With this conviction, I venture to offer the present volumes, with such modifications of the original plan as circumstances have rendered necessary, as a guide for the Student, and the Amateur Collector—for the intelligent Reader who may require a general knowledge of the subject, without intending to pursue Geology as a science—and for the Tourist who may wish, in the course of his travels, to employ profitably a leisure hour in quest of those interesting memorials of the ancient physical revolutions of our globe, which he will find everywhere presented to his observation.

CRESCENT LODGE,
CLAPHAM COMMON,
May, 1844.

"If we look with wonder upon the great remains of human works, such as the columns of Palmyra, broken in the midst of the desert; the temples of Pæstum, beautiful in the decay of twenty centuries; or the mutilated fragments of Greek sculpture in the Acropolis of Athens, or in our own museums, as proofs of the genius of artists, and power and riches of nations now past away; with how much deeper feeling of admiration must we consider those grand monuments of nature which mark the revolutions of the Globe; continents broken into islands; one land produced, another destroyed; the bottom of the ocean become a fertile soil; whole races of animals extinct, and the bones and exuviæ of one class covered with the remains of another; and upon the graves of past generations—the marble or rocky tombs, as it were, of a former animated world—new generations rising, and order and harmony established, and a system of life and beauty produced out of chaos and death; proving the infinite power, wisdom, and goodness of the Great Cause of all things!"

Sir H. Davy.

ADDRESS TO THE READER.

"Some Books are to be tasted—others to be swallowed—and some few to be chewed and digested; that is, some Books are to be read only in parts—others to be read, but not curiously—and some few to be read wholly, and with diligence and attention."—LORD BACON'S ESSAYS.

ANXIOUS that the "COURTEOUS READER"* should derive from this work all the information it is designed to impart, the Author presumes to offer a few words in explanation of the plan upon which it has been constructed, and some suggestions as to the best means of rendering its contents most available to the varied tastes and pursuits of different classes of readers.

In its arrangement, a three-fold object was had in view; namely, in the first place, to present such an epitome of Palæontology, or the science which treats of the fossil remains of the ancient inhabitants of the Globe, as shall enable the intelligent reader† fully to comprehend the nature of the principal discoveries in modern Geology; and the method of investigating natural phenomena, by which such

* "And still more COURTEOUS PURCHASER."—*Lord Byron.*

† "INTELLIGENT READER:" for, as an able Critic in the Athenæum has shrewdly observed, there can be no "Geology for Beginners;" we should know something of the *natural world as it is*, before we attempt to pry into the mysteries of the world *as it was.*

highly interesting, and unexpected results, have been obtained.

Secondly, to assist the COLLECTOR in his search for Organic Remains—direct attention to those objects which possess the highest interest, and are especially deserving of accurate examination—instruct him in the art of developing and preserving the specimens he may discover—and point out the means to be pursued, for ascertaining their nature, and their relation to existing animals or plants.

Thirdly, to place before the STUDENT a familiar exposition of the elementary principles of Palæontology, based upon a knowledge of the structure and functions of vegetable and animal organization; excite in his mind a desire for further information, and prepare him for the perusal and study of works of a far higher order than these unpretending volumes; and point out the sources from which the required instruction may be derived.

Although fully aware of the very imperfect manner in which these intentions are fulfilled, the Author trusts that the indulgence claimed by one of the most able writers of our times (*Sir E. L. Bulwer*), may be extended to him; and that "if the design be good upon the whole, the work will not be censured too severely for those faults, from which, in parts, its very nature would scarcely allow it to be free."*

* Preface to the second edition of "THE DISOWNED."

With regard to the best means of making use of this work, the advice of the great founder of Inductive Philosophy, on the Study of Books in general, expressed in the quotation prefixed to this address, is peculiarly applicable to the different classes of readers for whom these volumes are designed.

Thus, "*the Book may be tasted, that is, read only in parts,*" by the intelligent reader, who requires but a general acquaintance with the subjects it embraces. The perusal of the introductory and concluding remarks of each chapter, of the general descriptions of fossil remains, and of the circumstances under which they occur, omitting the scientific terms and descriptions, and a cursory examination of the illustrations, will probably satisfy his curiosity; and the work may be transferred to the library for occasional reference, or taken as a travelling companion and guide to some interesting geological district.

But the Book "*must be swallowed, that is, read, but not curiously,*" by the reader desirous of forming a collection of organic remains. A general acquaintance with its contents, and a careful investigation of the characters of the specimens, and comparison with the figures and descriptions, will be requisite to enable the amateur collector to determine the nature of the fossils he may discover.

By the STUDENT the Book "*must be digested, that is, read wholly, and with diligence and attention.*"

He should fully comprehend one subject before he advances to the consideration of another, and should test the solidity of his knowledge by practical research. He should visit some of the localities described; collect specimens, and develope them with his own hands; examine their structure microscopically; nor rest satisfied till he has determined their general character, and ascertained their generic and specific relations. Nor is this an arduous or irksome task; by a moderate degree of attention, a mind of average ability may quickly overcome the apparent difficulties, and will find in the knowledge thus acquired, and in the accession of mental vigour which such investigations never fail to impart, an ample reward for any expenditure of time and trouble. It is, indeed, within the power of every intelligent reader, by assiduity and perseverance, to attain the high privilege of those who "walk in the midst of wonders, in circumstances where the uninformed and uninquiring eye can perceive neither novelty nor beauty;"* and of being

"Even as one,
Who by some secret gift of soul or eye,
In every spot beneath the smiling sun,
Sees where the Springs of living Waters lie!"

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* Sir J. F. W. Herschel's Discourse, Nat. Phil. p. 15.

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VOL. I.

CONTENTS OF VOL. II.

For the information of persons engaged in works on Natural History, the addresses of the excellent artists by whom the LIGNOGRAPHS, *or wood-cuts, were engraven, are subjoined.*

Mr. WHEELER, 3, Guildford Street, Gray's-Inn Lane, by whom all the blocks were executed, except those specified below.

Mr. WHIMPER, 20, Canterbury Place, Lambeth. The Engravings illustrative of the Geological Excursions.

Mr. JAMES LEE, 97, Prince's Square, Kensington; to whose accuracy, punctuality, and despatch, the Author is much indebted. See *Lign.* 90, 92, 96, 97, 112, 113, 115, 116, 117, 119, 121, 125, 126, 128, 129, 131, 132, 133, 135, 136, 138, 139, 140, 142, 143, 145, 146, 147, 149, 153, 154, 155.

*** I cannot refrain from expressing, in the strongest terms, how much I have reason to commend the excellent Printer, from whose press these volumes emanate; and how greatly I am obliged to the compositors for their skill and patience in deciphering hieroglyphics, at all times somewhat illegible, and rendered peculiarly so on the present occasion, from the greater part of the manuscript having been written under the pressure of severe bodily suffering. I may say, with *Gerald Griffin*, that "I verily "believe, if I shut my eyes, or flung the pen at the paper, so as to make "a mark of any kind, my printers would find out what I meant. They "always send me back my manuscript with the printed proofs for correc-"tion; and I actually have repeatedly been unable to make out what I had "written until I referred to the same sentence in print."

DIRECTIONS TO THE BINDER.

PLATE I.—Frontispiece to Vol. I.
PLATE II.—Frontispiece to Vol. II.
PLATES III., IV., V., and VI., to follow the Table of Contents, and be placed opposite the description of each.
LIGN. 151, to face page 815.

THE

MEDALS OF CREATION.

INTRODUCTION.

"Geology, in the magnitude and sublimity of the objects of which it treats, undoubtedly ranks next to Astronomy in the scale of the sciences."—*Sir J. F. W. Herschel.*

Geology (a term derived from two Greek words, signifying a discourse of the Earth) may be denominated the physical history of the globe; it is the science that investigates the structure of the planet on which we live, and the character and causes of the various changes which have taken place in the organic and inorganic kingdoms of nature, and is therefore intimately connected with every other branch of natural philosophy.

While in common with other scientific pursuits it possesses the power of conferring upon us the noblest and purest pleasures of which our natures are susceptible, enabling us to see evidences of creative wisdom and benevolence in circumstances where the uninformed or uninquiring mind can perceive neither interest nor beauty, it has this peculiar claim upon our attention, that it offers an inexhaustible field of inquiry, and its cultivation, beyond that of any other department of science, is more independent of external circumstances, and can be pursued in whatever situation or condition of life we may happen to be placed.

The eulogium passed by the most distinguished philosopher of our times on science in general, is strikingly applicable to geological researches. "The highest worldly prosperity, so far from being incompatible with them, supplies additional advantages for their pursuit; they may be alike enjoyed in the intervals of the most active business, while the calm and dispassionate interest with which they fill the mind, renders them a most delightful retreat from the agitations and dissensions of the world, and from the conflict of passions, prejudices, and interests, in which the man of business finds himself continually involved."*

From the present advanced state of geological science, particularly of that department which it is the more especial object of these volumes to elucidate—the study of organic remains—it seems

* Sir J. F. W. Herschel, "Discourse on the Study of Natural Philosophy."

scarcely credible, that but a century ago it was a matter of serious investigation with the philosophers of those times, whether the shells imbedded in the earth had ever been recent shells, secreted by their respective inhabitants; or whether the shells, bones, plants, wood, &c. discovered in a fossil state, were not formed by what was termed the plastic power of the earth; in the same manner as mineral ores and crystals are produced.

In a natural history of England published towards the end of the last century, it is gravely stated that at Bethersden in Kent, stone is found full of shells, "*a proof*," says the learned editor, "*that shells and the animals we find in them living, have no necessary connexion.*" And at no remote period, we have another amusing instance of the prevailing opinions, for it is stated in a history of the county of Surrey, that in a search for coal near Guildford the borers broke, and "this was thought by Mr. Peter Lely, the astrologer, to have been the work of subterranean spirits, who broke off the augers of the miners, lest their secret haunts should be invaded."

But there were many eminent men in England who were greatly in advance of the age in which they lived, and strenuously exerted themselves to discover and promulgate correct principles in this science. Among these, Dr. Martin Lister, physician to Queen Anne, was one of the most distinguished. This accomplished naturalist, in his great work on shells, which remains to this day a splendid monument of his labours, and of the talents and filial affection of his two daughters, by whom all the plates were engraved, figures many fossil shells, and describes them as real animal productions, and carefully compares them with the recent species. To him also the honour is due of having first suggested the construction of geological maps; Dr. Lister was likewise well acquainted with the position and extent of the chalk and other strata of the south of England.*

From the numerous foreign writers, who at a very early period began to entertain correct notions of the structure of our planet, and of the nature of the revolutions which it had undergone, I am induced to select the following highly philosophical and beautiful illustration of the physical mutations to which the surface of the earth is perpetually exposed. It is from an Arabic manuscript written in the thirteenth century.† The narrative is supposed to be given by Rhidhz, an allegorical personage.

"I passed one day by a very ancient and populous city, and I asked one of its inhabitants how long it had been founded? 'It is, indeed, a mighty city,' replied he; 'we know not how long it has existed, and our ancestors were on this subject as ignorant

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* This celebrated physician, and first of British geologists, died in 1712, and was interred in the old church in this place (Clapham); a tablet to his memory is affixed to the north wall of St. Paul's Chapel.

† Quoted by Mr. Lyell in his "Principles of Geology."

as ourselves.' Some centuries afterwards, as I passed by the same place, I could not perceive the slightest vestige of the city. I demanded of a peasant, who was gathering herbs upon its former site, how long it had been destroyed? 'In sooth, a strange question,' replied he, 'the ground here has never been different from what you now behold it.' 'Was there not,' said I, 'of old a splendid city here?" 'Never,' answered he, 'so far as we know, and never did our fathers speak to us of any such.'

"On my return there again, after the lapse of other centuries, I found the sea in the same place, and on its shores were a party of fishermen, of whom I inquired how long the land had been covered by the waters? 'Is this a question,' said they, 'for a man like you? This spot has always been what it is now.'

"I again returned ages afterwards, and the sea had disappeared. I inquired of a man who stood alone upon the ground, how long ago the change had taken place, and he gave me the same answer that I had received before.

"Lastly, on coming back again after an equal lapse of time, I found there a flourishing city, more populous and more rich in buildings than the city I had seen the first time; and when I would have fain informed myself regarding its origin, the inhabitants answered me, 'Its rise is lost in remote antiquity—we are ignorant how long it has existed, and our fathers were on this subject no wiser than ourselves.' "

We may smile at the ignorance of the inhabitants of the fabled cities, but are we in a condition to give a more satisfactory reply should it be inquired of us, What are the physical changes which the country you inhabit has undergone?—and yet cautious observation, and patient and unprejudiced investigation, are alone necessary to enable us to answer the interrogation.

Dismissing from his mind all preconceived opinions, the student must be prepared to discover that the earth's surface has been, and still is, subject to perpetual mutation,—that the sea and land are continually changing place,—that what is now dry land was once the bottom of the deep, and that the bed of the present ocean will, in its turn, be elevated above the water and become dry land,—that all the solid materials of the globe have been in a softened, fluid, or gaseous state,—and that the remains of countless myriads of animals and plants are not only entombed in the rocks and mountains, but that every grain of sand, and every particle of dust wafted by the wind, may teem with the relics of beings that lived and died in periods long antecedent to the creation of the human race. Astounding as are these propositions, they rest upon evidence so clear and incontrovertible, that they cannot fail to be admitted by every intelligent and unprejudiced reader, who will bestow but a moderate share of attention to the phenomena, of which it is the purport of these volumes to offer a familiar exposition.*

I cannot conclude these introductory observations, without adverting to the great benefits resulting from scientific pursuits in general, and of Geology in particular, on the young and inquiring mind. An able modern writer has forcibly and justly remarked that,—

"It is fearfully true, nine-tenths of the immorality that pervades the better classes of society, originate in the first place from the want of a pleasing and harmless occupation to fill up the vacant time; and as the study of the natural sciences is as interesting as it is beneficial, it must necessarily exert a moral, not to say religious influence upon the character. He who is fond of scientific pursuits will not enter into revelry, for artificial excitements have for him no fascination. The overflowing cup, the unmeaning or dishonest game cannot entice him. If any one doubts the beneficial influence of these studies on the morals, I will ask him to point out the immoral young man who is devotedly fond of any branch of natural science: I never knew such an one. There may be such individuals—for religion only can change the heart—but if there be, they are very rare exceptions; and the loud clamours always raised against the man of science who errs, is a

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* See Wond. Lect. I.

proof of the truth of my proposition—the ennobling effects of the study of God's works upon a well-regulated mind. Fortunate, indeed, is it for the youth of either sex, who early imbibes a taste for natural objects, and whose pursuits are not thwarted by injudicious friends."

And while Geology has the hallowing tendency so well expressed in the above remarks, in common with every other department of natural knowledge, it has, in my estimation, this great advantage, that it offers fields of research adapted to every capacity. On some of its investigations the highest intellectual powers, and the most profound acquirements in exact science may be brought to bear; while many of its problems can be solved by any one who has eyes and will use them, and possesses but an average share of diligence and observation.

But I need not dwell longer on the interest and importance of a study, which instructs us that every pebble we tread upon bears the impress of the Almighty's hand, and evidence of Creative wisdom and goodness;—that every grain of sand, every particle of dust scattered by the wind, may be composed of the petrified skeletons of beings, so minute as to elude our unassisted vision, yet were once teeming with life and happiness, and possessed an organization as marvellous as our own; a science whose discoveries have realized the wildest imaginings of the poet—whose realities far surpass in grandeur and sublimity the most imposing fictions of romance ; a science, whose empire is the earth, the ocean, the atmosphere, the heavens—whose speculations embrace all elements, all space, all time —objects the most minute, objects the most colossal —carrying its researches into the smallest atom which the microscope can render accessible to our visual organs—and comprehending all the discoveries in the boundless regions above us, which the most powerful telescope can reveal.

I may add that, while none of the physical sciences can more strongly impress on the mind, that deep sense of humility and dependence, which a proper knowledge of the works of the Eternal is calculated to inspire, so none can more powerfully encourage our aspirations after truth and wisdom. Every walk we take offers subjects for profound consideration—every pebble that attracts our notice, matter for serious reflection ; and contemplating the innumerable proofs afforded us of the incessant dissolution and renovation which are taking place around us, we feel the force and beauty of the exclamation of the poet,—

> "My heart is awed within me, when I think
> Of the great miracle which still goes on
> In silence round me—the perpetual work
> Of Thy creation, finished, yet renewed
> For ever!"

PRELIMINARY REMARKS.

ON THE PLAN OF THE WORK, AND THE ARRANGEMENT OF THE SUBJECTS IT EMBRACES.

WITH the view of economising space, and of avoiding the usual practice of copying figures and descriptions from works of easy access, I beg to recommend the three following, as a library of reference for the student; I shall thus be able to abridge my remarks on some subjects which it is necessary should be fully illustrated, and that are treated of at large in those volumes. By such an arrangement I hope to afford the student a comprehensive view of the science, render the work more extensively useful, and restrict it within the limits which as a guide or hand-book it would be inconvenient to exceed; at the same time it will be complete in itself, and contain all the information which may be required by the amateur or general reader, for the study of organic remains.

1. DR. BUCKLAND'S *Bridgewater Treatise:* 2 vols. 8vo.—These volumes contain more accurate and beautiful figures of organic remains than any

other English work; and as they are to be found in every public, and good private library in the kingdom, are within the reach of every reader.

2. *The Elements of Geology*, by CHARLES LYELL, Esq. 2 vols. second edition.—The elements of physical geology, and the nature and distribution of the fossils which characterise the different formations, are admirably enunciated in this work; the figures of organic remains are numerous and excellent.

3. *The Wonders of Geology, or a Familiar Exposition of Geological Phenomena;* fourth edition, 2 vols. with ten coloured plates, and numerous figures, by the AUTHOR.—This work is designed to afford the intelligent reader a general view of the science, divested as much as possible of scientific language: by reference to its pages, much unnecessary repetition will be avoided.

To the above may be added PHILLIPS's *Mineralogy*, which treats of the various mineral substances that enter into the composition of the strata and of fossil remains.

A good geological map of Great Britain is indispensable. Professor Phillips's in a pocket case will be found an excellent travelling companion; by a reference to the map, the geological character, and the prevailing fossils of a district, may be readily ascertained.

The above works will be referred to in the following manner: viz.

Bd. Dr. Buckland's Treatise.

Ly. Mr. Lyell's Elements of Geology.

Wond. The Wonders of Geology.

The following abbreviations are also employed:—

§ 1. *Relative to the Rocks or Strata.*

Alluv. Alluvial deposits, or Drift.

Tert. Tertiary. *Lond. C.* London clay.

Cret. Cretaceous formation. *Ch. u.* Upper chalk. *Ch. l.* Lower chalk. *S. s.* Shanklin, or lower green sand.

New R. S. New red sandstone or Saliferous deposits.

Carb. Carboniferous or Coal formation.

Mt. L. Mountain or Carboniferous limestone.

Devon. Devonian or Old Red Sandstone formation.

Silur. Silurian system, or formation.

§ 2. *Relative to Organic Remains.*

Nat. Natural size.

× Magnified in diameter: *e. g.* × 8, magnified eight diameters, &c.

× × Highly magnified; the degree not accurately determined.

Inv. Invisible to the naked eye.

— less than natural: *e. g.* — $\frac{2}{3}$, two-thirds in diameter of the size of the original.

Lign. Lignograph or woodcut.

The illustrations are for the most part from British specimens in the cabinet of the author; or from authentic figures reduced from works not readily accessible to the student or general reader; and, except when otherwise specified, are by Miss Ellen Maria Mantell.

Outlines have been in many instances preferred to shaded figures, as presenting more distinct and simple illustrations of the respective objects.

The following works, to which reference will often be made, are thus denoted :—

Foss. Flor. The Fossil Flora of Great Britain, by Dr. Lindly, and W. Hutton, Esq. 3 vols. 8vo.

Veg. Foss. Histoire des Végétaux Fossiles, par M. Adolphe Brongniart. 1 vol. 4to.

Geol. Trans. Transactions of the Geological Society of London. 5 vols. 4to., and 5 vols. new series.

Geol. Proc. Geological Proceedings. 3 vols. 8vo.

Murch. Sil. The Silurian System, by R. I. Murchison, Esq. 2 vols. 4to. with plates and map.

Org. Rem. Parkinson's Organic Remains of a Former World. 3 vols. 4to.

Oss. Foss. Ossemens Fossiles, par Baron Cuvier. 5me. edit.

Min. Conch. Sowerby's Mineral Conchology. 6 vols. 8vo.

Phil. York. Geology of Yorkshire, by Professor John Phillips. 2 vols. 4to.

South D. Fossils of the South Downs, 1 vol. 4to. by the Author.

Geol. S. E. Geology of the South-east of England. 1 vol. 8vo. by the same.

Foss. Til. For. Fossils of Tilgate Forest. 1 vol. 4to. by the same.

Poiss. Foss. Recherches sur les Poissons Fossiles, par M. Agassiz; this work is incomplete.

Explanation of Terms.—A short glossary is appended to the Wonders of Geology; but as frequent reference to another volume would be inconvenient, in the present work, upon the occurrence of a word apparently requiring explanation, the *meaning*, where practicable, is placed in a parenthesis, instead of the customary method of giving the Greek or Latin etymology; for example, Caulopteris (*fern-stem*); carboniferous (*coal-bearing*); except in the case of arbitrary names, and those the meaning of which cannot be concisely expressed.

The subjects will be considered under the following heads or chapters:—

PART I.

1. On the nature and arrangement of the British strata and their fossil contents.
2. Tabular chronological arrangement of the strata.
3. On the nature of Fossils or Organic remains.
4. On mineralized Vegetable remains, and the mode of conducting their investigation.
5. On Peat, Lignite, and Coal.
6. Fossil Botany.
   - *a.* Remains of the Cellular and Cryptogamic plants.
   - *b.* . . . . . Vascular Cryptogamia.
   - *c.* . . . . . Filicites or Ferns.
   - *d.* . . . . . Sigillariæ and Stigmariæ.
   - *e.* . . . . . Lepidodendra.
   - *f.* . . . . . Cycadeous plants.
   - *g.* . . . . . Coniferæ.
   - *h.* . . . . . Palm tribe.
   - *i.* . . . . . Liliaceous plants.
   - *k.* . . . . . Flowering dicotyledons.
   - *l.* Retrospect, and list of localities of Vegetable Fossils.

Part II.

Palæontology, or the Fossil remains of the Animal Kingdom.

1. The Fossil Infusoria or Animalculites.
2. Polypiaria and other Zoophytes.
3. Echinoderma, comprising
   (1.) The Crinoidea or Lily-shaped animals.
   (2.) The Stelleridæ or Starfish.
   (3.) The Echinidæ or Sea-urchins.
4. Fossil Mollusca or Shells.
5. Crustacea and Insects.
6. Fishes.
7. Reptiles.
8. Birds.
9. Mammalia.

Part III.

1. Geological Excursions in illustration of the investigation of Geological Phenomena, and the collection of Organic Remains.

2. Miscellaneous. On the prices of Fossils, list of Dealers, Localities, &c.

LIST OF LIGNOGRAPHS,

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26. Sigillaria elegans. Anatomy of the stem.
27. Stigmaria ficoides. Derbyshire.
28. Transverse section of a stem of Stigmaria, showing the vascular axis.
29. Erect trunk of Sigillaria with the roots (*Stigmariæ*) attached. Coal-strata near Liverpool.
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    1. Cardiocarpon acutum. Leicestershire.
    2. Carpolithes Bucklandii.
    3. Trigonocarpum olivæforme,
    4. ——————— Nöggerathi.
35. 1. Sphenophyllum Schlotheimi. Carb.
    2. ——————— erosum.
36. Leaf of Zamia pectinata. Stonesfield.
37. Leaf of Pterophyllum comptum. Oolite. Scarborough.
38. Fruits of Cycadeous plants.
    1. Zamia crassa. Yaverland, Isle of Wight.
    2. ——— ovata. Faversham, Kent.
39. Fruit of Zamites lanceolata, from Scarborough.
40. 1. Branch of Auracaria peregrina. Lyme Regis.
    2. Calamites nodosus. Coal shale.
41. Fragment of coniferous wood in flint, from the ruins of Lewes Priory.
42. Fossil fruits from the Isle of Sheppey, including the palms called Nipatites.
43. Fossil fruits from the Isle of Sheppey, with the seed-pod of Mimosites.
44. Stems and fruit of Clathraria Lyellii. Tilgate Forest.
45. Fossil Charæ and Nymphea or water lily.
46. Fossil fruits and flower. Tertiary strata.
47. Dycotyledonous leaves. Tertiary strata.

CHAPTER I.

ON THE NATURE AND ARRANGEMENT OF THE BRITISH STRATA, AND THEIR FOSSIL CONTENTS.

"Every rock in the desert, every boulder on the plain, every pebble by the brook side, every grain of sand on the sea shore, is replete with lessons of wisdom to the mind that is fitted to receive and comprehend their sublime import."

THE solid materials of which the earth is composed, from the surface inhabited by man to the greatest depths within the reach of his observation, consist of minerals and fossils.

MINERALS are *inorganic* substances formed by natural operations, and are the product of chemical or electro-chemical action.

FOSSILS are the remains of animals and vegetables which have been imbedded in the strata by natural causes in remote periods; originally elaborated from inorganic matter by that marvellous principle termed vitality, and subsequently more or less altered in structure and composition by the influence of those physical forces, by which the inert substances of the mineral kingdom are subjected to perpetual change.

The soft and delicate parts of animal and vegetable organisms rapidly decompose after death; but the firmer and denser structures, such as the bones and teeth of the former, and the woody fibre of the latter, possess considerable durability, and under certain conditions will resist decay for many years, or even centuries. And when deeply imbedded in the earth, protected from atmospheric influences, and subjected to the conservative effects of various mineral solutions, the decomposition even of the most perishable tissues is often arrested, and their organization, transformed into stone, may be preserved for incalculable periods of time. Certain animal structures are even more permanent than those of vegetables, and the shells or cases of innumerable species of animalcules being composed of lime and silex or flint, are so indestructible, and occur in such inconceivable quantities, that the belief of some eminent naturalists of the last century, that every grain of flint, lime, and iron, may have been elaborated by the energies of vitality, can no longer be regarded as an extravagant hypothesis.

Some idea may be formed of the large proportion of the solid materials of our globe, which has unquestionably originated from this source, by the following list of strata, which are wholly, or in great part, composed of animal remains.

ROCKS COMPOSED WHOLLY OR PARTLY OF ANIMAL REMAINS.

Strata.	*Prevailing Fossils.*	*Formations.*
Trilobite schist	Trilobites and shells	Silurian system
Dudley limestone	Corals, crinoidea, shells, and trilobites	—
Shelly limestone	Productæ, spiriferæ, &c.	—
Mountain limestone	Corals and shells	Carboniferous system
Encrinital marble	Lily-shaped animals and shells	—
Mussel-band	Fresh-water mussels	—
Ironstone nodules	Trilobites, insects, and shells	—
Lias-shales and clays	Pentacrinites, reptiles, fishes	Lias
Limestone	Terebratulæ and other shells	—
Lias conglomerates	Fishes, shells, corals	—
Gryphite limestone	Shells, principally gryphites	—
Limestone	Terebratulæ, and other shells	Inferior oolite
Stonesfield slate	Shells, reptiles, fishes, insects	Oolite
Pappenheim schist	Crustacea, reptiles, fishes, insects	—
Bath-stone	Shells, corals, crinoidea, reptiles, fishes	—
Limestone	Cephalopoda, principally ammonites	—
Coral-rag	Corals, shells, echini, ammonites	—
Bradford limestone	Crinoidea, shells, corals, cephalopoda	—
Portland oolite	Ammonites, trigoniæ, and other shells	—
Purbeck and Sussex marble	Fresh-water shells, crustacea, reptiles, fishes	Wealden
Wealden limestone	Cyclades, and other fresh-water shells, crustacea, reptiles, fishes	—
Tilgate grit (some beds)	Reptiles, fishes, fresh-water shells	—
Farringdon gravel	Sponges, corals, echini, and shells	Shanklin sand
Jasper and chert	Shells, sponges, and animalcules	—
Greensand	Fibrous zoophytes	—
Chalk	Corals, infusoria, echini, shells, fishes.	Chalk

Strata.	*Prevailing Fossils.*	*Formations.*
Maestricht limestone	Corals, shells, ammonites, belemnites, and other cephalopoda—reptiles	Chalk
Hippurite limestone	Shells, principally hippurites	—
Hard chalk (some beds)	Echini and belemnites	—
Flints	Sponges, and other fibrous zoophytes.	—
	Infusoria, and spines of zoophytes.	—
	Echini, shells, corals, crinoidea	—
Limestone	Fresh-water shells	Tertiary
Nummulite rock	Nummulites	—
Septaria	Nautili, turritellæ, and other shells.	—
Calcaire grossier	Shells and corals	—
Gypseous limestone	Mammalia, (palæotheria, &c.) birds, reptiles, fishes	—
Siliceous limestone	Shells	—
Lacustrine marls	Cyprides, phryganeæ, fresh-water shells	—
Monte Bolca limestone	Fishes	—
Bone-breccia	Mammalia, and land-shells	—
Sub-Himalaya sandstone	Elephant, Mastodon, &c. reptiles	—
Tripoli	Infusoria	—
Richmond marl	Animalcules and infusoria	—
Semiopal	Infusoria	—
Mountain meal	Infusoria	—
Guadaloupe limestone	HUMAN skeletons, land-shells and corals.	Human epoch
Bermuda limestone	Corals, shells, serpulæ	—
Bermuda chalk	Comminuted corals, shells, &c.	—
Bog iron ochre	Infusoria	—

Nor has the contribution of the vegetable kingdom to the solid crust of the earth been unimportant. Immense tracts of country are almost wholly composed of the remains of plants in the state of anthracite, coal, lignite, and brown coal; of submerged forests and peat morasses; and of layers of trees and plants transmuted into siliceous or calcareous rock.

Although these relics of animal and vegetable organization are found in almost every sedimentary deposit, whatever may be its nature, yet they occur far more abundantly, and in a better state of preservation in some strata than in others: nor are they equally distributed throughout the same bed, but are heaped together in particular localities, and occur but sparingly, or are altogether absent in other layers of the same rock. Neither are the remains of the same kinds of animals and plants found indiscriminately in strata of different ages: on the contrary many species are restricted to the most ancient, others to the most recent formations; while some genera range through the entire series of rocks, and also appear as denizens of the existing lands and seas. Hence organic remains acquire a high degree of importance, not only from the intrinsic interest which they possess as objects of natural history, but also for the light they shed on the physical condition of our planet in the most remote ages; and for the invaluable data they afford as chronometers of the successive revolutions which the surface of the earth has undergone.

They have been eloquently and appropriately termed the MEDALS OF CREATION; for as an accomplished numismatist, even when the inscription of an ancient and unknown coin is illegible, can from the half-obliterated characters, and from the style of art, determine with precision the people by whom, and the period when it was struck; in like manner the geologist can decipher these natural memorials, interpret the hieroglyphics with which they are inscribed, and from apparently the most insignificant relics, trace the history of beings of whom no other records are extant, and restore anew those forms of organization which lived and died, and whose races were swept from the face of the earth, ere man, and the creatures which are his contemporaries, became its denizens. Well might the illustrious Bergman exclaim, "Sunt instar nummorum memorialium, quæ de preteritis globi nostri fatis testantur, ubi omnia silent monumenta historica."

To derive from these Medals of Creation all the information they are capable of affording, regard therefore must be had, not only to their peculiar characters, but also to the geological position of the strata in which they are found deposited. Data may be thus obtained by which the relative age of a formation or group of strata may be determined, as well as the mode of its deposition, and the agency by which it was effected; whether in the bed of an ocean, or of a lake, or estuary—by the action of the sea, or of rivers—of lakes or of running streams—by the effects of icebergs or glaciers—by slow processes through long periods of time, or by sudden inundations or deluges—or by the agency of volcanoes and earthquakes.

The discovery that particular fossils are confined to certain deposits, has been fruitful in important consequences to the advancement of modern Geology; for although the justly celebrated naturalist Dr.

Lister, more than a century ago, had obtained a glimpse of this law, its principles were neither understood nor regarded in this country until the late Dr. William Smith, by his own unaided exertions, proved by numerous observations on the British strata, its value and applicability for the identification of a deposit, in districts remote from each other. This phenomenon did not escape the notice of the distinguished French philosophers, M.M. Cuvier and Brongniart, who in their admirable work, "Géographie Minéralogique des Environs de Paris," thus enunciate the same principle:—"Le moyen que nous avons employé pour reconnoître au milieu d'un si grand nombre de lits calcaires, un lit déjà observé, dans un canton très-éloigné, est pris de la nature des fossiles renfermés dans chaque couche; ces fossiles sont toujours généralement les mêmes dans les couches correspondantes, et présentent d'un système de couche à un autre système, des différences d'espèces assez notables. C'est un signe de reconnoissance qui jusqu'à présent ne nous a pas trompés."* Now, although recent discoveries have shown that this rule has many exceptions, and that its too stringent adoption has been productive of some erroneous generalizations, yet if it be employed with due caution it is fraught with the most important and interesting results; and is the only certain basis of our knowledge respecting the appearance, con-

* Géog. Min. Oss. Foss. tom. ii. p. 266.

tinuance, and extinction of the lost races of animals and plants on the surface of our planet.

In the "Wonders of Geology" will be found a comprehensive sketch of the composition and arrangement of the different formations or groups of strata; and the subject is treated of in detail by Mr. Lyell in the "Elements;" a reference to these works will afford the student full information on this branch of Geology. For the convenience of the general reader I subjoin a tabular view of the characters and relations of the principal formations.

The entire series of rocks within the scope of human examination, is estimated at a thickness of from fifteen to twenty miles, reckoning from the summit of the highest mountains to the greatest depth hitherto penetrated; and as this thickness scarcely equals 1-400ths of the diameter of our globe, it is familiarly termed the earth's crust. The substances of which the strata are composed appear to have been deposited by the action of water, and subsequently more or less modified in structure and composition by heat, and by electro-chemical forces. When these materials occur as irregular accumulations of waterworn detritus, consisting of gravel, boulders, sand, clay, &c. they are termed *Drift*, or *alluvial* and *diluvial* deposits. When the layers or strata in which they were successively thrown down are obvious, they are said to be *stratified;* when the nature of the materials has been altered by igneous action or high temperature, but the lines of deposition are not wholly effaced, they are denominated *metamorphic* (*transformed*) rocks. When all traces of organic remains and of sedimentary deposition are lost, and the mass is crystalline, and composed of substances which are known to be the products of igneous action, such rocks are named *plutonic*, as granite, sienite, and the like. Lastly, rocks resembling the lavas, scoriæ, and other substances emitted by burning mountains still in activity, are called *volcanic*.

The original sedimentary character of the most ancient crystalline rocks is, of course, hypothetical, since all evidence of aqueous origin is wanting, and the minerals (mica, quartz, and felspar) of which they are so largely constituted, are not readily soluble in water under ordinary circumstances. But rocks unquestionably sedimentary, when exposed to intense heat under great pressure, assume a crystalline structure, (*Wond.* p. 751.); and a series of changes, from a loose earthy deposit, to compact volcanic lava, may be traced in numerous instances, so as to leave no doubt that all the rocks formerly called primitive and primary, *may* have originally been either argillaceous, siliceous, or calcareous strata, teeming with organic remains. (*Wond.* p. 704.) These igneous crystalline masses have been produced at successive periods; for granite is found of all ages, occurring in the most ancient, as well as in the comparatively modern epochs. The difference between the composition and aspect of these rocks, and those of recent volcanic origin, is attributed to the circumstance of the latter having been sub-aerial, that is, erupted on the surface, by which the gaseous products were allowed to escape; while the former were sub-marine, having been ejected beneath the sea, or under extensive sedimentary deposits, and subjected to great pressure, by which the volatile elements were confined, and underwent new combinations. In like manner, chalk when burnt in the open air is converted into lime, the carbonic acid gas escaping; but when exposed to the same heat under pressure, it becomes granular marble. (*Wond.* p. 91.)

From these ancient crystalline rocks very generally underlying the sedimentary strata, and never appearing as if they had overflown from a cone or crater, the term *hypogene* (*underlying*) is employed by Mr. Lyell to designate the whole class; and they are subdivided into, *Plutonic*, those in which all traces of sedimentary origin are lost, as granite; and *Metamorphic*, those which still manifest traces of stratification, as mica-schist, &c.

The sedimentary fossiliferous rocks, are, for the convenience of study, separated into three grand divisions.

1. The Tertiary; comprising all the deposits from the alluvial drifts to the chalk.

2. The Secondary; from the Chalk to the Old Red, or Devonian system, inclusive.

3. The Silurian; from below the Devonian to the upper part of the Cambrian system, in which all traces of organic remains disappear.

In the following arrangement the strata are enumerated as if lying in regular order, one beneath the other; but in nature no such series has ever been observed. A few groups only occur in a serial order, and these but rarely in their original position. The strata are broken up, dislocated, and thrown into every degree of inclination, from the horizontal to the perpendicular; sometimes they are completely retroverted, the newest strata underlying those upon which they were originally deposited. The order of succession has, therefore, been ascertained by careful observation of the relative position of different members of the series in different countries; and from an immense accumulation of facts collected by able observers from all parts of the globe. Diagrams in illustration of this table are given in *Wond.* plates vii. viii. ix.; and in *Ly.* of the different groups in the several chapters devoted to them. Dr. Buckland's Treatise contains a comprehensive illustration, drawn by Mr. Webster (*Bd.* Vol. II. frontispiece).

CHAPTER II.

"To discover order and intelligence, in scenes of apparent wildness and confusion, is the pleasing task of the geological inquirer." DR. PARIS.

IT may be necessary to remind the reader, that there are three elements of classification applicable to the stratified rocks, namely, 1st, their mineral structure, 2dly, their order of superposition, and 3dly, the nature of the organic remains which they contain; the following arrangement is in accordance with these principles.

CHRONOLOGICAL ARRANGEMENT OF THE BRITISH FORMATIONS,

COMMENCING WITH THE UPPERMOST OR NEWEST DEPOSITS.

FOSSILIFEROUS STRATA.

I. DRIFT. Comprising the superficial deposits of waterworn transported materials, and consisting of gravel, boulders, sand, clay, &c.

Subdivisions.—1. The MODERN or ALLUVIUM; (*Wond.* p. 123.) characterised by the remains of man, and contemporaneous animals and plants, &c.

2. The ANCIENT or DILUVIUM; containing immense quantities of the bones of large mammalia and carnivora, of species and genera, both recent and extinct.

Observations.—These beds appear to have been accumulated by a variety of causes; by land-floods and inundations, by irruptions of the sea, and by the agency of glaciers and icebergs. They are the repository of the extinct colossal mammalia—of the mastodon, mammoth, rhinoceros, hippopotamus, elk, horse, ox, whale, &c.

II. The TERTIARY SYSTEM (*Ly.* I. p. 270. *Wond.* p. 197.). An extensive series, comprising many isolated groups of marine and lacustrine deposits, characterised by the remains of animals and vegetables of all classes, the greater portion of which are extinct. Volcanoes of great extent were in activity during this geological epoch.

Subdivisions.—1. The PLIOCENE* (more new, or recent. *Ly.* I. p. 286.); strata in which the shells are

* In the present state of our knowledge, this arrangement is of great utility, but it appears probable that it will require considerable modification, and perhaps must hereafter be abandoned with the progress of geological research; for it cannot be doubted, that strata in which no recent species have

for the most part of recent species, having only about ten per cent. of extinct forms.

2. The MIOCENE (less recent. *Ly.* I. p. 317.); containing about 20 per cent. of recent species of shells; as the *Crag*.

3. The EOCENE (*dawn of recent*, in allusion to the first appearance of recent species —*Wond.* p. 209. *Ly.* p. 337.); containing very few existing species of shells; not more than five per cent. London clay, Paris basin, &c.

Obs. — The marine are often associated with fresh-water deposits, and the general characters of the Tertiary system are alternations of marine with lacustrine strata. In England the most important Tertiary deposits are those of London, the Isle of Sheppey, the western coasts of Sussex and Hampshire, the Isle of Wight, and of the eastern counties Essex, Norfolk, Suffolk, where these strata are termed *Crag*: (*Ly.* I. p. 317. *Wond.* p. 206.) and are subdivided into the Upper or Red Crag, and the Lower Crag.

SECONDARY FORMATIONS.

III. THE CHALK, OR CRETACEOUS SYSTEM. (*Wond.* p. 291. *Ly.* I. p. 385.) A marine formation, com-

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yet been found, may yield them to more accurate and extended observations, and those in which but a few recent species occur with a large number of extinct forms, may have these proportions reversed.

prising limestones, sandstones, marls, and clays, abounding in the remains of zoophytes, mollusca, cephalopoda, echinoderma, fishes, &c.; drifted wood, and marine plants; with crocodiles, turtles, and other extinct reptiles, and *birds.*

Subdivisions.

1. The *Maestricht beds.* Friable coralline and shelly limestone, with flints and chert.

2. *Upper chalk*, with flints . . . 3. *Lower chalk*, without flints . .	*Craie blanche* of the French geologists.
4. *Chalk marl*	*Craie tufeau.*
5. *Firestone*, malm-rock, upper green sand, or glauconite . .	*Glauconie crayeuse.*
6. *Galt*, or Folkstone marl . . .	*Glauconie sableuse.*
7. *Shanklin*, or lower green sand	*Formation néocomien*; which is divided into *N. supérieur*, the English upper divisions of the green sand or Kentish rag; and *N. inférieur*, the lower beds of sand and clay, as on the southern shores of the Isle of Wight, at Atherfield.*

* Another subdivision, with *other* names, has lately been proposed by M. D'Orbigny; which I mention with the more regret, since this eminent naturalist has hitherto been most cautious in avoiding the censurable practice of modern systematists.

Obs.—The Maestricht beds are chiefly composed of fawn-coloured limestones of friable texture, abounding in corals, shells, fishes, and reptiles. The chalk is generally white, but in some localities is of a deep red, in others of a yellow colour; nodules, layers, and veins of flint occur in the upper, but are seldom present in the lower chalk. The *Marl* is an argillaceous limestone, which generally prevails beneath the white chalk; it sometimes contains a large intermixture of green sand, and then is called *firestone*, or *glauconite*. The *Galt* is a stiff, blue or black clay, abounding in shells which frequently retain their pearly lustre. The *Shanklin*, or *lower green sand*, is a triple alternation of sands and sandstones with clays. Chert and fuller's earth abound in some localities.

IV. THE WEALDEN; (a formation, whose *fresh-water* character was discovered and established by the researches of the author. *Wond.* p. 344.) A series of clays, sands, sandstones, and limestones, with occasional layers of lignite; characterised by the remains of several kinds of peculiar terrestrial and aquatic reptiles, namely, *Iguanodon*, *Hylæosaurus*, *Megalosaurus*, *Crocodile*, *Cetiosaurus*, *Plesiosaurus*, *Turtles*, &c.; of terrestrial monocotyledonous plants; fluviatile mollusca, and crustacea; Fishes, and *Birds*. These deposits evidently once constituted a vast delta or estuary.

Subdivisions.

1. *Weald* clays, with Sussex or Petworth marbles.
2. *Tilgate-grit*, and *Hastings* sands.
3. *Ashburnham* clays, shales, and grey limestones.
4. *Purbeck beds;* argillaceous shale, and freshwater limestones and marbles. Petrified forests, and layers of vegetable earth, with cycadeous plants, and other coniferæ.

Obs.—Clays and limestones, almost wholly composed of fresh-water snail-shells, and minute crustacea, occupy the uppermost place in the series; sand and sandstones, with shales, and lignite, prevail in the middle; while in the lowermost, argillaceous beds, with shelly marbles or limestones, again appear; and, buried beneath the whole, is a petrified pine-forest, with the trees still standing, and the vegetable mould undisturbed! The upper clay beds and marbles form the deep valleys or wealds of Kent and Sussex, and the middle series constitutes the forest-ridge. The Purbeck strata are obscurely seen in some of the deepest valleys of eastern Sussex; they emerge on the Dorsetshire coast, form the island or peninsula whose name they bear, and surmount the northern brow of the Isle of Portland. At the back of the Isle of Wight, the Wealden beds appear beneath the Shanklin sands; and their characteristic fossils are continually being washed up on the shore, near Brook-point.

V. THE OOLITE. (*Wond.* p. 439. *Ly.* II. p. 39.) A marine formation of vast extent and thickness, consisting of limestones and clays, which abound in marine shells, corals, fishes, and reptiles, both terrestrial and marine. Land plants of peculiar species, and the remains of two or more genera of *marsupial* animals, and several species of insects.

Subdivisions.

Upper Oolite of Portland, Wilts, Bucks, Berks, &c.	1. *Portland oolite*—limestone of an oolitic structure, abounding in ammonites, trigoniæ, &c. and other marine exuviæ—green and ferruginous sands—layers of chert. 2. *Kimmeridge clay*—blue clay, with septaria, and bands of sandy concretions—marine shells and other organic remains—*ostrea deltoidea*. Beds of lignite.
Middle Oolite of Oxford, Bucks, Yorkshire, &c.	1. *Coral oolite*, or coral rag — limestone composed of corals, with shells and echinites. 2. *Oxford clay;* with septaria and numerous fossils—beds of calcareous grit, called Kelloway-rock, abounding in organic remains.

Lower Oolite of Gloucestershire, Oxfordshire, and Northamptonshire.	1. *Cornbrash*—a coarse shelly limestone. 2. *Forest marble*—sand, with concretions of fissile arenaceous limestone—coarse shelly oolite—sand, grit, and blue clay. 3. *Great oolite*—calcareous oolitic limestone and freestone; reptiles, corals, &c., upper beds shelly. 4. *Fuller's earth beds*—marls and clays, with fuller's earth – sandy limestones and shells. 5. *Inferior oolite*—coarse limestone—conglomerated masses of terebratulæ and other shells—ferruginous sand, and concretionary blocks of sandy limestone, and shells. *Stonesfield slate*—land plants, insects, reptiles, *mammalia*.
Lower Oolite of Brora in Scotland.	1. *Shelly limestones*—alternations of sandstones, shales, and ironstone, with plants. 2. *Ferruginous limestone*, with carbonized wood and shells. 3. *Sandstone and shale, with two beds of coal.*
Lower Oolite of the Yorkshire coast.	1. *Cornbrash*—a provincial term for a bluish grey rubbly limestone, with intervening layers of clay. 2. *Sandstones and clays*, with land plants, thin beds of coal and shale—calcareous sandstone and shelly limestone. 3. *Sandstone*—often carbonaceous, with clays: coal-beds and iron-stone, with remains of vegetables. 4. *Limestone;* ferruginous and concretionary sands.

Obs. — The difference observable between the lower beds of the Oolite in the midland counties, and those of Yorkshire and Scotland, is a fact of considerable interest. The accumulation of vegetable matter in the state of coal, with the remains of land-plants at Scarborough and Brora, together with the presence of insects, fresh-water crustacea, mammalia, and terrestrial plants in the Stonesfield slate, attest the existence of land, and the action of rivers and currents.

VI. THE LIAS. (*Wond.* p. 454. *Ly.* II. p. 59.) A series of clays, shales, and limestones, with marine shells, cephalopoda, crinoidea, and fishes in great abundance; reptiles, (particularly of two extinct genera, *plesiosaurus*, and *icthyosaurus*,) in immense numbers. Drifted wood and land plants: coniferæ, cycadeæ, &c.

Subdivisions.—1. Upper lias shale, full of saurian remains, belemnites, ammonites, &c. intercalated with the lowermost beds of the oolite: nodules and beds of limestone.

2. Lias marlstone—calcareous, sandy, and ferruginous strata, very rich in terebratulæ and other marine fossils.

3. Lower lias clay and shale—abounding in *gryphea incurva*, and other marine shells; interlaminations of sands and clays, with nodules of limestone.

4. Lias rock; a series of laminated limestones, with clay partings. Bone-bed, with numerous remains of fishes.

Obs.—The Lias is the grand depository of those extraordinary marine reptiles, the Icthyosauri and Plesiosauri, whose remarkable forms, structure, and state of preservation, have excited the attention even of the most incurious. The collection of these remains in the British Museum, principally formed by Mr. Hawkins, is unrivalled.

VII. THE SALIFEROUS, OR NEW RED SANDSTONE SYSTEM.* (*Wond.* p. 461. *Ly.* II. p. 81.) Comprising variegated marls, sandstones, and conglomerates, frequently of a red colour, with shells, crinoidea, marine and terrestrial plants, fishes and reptiles. This series contains vast deposits of rock-salt, and brine springs.

Subdivisions.—1. *Upper New Red.*

(Comprising the *Trias*, or triple group, *viz.* the *Keuper*, *Muschelkalk*, and *Bunter Sandstein* of the German geologists.)

a. Variegated red, blue, and white marls, and shales, with gypsum and rock-salt. (*Marnes irisées* of the French.)

b. Variegated red and white sandstones.

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* Called by some geologists *poikilitic* (variegated) group.

c. Conglomerates formed of the detritus of the older rocks.

d. Red mottled sandstone, and marls. (*Grès-bigarré—French.*)

Total thickness, about 300 yards.

2. *Lower New Red.*

a. Red and white marls, and Dolomite. (*Zechstein. Germ.*)

b. Magnesian limestones; white, red, or yellowish limestone, with a large proportion of magnesia, in thick beds, with marine organic remains.

c. Marl slate, in thin layers, containing reptiles and fishes. The *Keuper Schist* of Mansfeld.

d. Red marls and conglomerates, with sandstones and clays of variable character.

Total thickness, about 100 yards.

Obs.—The New Red or Saliferous system, consists of a series of variegated, blue, yellow, and red marls, abounding in gypsum and salt; with sandstones, limestones, and conglomerates coloured by peroxide of iron. The limestone in the lower divisions is often granular, and contains a considerable proportion of magnesia; it is called *Dolomite.* This formation constitutes the principal deposit in Leicestershire and other midland counties of England. Fossils are not generally abundant, but some localities yield most interesting remains. The shelly limestone called Muschelkalk, which furnishes the *lily encrinite*, &c. does not occur in England. Near Mansfeld, in Thuringia, slate with copper pyrites (*Keuper schist*) abounds, and contains fish of great beauty. Coniferous plants allied to the yew and araucaria, are found near Strasburgh; and enormous batrachian reptiles near Stutgard.

VIII. THE CARBONIFEROUS, OR COAL SYSTEM. (*Wond.* p. 595. *Ly.* II. p. 104.) Sandstones, grits, shales, layers of ironstone, and clay, with immense beds of coal; fresh-water limestones sparingly; marine limestones abundantly.

Subdivisions.—1. *The Coal Measures.*

a. Sandstone, shale, and numerous layers of coal, alternating with clay; seams of ironstone with nodules. Land plants in profusion.

b. Limestone with fresh-water shells (*mussels*) in some districts, and with marine shells in others.

Estimated thickness, 1000 yards.

2. *Millstone Grit.*

a. Sandstone, shale, and quartzose conglomerate and grit (*provincially* millstone grit).

b. Shale and thin seams of coal, in some localities, with plants of the coal measures.

Estimated thickness, from 500 to 650 feet.

3. *Carboniferous*, or *Mountain Limestone.*

a. Limestone and flagstone, abounding in crinoidea and marine shells; with layers and nodules of chert. Ores of lead, zinc, copper, barytes; fluor spar, &c.

b. Limestone, with innumerable shells of the genera productus, spirifer, goniatites, orthocera, bellerophon, &c.

c. Several varieties of black, bluish grey, and variegated marbles.

Obs.—The strata comprised in the carboniferous (*coal-bearing*) system, consist of sandstones more or less felspathic, and of dark bituminous shales with innumerable ferns, and other vascular cryptogamia, and coniferæ, &c. The uppermost group is composed of numerous alternations of coal, clay, shale, ironstone, and sandstone; the middle, of sandstones, shales, clays, and coarse quartzose conglomerates, generally of a dull red colour; and the lowermost, of crystalline limestones with occasional layers of chert, abounding in marine shells, corals, crinoidea, and other exuviæ. These lower limestones are the principal repositories of the lead ores of Derbyshire.

IX. The Devonian or Old Red System. (*Ly.* II. p. 145. *Wond.* p. 613.) Conglomerates, quartzose grits, sandstones, marls, and limestones; the prevailing colour of all, is a dull red. Shells, corals, and fishes, many of which are peculiar.

Subdivisions. — 1. Sandstone, quartzose conglomerates, and shale, with but few fossils.

2. Flagstones, marls, and concretionary limestones; provincially termed *corn-stones;* laminated reddish and greenish micaceous sandstones, (*prov. tilestones.*) Peculiar genera of fish; orthocerata, and many species of marine shells.

Obs.—This group is called *Devonian*, because it is so largely developed in Devonshire. It lies immediately beneath the mountain limestone. The sandstones are in various states of induration, and when slaty, are employed for roofing. The red colour predominates in the marls, and is derived from peroxide of iron. The formation of these rocks has manifestly resulted from the waste of ancient slate rocks, their detritus being cemented together by red sand or marl, into coarse conglomerates.

In South Devonshire, beautiful coralline marbles occur in this group; with many marine shells, and several remarkable genera of fishes.

PALÆOZOIC* FORMATIONS.

X. The Silurian System. (*Wond.* p. 695. *Ly.* II. p. 159.) Marine limestones, shales, sandstones,

* *Palæozoic*—containing ancient animal remains; a term applied to the older fossiliferous strata.

and calcareous flagstones: abounding in shells, corals, *trilobites*, and crinoidea, many of which are of peculiar types.

Subdivisions.

Upper Silurian, thickness about 4000 feet.	*Ludlow rocks* — slightly micaceous grey-coloured sandstone. Blue and grey argillaceous limestone. Dark-coloured shales and flag-stones, with concretions of earthy limestone, containing marine shells, orthocerata, spiriferæ, and trilobites. *Fishes.*
	Wenlock, or *Dudley limestone*—sub-crystalline blue and grey limestone, abounding in trilobites, crinoidea, polyparia, spiriferæ, orthocerata, &c.
	Wenlock shale — dark grey argillaceous shale, with nodules of sandstone.
Lower Silurian, thickness about 3500 feet.	*Caradoc sandstone*—shelly limestones, and finely laminated, slightly micaceous, greenish sandstones. Corals, mollusca, trilobites.
	Llandeilo flags and limestones. Freestone, conglomeritic grits, and limestones. Dark-coloured flags. Beds of schist with abundance of trilobites and mollusca.

Obs.—The Silurian System, (from the *Silures*, the ancient Britons who inhabited the region where these strata are most distinctly developed,) occupies the border counties of England and Wales, and spreads over a considerable area of South Wales; forming a link, which connects the carboniferous series with the ancient slate rocks of that country. The strata are entirely of marine origin, and many of the beds (as the well-known Dudley limestone) are composed of shells, corals, crinoidea, and those peculiar crustaceans termed *trilobites*, held together by calcareous cement. No vegetable remains, except a few traces of fuci, have been found in Britain below the Old Red sandstone.*

XI. The CAMBRIAN or SCHISTOSE SYSTEM. (*Wond.* p. 698.) Consists principally of a largely developed series of slate rocks, and conglomerates, with a few shells and corals.

Subdivisions.—Plynlymmon rocks.—Slates, with beds of conglomerates. Thickness, several thousand yards.

Bala limestone.—Dark limestone, associated with slate, containing a few species of shells and corals.

Snowdon rocks. — Slates, fine-grained, and of various shades of purple, blue, and green. Fine and coarse conglomerates. A few organic remains. Thickness, probably several thousand yards.

Obs.—The upper dark-coloured schists contain a few corals and fuci; in the slate of Snowdon four or five species of shells have been discovered; and with these, all traces of organic remains disappear. The fineness of grain, general aspect, hardness, and texture of these rocks, are well known, from the

* Mr. Murchison's splendid work "The Silurian System," contains admirable figures of all the organic remains.

universal employment of slate for economical purposes. This system extends over a great part of Cumberland, Westmoreland, and Lancashire, reaching to elevations of 3000 feet, and giving rise to the grand scenery of the Lakes, and of North Wales.

HYPOGENE ROCKS. (*Wond.* p. 705.)
(*Non-fossiliferous.*)

XII. METAMORPHIC (*transformed*) or stratified crystalline rocks.

Subdivisions.—1. *Mica-schist System.* (*Ly.* II. p. 401. *Wond.* p. 706.) Probably sedimentary rocks altered by high temperature. Mica-slate, quartz rock, crystalline limestone, and hornblend schist.

2. *Gneiss System.* (*Wond.* p. 707.) Layers of gneiss, sienite and quartz-rock, alternating with clay-slate, mica-schist, &c.

XIII. PLUTONIC, or unstratified crystalline rocks.

Granitic System. (*Wond.* p. 709. *Ly.* II. p. 324.) Porphyry, serpentine, trap. These rocks occur in amorphous masses, or in dykes and veins.

Obs.—No certain traces of fossils have been detected in these rocks: but the intense igneous action which the masses appear to have undergone, may have obliterated all evidence of animal or vegetable structures, should they ever have contained organic remains. By the aid of the microscope, we may yet perhaps solve the mystery of their origin, and the student may take up the investigation, with the certainty of obtaining much valuable information, even should the search for vestiges of organic structure prove abortive. It is not, however, impossible that the siliceous shells or cases of animalcules may have escaped destruction, and remain to reward the labours of some skilful and indefatigable observer. Mr. Reade detected in mica-schist, bodies which much resembled shields of infusoria (*Gaillonella*—see *Wond.* p. 771); but their animal origin is equivocal.

XIV. Volcanic Rocks. (*Ly.* II. p. 185. *Wond.* p. 711.) The products of fire, or of subterraneous heat, ejected from beneath the surface through fissures in the earth's crust, whether in ancient or modern times.

Subdivisions.—1. *Trap, basalt, toadstone, tuff;* the erupted materials of ancient extinct volcanoes.

2. *Lava, scoriæ, pumice, ashes;* the products of recent and active sub-aerial volcanoes.

Obs. These igneous productions are of all ages; they traverse alike the hypogene rocks, the older and newer sedimentary, and the contemporaneous deposits. Their nature, and the effects they have produced, are fully considered in the works to which reference is made.

By an inspection of the geological map of England (*Wond.* pl. x.), it will be seen, that viewed on a broad scale, the several formations appear on the surface in a chronological order, from the south-east to the north-west. Thus the principal Tertiary deposits are situated in the eastern and south-eastern parts of our island; and proceeding towards the north-west, we successively pass over the Upper Secondary—the Chalk, Oolite, and Lias; then the Lower Secondary—the Carboniferous and Devonian groups; next the Silurian; and lastly the Cambrian and Metamorphic rocks. It is this distribution of the strata that has determined the physical character of the geography of England. The Alpine or mountainous districts, which extend north and south along the western portion of England and Wales, from Cornwall to Cumberland, are formed by the elevated masses of the Metamorphic, Cambrian, and Silurian rocks. Next we have a band of the Carboniferous, and associated strata of red marls and sandstones, with occasional interspersions of Metamorphic and Basaltic masses, stretching from the coast of Devonshire, through the midland counties, by Derbyshire to Durham. On the east of this line, the Lias, Oolite, and Chalk, constitute a calcareous district, which spreads over the whole of the eastern and south-eastern portion of the island, from the southern shores of Dorset, Hants, and Sussex, to Flamborough-head and Whitby, on the coast of Yorkshire. And lastly, on the Upper Secondary strata in the eastern maritime districts, and in basins or depressions in the south-eastern, the Tertiary formations appear; and on these last are distributed vast local accumulations of Drift, or Alluvial debris.

CHAPTER III.

ON THE NATURE OF FOSSILS, OR ORGANIC REMAINS.

IT is very generally the case, that persons who are not conversant with the nature of organic remains, imagine that all fossils are petrifactions; and unless a specimen has the aspect and hardness of stone, they regard it as of modern origin, and devoid of interest. Hence they are surprised to find among the choicest treasures in the cabinet of the geologist, shells and corals as perfect in form, as if recently collected from the sea-shore; bones as little changed, as if they had been interred but for a short period; and teeth possessing their sharp edges and enamel unimpaired. In my early researches I fell into this error, and threw away many beautiful shells that were associated with ammonites, in the marl at Hamsey, supposing, from their perfect state, that they had been accidentally imbedded, and were not genuine fossils. But the state of preservation, and the degree of change which an organic body has undergone in the mineral kingdom, have no necessary relation to its antiquity. The shells in some of the ancient secondary strata are frequently as perfect as those of modern tertiary deposits. I have collected in the lowermost clays of the Wealden, fresh-water shells having traces of the epidermis, and of the ligament by which the valves were held together; and bones of reptiles in Tilgate Forest, as light and porous as those of the bear and hyena, from the caverns of Germany. On the other hand, fossil remains from the newest tertiary formations are often completely petrified, that is, permeated by, or transmuted into stone.

Another prevalent error is that of considering incrustations to be petrifactions; a mistake which is sanctioned, by the custom of calling waters that are loaded with calcareous earth (*lime*), and deposit it in considerable quantity, petrifying springs or wells; as those of Matlock, and other places in Derbyshire. (*Wond.* p. 58.) But incrustations are not petrifactions; stems and branches of trees, skulls, bones, shells, &c., are simply invested with a calcareous coating or crust, which is sometimes porous and friable, but often crystalline and compact. The enclosed bodies are not permeated by the stony matter; if the mass be broken, or the incrustation removed, we find either the twig, or stem, dry and shrivelled, as in the specimens, figs. 2, 3, 4, Plate III.; or tubular cavities left by the decay and removal of the vegetable structure, as in fig. 10, Plate III.

But although incrustations be not petrifactions, natural specimens, (not the so-called petrified nests and wigs, in which the bad taste of the guardians of the Derbyshire springs is embodied, and dispersed all over England,) are objects of considerable interest, as illustrative of a process, by which important changes are effected in the mineral kingdom. Thus springs as clear and sparkling as poets ever feigned or sung, may transform beds of loose sand and gravel into rock, and porous stone into solid marble, and cover extensive tracts of country with layers of concretionary and crystalline limestone. This process is effected in the following manner. Most fresh water holds in solution a certain proportion of carbonate of lime; and changes of temperature, as well as other causes, will occasion this calcareous earth to be in part or wholly precipitated. The *fur*, as it is called, that lines a kettle or boiler which has been long in use, affords a familiar illustration of this fact. At the temperature of 60° lime is soluble in 700 times its weight of water; and if to the solution a small portion of carbonic acid be added, a carbonate of lime is formed, which is thrown down in an insoluble state. But if the carbonic acid be in such quantity as to supersaturate the lime, it is again rendered soluble in water: it is thus that carbonate of lime, held in solution by an excess of carbonic acid, not in actual combination with the lime, but contained in the water, and acting as a menstruum, is commonly found in all waters. An absorption of carbonic acid, or a loss of that portion which exists in excess, will therefore occasion the lime to be set free, and precipitated on the foreign bodies in the water, as stones, twigs, leaves, &c.

The substance thus deposited is termed tufa, or travertine ;* and in some parts of Italy, and of our own island, it constitutes beds of stone of great extent, in which bones, shells, and the impressions of leaves and stems, are preserved. The stalactites and stalagmites of caverns have a similar origin; many of these caves are of incalculable antiquity, and beneath their stalagmitic floors, the bones and teeth of extinct carnivorous animals are found in vast quantities (*Wond.* p. 164.).

Silex, or the earth of flint, is also held in solution in large proportions, in certain thermal or boiling springs, which, on cooling, deposit the siliceous matter, (in the same manner as the travertine is precipitated from incrusting streams,) on foreign substances, and produce exquisite chalcedonic infiltrations of mosses, &c. But this operation is now only known to be in activity in the immediate neighbourhood of foci of volcanic action, as in the celebrated Geysers of Iceland, (*Wond.* p. 83.) and the boiling springs of the volcano of Tongariro, in New Zealand. But we have everywhere evidence that in former periods, the petrifaction, as well as the incrustation of organic bodies by silex, was carried

* *Travertine*, so called from the river *Tiber*, whose waters are loaded with calcareous earth—*Tiburtina*, *Ital. travertina.*

on to an immense extent; and probably, far beneath the surface, the same operation may at the present moment be in constant progress, and effecting as important changes in the consolidation of loose materials, as in the earlier geological epochs.

I now proceed to consider the various states, in which the remains of animals and plants are preserved in the strata, and I shall occasionally offer suggestions for collecting and preparing specimens; but particular instructions on this head will be given, when the different kinds of fossils are respectively considered.

ANIMAL REMAINS.—Of the higher orders of animals, the durable portions of the skeletons, as the bones and teeth, are almost the only parts that occur in the mineral kingdom; with the exception of those remarkable instances, in which the entire carcase of colossal mammalia allied to the elephant, and of extinct kinds of rhinoceros, are found imbedded in solid ice. (*Wond.* p. 139.) The countries of arctic regions are now the only localities in which such phenomena are likely to be met with; it appears, however, that in some remote periods of the earth's physical history, the carcases of large mammalia were transported by icebergs into temperate regions, where the ice melted, and the bodies either sunk to the bottom of the sea, or were drifted into estuaries, or stranded on the shore: the soft parts then decomposed, and the skeletons and detatched bones were imbedded in the silt, sand, or shingle.

In this manner alone can be explained the occurrence of bones and teeth of the mammoth, rhinoceros, hippopotamus, &c. so common in the alluvial or drifted deposits of this country; for these relics, although extremely friable, and buried in shingle, boulders, and other transported materials, are not waterworn, but in numerous instances remain as sharp and perfect as when recent. In the ancient shingle of Brighton cliffs (*Wond.* p. 102.), I have found fossil bones of horse, deer, ox, whale, &c. lying in the midst of quartz and granite pebbles and boulders, the bones, though crumbling to pieces if not very carefully removed, being quite perfect, and the whole mass held together by calcareous spar, deposited by water that had, during the lapse of ages, percolated through the chalk rubble above.

The cavities of the long-bones of mammalia, and the cancellated structure, (that is, the little cells or pores of the bone,) are often filled, or lined with crystallized carbonate of lime; as for example, in the bones found in caverns in England and Germany; and in the breccia of Gibraltar, and the conglomerates of Ava, and the Sub-Himalaya mountains. I have never seen silicified bone, except in two or three fragments of fish-bone, and a vertebra of the Mosæsaurus, from the Sussex chalk.

HINTS *for collecting fossil bones.*—The light, friable, porous bones, require great care in their removal from the deposit in which they are imbedded, whether it be clay, consolidated shingle, or limestone; if of considerable size, they will almost invariably break to pieces, and many examples will not admit of repair. It is therefore always desirable, before attempting to extract a large bone, to make a sketch of it; its form will thus be known, should it be destroyed; and if it crack into fragments that will admit of reunion, the drawing will be a valuable guide for the replacing of the separated parts. If only a few pieces remain, those which show any part of the terminations, or joints, should be preserved, as they afford the most precise and important characters. The faithful record even of an imperfect and unknown fossil is not without value; and as the antiquary carefully preserves shreds of ancient manuscripts, in the hope that other documents may come to light, by which he may be enabled to interpret these now unintelligible relics; so the geologist should treasure up every fragment of an undetermined organic remain, for the time may arrive when other specimens will explain its nature, and prove it to possess considerable interest.

The broken, porous bones, may be easily repaired by thin, hot glue; and when the joinings are set, the bone should be saturated with thin glue, well brushed in, and the surface, before the glue congeals, be sponged clean with very hot water: when dry, the specimens will be found to possess considerable firmness and durability. By this process the tusks of mammoths and elephants may be restored, however much crushed; time, patience, and a little dexterity only are required, to convert a heap of mere fragments into a valuable relic of the ancient world.

When the bones are tolerably perfect, but very dry and friable from the loss of their animal oil, they may be made durable by saturating them with drying oil, and exposing them to a considerable degree of heat; in this manner the magnificent skeletons of the sloth tribe, the Megatherium, and Mylodon, in the Hunterian Museum, were prepared. When a bone appears as if cracked into numerous pieces before its removal, but still preserves its form, the only method by which it may be successfully extracted, is by putting over it a thick coating of plaster of Paris, which should be used of the consistence of cream; when it sets, (which, if the plaster be recently prepared, will be in the course of a few minutes,) the specimen may be carefully extricated from the stratum, and the plaster removed or not, according to the nature of the fossil, and the parts requiring to be displayed. The bones of the large reptiles which occur in the Wealden and Oolite, may be restored in the same manner. These remains, although generally petrified by an infiltration of iron, or calcareous spar, are very brittle, and when imbedded in hard grit cannot be extracted whole: they will often fly to pieces on the slightest blow of the hammer or chisel. When of moderate size, it is best not to attempt their removal from the stone, but to trim the block into a convenient shape, and carefully chisel away the surrounding part, so as to expose the essential character of the bone. In all cases this is an excellent method where practicable, for such specimens have a double interest; they are at once illustrative examples of the fossils, and of the rock in which they were deposited.

But many specimens will not admit of the adoption of this method; and with large ones it is inconvenient and undesirable, except where bones lie in juxta-position. The large specimens in Tilgate grit, (figured in the fossils of Tilgate Forest,) were all extracted piecemeal from the rock: and most of the large bones of the Iguanodon, &c. now in the British Museum, were originally in many hundred pieces, and were cemented together with glue in the manner above described; no method is so convenient and effectual.

When a bone is too imperfect to be united as a whole, it may be imbedded in Roman cement, or plaster of Paris, which when dry may be coloured of the prevailing tint of the rock. For large, heavy specimens, the cement is preferable; it is of easy application, and the fissures and cracks of the bones may be filled up with it, taking care first to cover the parts with thin hot glue, or the cement, when it dries, will shrink and fall out. A thin coating of mastic varnish will restore the colour, and by excluding the air, tend to preserve the specimens.

The teeth have generally undergone the same changes as the bones with which they are associated. The elephants' and mammoths' teeth that are imbedded in loose calcareous earth, like the loam and chalk rubble of Brighton cliffs, and of Walton in Essex, are often very friable, and apt to split into pieces in the direction of the vertical plates of dentine, and bone: the pieces should be glued together, and when set, the tooth be thoroughly saturated with thin glue, used very hot, and the superfluous glue removed, with a sponge wrung out as dry as possible from boiling water. If there be any portion of the jaw attached to the teeth, it must be carefully preserved; and search should be made for fragments of the articulations, or parts of the joints or sockets.

In argillaceous strata, as the Lias Shale, London Clay, &c., fossils are often found saturated with a yellowish, brilliant mineral, called pyrites, or sulphuret of iron, which decomposes upon exposure to the atmosphere, and occasions the destruction of the specimens. The fossils of the Isle of Sheppey are peculiarly obnoxious to this change. The remains of vertebrated animals in the Lias, very generally occur as skeletons more or less perfect, the entire configuration of the original being preserved in many instances. (*Bd.* pl. 7. *Wond.* p. 487.) But the deposit in which they are often found, is a laminated shale, that flakes off with great facility; much time, labour, and practice are therefore required, to obtain specimens of any considerable size. To Miss Mary Anning, of Lyme Regis, the merit is due, of having first accomplished this difficult task; Mr. Hawkins has subsequently carried the art to perfection, as may be seen in the marvellous examples of Ichthyosauri and Plesiosauri, in the British Museum.

The small specimens, such as the detached paddles, groups of vertebræ and ribs, &c., that are likely to come under the collector's notice in his personal researches, are not difficult of preservation. Mr. Hawkins employed a strong watery solution of gum arabic as the cement, and plaster of Paris as the ground, using shallow wooden trays of well-seasoned wood, in which the specimens were permanently imbedded: the bones, scales, &c. were then varnished with a solution of mastic; and the ground coloured blue, like the Lias. I have had considerable practice in the dissection of skeletons in the Lias, and having found the methods previously described answer every purpose, have not employed that recommended by Mr. Hawkins.

The scales of reptiles and fishes, either in connected masses or detached, are frequently in great perfection, and sometimes associated with the teeth and bones. In the Lias, even the remains of the skin and integuments (*Bd.* pl. 10.) are occasionally to be met with. Whenever any part of a skeleton is found lying in shale or stone, the surrounding block should therefore be carefully examined, to ascertain if traces of the skin or integuments be present, before any part is removed by the chisel. The specimen of an Ichthyosaurian paddle, figured in the second volume of this work, affords a good illustration of the propriety of this caution. Around the bones are seen the carbonized remains of the cartilaginous fringe that supported the integuments, and thus the perfect form of the paddle has been ascertained. Had the stone been chiselled away around the bones, these important characters would have been obliterated, as probably they have been in numerous instances.

The scales of fishes, and the integuments of marine reptiles, are not the only vestiges of the dermal covering of vertebrated animals, that are preserved by mineralization. Traces of the wing-integument of flying reptiles, and of the feathers of birds, are sometimes manifest: and even when every atom of organized structure is lost, the impressions may remain, and afford highly interesting results. The footmarks of unknown animals are often preserved in the rocks (*Bd.* pl. 26. *Wond.* p. 478.), and the imprints of the feet of several species of birds of colossal size, and in tracks as distinct as if but recently walked over, have been discovered in the New Red sandstone of North America; this is one of the most striking, and unexpected phenomena, revealed by modern Geology. (*Bd.* pl. 27.) In the section on fossil birds, this highly interesting subject will be fully explained.

The student, even from this brief review, will perceive how many valuable facts may be unnoticed, and irretrievably lost, unless attention be given to the various circumstances under which fossil remains are presented to his notice.

Of the invertebrated orders, the most durable, and consequently the most numerous fossils, are shells and corals; and the siliceous and calcareous cells and cases, of polypiaria and animalcules. The eyes, antennæ, and wings of insects occur, and the shelly coverings of crustacea are not uncommon; those of the echinoderma, and the ossicula of the starfish, and of the lily-animals of the same family, are very abundant. The necessary instruction for the collection and arrangement of these fossil remains, will be given under the different heads in which each class is described.

CHAPTER IV.

FOSSIL VEGETABLES.

THE remains of the vegetable kingdom are presented to the notice of the geologist, in various conditions; in some instances but little changed in their aspect, as in the recent accumulations of mud and silt, at the bottoms of lakes and rivers, and in morasses, and peat bogs; in tufaceous incrustations, as decayed wood, with the imprints of the leaves and stems, preserved on the solid masses of concretionary, or crystalline limestone.

In the ancient deposits, vegetables are found in two different states. In the one their substance is completely permeated by mineral matter; it may be calcareous (*lime*), siliceous (*flint*), ferruginous (*iron*), or pyritous (*sulphuret of iron*); and yet both the external characters, and the internal structure be preserved. Such are the fossil trees of the Isle of Portland, fragments of which so closely resemble decayed wood, as to deceive the casual observer, until by close examination of their texture and substance he finds that they possess the weight and hardness of stone. In the silicified wood (that is, petrified by silex or flint,) which abounds in many of the tertiary strata, the most delicate tissue of the original is generally preserved, and by microscopical examination (see Pl. V.) may be displayed in the most distinct and beautiful manner. Calcareous wood also retains its structure; and in many limestones, leaves and seed-vessels are well preserved.

The ligneous coverings, or the husks and shells of nuciferous fruits, and the cones or strobili of firs and pines, are frequently in an excellent state of preservation; and in some rare instances indications of flowers have been observed. The parts of fructification, in some of the fern tibe, (*Lign.* 18 and 20.) occur in coal-shale, and in the grit of Tilgate Forest (*Wond.* p. 372.): and even the pollen of coniferæ has been found in tertiary marls, associated with animalculites.* The resinous secretions of pines and firs, are also found in a mineralized state. Amber is too well known to require further notice in this place, than that its vegetable nature is unquestionable; this substance has been observed in its natural position, in trunks of coniferæ. (*Wond.* p. 637.) The *fossil resin* of the London clay, discovered at Highgate, and the Isle of Sheppey, has had a similar origin. In the Clathrariæ (*Wond.* p. 374.) of Tilgate Forest, indications of a resinous

* *Animalculites*—fossil animalcules.

secretion have been detected. The diamond, which is pure charcoal, is probably a vegetable secretion, that has acquired a crystalline structure by electro-chemical action (*Wond.* p. 638.). When the microscope is more extensively employed in investigations of this kind, it is probable that the siliceous spines and stars, so abundant on the foliage of many plants (as the *Deutzia*, *Lithospermum officinale*, &c.) will be found fossil, for they are as indestructible as the spines of sponges and other animal remains, so commonly imbedded in flint and chalcedony.

But vegetables occur not only as petrified stems, leaves, and fruits, associated with other remains in the strata, but in beds of great thickness and extent, consisting wholly of plants transmuted, by that peculiar process which vegetable matter undergoes when excluded from atmospheric influence, and under great pressure, into carbonaceous masses, called Lignite, and Coal. And there are intermediate stages of this process, in which the form and structure of the trees and plants are apparent; and a gradual transition may be traced, from the peat-wood and submerged forests of modern epochs, in which leaves, fruits, and trunks of indigenous species are preserved, to those accumulations of the extinct species of an ancient Flora, whose vegetable origin the eye of science can alone detect.

For the collection and preservation of vegetable fossils, with the exception of those which are permeated with pyrites, (as those of the Isle of

Sheppey, &c.), but few instructions are required. The silicified and calcareous stems are generally easy of extraction, even when imbedded in hard stone, and if broken can be repaired with glue. When the stems bear the imprints of leaf-stalks, (as in *Lign.* 30 and 44.) the surrounding stone should be carefully examined, with the view of detecting impressions, or other indications of the foliage. Delicate leaves in clay, or shale, must not be washed; a thin coat of mastic varnish, applied with a camel-hair pencil, will preserve them, and render them more distinct. When a leaf, fruit, seed-vessel, or other fragile object is attached to clay or friable sandstone, it is advisable to glue the specimen to a piece of thin wood or pasteboard, of suitable proportions.

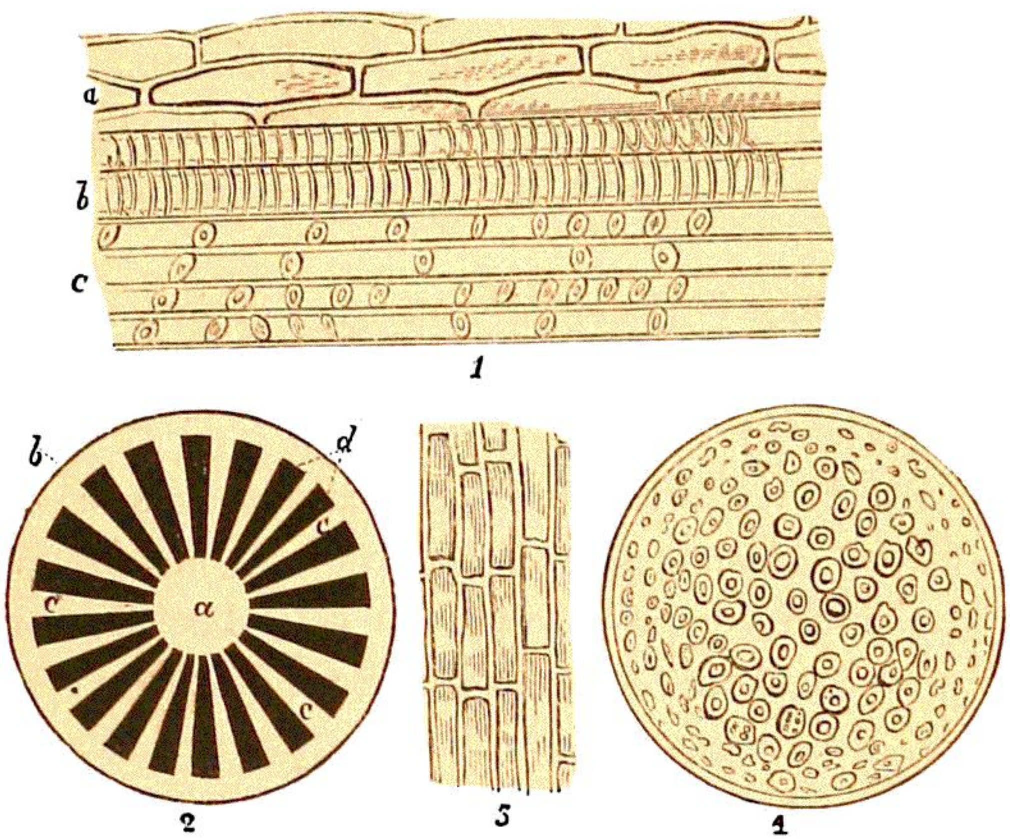
ON THE INVESTIGATION OF THE FOSSIL REMAINS OF VEGETABLES.

VEGETABLE ORGANIZATION.—As fragments of the stems or trunks, and branches, are very often the only vestiges of many species of fossil plants, a knowledge of the characters by which the principal divisions of the vegetable kingdom may be distinguished by their internal structure, is indispensable to the successful investigation of the Flora of the ancient world. Although I have treated of this subject in the Wonders of Geology, (*Wond.* p. 622.)

it will here be necessary to present the student with more ample details. The excellent introductory botanical works of Dr. Lindley, and Professor Henslow, convey full information on this, and every other department of the science, and should be consulted by those, who intend to make this branch of Geology their particular study. For the general reader, and amateur collector, the following notice of a few obvious essential characters of vegetable organization, will probably afford sufficient information.

Every plant is essentially an aggregation of cells; and the most simple forms of vegetation consist of a congeries of cells (*cellular tissue*) of the same kind, and have no visible fructification; such are the sea-weeds (*algæ*, *confervæ*, &c.), mosses, and lichens. In the more complex tribes the cells become variously modified, are elongated into tubes or vessels (*vascular tissue*), some of which possess a spiral structure, and others have their sides studded with little glands. The vascular tissue consists of two kinds of vessels. 1. The *spiral* or *tracheæ:* these are membranous tubes, with conical extremities, having within, a coil of elastic fibre spirally twisted, and capable of being unrolled (*Lign.* 1, *b.*). 2. The *ducts;* which are a modification of the structure of the spiral vessel; their extremities are rounded or conical, and their sides marked with transverse lines, rings, or bars. Their functions appear to be different from those of the spiral vessels, and they are found in situations where the latter never occur.

The organization of the stem in the whole class of flowering plants, possesses characters so evident, as to afford the most important aid in the investigation of their fossil remains. Without dwelling



LIGN. 1. SECTIONS OF RECENT VEGETABLES; illustrative of their internal organization. (Dr. Lindley.)

Fig. 1.—Longitudinal Section of Coniferous Wood.
a. The ducts. *b.* Spiral vessels. *c.* Glandular vessels.

2.—Transverse section of a dicotyledonous stem.
a. Pith, or central column. *b.* The bark. *c.* Medullary rays.
d. Vascular tissue between the medullary rays.

3.—Elongated cellular tissue, forming the medullary rays.

4.—Transverse section of a monocotyledonous stem.

on minor modifications, they are separable into two grand divisions, namely, the endogenous (signifying *to grow from within*), and the exogenous (*to grow* *from without*). Both possess vascular tissue, but so differently arranged in the two classes, as to constitute distinctive characters which are seldom obliterated, although what was once a flexible stem, is now a mass of flint.

ENDOGENOUS STEMS.—As the seeds of the plants belonging to this division have but one cotyledon, or *seed-lobe*, as the lily, they are also termed monocotyledonous; the reader therefore must remember that these terms are synonymous. These stems consist of an uniform mass of cellular tissue, in which bundles of vascular or woody fibre are imbedded; a transverse section presents a surface dotted over with spots, produced by the division of these groups of vessels, pretty uniformly distributed, but more densely arranged towards the circumference (*Lign.* 1, fig. 4.). A slice of cane affords an illustration of this structure.

The increase of these stems is effected by the formation of new cells and bundles of vessels in the central axis, which force their way among the old tissue, and occasion the condensation of the latter towards the outer edge. These plants have neither pith, concentric circles of woody fibre, nor true bark; negative characters of the highest importance.

EXOGENOUS STEMS.—The seeds having two cotyledons, or seed-lobes, as the bean; this class is also called dicotyledonous. In these stems the cellular tissue forms a central column, or pith (*Lign.* 1, fig. 2, *a.*) and an external band, or cylinder, called the bark (fig. 2, *b.*); the two being connected by thin vertical plates, termed medullary rays, which are also formed of cells (fig. 2, *c*, *c.*). The diagram, *Lign.* 1, (from Dr. Lindley's *Introd. Bot.*) exhibits this arrangement. The interval between the pith and the bark, and the interspaces of the vertical radiating plates (fig. 2, *d.*), are filled up by woody fibre or vascular tissue, consisting of spiral and other vessels. The ligneous structure of exogenous stems, therefore, consists of a cylinder, surrounded by the bark, formed of wedge-shaped processes, that extend between the medullary rays to the pith. A new zone of woody fibre is added annually between the bark and the former cylinder, and from this mode of increase the term *exogenous* is derived. A transverse section of a branch of oak or ash will show this structure. The rings, or concentric circles, are the annual zones of wood; the fine lines radiating from the centre, or pith, to the circumference, or bark, are the medullary rays (*Lign.* 1, fig. 2, *c.* See also Plate V. fig. 4.).

The organization above described, will be found more or less manifest in fossil wood, stems, and branches. The monocotyledonous structure is beautifully preserved in the silicified stems of palms from Antigua (Plate V. fig. 1, 1[a.]): and the dicotyledonous, in petrified trees from Egypt. The pith, medullary rays, vascular tissue, and circles of growth, are preserved in the siliceous and calcareous wood found in many parts of England.

STRUCTURE OF CONIFERÆ (*cone-bearing*).—The remains of a numerous family of dicotyledonous trees, termed *coniferæ*, as the pine, fir, larch, &c. are so abundant in the stratified rocks, that it is necessary to describe the peculiarity of structure by which their stems and branches may be recognised. The most delicate woody tissue, as we have above stated, consists of elongated cells or tubes, of two kinds: in one, the membrane of which they are composed is smooth; in the other, the walls of the tubes are covered by little oval or circular bodies called glands (*Lign.* 1, fig. 1, *c.*). A branch of larch or pine, split longitudinally, and viewed by a powerful lens, will exhibit the appearance here described. This glandular structure is so constantly and largely developed in the coniferæ, that although it is also possessed by other aromatic trees, we shall rarely err in referring fossil wood in which this organization is apparent, to this family of vegetables (See Plate V. figs. 2, 3.). These glands in the pines and firs, are supposed to be the cells which secrete a colourless volatile oil, that exudes in the state of turpentine.

From this general view of such organs and structures of recent vegetables, as may be expected to occur in the fossilized remains of trees and plants, we proceed to consider the application of the data thus obtained.

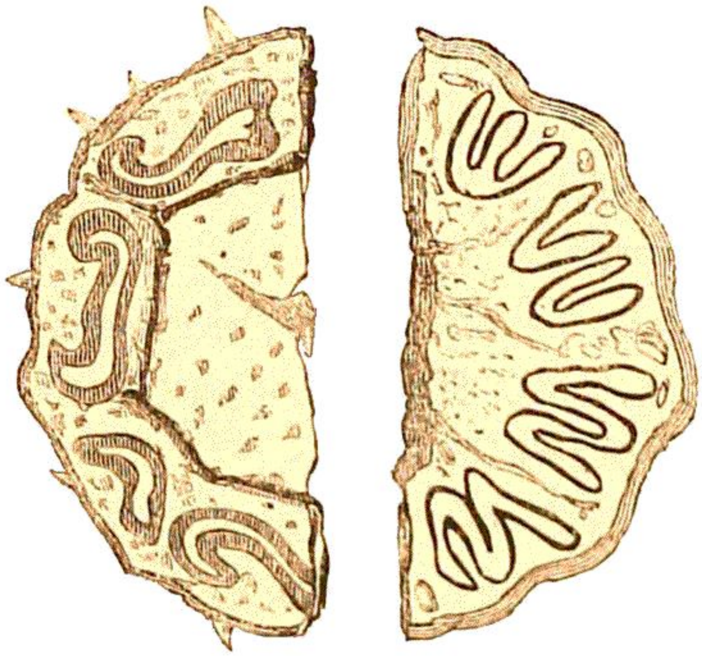
THE MODE OF INVESTIGATION. — The distinguished authors of the British Fossil Flora* justly remark, that a few isolated, and often times very imperfect data, exclusively afforded by the remains of the organs of vegetation, are the sole guide to the class, order, or genus of the fossil plants which the geologist has to examine; hence a general idea only can be obtained of the nature of the original. For his guidance they offer some admirable suggestions, which have served as the basis of the following directions to the student for the investigation of vegetable remains, and which our previous remarks will, we trust, enable him clearly to comprehend.

1. *The Trunk, or Stem.*—Examine if the wood in a transverse section be disposed in concentric circles (as Plate V. fig. 4.): if so, it belonged to an exogenous tree: if, on the contrary, the wood appears deposited irregularly in spots (*Lign.* 1, fig. 4.), then the original was endogenous. If a transverse section show remains of sinuous, unconnected layers, resembling arcs with their ends directed outwards, and of a solid structure, and imbedded among looser

* Foss. Flor. Vol. I. p. xxvi.

tissue, then it belonged to an arborescent fern; see the subjoined figures (*Lign.* 2.).

If the stem be in a state of preservation that will admit of the slicing, or chipping off a piece for microscopical investigation, the process described at the conclusion of this section should be employed.



LIGN. 2. SECTIONS OF FERN-STEMS.

Transverse sections (half the diameter) of two stems of recent arborescent ferns, to show the zone of woody fibre disposed in arcs. This structure is preserved in the silicified trunks from Chemnitz.

The following data may be thus obtained. If the structure be entirely cellular, and it can be satisfactorily ascertained that it never possessed vascular tissue, the original belonged to the cryptogamia, as fuci, mosses, and the like.

If it consist of parallel tubes, and has neither pith, nor rays passing from the centre to the circumference, the original was endogenous; as the palm. If any trace be present of tissue crossing the longitudinal tubes at right angles, radiating from the centre to the circumference, this will prove the existence of medullary rays, and the original must have been exogenous, as the oak, elm, &c. And if in a transverse section the tubes appear of equal size, the original was probably coniferous or cycadeous (related *to the plants called Cycas and Zamia*); but if larger tubes appear among the smaller ones, disposed in a definite manner (see Plate V. fig. 4.), it belonged to some other tribe of exogenous plants.

If the walls of the tubes be studded with glands (*Lign.* 1, fig. 1, *c.* Plate V. figs. $2^{b.}$ $3^{b.}$), the fossil belongs to the coniferæ.

If any vestige of a central pith be discovered, the exogenous nature of the original is undoubted, for no other class, as we previously stated, possesses a central, cellular column.

The absence or presence of a true cortical investment, or bark, is important, for a distinct bark is the characteristic of the exogenous class:* a cortical integument, or rind, not separable from the enclosed structure, indicates the monocotyledonous; and the entire absence of any rind, the cryptogamia.

The markings on the stems, occasioned by the scars or cicatrices left by the separation of the

* An apparent exception to this rule is found in the fossil genus *Clathraria*, described hereafter.

petioles or leaf-stalks (as on the stalk of a cabbage,) afford important evidence, since they are very commonly present even when the cylindrical trunk is compressed into a flat thin layer of coal; as we shall often have occasion to remark. In this place it need only be stated, that by these scars may be detected the position of the leaves, and the form of their bases; their probable direction, whether they were opposite, alternate, verticillate, or spirally disposed, deciduous or persistent, imbricated or remote. Even when no traces of the leaves remain, the origin of the branches, and their bifurcation may perhaps be determinable.

2. *The Leaves.*—In a fossil state the texture and surface of the leaves are sometimes preserved; but in general the outline of the leaf, its division and arrangement, and its mode of venation, can alone be ascertained. The *venation*, that is, the form and distribution of the vascular tissue, or vessels, through the leaf, is the most important character for our guidance; and Dr. Lindley offers the following suggestions on this point. If the veins be all parallel, not branched, or only connected by little transverse bars, and the leaves undivided (as in the lily or hyacinth), the plant was probably endogenous; but if the leaf be divided or pinnated, it may be referable to cycadeæ (*Lign.* 36 and 37.).

Leaves having the veins of equal, or nearly equal thickness, and dichotomous (*forked*), or very fine, and simply divided, belong to the fern tribe; to this division an immense proportion of the foliage found in the carboniferous strata is referable; the genera of fossil ferns have been constructed principally from the venation.

If the veins of a leaf be obviously of unequal thickness, and reticulated, or disposed in net-like meshes, as in the rose and apple, the original was dicotyledonous (Plate. III. figs. 4, 8.).

Leaves of a large size, and having no veins, and irregularly divided, probably belong to fuci, or other marine plants (*Lign.* 5.).

Such are the rules for the investigation and interpretation of the characters of the stems and foliage, which have been preserved by mineralization. Their application is not difficult, and the student may by their assistance obtain some general indications as to the nature of the original tree or plant, whose petrified remains form the subject of his examination.

ON THE MICROSCOPICAL EXAMINATION OF FOSSIL VEGETABLES.

Mr. Nicol, who first suggested the method now generally adopted for preparing fossil wood, coal, &c. for microscopical examination, and which was employed by Mr. Witham in the illustrations of his beautiful work on the structure of fossil plants,*

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* Observations on Fossil Vegetables. 4to. 1833.

has so clearly explained the process, that by a little practice the student will be able to prepare specimens sufficiently thin for every useful purpose. Several lapidaries in London, (see list at the end of this work,) polish and mount vegetable and other fossils, in a very superior manner; but their charges are high, and they frequently injure specimens by grinding them too thin, and thus obliterating structure. I would recommend that a small chip of the specimen, if possible in a *radial* direction, should be examined by reflected light, always beginning with the lowest object-glass and eye-piece, and ascending to the highest power; at first without any preparation;* subsequently the object should be immersed in oil of turpentine, which will render it somewhat transparent, and it then should be examined by transmitted light. By this exploration we may detect structure, and ascertain if the specimen be worth the trouble or expense of farther preparation.

Coal may be prepared for examination, by removing with a sharp knife a thin pellicle, or a minute scraping; immerse it in a drop of oil of turpentine on a piece of glass; then add a little Canada balsam, and hold the glass over the flame of a lamp till the balsam is spread evenly over the

* The drawings in Plate V. figs. 2 and 3, of fossil coniferous wood, were from chips seen by reflected light, and without any preparation.

specimen. But without any preparation, the surface of coal recently broken may be successfully investigated. One of the most interesting examples of coniferous structure in coal that my cabinet contains, was discovered by my son in a piece lying on the fire, and which had cracked from the heat; and I have another fragment, showing the spiral vessels, and coniferous glands, which the Rev. J. B. Reade obtained in the same manner. But for choice specimens, the following method is to be employed; and in many cases no other plan will succeed. Sections of teeth, bone, marble, &c. are to be prepared in a similar manner.

MODE OF PREPARING SLICES OF FOSSIL WOOD FOR MICROSCOPICAL EXAMINATION.

"Let a thin slice be cut off from the fossil wood, in a direction perpendicular to the length of its fibres—the slice thus obtained must be ground perfectly flat and polished. The polished surface is then to be cemented to a piece of plate glass (3 in. long and 1 in. wide) by Canada balsam—a thin layer of balsam must be applied to the polished surface of the slice, and also to one side of the glass—the slice and the glass are now to be laid on any thin plate of metal, and gradually heated over a slow fire, or a spirit lamp, to concentrate the balsam. The heat must not be so great as to throw the balsam into a state of ebullition; for if air bubbles be formed, it is difficult to remove them, and if not removed they will prevent the complete adhesion of the two surfaces when applied to each other; the heat of the metal should never be so great that the fingers may not be held in contact with it for a few seconds without inconvenience. When air bubbles are formed, they may be removed by a small piece of wood tapering to a point; when the balsam is thought to be sufficiently concentrated, and all air bubbles completely removed, the slice and glass may be taken from the heated metal, and applied to each other. A slight degree of pressure will be necessary to expel the superabundant balsam, and this will be facilitated by gently sliding the one over the other; by this kind of motion any air that may have got entangled in the balsam, when the two surfaces were brought in contact, will also be removed. When the whole is cooled down to the temperature of the air, and the balsam become solid, that part of the balsam which adheres to the surface of the glass surrounding the slice, should be removed with the point of a penknife; and by this operation, it will at once be seen whether the balsam has undergone the requisite concentration; for if it flakes off before the knife, it will be found that the slice and glass will cohere so firmly, that in the subsequent grinding, there will be no risk of their separating from each other; but if the balsam has not been sufficiently concentrated, it will slide before the knife, and in that case the two bodies will not adhere with requisite firmness. If the layer of balsam applied to the two surfaces be not too thick, its due concentration will be accomplished in four or five minutes, provided the application of the heat be properly regulated. The slice must now be ground down to that degree of thinness which will permit its structure to be seen by the help of a microscope. This will be accomplished by rubbing the slice, by a rapid circular motion with the hand, on a piece of sheet lead, supplied with a little emery (*size No.* 1.) moistened with water; when the emery ceases to act, the muddy matter remaining should be removed, and a fresh portion of emery applied; this must be repeated until the surface of the slice is perfectly flat; a sheet of copper must then be substituted for the lead, and the fossil ground as smooth as possible by flower of emery, freed from its coarser parts. The surface may then be polished by friction, with *crocus* or rotten stone, on a transverse section of any soft wood."*

* Mr. Witham, Obs. Foss. Veg.

CHAPTER V.

ON PEAT-WOOD, LIGNITE, AND COAL.

1 2 3 4

LIGN. 3. NODULE OF IRONSTONE ENCLOSING A FERN-LEAF.
Coal.

Fig. 1.—The nodule in its natural state.
2, 3.—The same split open longitudinally. The leaf remains attached to fig. 2, and the impression of its upper surface is seen on fig. 3.
4.—Outline of the form of the leaf, which is a species of Pecopteris.

BEFORE entering upon the examination of the specific and generic character of fossil plants, and their natural relations to those of the existing Floras, it will be requisite to notice those vast accumulations of vegetable matter, which occur in the strata, in various states of carbonization.

SUBMERGED FORESTS. PEAT, LIGNITE. — The phenomenon of extensive tracts of marsh-land, with layers of prostrate trees of all ages, lying but a few feet beneath the common alluvial soil, is of frequent occurrence, both inland, and in many places along the shores of our island. (*Geol. S. E.* p. 18. *Wond.* p. 49.) These submerged forests are often situated below the level of the sea, and they afford unquestionable proof of subsidences of the land. The trees are of the kinds indigenous to the districts in which they occur; and leaves and seeds of the hazel, beech, elm, &c. are often preserved in the silt in which the prostrate forests are engulfed. On the Sussex coast there are various accumulations of this kind, as at Bexhill, Pevensey levels, Felpham, &c.

The wood in these cases has undergone no change but that of being dyed black, from an impregnation of iron; and many trunks are in so sound a state as to be employed in building. The oak timbers of the Royal George, lately raised up from off Portsmouth, after being immersed in silt about sixty years, closely resembled in colour and texture the sound wood of the submerged forests. Associated with these buried vegetables, bones of deer, and swine, are occasionally met with, and the canoes and stone implements of the aboriginal inhabitants of our island. (*Wond.* p. 47.)

In the extensive peat bogs of Ireland (*Wond.* p. 49.), large forest trees are often buried, together with the skeletons of the elk, deer, and other animals of the chase, and sometimes the bodies of the primitive hunters, wrapped in skins. In Belfast Lough, a bed of submarine peat is situated beneath the ordinary level of the waters, but is generally left bare at the ebb tides. Trunks and branches of trees, with vast quantities of hazel nuts, are imbedded in the peat; the whole being covered by layers of sand, shells, and blue clay, or silt.

In most cases the nut-shells of peat bogs are empty, the kernels having perished; but on the eastern side of this Lough, which is bounded by limestone rocks, the nuts contain calcareous spar, which in some examples fills up the cavity and assumes the form of the kernel, (see Plate III. fig. 7.) and in others forms a lining of delicate crystals (Plate V. fig. 6.). The pericarps, or shells, are entire, and in the state of common dried hard nuts; the water which deposited the calc-spar in their cavities, having left not a particle of mineral matter in the ligneous pericarp through which it filtered.

LIGNITE, (*wood-stone*,) BROWN COAL, or CANNEL COAL, are terms employed to designate certain varieties of carbonized wood, which still obviously present a ligneous structure; it may be designated imperfect coal; for in its chemical properties it holds an intermediate place between peat and coal. It is generally deposited among the newer strata, and is found in the most recent as well as in the oldest tertiary formations; it is not unfrequent in some of the ancient secondary deposits, and may occur in the earliest sedimentary rocks which contain organic remains.

The newer deposits of brown or wood-coal, are commonly situated in depressions or basins, as if they had been produced by the submergence of woods and forests, beneath a swamp or morass. Specimens often exhibit the carbonized ligneous structure passing into a pure black coal, differing in no respect from true coal, except that it is less dense. One of the most instructive deposits of brown coal in England, is that of Bovey Heathfield, near Chudleigh in Devonshire, which is of considerable thickness and extent, and presents all the characters of a true coal-field; namely, beds of carbonized vegetables, alternating with clay and marl.

The Bovey coal is in the state of bituminized wood, the vascular tissue (which is coniferous in the specimens that have come under my notice) being very apparent. It is easily chipped or split, and it leaves a considerable quantity of white ashes after combustion. The layers of coal vary in thickness from one foot, to three feet; and there are eighteen or twenty in a depth of about 120 feet; this coal-field extends seven or eight miles. No leaves or fruits have been found in the Bovey coal-field; bitumen has been observed both in the coal and in the intermediate clays. Calcareous spar, and iron pyrites, prevail in many of the strata. In some places this brown coal is covered by a bed of peat, in which trunks and cones of firs are imbedded. The whole series of strata appears to have been a lacustrine deposit; probably formed in a lake or bay, into whose basin rafts of pine forests were drifted by periodical land-floods (*Org. Rem.* I. p. 127.).

The brown-coal formations on the banks of the Rhine, present the same phenomena on a more extended scale, and complicated with changes induced by volcanic action (*Wond.* p. 269.). In Iceland, where at the present time woods are unknown, there are extensive deposits of lignite of a peculiar kind, which is termed *surturbrand.*

The beautiful substance called *Jet*, is a compact lignite, and the vascular tissue may be detected even in the most solid masses; when prepared in very thin slices, it appears of a rich brown colour by transmitted light, and the woody texture is visible to the naked eye.

Jet is found in great purity and abundance in the cliffs of alum-shale on the Yorkshire coast, which were celebrated in the early centuries for the production of this substance. At Whitby and Scarborough extensive manufactories of ornaments and trinkets of jet are established. The sandstone cliffs near Whitby contain an impure or stony jet, termed anthracite. In the front of the cliff, on the north-west side of Haiburn Wyke, the stump of a tree was observed in an erect position, about three feet high, and fifteen inches in diameter; the roots were in a bed of shale, in the state of coarse jet, while the trunk, which extended into the sandstone, consisted in part of silicified wood, and in part of wood in a state of decay, with a sooty aspect.*

Thin seams and layers, and nodular masses, as well as regular coal-fields of lignite, occur in the tertiary formations. At Castle Hill, near Newhaven, in Sussex, (*Wond.* p. 225. *Geol. S. E.* p. 55.) a layer of lignite, a few inches thick, resembling the surturbrand of Iceland, is interposed between strata of red marl, in which are carbonized leaves of dicotyledonous trees.

At Alum Bay in the Isle of Wight, beds of lignite are seen between the vertical gravel and sand, of that interesting locality.

The Wealden formation contains, principally in its middle division of strata, thin layers of lignite, which alternate with finely laminated micaceous sandstones, marls, and clays, abounding in minute carbonized fragments of leaves, fresh-water shells, and crustacea. This series so remarkably exhibits

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* Geological Survey of the Yorkshire Coast; by Rev. G. Young; 1828; p. 197.

all the features of a coal-field, that many years since extensive works were carried on in the expectation that coal might be obtained of suitable quality for economical purposes. The search was unsuccessful, but the attempt deserves not the censure that was bestowed upon it, in the infancy of geological science (See Sir J. F. W. Herschel's Discourse on *Nat. Phil.*). Experience has since shown, that although the true coal-measures are only found beneath the saliferous formation, the production of good combustible bituminous coal is not necessarily restricted to any period or series of strata, but may occur wherever the local conditions were favourable to the complete bituminization of beds of vegetable matter. In fact, the productive coal-fields of Bückeburg, in Hanover, are situated in deposits of the Wealden epoch (*Wond.* p. 688.). A microscopical examination of the lignite of Tilgate Forest, has hitherto afforded me no trace of structure; from which it may be presumed, that this substance has not resulted from coniferæ, since their vascular tissue is easily detected in coal, but from plants possessing a less durable organization.

Many interesting facts relative to the carbonization of vegetables, came under my observation during my researches in the Wealden strata; and it is a subject of regret to me, that circumstances prevented my following up the investigation of those very imperfectly explored deposits. Small nodular portions of coal, in which no structure is apparent, often occur in the calciferous grit of Tilgate Forest; and sometimes large masses of lignite, fissured in every direction, and having the interstices filled with white calcareous spar.* Some of the Tilgate sandstones are discoloured from the abundance of very minute particles of lignite, resulting from the disintegration of the foliage of the peculiar ferns that once clothed the country of the Iguanodon.

That the original structure and composition of a plant affected its carbonization, there can be no doubt; for in the same layer of stone, the stems resembling palms (*Endogenites*, *Wond.* p. 373. *Foss. Til. For.* plate 3.) hereafter described, invariably possess a thick, outer crust, of coal: while the stems and roots of the Clathrariæ, plants allied to the Yucca, or Dracæna, (see *Wond.* p. 373.) have not a particle of carbonaceous matter, but are surrounded by a reddish brown, earthy crust. The nature of the stratum in which the plants were imbedded, must of course have also influenced the bituminous fermentation. Vegetable remains when interposed between beds of tenacious clay, by which the escape of the gaseous elements set free by decomposition was prevented, appear to have been most favourably situated for their conversion into lignite or coal. This subject is treated of at length in *Wond.* p. 632. That the production of lignite is still going on there can be no doubt; and the

* A fine specimen of this kind is in the British Museum.

following instance of a bed of very recent origin, affords an instructive illustration of the subject. Near Limerick, in the district of Maine, one of the States of North America, there are peat bogs of considerable extent, in which a substance exactly similar to *cannel coal* is found at the depth of three or four feet from the surface, amidst the remains of rotten logs of wood, and *beaver sticks:* the peat is twenty feet thick, and rests upon white sand. This coal was discovered on digging a ditch to drain a portion of the bog, for the purpose of obtaining peat for manure. The substance is a true bituminous coal, containing more bitumen than is found in any other variety.* Polished sections of the compact masses exhibit the peculiar structure of coniferous trees, and prove that the coal was derived from a species allied to the American fir.

We now proceed to the examination of that remarkable substance which has resulted from the perfect transmutation of the vegetables of the ancient world, COAL.

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* An analysis of 100 grains gave the following results:

Bitumen	72
Carbon	21
Oxide of iron	4
Silica	1
Oxide of Manganese	2
	100

COAL.

Although at the present time, no one at all conversant with geological science doubts the vegetable origin of coal, the period is not distant, when many eminent geologists were sceptical on this point; and the truth in this, as in most other questions of natural philosophy, was established with difficulty. The experiments and observations of the late Dr. M'Culloch, mainly contributed to solve the problem as to the vegetable nature of this substance; and that eminent chemist and geologist, successfully traced the transition of vegetable matter from peat-wood, brown coal, lignite, and jet, to coal, anthracite, graphite, and plumbago (*Wond.* p. 639.). Nor must the meritorious labours of that accomplished naturalist, and excellent man, the late author of the "Organic Remains of a Former World," in this field of research be forgotten. The first volume of that work, which treats on vegetable fossils, contains much original and valuable information on the transmutation of vegetable matter, by bituminous fermentation, into the various mineral substances in which its original nature and structure are altogether changed and obliterated; it may be consulted by the student with advantage.

Although the vegetable origin of all coal will not admit of question, yet evidence of the original structure is not always attainable. The most perfect bituminous coal has undergone a complete liquefaction, and if any portions of organization remain, they appear as if imbedded in a pure bituminous mass. The slaty coal generally preserves traces of cellular or vascular tissue, and the spiral vessels, and the dotted cells, indicating coniferous structure, may readily be detected by the aid of the microscope, in chips or slices, prepared in the manner previously pointed out. In many examples the cells are filled with an amber-coloured resinous substance; in others the organization is so well preserved, that on the surface exposed by cracking from heat, vascular tissue, spiral vessels, and cells studded with glands may be detected. Even in the white ashes left after the combustion of coal, traces of the spiral vessels are discernible by a high magnifying power. Some beds of coal appear to be wholly composed of minute leaves, or disintegrated foliage; for if a mass be recently extracted from the mine, and split asunder, the exposed surfaces are found covered with delicate pellicles of carbonized leaves and fibres, matted together; and flake after flake may be peeled off through a thickness of many inches, and the same structure be apparent. Rarely are any large trunks or branches observable in the coal, but the appearance is that of an immense deposit of delicate foliage, shed and accumulated in a forest, (as may be observable in existing pine districts,) and consolidated by great pressure, while undergoing that peculiar fermentation by which vegetable matter is changed into a carbonaceous mass.

The geological position of the coal, the manner in which it is interstratified with layers of clay, shale, micaceous sandstone, grit, and ironstone—in some districts associated with beds of fresh-water shells (*Murch. Sil. Syst.* p. 84)—in others alternating with strata containing marine remains, are fully treated of in *Wond.* pp. 598—620, *Bd.* p. 525, and *Ly.* II. pp. 106, 127; and it is not within the scope of this work to dwell in detail, upon what may be termed the physical geology of the carboniferous deposits. But a few observations on the phenomena presented by these accumulations of bituminized vegetables, and their associated strata, are necessary, to render the subsequent remarks on the habits and affinities of the plants composing this ancient Flora, intelligible to the general reader.

It may here be necessary to remind the student, that while the essential conditions for the conversion of vegetable substances into coal, appear to be the imbedding of large quantities of recent vegetables in a deposit which shall exclude the air, and prevent the escape of the gaseous elements, when released by decomposition from their organic combination, so, according to the more or less perfect manner in which these conditions are fulfilled, will result coal, jet, lignite, brown coal, or peat-wood; or a mass of partially carbonized vegetables, like that observable when new-mown hay undergoes spontaneous combustion, from bituminous fermentation in the atmosphere. (*Wond.* p. 633. *Org. Rem.* I. p. 181.)

The manner in which the carboniferous strata have been deposited, has been a fruitful source of dispute among geologists. Some contend that the coal measures were originally peat-bogs, and that the successive layers were occasioned by repeated subsidences of the land; others, that the vegetable matter originated from rafts, like those of the Mississippi, which floated out to sea, and there became engulfed; others, that they were formed in vast inland seas or lakes, the successive beds of vegetable matter being supplied by periodical land-floods; and the supporters of each hypothesis bring numerous facts in corroboration of their respective opinions. There can, I think, be no doubt that coal may be, and has been formed, under all these conditions; and that at different periods, and in different localities, all these causes have been in operation; in some instances singly, in others in combination. Coal may have been produced in peat-bogs; at the bottom of fresh-water lakes, associated with freshwater shells and crustacea, as at Burdie House, (*Wond.* p. 621.) and in some of the Derbyshire and Yorkshire deposits; in the beds of rivers and estuaries, as in the Wealden, and in the Shrewsbury coal-field* (*Geol. S. E.* p. 206.); and

* In this coal-field are beds of limestone several feet thick, abounding in *cyprides*, freshwater mollusks, &c.—*Murch. Sil. Syst.* p. 84.

in the abyss of the ocean; and the remains of terrestrial, lacustrine, and marine animals will accordingly be found associated with it, in the respective strata.*

But although there are many coal-fields (or basins, as they are termed, because they occupy depressions) that have evidently been formed by different, and local agencies, the grand series of ancient coal-beds comprised in the carboniferous groups, setting aside unimportant variations, present a remarkable uniformity of character in their nature and arrangement, not only throughout Great Britain and Europe, but in America, and in every other part of the known world. My late excellent friend, Mr. Bakewell, used to explain the manner in which the beds of coal are interstratified with layers of clay and shale, by the following apt illustration. Let a series of mussel shells be placed one within the other, and a layer of clay be interposed between each; the shells will represent the beds of coal, and the partitions of clay, the earthy strata interposed between the carboniferous layers. If one side of the shell be raised to indicate the general rise of the strata in that direction, and the whole series be dislocated by partial cracks and fissures, the general arrangement of the beds, and their displacement, will be

* Mr. Murchison has treated this subject with great ability: see *Sil. Syst.* chap. xi., and the illustrative maps opposite, p. 152.

represented. The series of strata which constitutes a coal-field is, therefore, an alternation of layers of coal and of clay, of variable thickness, resting (very generally) on grit or marine limestone, abounding in shells, corals, and crinoidea.

In this review of the carboniferous strata the principal feature which arrests attention, is the *uniform presence of a thick bed of clay beneath every layer of coal;* but a still more extraordinary fact remains to be mentioned: it is, that a common plant of the coal strata, called *Stigmaria*, (hereafter described, see *Lign.* 27, 28.) *invariably occurs, more or less abundantly, in this bed of underclay*, although very rarely to be met with in the coal or shale above. This fact, long since noticed by Mr. Martin, Dr. M'Culloch, and other authors, but whose value was not duly estimated till the recent observations of Mr. Logan, (*Geol. Proc.* Vol. III. p. 275.) is also found to prevail throughout the entire thickness of the Welsh coal formation, which is upwards of twelve thousand feet, and contains more than sixty beds of coal, and as many of clay with stigmariæ. And in the Appalachian coal strata of the United States the same phenomenon appears.* To place this interesting question before the student in a distinct point of view, I will more particularly describe one of the series of which a coal-field is composed.

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* See Proceedings of the American Geologists, Prof. Rogers, p. 453; and Geol. Proc. III. p. 710.

1. Lowermost stratum. Clay (called under-clay). This is a tough argillaceous substance, which changes upon drying into a grey friable earth. Occasionally it is black, from the presence of carbonaceous matter. It contains innumerable stems of stigmariæ, which are generally of considerable length, and have their fibrous processes (see *Lign.* 27 and 29.) still attached, and extending in every direction through the clay: the stems commonly lie parallel with the planes of the stratum, and nearer to the *top than to the bottom.*

2. Coal. This is a carbonized mass, in which the external forms of the plants and trees composing it are obliterated, but the internal structure remains. Large trunks or stems, and leaves, are rarely distinguishable in it; but the vast prevalence of coniferous wood which enters into its composition, proves that this arises, not from the absence of such remains, but from their forms having been obliterated by the process of bituminization.

3. The Roof, or upper bed. This generally consists of slaty clay, which abounds in leaves, trunks, stems, branches, and fruits; and often contains layers of ironstone nodules, in which leaves, insects, crustacea, &c. are imbedded (see *Lign.* 3.). Occasionally beds of fresh-water mussels, or layers of marine shells, are associated with it. Interstratified with the shale, finely laminated clay, micaceous sand, grit, and pebbles of limestone, granite, sandstone, and other rocks, often occur. This bed,

in short, appears to be an accumulation of drifted materials, promiscuously intermingled with the dense foliage and stems of a prostrate forest.

It is from these upper beds, that the illustrative specimens of leaves, fruits, stems, &c. of the Flora of the coal are principally obtained. Thus we have, in the first place, spread uniformly over the bottom, and constituting the bed on which the coal reposes, a stratum of clay, composed of fine pulverulent materials, which may have once constituted the soil of a vast plain or savannah; the only remains found in it are the roots of gigantic trees (see *Lign.* 29.), for such the stigmariæ are now proved to have been, and not aquatic plants, as was formerly supposed (*Bd.* p. 476.).

Secondly, a bituminous mass composed of coniferous wood, gigantic ferns, club-mosses, &c.; occasionally with trunks of trees penetrating vertically through the bed.

Thirdly, a deposit of drifted materials, promiscuously mixed with the foliage and stems of numerous species of terrestrial plants; the whole appearing to have been subjected to considerable mechanical action. The first, or undermost bed, may have been the natural soil, in which the stigmariæ grew; the next, the coal, the carbonized stems, and other remains of the trees to which the roots belonged: and the last, or uppermost, forming the roof of the coal, the remains of the leaves and branches of the forest, overwhelmed and buried beneath the transported detritus of distant strata.

These phenomena may be explained by supposing the inundation of a thickly-wooded plain, by an irruption of the sea, or of a vast inland lake, occasioned by the sudden removal of some barrier; or by a subsidence of the tract of country on which the forest grew. But when we find an accumulation of strata, in which triple deposits of this kind are repeated some thirty or forty times through a thickness of many thousand feet, a satisfactory solution of the problem is very difficult. Not only subsidence after subsidence must have taken place, but the first submergence have been followed by an elevation of the land — another soil, fit for the growth of forest trees, been produced—another generation of vegetables, of precisely the same species and genera, have sprung up, and arrived at maturity — and then another subsidence, and another accumulation of drift. And these oscillations in the relative level of the sea and land, must have gone on uninterruptedly through a long period of time, not in one district or country only, but all over the world, and during the same geological epoch. At present I do not think we have data sufficient to explain these phenomena; what has been advanced may, perhaps, serve to elicit further information, by pointing out the difficulties in which the question is at present involved, and show the student what interesting fields of discovery are still unexplored, and how comprehensive and important are the objects that come within the scope of geological investigation.

I will conclude this chapter with the following admirable remarks of Dr. Buckland on the origin and nature of Coal, and the changes it undergoes when rendered subservient to the necessities and luxuries of man.*

"Few persons are aware of the remote and wonderful events in the economy of our planet, and of the complicated applications of human industry and science, which are involved in the production of the coal that supplies with fuel the metropolis of England.

"The most early stage to which we can carry back its origin, was among the swamps and forests of the primeval earth, where it flourished in the form of gigantic *Calamites*, and stately *Lepidodendra*, and *Sigillariæ*. From their native bed, these plants were transported into some adjacent lake, or estuary, or sea. Here they floated on the waters, until they sank saturated to the bottom, and being buried in the detritus of adjacent lands,

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* Bd. p 481.

became transferred to a new estate among the members of the mineral kingdom. A long interment followed, during which a course of chemical changes, and new combinations of their vegetable elements, converted them to the mineral condition of coal. By the elevating force of subterranean agency, these beds of coal have been uplifted from beneath the waters, to a new position in the hills and mountains, where they are accessible to the industry of man. From this fourth stage, coal has been removed by the labours of the miner, assisted by the arts and sciences, that have co-operated to produce the steam-engine, and the safety-lamp. Returned once more to the light of day, and a second time committed to the waters, it has, by the aid of navigation, been conveyed to the scene of its next and most considerable change by fire; a change during which it becomes subservient to the most important wants and conveniences of man. In this seventh stage of its long eventful history, it seems, to the vulgar eye, to undergo annihilation; its elements are, indeed, released from the mineral combinations which they have maintained for ages, but their apparent destruction is only the commencement of new successions of change and of activity. Set free from their long imprisonment, they return to their native atmosphere, from which they were absorbed by the primeval vegetation of the earth. To-morrow they may contribute to the substance of timber, in the trees of our existing forests; and having for a while resumed their place in the living vegetable kingdom, may, ere long, be applied a second time to the use and benefit of man. And when decay or fire shall once more consign them to the earth, or to the atmosphere, the same elements will enter on some further department of their perpetual ministration in the economy of the material world."

CHAPTER VI.

FOSSIL BOTANY.

I NOW proceed to explain the arrangement and nomenclature of the fossil plants which are likely to come under the observation of the student, either in collections, or in the course of his personal researches in the field. The definitions will be rendered as simple as the subject will permit, and accurate figures of one or more species of many of the genera will be inserted. To determine the specific relations of leaves and stems, reference must be had to works expressly devoted to the subject; namely, the British Fossil Flora, and Histoire des Végétaux Fossiles, by M. Adolphe Brongniart. The classification of the last-named eminent botanist will be adopted, as the most natural, and easy of application.

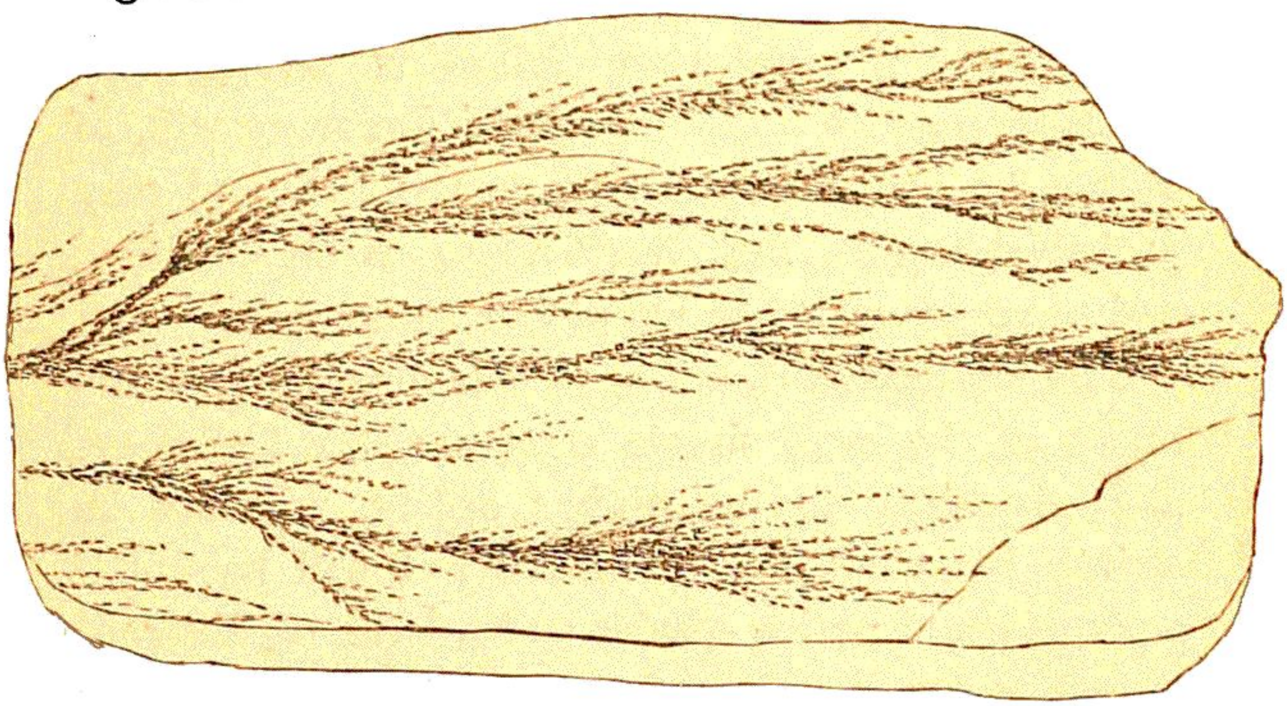
With regard to the nomenclature, it may be necessary to remark, that when a fossil undoubtedly belongs to a recent genus of plants, the usual botanical name is employed: for example, *Equisetum Lyellii.* When the fossil does not possess all the generic characters, yet is evidently nearly allied to the genus, the term *ites* (from *lithos*, stone,) is added—as *Equisetites*, *Palmacites*, &c. When the fossil plant differs altogether from any known recent genus, it is distinguished by some arbitrary name, as *Bucklandia*, *Stigmaria*, &c.

There are also a few provisional genera for the reception of such leaves, fruits, and stems, as are not admissible in the established classification, in consequence of their characters and relations being imperfectly known, as *Carpolithes*, *Endogenites*, &c. Upon these principles the following arrangement has been founded: the progess of discovery will, of course, be continually adding to the list, and may probably require the classification to be modified, and some genera to be altogether abandoned.

The arrangement, although commencing with the plants of the most simple structure, the *Cellulosæ*, and advancing to the higher orders, will not be strictly botanical, for occasionally it will be found convenient to notice species and genera of different orders under the same head, from their occurring under the same geological relations. It is estimated that scarcely one thousand species of plants have been discovered in a fossil state, while the known recent species amount to nearly one hundred thousand.

Agamia.—The plants of this class have no traces of fructification, and their structure consists of cells alone. It comprises the sea-weeds, and confervæ, or fresh-water mosses, as they are commonly termed.

CONFERVITES.—These cellular and aquatic plants are found sometimes in transparent quartz pebbles, and in chalk, in the state of fine ramose filaments, which, by the aid of the microscope, are seen to be articulated. As an example, a beautiful species, discovered by the late Samuel Woodward, Esq., author of the Geology of Norfolk, &c., is here figured.



LIGN. 4. CONFERVITES WOODWARDII; (G. A. M.)
Chalk, Norfolk.

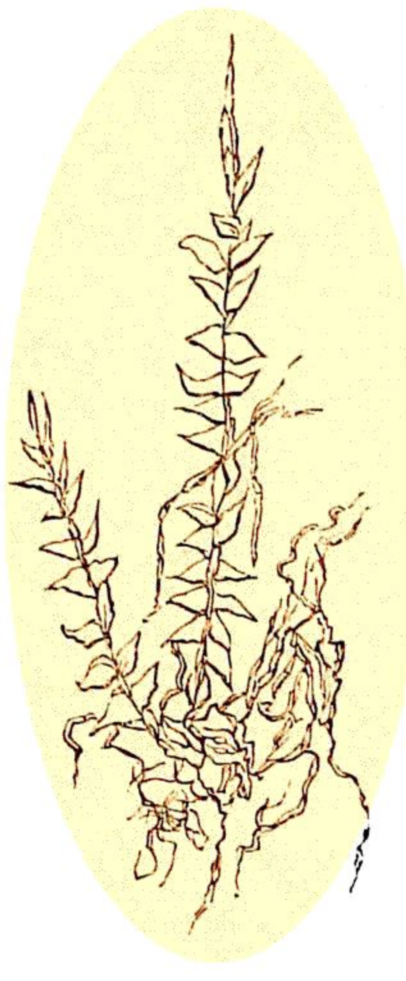
ALGÆ.—Of this family, which comprises the sea-weeds that are not articulated, the Ulvæ and Fuci, many species are found in the mineral kingdom, occurring in the most ancient fossiliferous strata, as well as in the modern deposits. In the Silurian limestone of North America, entire layers of rock are formed of a large digitate species of fucus (*Fucoides Alleghaniensis, Dr. Harlan, Phy. Res.*). The Firestone of Bignor in Sussex (*Geol. S. E.* p. 165.), abounds in a ramose variety, which is figured

LIGN. 5. FUCOIDES LAMOUROUXII.

Monte Bolca. (*Veg. Foss. Br.*)

in the vignette of the title-page of this volume; it is named *Fucoides Targionii* (*Veg. Foss.* p. 56.).

In the chalk flints ramose fuci occasionally occur, but not in a state of preservation that admits of an accurate determination of the forms of the originals. The tertiary marls and limestones of Monte Bolca yield several beautiful species, one of which is here figured in illustration of the genus (*Lign.* 5.).



LIGN. 6. MOSS AND CONFERVA, in transparent quartz. × 3.

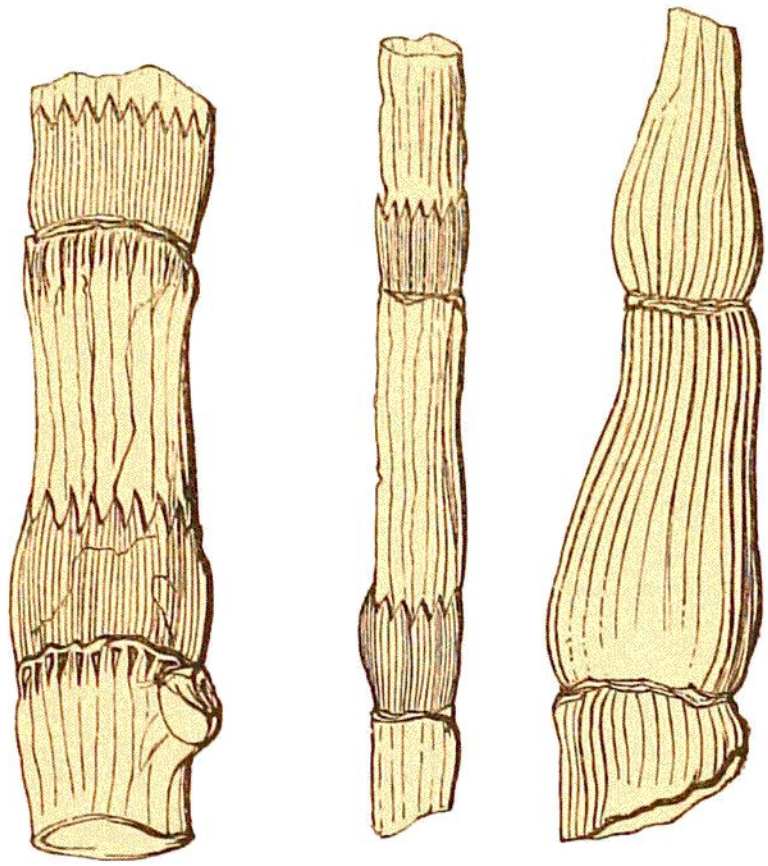
Of the little plants comprised in the class of cellular cryptogamia, which have stems, leaves, and fructification, but no true vessels, two or three species of Moss and Liverwort, have been met with in tertiary strata. Mosses as well as Fuci are occasionally imbedded in the pure quartz pebbles called *mocha stones*, in which they appear with their natural colour, and apparently floating in the transparent medium. A beautiful green moss, with a Conferva twined round its base, is figured *Lign.* 6. from a specimen of the late Dr. M'Culloch. It appears related to Hypnum (*Geol. Trans.* Vol. II.).

Vascular Cryptogamia.—The plants of this class possess, as the name implies, a more complicated structure than the preceding, having vascular tissue as varied as in the flowering or phanerogamous orders.

Equisetum.—The common species of Equisetum, or Marestail, is a plant that grows in marshy tracts, and on the banks of ditches and rivers; it has a jointed stalk, garnished with elegant sheaths which embrace the stem, and verticillate linear leaves. It grows to the height of two feet, and is half an inch in diameter. In the fossil state there are many plants allied to the Equisetum, but only a few that are generically the same. A species which I discovered in the Ashburnham limestone at Pounceford (*Geol. S. E.* p. 245.), must have closely resembled the Equisetum fluviatile: it has an articulated stem, and cylindrical, regularly dentated sheaths, embracing the stem at the joints (see *Lign.* 7.).

A transverse slice of these stems, exhibits under the microscope a cellular structure filled with calc-spar, and forms a beautiful object when viewed with the polarizing apparatus.

A gigantic species, (*Eq. columnare*) is common in the oolitic carbonaceous strata, near Whitby. (*Veg. Foss. Br.* Pl. 13.). In the sandstone of the inferior oolite of the Cleveland Hills, Yorkshire,



LIGN. 7. EQUISETUM LYELLII. (G. A. M.) Wealden. Pounceford.

Fig. 1.—A stem, having two sheaths, and a bud at the lowermost joint.

2.—Stem of a young plant, with sheaths, preserved in pyrites.

3.—Stem, with the cryptogamous head or termination.

numerous stems of this colossal marestail are found in an upright position, as if still occupying the spot where they grew. This interesting fact was observed at Carlton Bank, near Stokesly, forty miles from the coast, where the same phenomenon occurs. In both localities several species of fresh-water bivalves, were the only shells discovered in the laminated sandstone that contained the equiseta.*

CALAMITES.—Stem articulated, regularly striated, the articulations naked, or studded with tubercles, and sometimes encircled by a dentated sheath.

The plants of this fossil genus are closely related to the marestail, but differ in the absence of the encircling sheaths, and in being uniformly striated. Some of the species attain a gigantic size, from one to three feet in diameter, and from thirty to forty feet in height. They abound in the coal formation, and must have constituted an important feature in the forests of the carboniferous epoch. They occur also in strata far more ancient, and some species belong to the earliest terrestrial Flora of which any traces remain. In most instances when specimens are found lying in the same plane with the strata, they are pressed flat; but when occurring in a vertical position they retain their natural form, and are cylindrical. An outer crust, or pellicle of coal, generally surrounds the stem, but no remains of internal structure have been observed.

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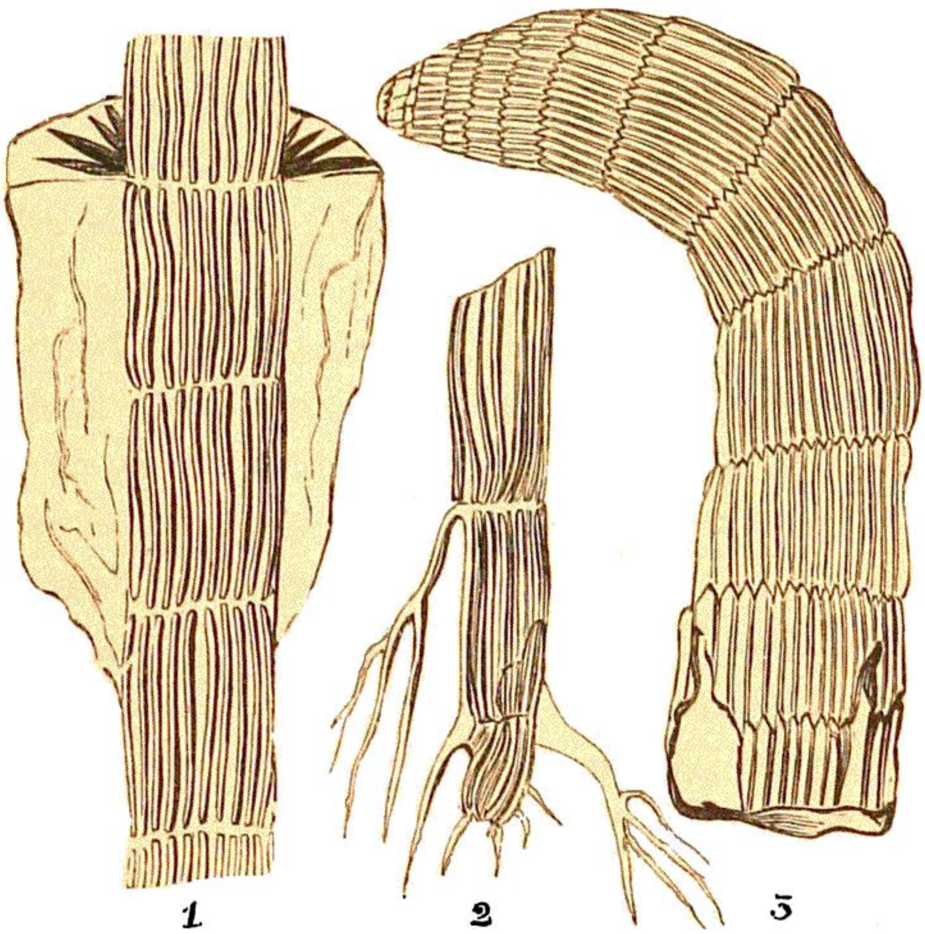
* Geol. Proc.

The stem figured *Lign.* 8. fig. 1, has a stellate sheath round one of the joints, and shows the difference between this appendage, and the cylindrical sheaths of the Equiseta. This example also proves the importance of preserving and examining the stone that surrounds fossil stems, for



LIGN. 8. CALAMITES, IN COAL SHALE.

Fig. 1.—Calamites radiata, with the remains of one of the sheaths.—$\frac{1}{2}$ *nat.*

2.—Stem, with remains of roots.—$\frac{1}{2}$ *nat.*

3.—Calamites approximata, showing the cryptogamous head and curved upper extremity of the plant.—$\frac{1}{5}$ *nat.*

without attention to this precaution in the present instance, no knowledge would have been obtained of this important character. It is very rarely that any traces of the roots remain; the specimen figured (fig. 2.) is from the *Foss. Flor.* A beautiful example of the foliage of another species of Calamites, from the same authority, is figured *Lign.* 40, fig. 2.

Filicites, or Ferns.

We now arrive at the consideration of one of the most numerous and interesting tribes of vascular cryptogamous plants, that adorned the Flora of the ancient world, and the living species of which impart beauty and elegance to the scenery of the countries where they prevail. One of the most essential characters of these plants, is that of developing their fructification on the leaves; a fact familiar to every one who has even but cursorily examined the polypody growing on our walls, or the brake of our hedge-rows and commons. The largest species of British ferns scarcely exceed four or five feet in height; but the arborescent, or tree-ferns, of warm climates, attain an altitude of thirty or forty feet. There is too this peculiarity in the arborescent ferns, that while in our indigenous species the leaves surround the stem, and incline towards the upper part of the plant, the foliage of the former bends downwards, and spreads out from the crown, or summit, into an elegant canopy.

The leaves of our branched ferns are persistent, and when they are shed, the markings, left by their attachment to the stalk, are soon obliterated. In the arborescent ferns, on the contrary, the petioles become detached from their bases, and fall entire, producing scars or cicatrices on the stem; and the impressions are so regularly and symmetrically disposed, as to afford an unerring character by which these trunks may be distinguished from those of other trees. Thus the stems of the tree-ferns may be recognised in a fossil state by their cylindrical forms without ramification, and by the regular disposition and peculiar character of the scars left by the separation of the petioles. The leaves may be identified by the form of their segments, which are disposed with remarkable regularity, and have a peculiar mode of subdivision; and above all, by the delicacy, evenness, and distribution of the veins. There are upwards of two thousand species of living ferns, and in the fossil kingdom the number is considerable; more than one hundred and fifty have been collected from the carboniferous strata. The large tree-ferns are confined almost exclusively to the equinoctial regions; humidity and heat being the conditions most favourable to their development. (*Vég. Foss.* p. 141. *Bd.* p. 461. *Wond.* p. 651.)

The following genera have been established by M. Ad. Brongniart, from the form of the leaves and their venation; that is, the distribution of their vessels or veins. In the descriptions many botanical terms occur, and the student should refer to the introductory works of Professor Henslow or

Dr. Lindley; for the general reader, I subjoin an explanation of a few that are frequently employed.

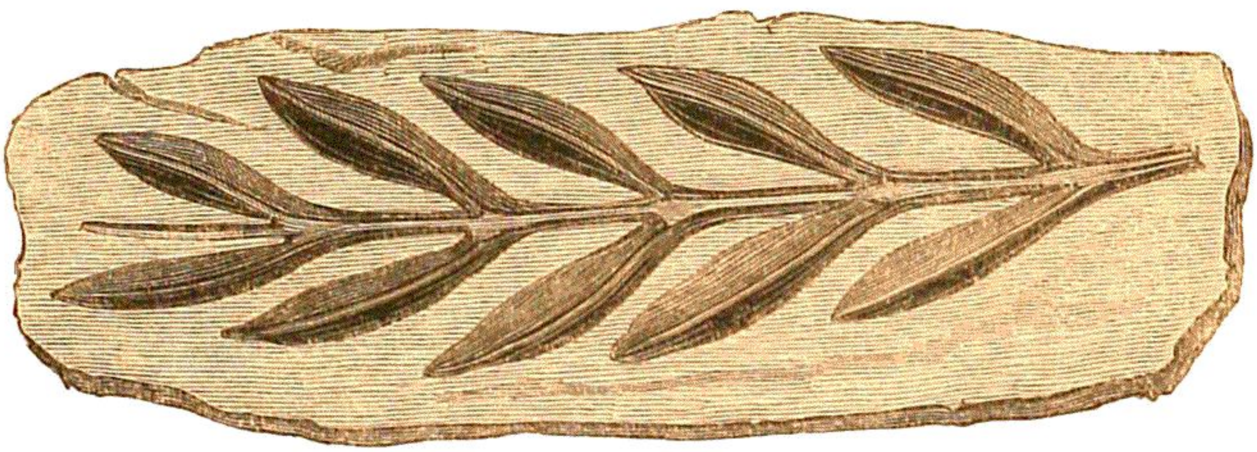
LIGN. 9. PECOPTERIS SILLIMANI.
Coal Shale. Ohio.

a. The Stem.
b. Leaf-stalk, or petiole.
c. Leaf, or frond, which is bipinnate.
d. *e*. Leaflets, or pinnæ; the upper, *d*, are entire; the lower, *e*, are pinnatifid.
f. The pinnules, lobes, or segments.
g. The midrib, or median vein.
h. The veins. The veins are introduced in the leaflets, *d*; but in the lower ones, *e*, the midribs only are marked.

PACHYPTERIS* (*thick-fern*). *Lign.* 10.—The fronds

* The names of these genera are derived from *pteris*, fern, to which is prefixed a term indicative of the peculiar character.

are pinnated, or bipinnated; the leaflets entire, without visible veins, having but a single midrib, and being contracted at the base. The absence of veins, and the leaflets not being lobed, are the essential distinctions of this genus.



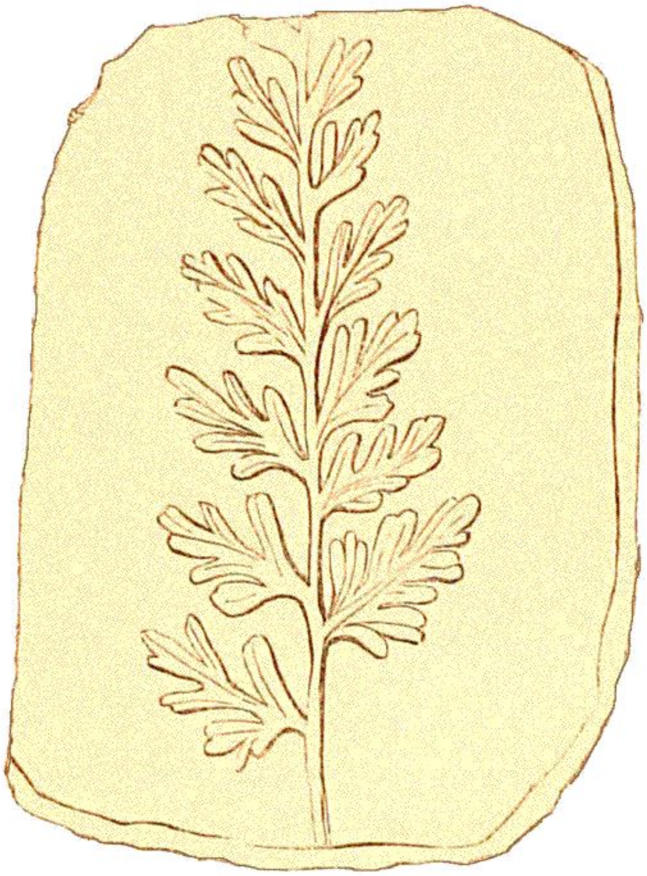
LIGN. 10. PACHYPTERIS LANCEOLATA.

Inferior Oolite. Whitby.

SPHENOPTERIS (*wedge-leaf fern*). *Lign.* 11.—The leaves are twice or thrice pinnated, the leaflets *contracted* at their base, and more or less deeply lobed: the lobes divergent and palmated: the veins radiating from the base.

The plants of this genus are extremely elegant, and comprise upwards of forty species. The Wealden has yielded three or four species, which have not been discovered in any other formation. (*Wond.* p. 379. *Geol. S. E.* p. 239.) An elegant form (*S. affinis*, *Wond.* p. 653.) occurs abundantly in the fresh-water strata of the mountain limestone, at

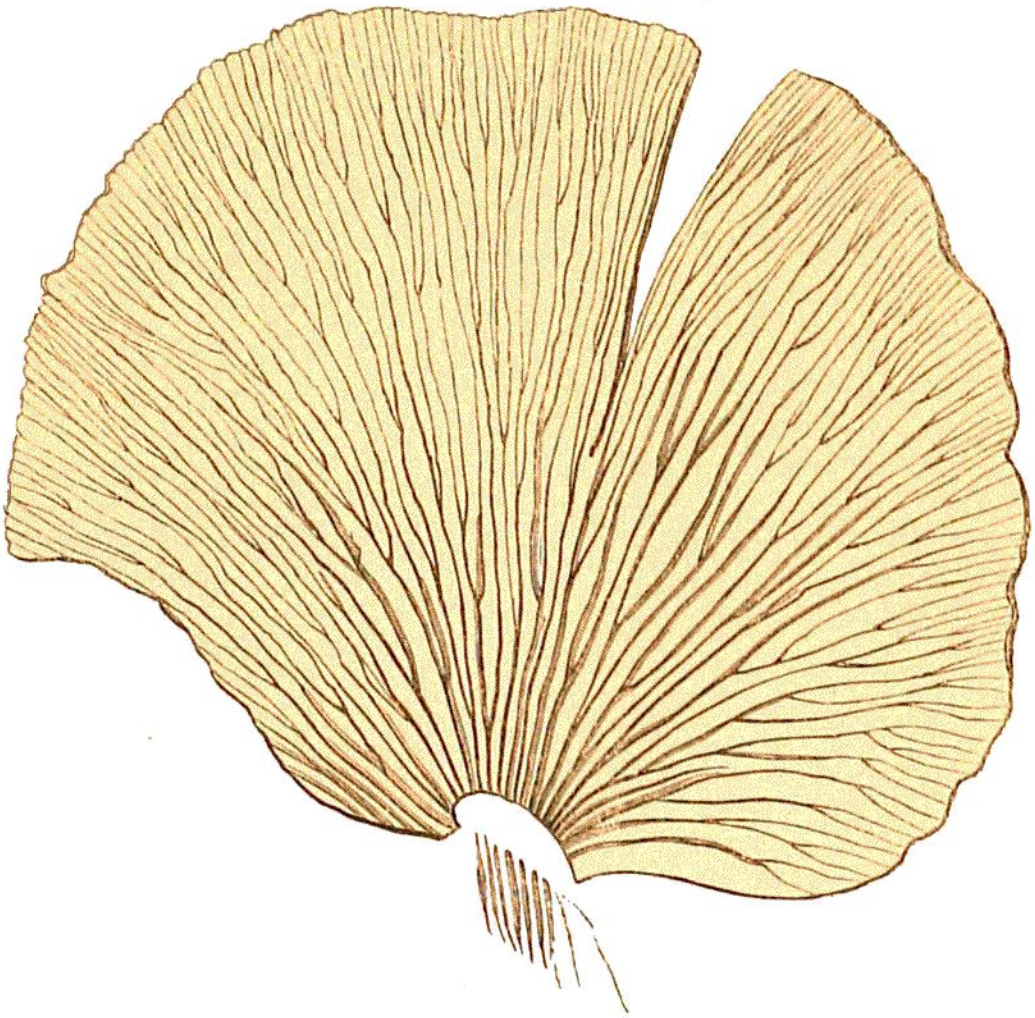
Burdie House, near Edinburgh.* A very beautiful species, in coal-shale, is represented in the frontispiece (fig. 1.) of this volume.



LIGN. 11. SPHENOPTERIS ELEGANS.
Coal-shale, Waldenburg, Silesia.

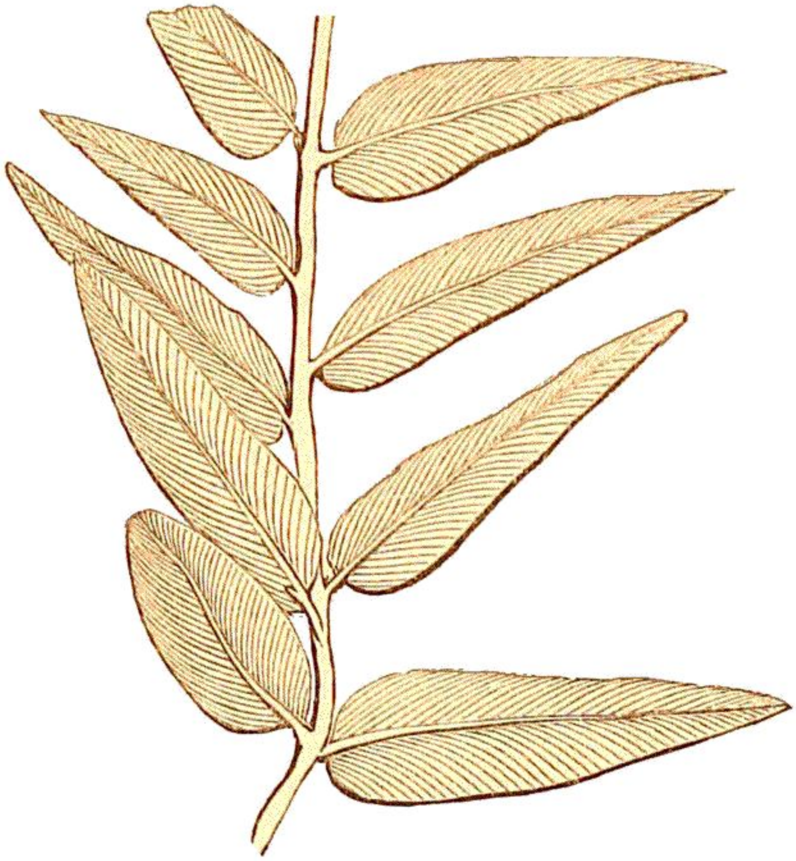
CYCLOPTERIS (*round-leaf fern*). *Lign.* 12.—The frond is simple and entire, and generally orbicular, or kidney-shaped: the veins numerous, equal, and dichotomous, or forked, and radiating from the base. The form and disposition of the veins resemble those of some living species; the essential distinction is the absence of a median vein. The fructification is supposed to have been marginal.

* See Dr. Hibbert's Memoir on this formation and its fossils; 4to. 1835.



LIGN. 12. CYCLOPTERIS TRICHOMANOIDES.
Oolite, near Scarborough.

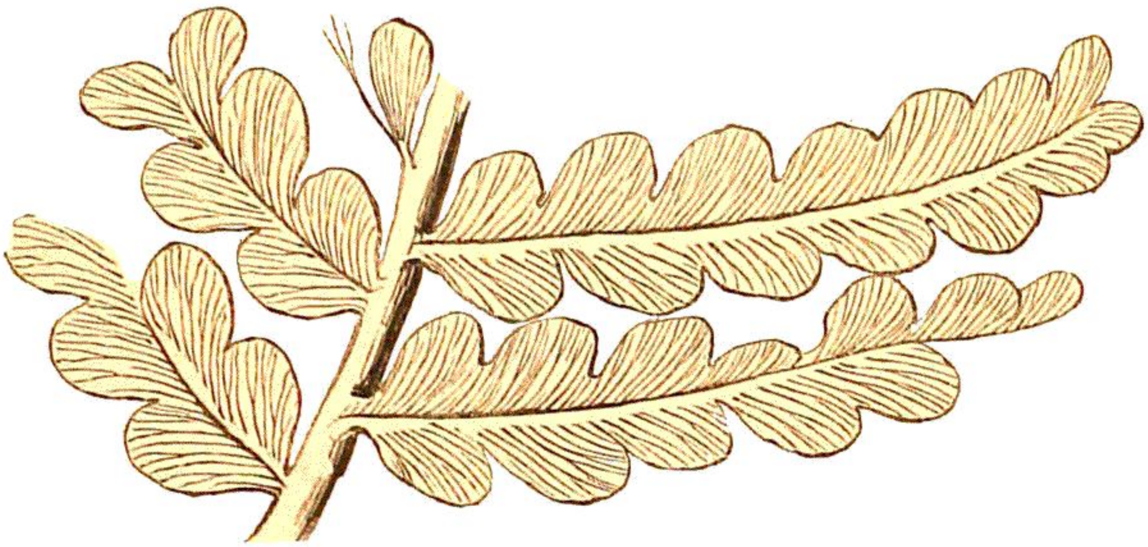
NEUROPTERIS (*nerved-leaf fern*). *Lign.* 13.—The fronds are pinnate or bipinnate; the leaflets more or less cordiform and entire, not adhering by their base to the rachis; veins very fine, arched, rising obliquely from the base of the leaflet. This is a very numerous genus, comprising thirty or more species, which are principally found in the coal-shale. Some of these plants bear a general resemblance to the *Osmunda regalis*, but differ in their essential characters; their leaflets often form the nuclei of iron-stone nodules.



LIGN. 13. NEUROPTERIS ACUMINATA.
In Coal-shale, Yorkshire.

LIGN. 14. GLOSSOPTERIS PHILLIPSII.
Oolite, Scarborough.

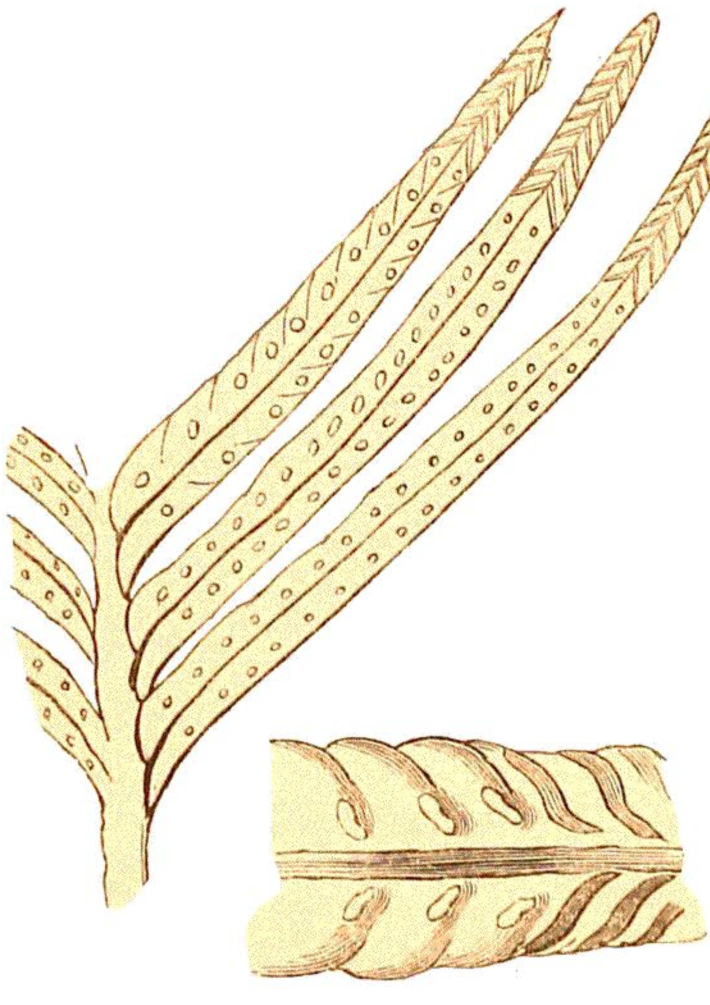
GLOSSOPTERIS (*tongued-leaf fern*). *Lign*. 14.—Leaves, simple, sub-lanceolate, gradually contracting towards the base; midrib thick at the base, and vanishing towards the apex of the leaf; veins very fine, curved, oblique, frequently dichotomous, sometimes reticulated, or anastomosing at their base. The plants of this genus resemble the ferns with simple leaves. A few species only are known; of these two are from the coal-shale, one from the lias, and one from the oolite.



LIGN. 15. ODONTOPTERIS SCHLOTHEIMII.
Coal-shale of Saxony.

ODONTOPTERIS (*toothed-leaf fern*). Leaf bipinnate, the leaflets adhering to the rachis by their base, which is not contracted: the veins equal, simple, dichotomous, arising from the rachis; no distinct mid-rib. In their general aspect these plants resemble some South American species of Osmunda. Five species only are known, all of which belong to the most ancient coal strata.

ANOMOPTERIS (*anomalous-fern*—so named from the plants differing from both recent and fossil ferns). Leaves deeply pinnated; leaflets very long, entire, linear, traversed by a distinct midrib, equal throughout; secondary veins simple, perpendicular to the



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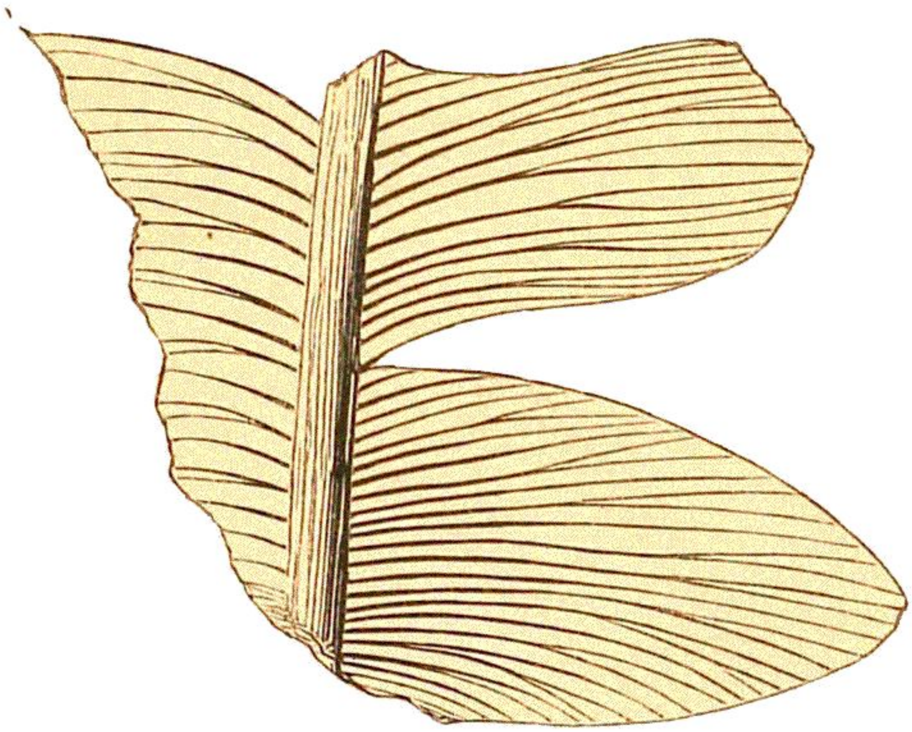
LIGN. 16. ANOMOPTERIS MOUGEOTII.
New Red Sandstone, at Sulz-les-bains, near Strasburgh.

Fig. 1.—Three leaflets.
2.—A portion magnified to show the fructification.

median vein, swoln at their free extremities, and not extending to the margin of the leaflet. But one species is known. These leaves are of great size, and doubtless belonged to some arborescent fern; in several examples the fructification is preserved. My collection contained a splendid specimen, collected by the late M. Voltz, from the above locality, with other plants (*Wond.* p. 685.), which are now in the British Museum.



LIGN. 17. TŒNIOPTERIS LATIFOLIA.
Stonesfield Slate.

TŒNIOPTERIS (*wreathed fern*). Leaves simple, entire, straight, with parallel margins, traversed by a strong midrib, which extends to the apex; secondary veins, simple or bifurcated at their base, and almost perpendicular to the median vein. These ferns closely resemble some species of Polypodium. Three species are known; two from the oolite, and one from a tertiary deposit. The specimen figured is a fragment.

PECOPTERIS (*embroidered fern*). Leaves once, twice, or thrice pinnated; leaflets adhering by their base to the rachis, or rarely free; traversed by a strong midrib, which extends to the apex; veins simple, or once or twice dichotomous, almost perpendicular to the median vein. This genus embraces by far the largest proportion of the ferns which have contributed to the formation of the coal, and

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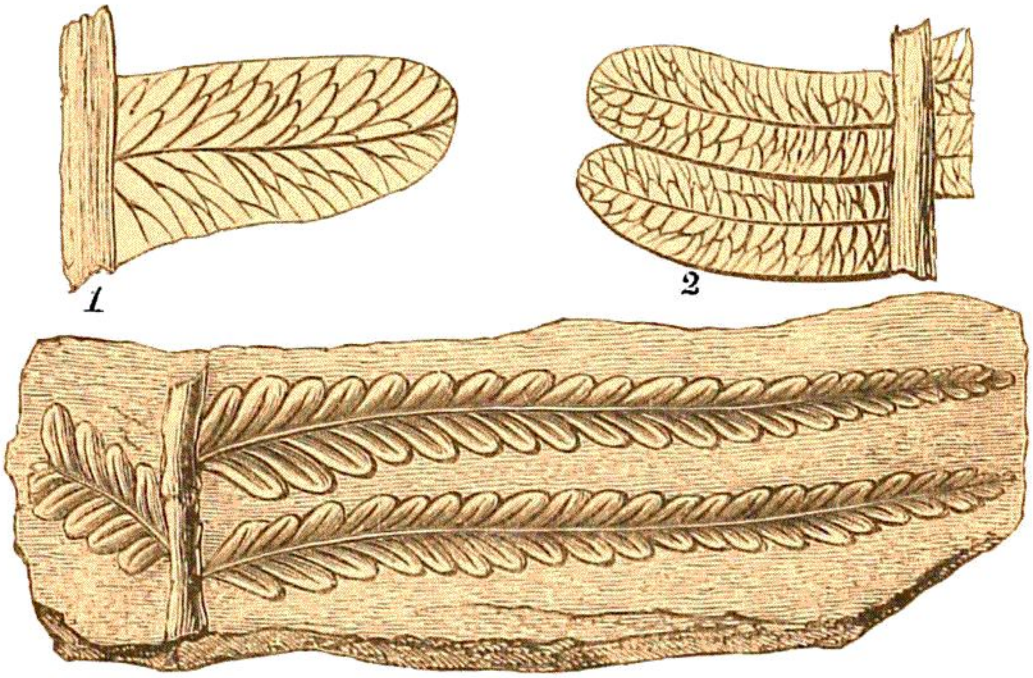
LIGN. 18. Fig. 1.—PECOPTERIS MURRAYANA; a pinnule with the fructification. *Inf. Oolite, Scarborough.*
2.—PECOPTERIS LONCHITICA. *Coal-shale, France.*

whose leaves and stems are preserved in the associated strata. The originals of many species were undoubtedly arborescent, and attained a large size. Some leaves have been observed which were four feet wide, and of a proportionate length. More than one hundred species have been determined. An American species is figured in illustration of certain botanical terms (*Lign.* 9.).

LONCHOPTERIS (*spear-leafed fern*).—Leaves many times pinnated; leaflets more or less adherent to each other at their base, traversed by a midrib;

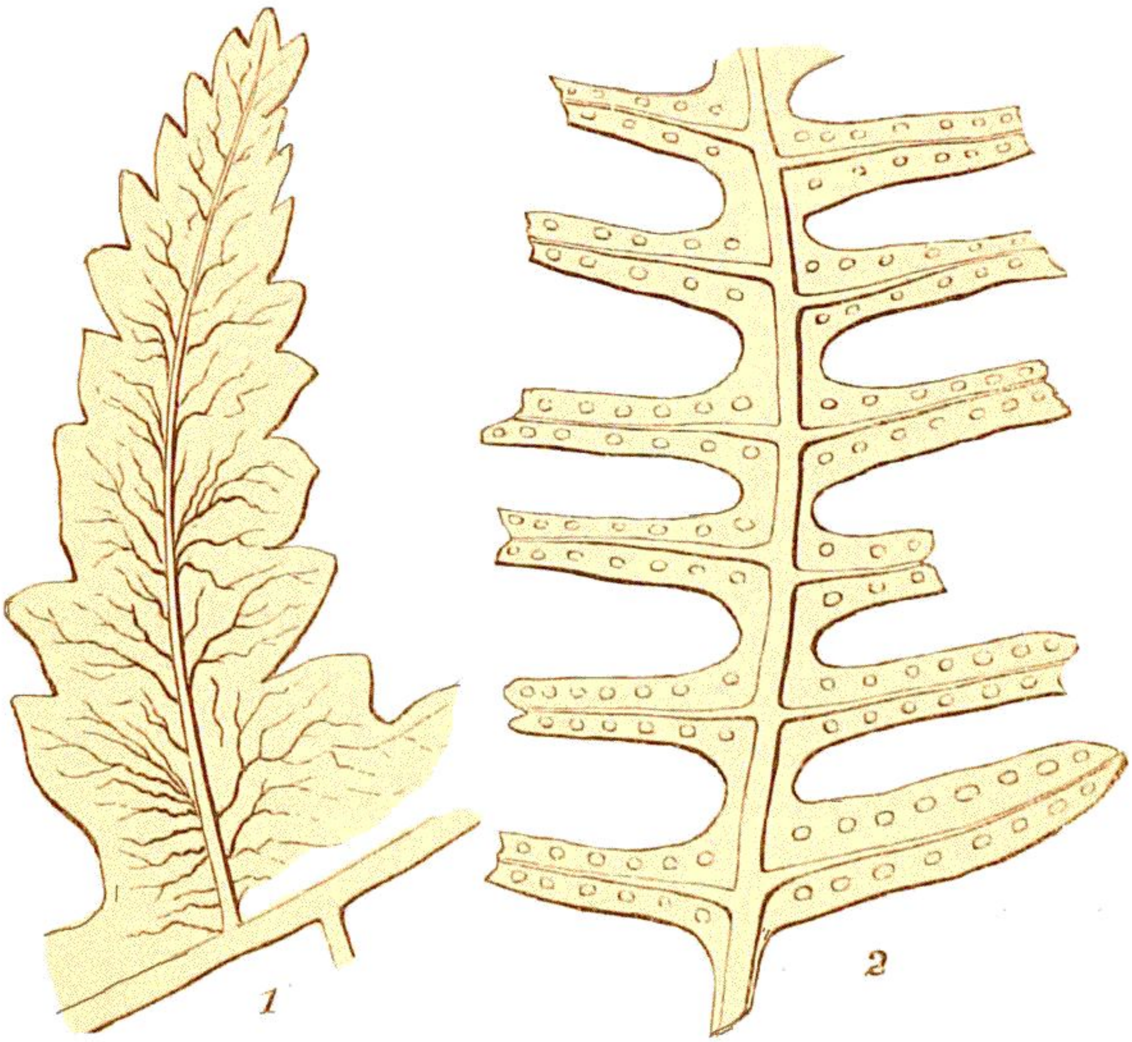


LIGN. 19. LONCHOPTERIS MANTELLI.

Wealden, Tilgate Forest.

Fig. 1.—A leaflet, highly magnified, to show the reticulation of the veins.
2.—Two leaflets magnified.

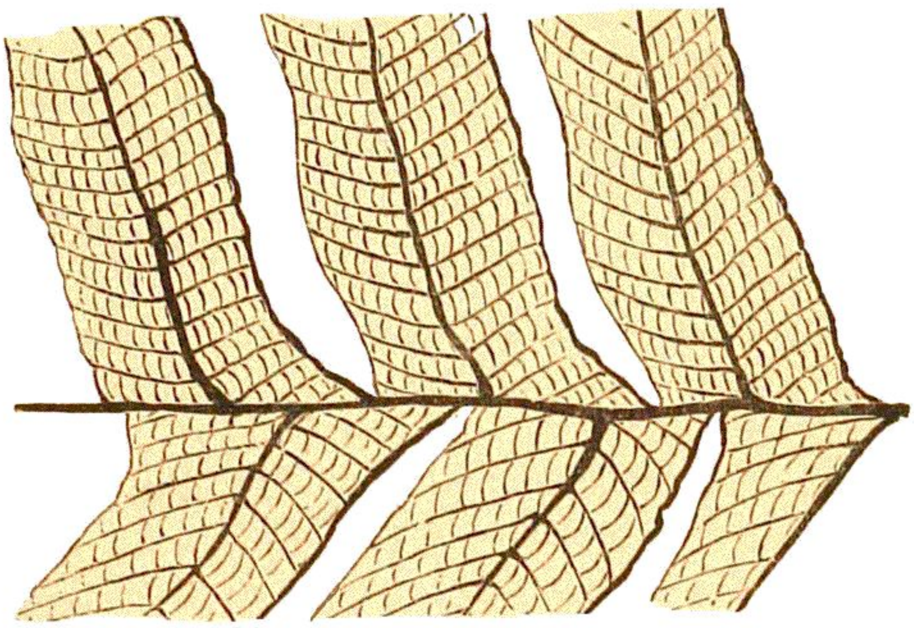
secondary veins reticulated. The three species composing this genus resemble the living ferns of the genera Lonchitis, Woodwardia, &c. Two have been found in the coal-measures, and the other discovered in the strata of Tilgate Forest. (*Foss. Til. For.* pl. 3. *Wond.* p. 371.) This last appears to have been a delicate plant; for, although indications of its presence are very general throughout the fine micaceous grits, and even the clays of the Wealden, a perfect leaf is of rare occurrence. M. Graves has found the same fern near Beauvais in France, in strata, which, from the presence of the fresh-water limestone, Sussex marble, are supposed to belong to the Wealden.



LIGN. 20. Fig. 1.—PHLEBOPTERIS PHILLIPSII. *Oolite, Scarborough.*
2.—PHLEBOPTERIS PROPINQUA, *showing fructification.*

PHLEBOPTERIS (*veined-leaf fern*).—Leaves pinnated; leaflets, with the margin entire, or crenulated, the mid-rib strong; secondary veins anastomosing by arches, with large angular spaces, often unequally disposed; the finer veins are simple or divided; the apex sometimes free. The fructification was punctiform, and placed at the apices of the veins.

The foliage of these remarkable ferns has been mistaken for the leaves of dicotyledonous plants; but M. Brongniart has demonstrated that they belong to the present family. Six species have been found in the oolite and lias.



LIGN. 21. CLATHROPTERIS MENISCOIDES.

Portion of a leaflet: the original 1½ ft. long.
Wealden? Scania.

CLATHROPTERIS (*latticed-leaf fern*). — Leaf deeply pinnatifid; leaflets elongated, traversed by a strong midrib, extending to the apex; secondary veins numerous, simple, parallel, almost perpendicular to the midrib, united by transverse branches, which, with the finer veins, produce on the surface of the leaf a net-work of quadrangular meshes. This genus was instituted by M. Brongniart, for the reception of some magnificent fern-leaves from the shale of Hoer, in Scania, which resemble in structure the foliage of the recent *Polypodium quercifolium*, a native of the East Indies, and the Moluccas. One specimen of a leaf was four feet wide, and the leaflets, though imperfect, were eighteen inches long.*

Several other genera of ferns have been established from the form and venation of the leaves, and are described in *Brit. Foss. Flor.*, and other works, but which our limits will not permit us to notice.

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* Hoer is a little village, situated nearly in the centre of Scania, a province in the southern extremity of Sweden. The chalk formation appears in several parts of this district, and the carboniferous strata at Hoeganes. To the west of Hoer, there is a range of hills, composed of ferruginous grits, micaceous sandstones, clays, and beds of quartzose conglomerate. It is in these beds that the ferns and other terrestrial plants occur, and no animal remains whatever have been found in these strata; their geological position appears to be between the chalk and the coal, but on this point nothing positive is known. The general analogy of the plants with the group forming the Flora of the Wealden, has led M. Brongniart to suppose that the deposits in question may belong to that formation; and M. Nillson, of Lund, who examined my collection at Brighton, recognised, among some undescribed plants from Tilgate Forest, forms that he had collected from Hoer. See "*Observations sur les Végétaux Fossiles renfermés dans les Grès de Hoer en Scanie: par M. Ad. Brongniart. Ann. Sc. Nat.* 1825.

STEMS OF ARBORESCENT FERNS.—Notwithstanding the profusion with which the foliage of many kinds of ferns is distributed throughout the coal formation, the undoubted stems of plants of this family are rarely met with; for the numerous tribe called *Sigillariæ*, is now removed altogether from this class. It may, however, admit of question whether much of the foliage which, from the analogy of structure, has been referred to ferns, may not have belonged to those trees; for as in the animal kingdom, so in the vegetable, distinct types of living organisms are often found blended in the lost races; and as the stems of recent tree-ferns are even more durable than their leaves, it seems impossible to account for their absence in strata, that enclose entire layers of the foliage matted together. A few fossil stems, with all the essential characters of recent species, have been discovered, and these are arranged under the following genus.

CAULOPTERIS (*fern-stem*).—Stems not channelled, marked with discoidal, oblong, or ovate scars, arranged longitudinally; vascular cicatrices numerous. The specimen figured is from the coal, and resembles the trunks of the living tree-ferns in its proportions, and in the number, disposition, and size of the scars of the leaf-stalks; but these markings differ in their more lanceolate form, and pointed terminations, and in their peculiarly striated surface.

The coal also contains stems that are marked by deep oval or circular imprints, apparently produced by the separation of *cones*, and not by the attachment, and falling off of petioles, or leaf-stalks. (*Bd.* p. 475.) Two genera have been formed for their reception, (*Foss. Flor.* pl. 5, and pl. 80.), with the

LIGN. 22. CAULOPTERIS MACRODISCUS. *Coal.*

names *Bothrodendron* (pitted-tree), and *Ulodendron* (*Bd.* pl. 56.). The depressions on these stems are arranged in two longitudinal rows, placed on opposite sides of the trunk. Some are of a large size, the scars being five inches in diameter.*

* The collection in the British Museum contains some remarkably fine examples of these curious stems.

SILICIFIED FERN-STEMS.—Before entering upon the examination of other plants of the carboniferous strata, it will be convenient to offer a few remarks, in this place, on the silicified stems of ferns that abound in the New Red sandstone, near Hillersdorf, in the neighbourhood of Chemnitz, in Saxony.* They are of great beauty, and the organization of the original is so well preserved by the silex, that slices, examined by the microscope, display the peculiar structure of this family, as perfectly as in the recent plants. Transverse sections exhibit the arched bundles of vascular fibres which compose the ligneous cylinder, surrounded by the cellular tissue, as in the living stems (see *Lign.* 2.). From the stellated markings on these slices, occasioned by the section of the vessels of which the tissue is composed, and which are visible to the naked eye, these fossils have obtained the name of *staaren-stein*, or star-stone. Their external surface (at least, in the specimens I have had an opportunity of examining) is of a ligneous appearance, and of a dark reddish brown colour; but internally they are of a dull red, mottled with various tints of blue and yellow, from the agate and chalcedony, with which their vessels are permeated.†

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* An excellent work, "*Dendrolithen*," on these fossils, has been published at Dresden by M. Cotta.

† In Org. Rem. Vol. I. Plate VIII. fig. 1—7, are figures of these fossils, which convey a good idea of their appearance

Dr. Buckland has discovered in the New Red sandstone formation at Allesley, near Coventry, silicified trunks of trees, principally of coniferæ; and it is not improbable that further research in that locality, may bring to light fern-stems like those of Chemnitz.*

SIGILLARIA.

Among the most common, yet striking objects, that arrest the attention of a person who visits a coal-mine for the first time, and examines the numerous vegetable relics that are profusely dispersed among the heaps of slate, coal, and shale, are long flat slabs, with their surfaces longitudinally fluted, and uniformly ornamented with rows of deeply-imprinted symmetrical figures; these are disposed with such perfect regularity, that the specimens are often supposed to be engraved stones, instead of natural productions. These fossils are the remains of the epidermis, rind, or bark of the stems of gigantic trees; the regular imprints on the surface, being the scars left by the separation of the

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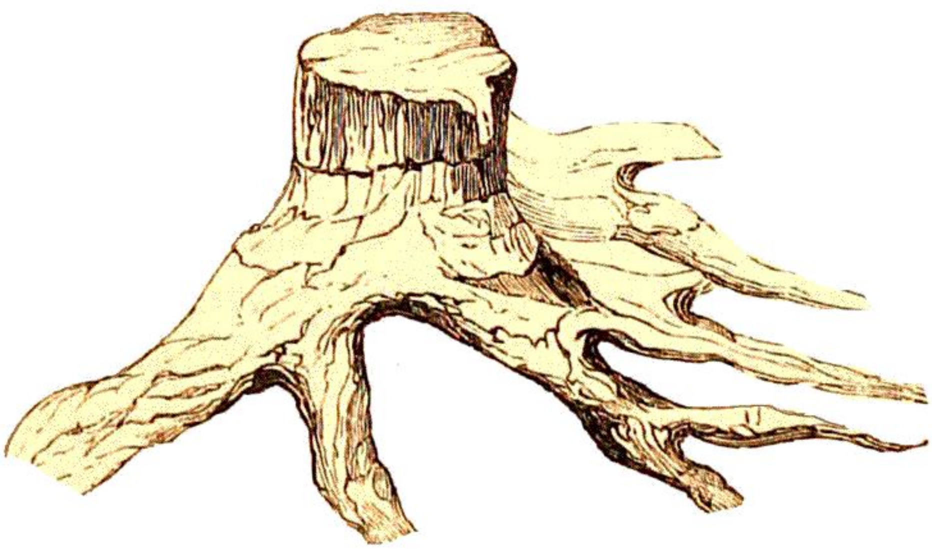
and structure. The reader will be amused by the perusal of the ingenious but unsuccessful attempt of the excellent author, to elucidate their nature. I have still a specimen which was presented to me by Mr. Parkinson, more than twenty years since, as one of the most curious and puzzling fossils that had ever come under his notice.

* Vide Geol. Proc. II. p. 438.

leaf-stalks, as in the arborescent ferns previously examined. The name *Sigillaria*, now commonly applied to this tribe of fossils, is derived from the Latin *sigillum*, a seal, and alludes to the regular and similar imprints on the surface. These trees are generally found lying in a horizontal position in the strata, and are quite flat, from the pressure produced by the superincumbent deposits, during their long entombment; but when they are in an erect position, at right angles to the plane of the beds, the original cylindrical form of the trunk is preserved. A remarkable instance, in which five stems of Sigillariæ were standing upright, with their roots in the soil below, apparently in the position in which they grew, was brought to light a few years since, in forming the Bolton and Manchester railway.* They stand on the same plane, and near to each other. Their roots are branched, and spread out in the bed of impure coal in which they are implanted. The trunks are surrounded by a soft blue shale. The largest tree is eleven feet high, and seven and a half feet in circumference at

* These trees still remain *in situ*, and, thanks to the scientific zeal of Mr. Hawkshaw, have been carefully preserved. They are situated at Dixon Fold, Clifton, near Manchester. Instructive models, of a small, convenient size, may be obtained of these highly interesting relics of the carboniferous forests. An excellent Memoir on this discovery, with illustrations, by Mr. Hawkshaw, will be found in *Geol. Trans.* Vol. VI. pl. 17. See also *Geol. Proc.* Vol. III. pp. 139 and 270.

the base; its trunk is gnarled and knotted, and has many decorticated prominences, like those in barked timber of our old dicotyledonous trees; the roots, too, partake of the same character.* The others are respectively from three to five feet in height. A sketch of one of the short stems is subjoined. All the trees were broken off as if by violence, and no traces of the upper part of the stems or branches were detected.



LIGN. 23. SIGILLARIA, with its roots, standing erect with five others, in carboniferous strata. The original is four feet high.

In the stratum through which the roots extend, a considerable quantity of the fossil cones, called *Lepidostrobi*, hereafter described, were imbedded (see *Lign.* 31); but there was no evidence that these fruits belonged to the trees around whose roots they had accumulated. A thin layer of coal, which invested the stems, was evidently the

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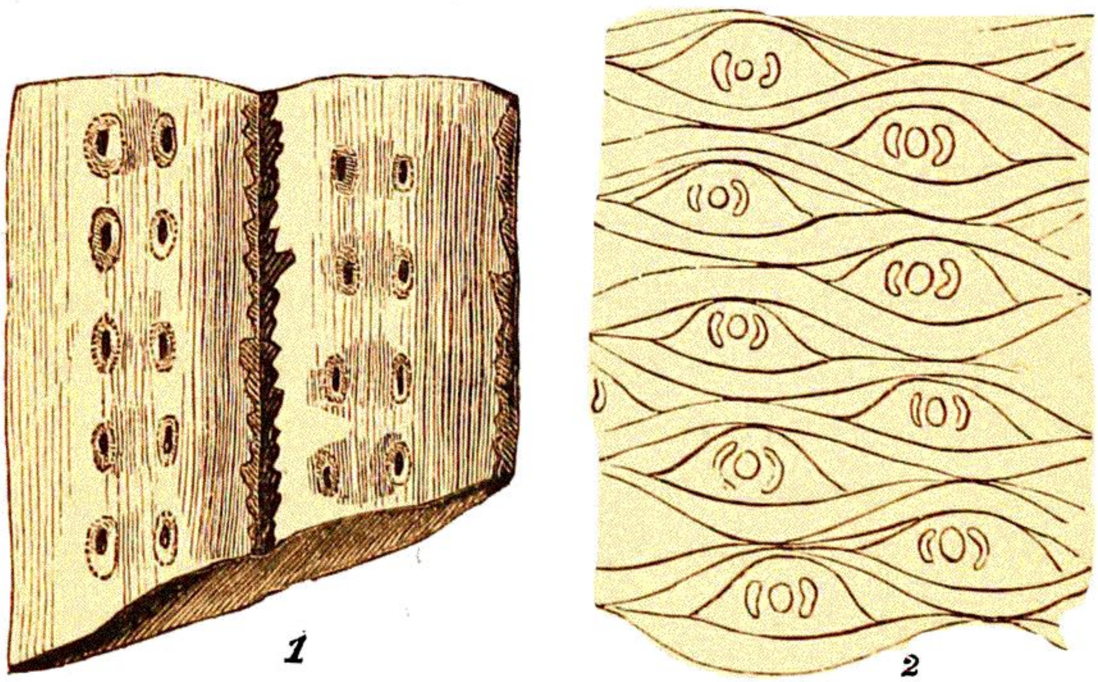
* See Mr. Bowman's Memoir, Geol. Proc. Vol. III. p. 270.

carbonized bark. All the stems were filled with blue clay, or shale, a proof that they were hollow when submerged in the mud, which is now consolidated into the shale, in which they are imbedded. But it is not probable that they were originally tubular, like a reed: on the contrary, there is evidence to show that they were highly organized. Their internal structure may have decayed, or been destroyed by insects, or other depredators; this is often the case in tropical climates, where even the trunks of timber trees are speedily excavated after their fall, and afford shelter to innumerable insects and reptiles, as the weary traveller often finds to his surprise and annoyance.* The late Mr. Bowman affirmed † that these trees were dicotyledonous, and stated that medullary rays and coniferous structure could be detected; an opinion, which the researches of M. Brongniart on the Sigillariæ have fully corroborated. Many other instances have been noticed of Sigillariæ standing more or less erect in the strata. In forming the railway tunnel at Claycross, five miles south of Chesterfield, through the middle portion of the Derbyshire coal measures, in 1838, a group of nearly forty trees (*Sigillariæ*) was discovered, standing not more than three or four feet apart, at right angles to the plane of the strata.‡ On the coast of Northumberland, within the length of half

* Mr. Hawkshaw, Geol. Proc. p. 269.

† Geol. Proc. Vol. III. p. 270. ‡ Ibid. 272.

a mile, twenty trees were observed by Mr. Trevelyan, in 1816 (*Bd.* p. 470.). The coal-pit at St. Etienne, in France, described by M. Alex. Brongniart, is celebrated for affording an example of this phenomenon (*Ly.* II. p. 137. *Wond.* p. 629.); but the positions of many of those stems are inclined at various angles, and their roots implanted in different beds, so that the perpendicularity of the erect trees is probably accidental (*Bd.* p. 471.).



LIGN. 24. SIGILLARIÆ; *in Coal-shale.*

Fig 1.—A specimen deprived of its carbonaceous bark, except in the interstices of the channels, and showing pits left by the external scars.

2.—The markings of S. Defrancii. (*Vég. Foss. Br.*)

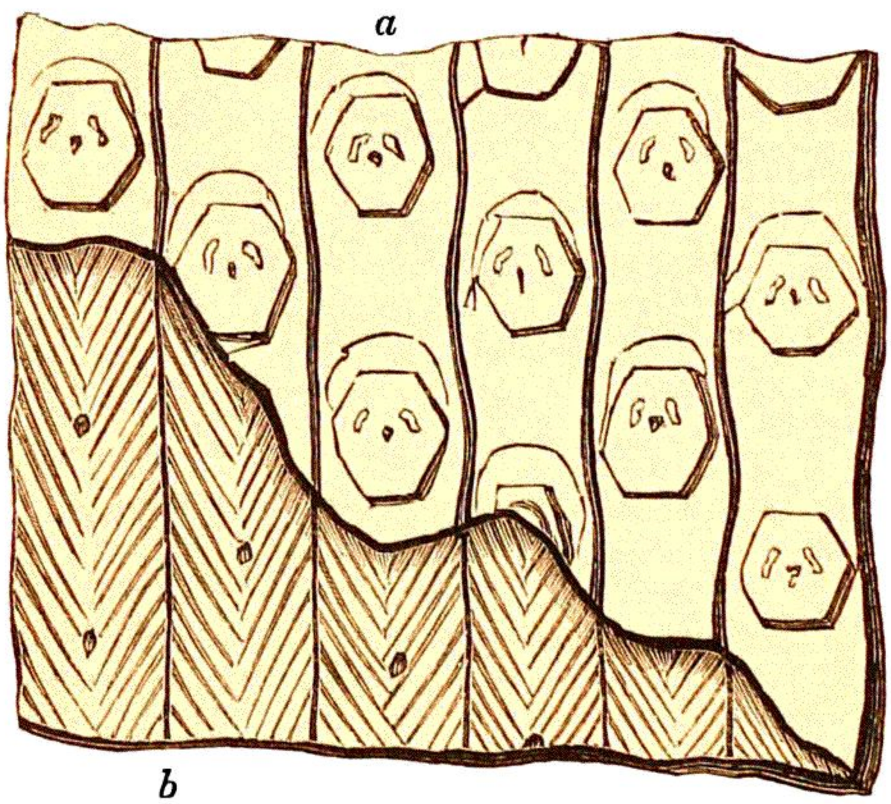
But the most remarkable instance hitherto observed, is on the southern shore of the Bay of Fundy, in Nova Scotia, where the cliffs, which are about two hundred feet high, are composed of carboniferous strata, consisting of coal, clay, grit, and shale, in which numerous erect trees, probably Sigillariæ, are seen on the face of the cliff; there are ten rows one above another, indicating, observes Mr. Lyell, repeated subsidences of the land, so as to allow of the growth of ten successive forests!*

The stems of the Sigillariæ vary in size from a few inches to five feet in diameter; and in length from five to sixty feet. They gradually taper from the base to the summit. A specimen surveyed by M. Brongniart was forty feet long, one foot in diameter at the base, and but six inches at the top, where it divided into two equal branches. The stems of Sigillariæ may be readily distinguished from those of other trees with which they are associated, by the fluted surface produced by the deep longitudinal grooves, and the regularly disposed imprints between the channels.† The carbonized bark, in large specimens, is often an inch thick, but in small examples it is a mere pellicle, and being extremely brittle, flakes off with the slightest touch, and leaves the inner surface exposed, the coal only remaining in the deep furrows and pits, as in *Lign.* 24, fig. 1. No traces of leaves, or fruit in connexion with the

* Mr. Lyell on the Coal Strata of Nova Scotia. Amer. Journ. Oct. 1843.

† The stems of some recent dicotyledonous trees from New Zealand, in the possession of our distinguished countryman, Dr. Robert Brown, possess similar longitudinal ribs and furrows, both on the bark and alburnum, or naked wood.

stems, have been observed. The subjoined sketches (*Lign.* 24 and 25) illustrate the usual characters of these fossils. The difference between the imprints on the outside of the bark, and those on the exposed stem, by the removal of the cortical covering (*Lign.* 25.), will not escape the notice of the reader.



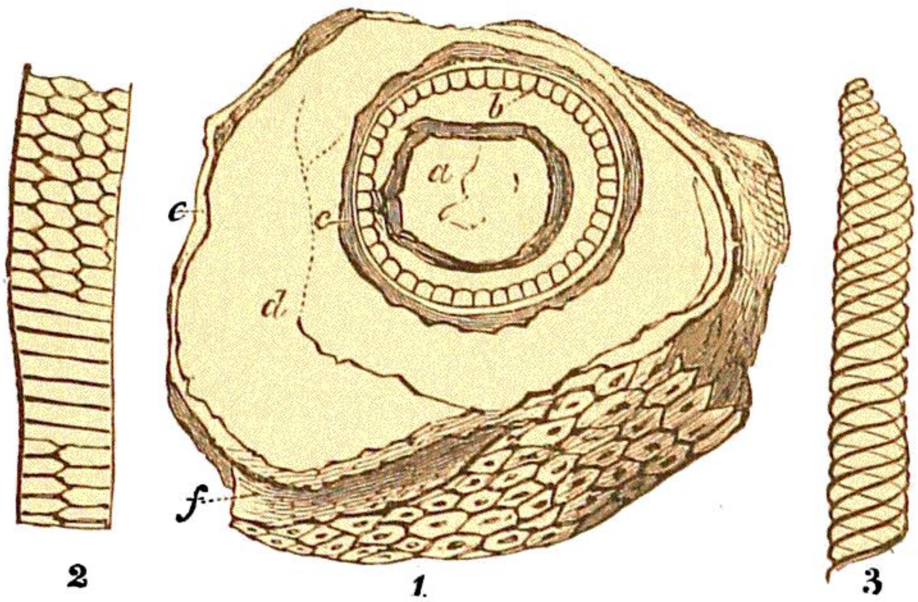
LIGN. 25. SIGILLARIA SAULLII.

Carb. Manchester.

a. The external imprints of the petioles.

b. The inner surface, exposed by the removal of the crust of carbonized bark.

INTERNAL ORGANIZATION OF THE SIGILLARIÆ.— Our knowledge of the structure of this numerous and interesting tribe of plants, has received an important accession, by the discovery of the silicified fragment of a stem, which, fortunately for the advancement of science, was placed at the disposal of M. Adolphe Brongniart. It has been described



LIGN. 26. SILICIFIED STEM OF SIGILLARIA ELEGANS.
(*M. Adolphe Brongniart.*)

Fig. 1.—A transverse section of the silicified stem, from Autun, *nat.*
a. Situation of the medullary tissue, occupied by coloured silex.
b. Zone, composed of bundles of vessels, forming the woody tissue.
c. Band of cellular tissue.
d. Space between the ligneous cylinder and the bark, with no evident structure, but originally occupied by the external cellular tissue.
e. Zone of indistinct cellular substance.
f. External cortical envelopment, or bark.
2.—Portion of one of the vessels of the medullary tissue, as seen in a longitudinal section. (× ×.)
3.—Portion of a spiral vessel of the same tissue. (× ×.)

and illustrated by that eminent botanist, in a Memoir which may justly be characterised as one of the most able contributions to fossil botany, that has hitherto appeared.*

The annexed figure (*Lign.* 26.) is an outline of the specimen that has afforded such interesting results. It is of the natural size; but this sketch must be regarded merely as a plan or diagram, for it is impossible without the aid of colour to convey a faithful idea of the original. The student should observe, that when mineral matter has permeated the stems of plants, the vascular tissue is often so well preserved, that one such specimen affords more important information, than hundreds of examples where the form alone remains.

The external surface of this specimen possesses the characteristic markings of *Sigillaria elegans*, formed by the insertion of the leaf-stalks. The internal organization, as seen in the transverse section, is thus composed:—

a. The centre, filled with flint; it exhibits no traces of structure.

b. The zone which surrounds the interspace on which the letter *b* is placed, is composed of bundles

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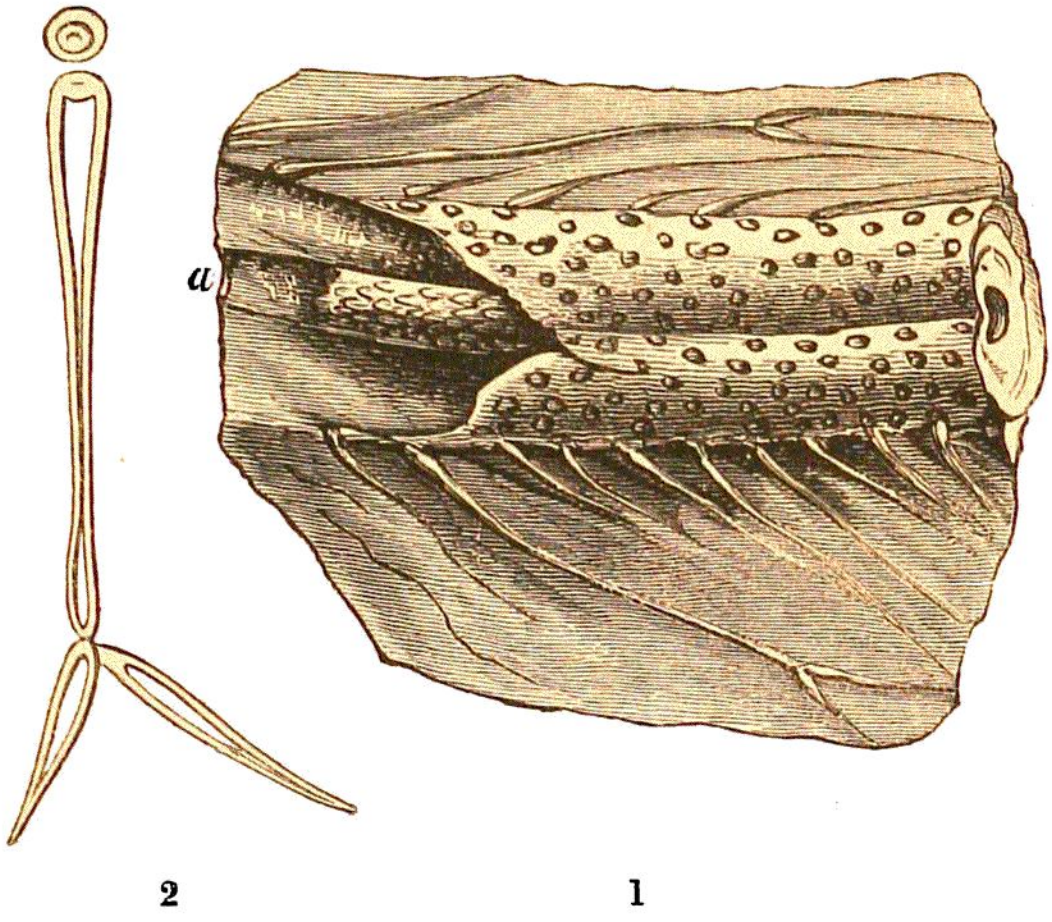
* The reader intending to make fossil botany his particular study, should refer to the original memoir, and become familiar with the facts and inferences so admirably enunciated by the author; not only for the illustration of the organization of the tribe of plants under consideration, but as a most valuable exemplification of the manner, in which all such investigations should be conducted. See Archives du Muséum d'Histoire Naturelle, Tom. I. Paris, 1839.

of vascular tissue. A portion of one of these bundles, highly magnified, is represented in Plate V. fig. 7. The *inner* circle of this zone, indicated by the *convex undulating line*, is made up of medullary vascular tissue; the external circle is divided by rays, and is composed of woody fibre, constituting a ligneous cylinder. One of the spiral vessels (fig. 3.), and another showing a remarkable difference of structure in a short space (fig. 2.), as seen in a longitudinal section of the medullary tissue, are figured in *Lign.* 26. The ligneous cylinder is surrounded by a band of cellular tissue, and the space between this and the cortical integument is occupied by silex, in which there are obscure traces of cellular structure. The inner layer of bark, *f*, is composed of elongated cells, disposed in a radiating manner, and traversed by fibro-vascular bundles, which pass towards the leaves.

From this dissection, M. Brongniart was enabled to institute a comparison, between the fossil and the stems of those recent plants which present the closest analogy. From the result of this examination, he concludes that the Sigillariæ constituted a peculiar family of coniferous plants, now extinct, which probably belonged to the great division of gymnospermous dicotyledons. In their external forms they somewhat resembled the *Cacteæ* or *Euphorbiæ*, but, by their internal organization, they were more nearly related to the *Zamiæ* or *Cycadeæ*. The leaves and fruits of these trees are unknown, for no satisfactory connexion has yet been established between their stems, and the foliage, and seed-vessels, with which they are collocated.

STIGMARIA.—This extended notice of the structure of the Sigillariæ, will materially assist in the illustration of the nature of an equally common vegetable fossil, known in every coal-mine by the name of spotted-stem, or *Stigmaria*. A reference to *Bd.* p. 476. *Ly.* II. p. 119. *Wond.* p. 660. will put the reader in possession of all that was known and conjectured upon this subject, when those works respectively appeared. In our remarks on the situation invariably occupied by these fossils, we found it necessary to anticipate the announcement of their real nature, but we reserved for this place a full elucidation of their organization.

The *Stigmariæ*, or *Variolæ*, are cylindrical bodies, varying from a few inches to several feet in length, and are often as large round as the arm; their surface being covered with numerous pits or areolæ, which are disposed in quincunx order. These markings are oval or circular, and have a small elevation, or tubercle, in the middle of each depression. When broken across, a small cylindrical body, or core, is found to extend in a longitudinal direction throughout the stem, like a medullary column. This core seldom occupies the centre or axis of the stem, but is commonly situated near to one side, and opposite to a groove, or channel, on the outer surface, that runs parallel with it. This internal body is often loose, and may be removed; its surface is covered with interrupted, irregular, longitudinal ridges, which leave corresponding depressions on the walls of the cavity in which it was contained. The following lignograph represents a fragment with the characters above described.



LIGN. 27. STIGMARIA FICOIDES. *Carb. Derbyshire.*

Fig. 1.—Portion of a stem, with some of the processes (formerly considered as leaves) extending into the surrounding clay. The internal body is seen at *a*; and the corresponding groove, on the portion of external surface that remains.

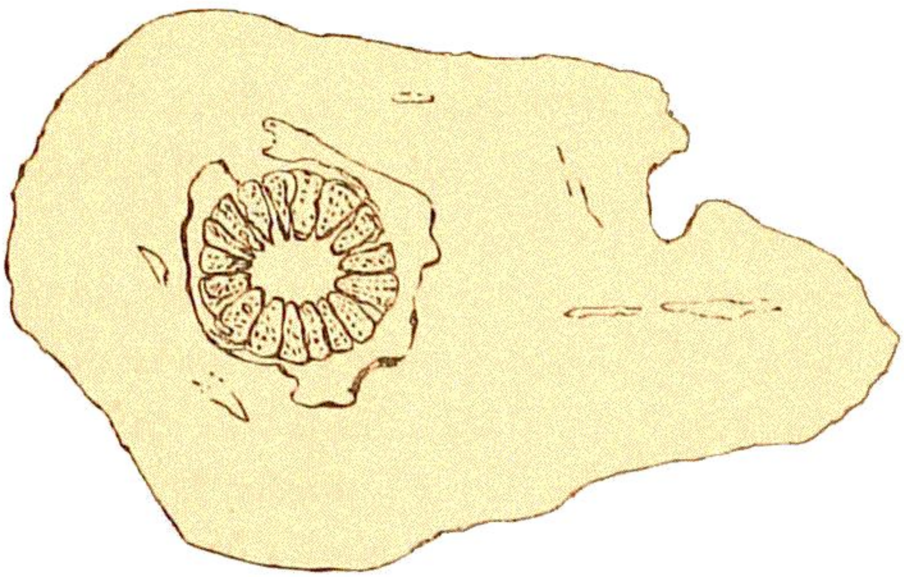
2.—An outline of one of the radicles or fibres, with a tubercle to show the mode of attachment to the root, which is that of a ball and socket joint.

When specimens of Stigmariæ are observed in the under-clay, to which stratum they are principally confined, long, tapering, subcylindrical fibres are seen attached to the tubercles of the pits with which the surface is covered; and these processes are often several feet in length; their form and mode of attachment are shown in *Lign.* 27. Instances occur in which many of these stems spring from a common centre, of a dome-like form, from whence they radiate in every direction (*Bd.* plate 56, fig. 8.), and the main branches divide and subdivide till they are lost in the surrounding rock.*

The situation in which the Stigmariæ invariably occur, namely, in the under-clay beneath the coal—the establishment of this important fact by Mr. Logan, not only in the principal coal measures of England, but also in Pennsylvania—and the hypothesis based on the supposed aquatic nature of these plants, have already been laid before the reader. But the distinguished author of the elaborate Memoir on the Sigillariæ, of which an abstract has been given, from a careful examination of the internal structure of the Stigmariæ, contended that they were not aquatic plants, but the roots of Sigillariæ; the central axis, or cylinder, (*Lign.* 27, fig. 1. *a.*) bearing a close analogy in organization to the stems of those trees. The annexed sketch (*Lign.* 28.),

* A very interesting description of these plants is given in Foss. Flor.

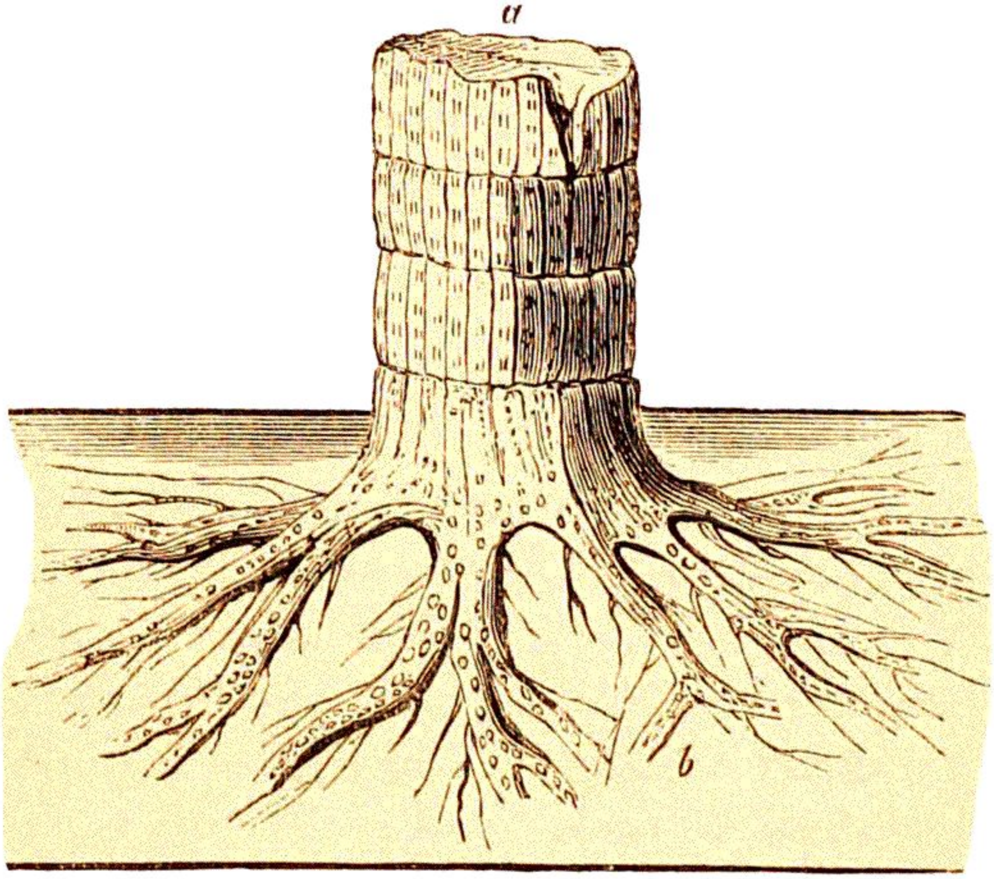
represents the transverse section of a small Stigmaria, with the axis displaced from its natural situation, and pressed on one side. This circumstance, as well as the corresponding external groove, has arisen from compression, by which the tough cylinder has been forced from its original position in the middle of the soft cellular tissue.



LIGN. 28. TRANSVERSE SECTION OF STIGMARIA FICOIDES. *Nat.*
(*M. Adolphe Brongniart.*)

This specimen shows the cylinder formed of bundles of vascular tissue, disposed in rays.

The central axis is thus shown to be a cylinder composed of bundles of vessels, disposed in a radiating manner, and separated from each other by medullary rays; the whole constituting a ligneous zone perfectly resembling that of *Sigillaria* (see *Lign.* 26.); but the inner ring of medullary tissue seen in the latter, is altogether wanting. This difference is in every respect similar to that existing between the stems or branches of a dicotyledonous tree, in which the woody cylinder is associated internally with bundles of medullary tissue, and the roots of the same tree that are destitute of them. Part of a vascular bundle from the woody tissue of a Stigmaria, seen by a high power and transmitted light, is figured Plate V. fig. 6; the smooth interspaces are composed of cellular tissue.



LIGN. 29. STEM AND ROOTS OF A SIGILLARIA.

Coal mine, near Liverpool.

a. The trunk of the tree, traversing a bed of coal.
b. The roots (*Stigmariæ*) spreading out in the under-clay.

This opinion of the eminent French savant, has very recently been confirmed by the discovery, at St. Helen's, near Liverpool, in Coal strata, of an upright trunk of a Sigillaria, nine feet high, with its roots eight or nine feet in length, still attached, and extending in their natural position. *These roots are undoubted Stigmariæ of the usual species, S. ficoides; and the radicles, formerly considered leaves, spread out in all directions to the extent of several feet.** I have obtained no further particulars of this highly interesting discovery, and therefore insert the sketch, *Lign.* 29, to render it clear to the student.

I need only add, that upwards of forty species of Sigillariæ are described; and that their fossil remains have been found in every locality of the carboniferous strata.

LEPIDODENDRON (*scaly-tree*). See *Bd.* pl. 55.

Stems cylindrical, covered towards their extremities with simple, linear, or lanceolate leaves, which are attached to elevated, rhomboidal spaces, or papillæ; papillæ marked in the upper part with a large transverse triangular scar; lower part of the stem destitute of leaves.

This is a tribe of plants whose remains abound in the coal formation, and rival in number and magnitude the Calamites and Sigillariæ above described: they are named *Lepidodendra*, from the imbricated or scaly appearance of their surface, occasioned by the

* From a communication to the British Association at Cork, 1843, reported in the Athenæum weekly paper.

little angular scars left by the removal of the leaves. Some of these trees have been found almost entire, from their roots to their topmost branches. One specimen, forty feet high, and thirteen feet in diameter at the base, divided towards the summit into fifteen or twenty branches, was discovered in the Jarrow coal-mine.* The foliage of these trees consists of simple, linear leaves, spirally arranged around the stem, and appears to have been shed from the base of the tree with age. The markings produced by the attachment of the leaves are never obliterated; and the twigs and branches are generally found covered with foliage, as in the specimen here figured (*Lign.* 30.).

The internal organization of the stems of the Lepidodendra differs from that of the Sigillariæ, in the absence of the woody cylinder and medullary rays, which constitute so peculiar and important a character in those plants. The Lepidodendra have only an eccentric, vascular, medullary zone, the interval between which and the bark is filled up by cellular tissue.† In their structure, external configuration, mode of ramification, and disposition of the leaves, these trees accord so closely with the *Lycopodiaceæ*, that, notwithstanding the disparity

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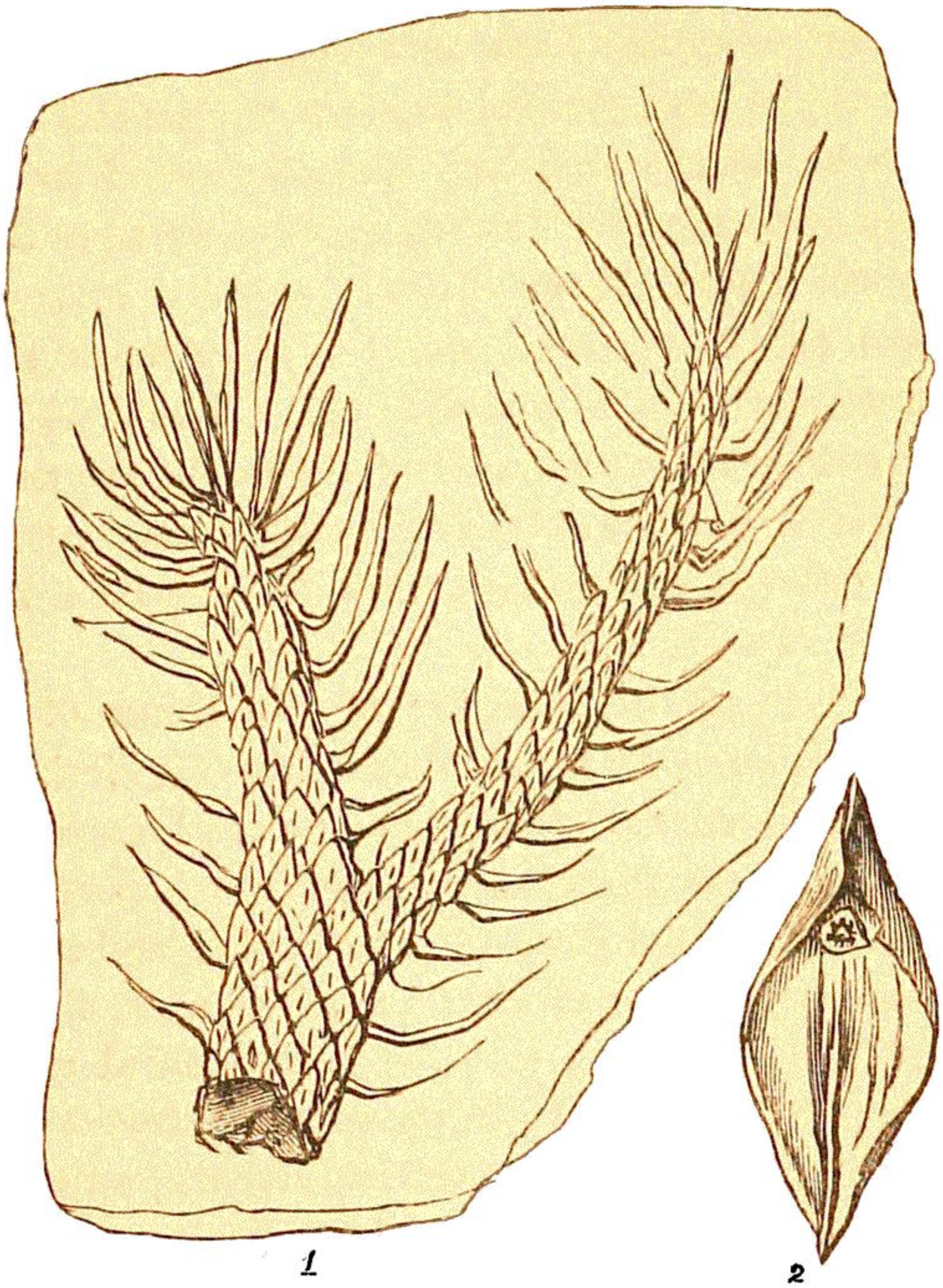
* Wond. p. 658. This specimen is figured and described in Foss. Flor.

† See M. Ad. Brongniart, Archives du Muséum d'Hist. Nat. Tom. I. (for 1839) Pl. XXX.

in size, M. Brongniart asserts they must be considered as gigantic arborescent club-mosses.*



LIGN. 30. Fig. 1.—A BRANCH OF LEPIDODENDRON, *In Coal-shale, Newcastle.*
2.—One of the scars left by the separation of a leaf. *Nat.*

* M. Corda, the able continuator of Count Sternberg's beautiful work (*Flora der Vorwelt*), is of opinion that the

The living species of this family amount to nearly two hundred, the greater number of which, like the ferns, inhabit the islands of intertropical regions. They are diminutive plants, with delicate foliage, none exceeding three feet in height. Most of them trail on the ground, but there are a few erect species, one of which (*Lycopodium densum*) is a native of New Zealand (*Ly.* p. 116.).

The fruit of the club-mosses is an oval or cylindrical cone, which in some species is situated at the extremity of the branches, and constitutes an imbricated spike. Now associated with the stems of the Lepidodendra, and very often imbedded in masses of their foliage, and in some instances apparently attached to the extremities of the branches, are numerous oblong, or cylindrical, scaly cones, garnished with leaves. These have received the names of *Lepidostrobi* (scaly-cones), and are believed to be the fruit of the trees with which they are usually collocated.

LEPIDOSTROBUS.—Cylindrical cones composed of winged scales, their axis traversed by a longitudinal cavity or receptacle, and terminating in rhomboidal disks, imbricated from above downwards.

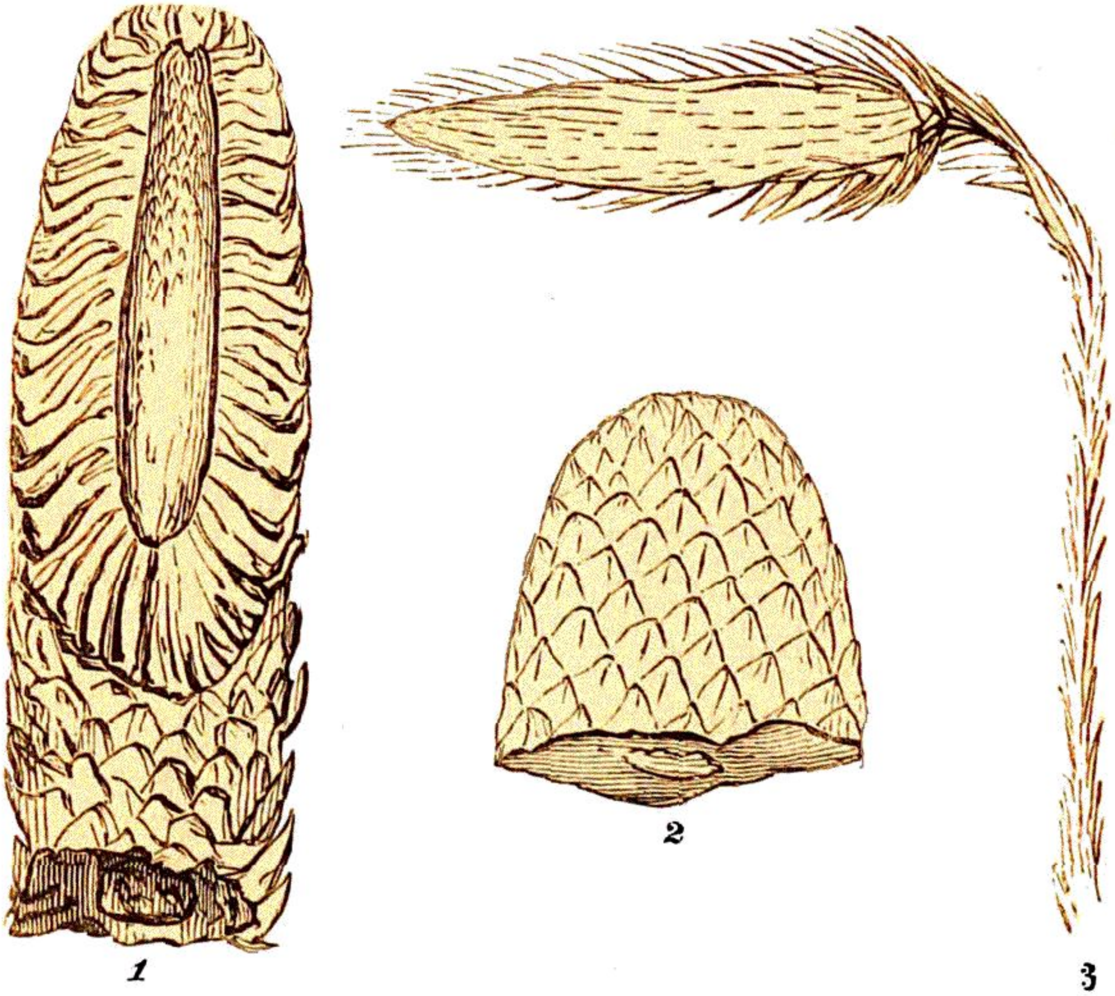
Lepidodendra were more nearly related, both in form and structure, to the *Crassulaceæ* (house-leek tribe), than to the club-mosses; but we think M. Brongniart has satisfactorily shown the contrary.

These fossils have long been known to collectors, and are figured by Martin (*Petrif. Derbiens.*), Parkinson (*Org. Rem.* Vol. I. Pl. IX.), and others. They are cylindrical imbricated bodies, rounded at both extremities, from two to six or seven inches long, and one to two inches in circumference. If broken, a cylindrical cavity is exposed, which is sometimes hollow, but frequently filled with mineral matter; and when specimens are found imbedded in the rock, the cone is fringed with linear or lanceolate leaves, as in *Lign.* 31, fig. 3. These cones often form the nuclei of ironstone nodules, like the fronds of ferns, and the leaves are then frequently replaced either by a white hydrate of alumine, or by the mineral called galena, or sulphuret of lead; and the receptacle is often filled with the same substances. This is generally the case in the specimens from Coalbrook Dale, many of which possess great brilliancy, and are exceedingly interesting as examples of the electro-chemical changes, which these fruits of the carboniferous forests have undergone.*

The figures in *Lign.* 31, show the appearance and structure of these fruits. The young specimen, fig. 3, terminates what appears to be a branch of Lepido-

* These mineralized cones are not liable to decompose, like the pyritous fruits from the Isle of Sheppey; they require no preparation for the cabinet; but it should be known that washing injures their lustre.

dendron; and M. Brongniart observes, "qu'il est impossible de ne pas reconnaître pour un Lepidostrobus jeune, fixé à l'extrémité d'un rameau."* It



LIGN. 31. LEPIDOSTROBI, *the supposed fruit of the Lepidodendra.*

Fig. 1.—A portion of a cone, showing the imbricated structure and internal cavity.

2.—The upper part of a large cone, displaying the imbricated surface.

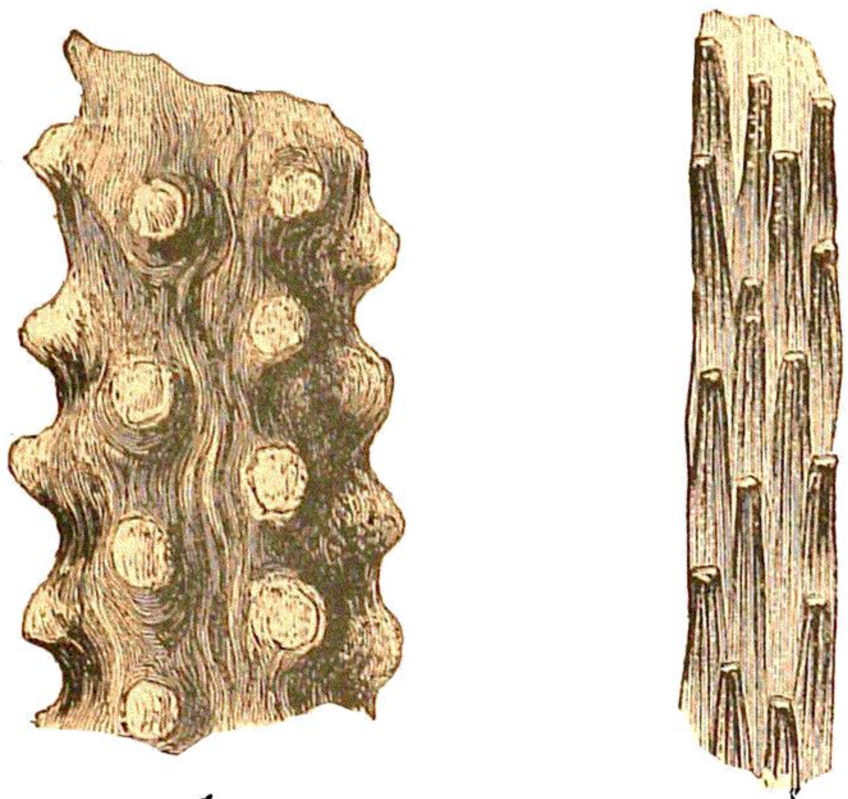
3.—A young specimen, surrounded with its leaves, and attached to the extremity of a branch.

is only in their young state that the spikes are found attached to the branches, for they appear to have been shed as soon as they arrived at maturity.

* Hist. Vég. Foss. Tom. II. p. 47.

Species of true Lycopodiaceæ occur in tertiary marls; a beautiful specimen, *Lycopodites Benettiæ*, from Germany, is figured *Wond.* p. 660.

HALONIA.—Stems marked as in the Lepidodendra, but having the same mode of branching as certain coniferous trees, are described under this name in



1 2

LIGN. 32. STEMS FROM THE COAL FORMATION.

Fig. 1.—HALONIA REGULARIS. *Coalbrook Dale.*
2.—KNORRIA TAXINA. *Roof of the high-main coal-seam, Jarrow colliery.* (*Brit. Foss. Flor.*)

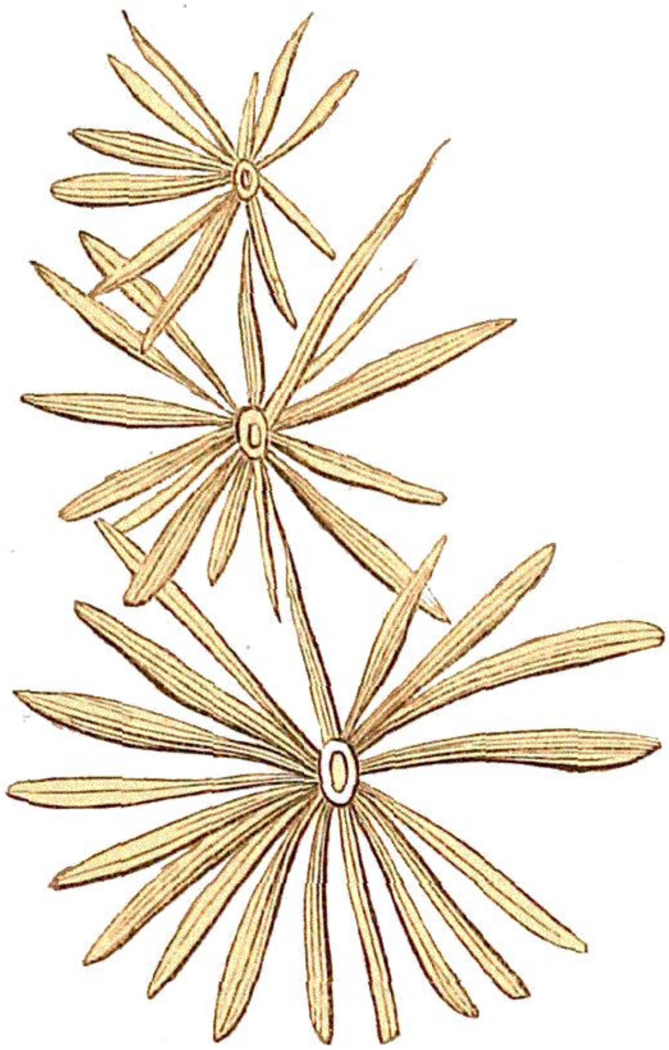
the Fossil Flora. Their knotted appearance is very remarkable, and the annexed sketch (fig. 1.) of a fragment from Coalbrook Dale, will enable the student easily to identify them: no internal structure has been detected. The specimens in my possession are mere casts, formed of a reddish sandstone.

Knorria.—Stems marked with projecting scars of petioles, disposed spirally. To this genus the authors of the *Foss. Flor.* refer those fossil plants, the leaves of which were densely arranged in a spiral manner, and have left projecting scars. The annexed figure (*Lign.* 32, fig. 2.) represents part of a beautiful specimen, which is stated to bear a close resemblance to a very young branch of Yew: the structure is unknown.

Although the following fossil vegetables belong to families which will subsequently be noticed, their occurrence in the carboniferous Flora induces me to describe them in this place.

Sternbergia.—The stems which belong to this genus occur in the Newcastle coal-field (*Foss. Flor.*). They are generally of sandstone, and are invested with a thin carbonaceous crust, or rind. When this coaly matter flakes off, the surface of the stem is found to be marked with annular depressions and gentle risings, which are intersected in some parts by perpendicular lines. These stems resemble the trunks of the Yucca, and Dracæna, or dragon-blood plant.

Asterophyllites (*star-like leaf*).—Plants with verticillate leaves are not uncommon in the coal-shale, blended with the fronds of ferns and Lepidodendra. Some species resemble the foliage of Equisetum or Hippuris, but no certain conclusions as to the nature of the originals have been established

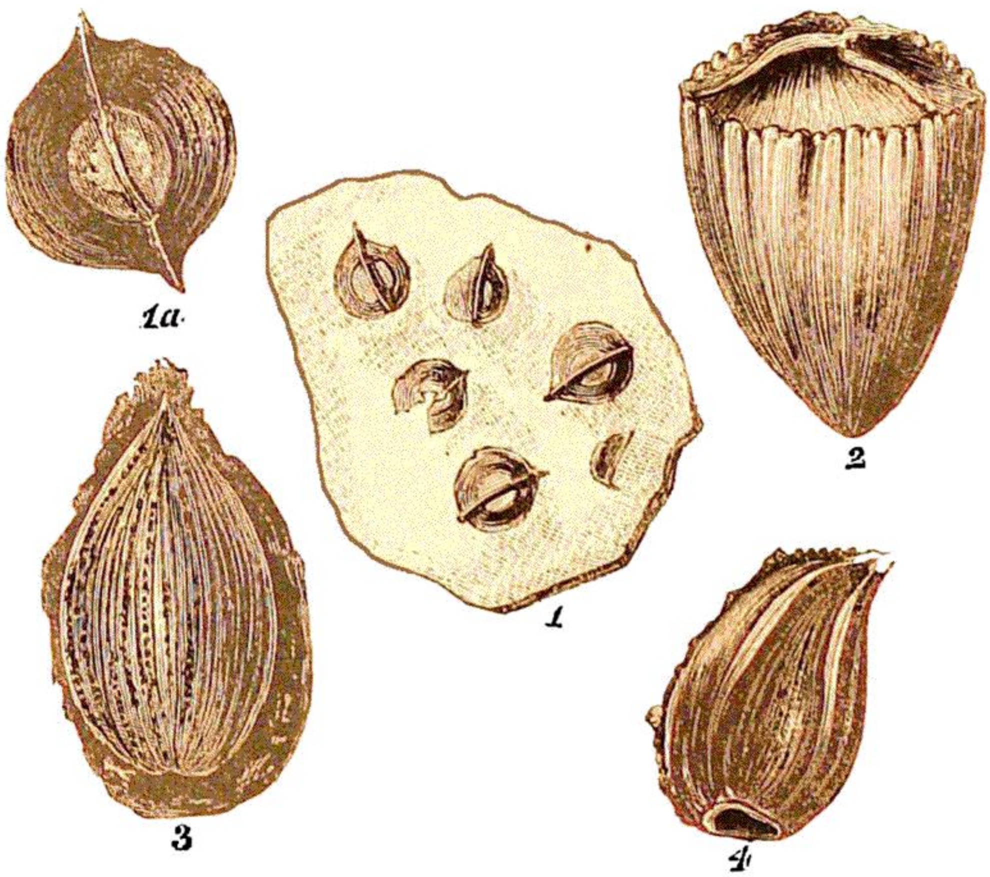


LIGN. 33. ASTEROPHYLLITES EQUISETIFORMIS.

Coal-shale. (*Foss. Flor.*)

from any specimens hitherto discovered; they are often associated with a peculiar fruit, which I will therefore notice in this place.

CARDIOCARPON.—These seed-vessels are found in the sandstone, grit, and coal-shale, and are so frequently imbedded among masses of foliage of the Asterophyllites, that it is suspected they may belong to that undetermined tribe of plants. They generally occur in groups of from five to twenty,



LIGN. 34. FRUITS, OF SEED-VESSELS, *from the Coal formation.*

Fig. 1.—CARDIOCARPON ACUTUM. *Snibstone Coal-mine, Leicestershire.*

1*a*.—One of the above magnified

2.—CARPOLITHES BUCKLANDII.

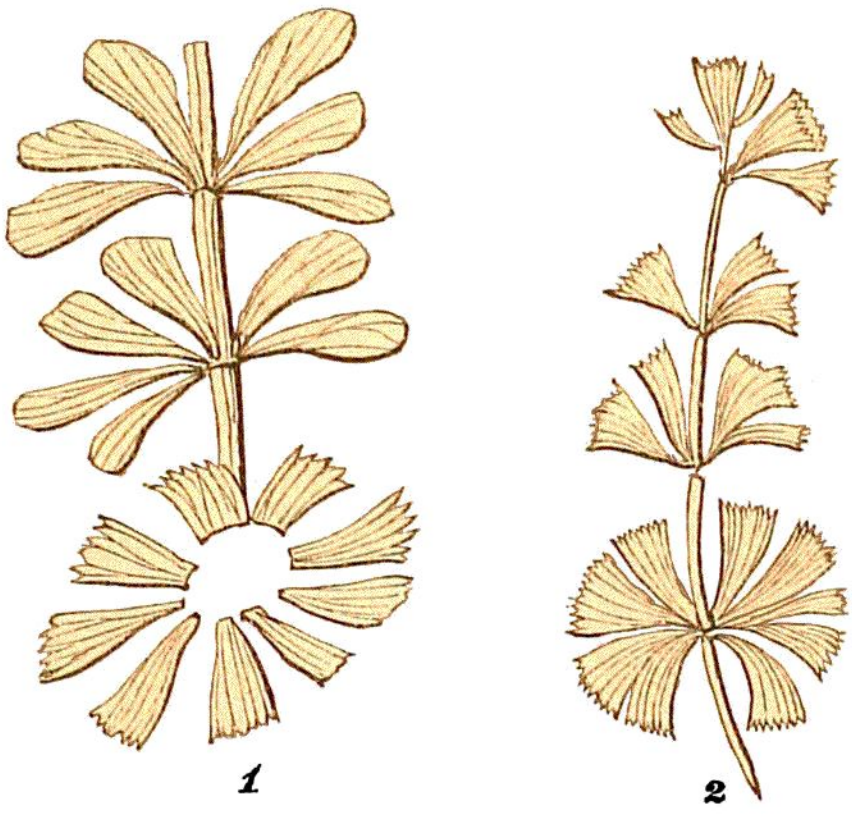
3.—TRIGONOCARPUM OLIVÆFORME.

4.—TRIGONOCARPUM NÖGGERATHI. (*Brit. Foss. Flor.*)

and evidently grew in pairs, or, to use a botanical term, were *didymous*. The magnified figure 1*a*.

shows the surface attached to the twin-seed (See *Foss. Flor.* p. 76.).

TRIGONOCARPUM.—These fossils, which resemble the fruits of some species of palm, are occasionally found in the coal of Leicestershire: see *Lign.* 34, figs. 3 and 4.



LIGN. 35. Fig. 1.—SPHENOPHYLLUM SCHLOTHEIMI. *Coal-shale.*
2.—SPHENOPHYLLUM EROSUM. (*Foss. Flor.*)

SPHENOPHYLLUM (*wedge-shaped leaf*).—Another elegant undetermined tribe of plants, having verticillate wedge-shaped leaves, occurs also in the coal-shales, and with the Asterophyllites, gives rise to those circular, fringed impressions, which often come under the notice of the observer, when a large slab of shale, covered with imprints, is split open and exposed to view. The natural relations of these plants are not ascertained, but they are conjectured to belong to the *Marsiliaceæ*, or pepper-worts.

The reader will perceive that the plants hitherto described have, with but few exceptions, been found in the coal formations, many exclusively, and all abundantly in those deposits. The remains of the four most numerous families—the Ferns, Calamites, Sigillariæ, and Lepidodendra, with masses of coniferous organization, have, in fact, contributed, in a great measure, to form those enormous accumulations of mineral fuel, which now supply materials for the luxuries and necessities of mankind.

Our review of the fossil vegetables will henceforth assume more of a botanical arrangement, and we shall briefly notice the most important species that occur in the other and more recent formations.

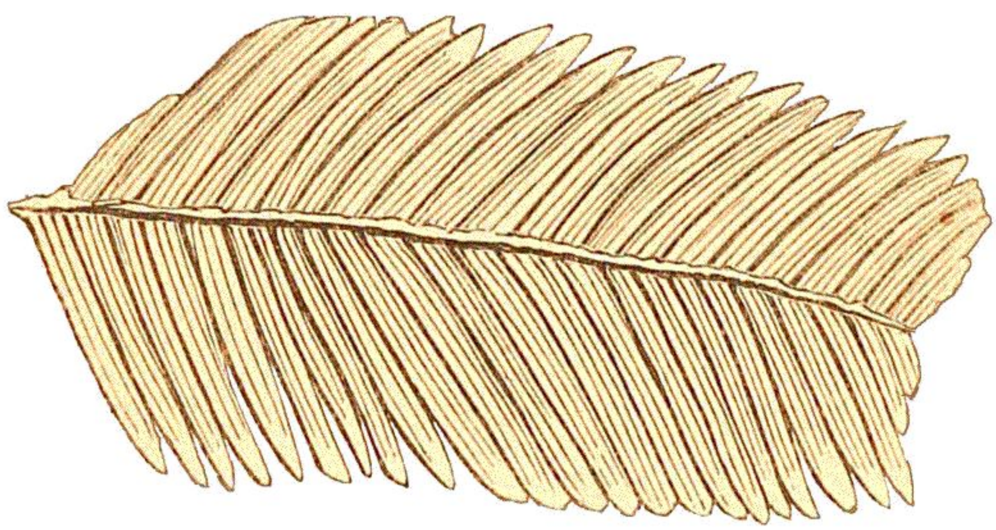
Cycadeæ (*Bd.* I. p. 490. pl. 57, 58, 59. *Wond.* p. 364.).—The plants and trees called Coniferæ, or cone-bearing, from the form of their fruit, possess remarkable botanical peculiarities: but the characters that require particular notice in the investigation of their fossil remains, belong to the fruit, and the internal structure of the stems. Of this family* the most remarkable tribe is the Cycadeæ, which are divided into two genera—*Cycas*, and *Zamia*. As several species of these plants are cultivated in our green-houses, their general aspect must be familiar to the reader. To the botanist they present an extraordinary character, that of having their seeds exposed; hence they are arranged in a distinct order (called Gymnospermous, *naked seeds*); the organization of their stems also differs from that of the other Coniferæ. (In Plate V. fig. 5. a transverse section of a stem is represented.)

Most of the Zamiæ are short plants, with stout cylindrical stems beset with thick scales, which are the bases of leaves that have fallen off: towards the summit they are garnished with a crown of elegant pinnated leaves with simple veins. The Cycas resembles the Zamia, but the trunk is generally longer, and in one species, *C. circinnalis*, attains a height of thirty feet. The leaves are tough, and in the young state are coiled up like a croisier, as in the ferns. Their fruit bears some resemblance to the cones of the pines, but the seeds are naked. They are the inhabitants of hot and humid climates, and

* Dr. Buckland has so fully and admirably elucidated the fossil remains of the whole family of Coniferæ, that it will not be requisite to enter in detail on this important division of fossil botany.

are found in the West Indies, Cape of Good Hope, the Molucca islands, India, China, &c.

Although some traces of Cycadeæ have been observed in the carboniferous strata, it is not until we arrive at the Liassic and Oolitic deposits, that they appear in any considerable number. The most fruitful locality of these plants in England, is along the Yorkshire coast, near Scarborough, where in the shale, and sandstone of the Oolite, the leaves and fruits of several species of Zamia and Cycas,



LIGN. 36. ZAMIA PECTINATA.

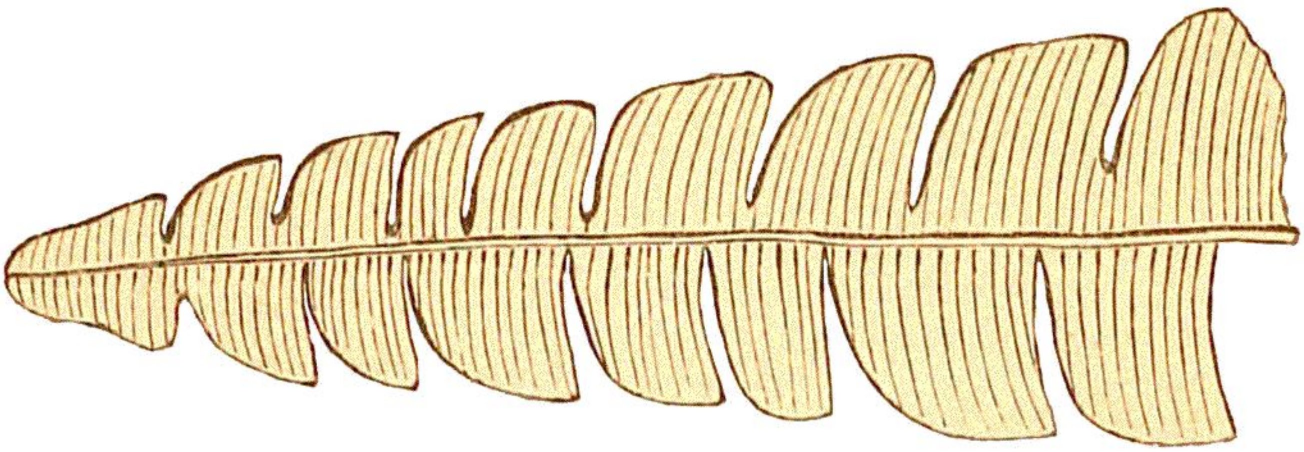
In Stonesfield slate; portion of a leaf nine inches long. (*Foss. Flor.*)

are found in great variety and perfection.* The leaves are changed into a carbonaceous substance, but their venation is distinctly preserved. At the foot

* In the carboniferous strata of Eastern Virginia, United States, which are referred to the Oolitic epoch, leaves of Cycadeous plants also abundantly prevail. See Trans. American Geologists, p. 298.

of Redcliffe Bay, leaves are found associated with jet, and pyritified dicotyledonous wood.

As these leaves differ from each other in their mode of venation, and in their segments, they have been arranged in three or four genera. Part of a leaf of Zamia pectinata is figured (*Lign.* 36.); and a species of *Pterophyllum*, a genus characterised by numerous veins of equal thickness, in *Lign.* 37.

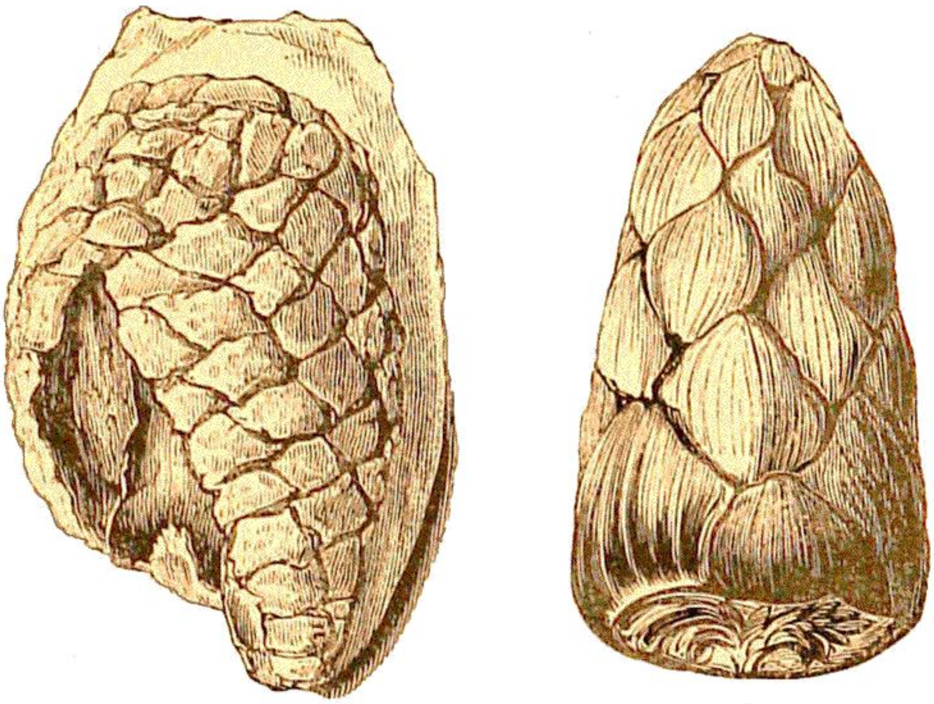


LIGN. 37. Part of a leaf of PTEROPHYLLUM COMPTUM.
Oolite, near Scarborough.

These are particularly abundant in the clay and shale at Gristhorpe Bay, near Scarborough, and are frequently ten or twelve inches long. The Stonesfield slate contains both foliage and fruit of several species of Zamia (see *Lign.* 36.). In the Lias shale of Dorsetshire very beautiful specimens also occur. Cycadeæ are rarely met with in the upper divisions of the Wealden; but one elegant leaf (*Cycadites Brongniarti. Geol. S. E.* p. 238.), has been found in sandstone near Reigate, in Surrey. But the most interesting assemblage of the fossil plants of this family, is to be found in the Isle of Portland, where Cycadeæ, transformed into flint, may be seen standing erect in the very places where they once flourished, between rows of petrified fir-trees, whose silicified roots extend into a bed of bituminous rubble (See *Wond.* p. 361. *Bd.* p. 404. *Geol. S. E.* p. 335). The fossil cycadeous plants of the Isle of Portland, have been beautifully illustrated by Dr. Buckland, in *Geol. Trans.* Vol. II. second series, of which memoir the account in *Bd.* p. 404, is an abstract. M. Ad. Brongniart has placed them in a new genus, with the following characters.

MANTELLIA.—Stems cylindrical, or almost spheroidal, without a distinct central axis; covered with rhomboidal scars, whose horizontal is wider than their vertical diameter. There are two species; one, which is short and spheroidal (*M. nidiformis*, called *crow's nests* by the quarrymen); the other is longer, and more cylindrical (*M. cylindrica*). A specimen has also been found in the Portland limestone at Swindon, in Wilts. On the shore near Yaverland, on the south coast of the Isle of Wight, the fruits of cycadeous plants have been washed up with the bones of the Iguanodon, and other characteristic Wealden fossils: these may have been the cones of the same species as the Portland stems. A figure of one of these fruits (from *Foss. Flor.*, where it is described under the name annexed), is given in *Lign.* 38.

In the Shanklin sand of Faversham, in Kent, several cones, belonging to some unknown species of this family, have been discovered by William Richardson, Esq. One specimen is figured and described as Zamia ovata in *Foss. Flor.*; a reduced sketch of it is represented below, *Lign.* 38, fig. 2.



LIGN. 38. Fossil Fruits of CYCADEOUS Plants.
(*Foss. Flor.* ½ *nat.*,)
Fig. 1.—ZAMIA CRASSA. *Yaverland, Isle of Wight.*
2.—ZAMIA OVATA. *Greensand, Faversham.*

The fruits of Cycadeæ, that occur with the foliage in the Scarborough Oolite, are very fine, and when imbedded in ironstone, or shale, the leaves and their impressions are often covered, or filled, with a powder of the purest white, which is hydrate of alumine; as in the example delineated,* *Lign.* 39.

* Beautiful examples of the fruits and leaves of these plants may be seen in the British Museum.

The specimens figured by some authors as flowers,* are, with much probability, conjectured by Dr. Lind-

IGN. 39. FRUIT OF ZAMITES LANCEOLATA, *nat.* *From near Scarborough.* The seeds are concealed by the leaves.

ley to be cones of Cycadeæ, broken transversely; the supposed petals being the scales, and the stamen and pistillum the fractured axis.

* Bird's Yorkshire, Tab. I. figs. 1 and 7.

CONIFEROUS WOOD AND TREES.

Stems, branches, and large masses of drifted wood, that under the microscope exhibit that peculiar structure which (as we have explained, p. 71.) prove the originals to have belonged to the family of Coniferæ, are among the most abundant vegetable remains of the upper secondary and tertiary deposits. The investigations of Mr. Nicol, and Mr. Witham (*Obs. on Foss. Veg.* Edinburgh, 1831), first demonstrated the existence of Coniferæ in the Coal, and their remains have been found in every formation of later origin. The recent vegetables arranged in this family are all arborescent, dividing into numerous branches, which are disposed in most genera with considerable regularity. Transverse sections of the stems exhibit annular lines of growth, and in the vertical direction the sides of the vessels are studded with little ducts (see *Lign.* 1.), which are readily seen by the aid of the microscope; many of the fossil species resemble the recent. Polished slices of Coniferæ, from the Carboniferous strata and Lias, are figured by Mr. Witham (*Obs. Foss. Veg.* Plates III. IV. and V.—*Bd.* p. 486.), who describes a trunk of an Araucaria, or Norfolk Island pine, nearly forty feet long, in Craigleith quarry, near Edinburgh, at a depth of 136 feet (*Ly.* II. p. 138.). The greater part of the fossil coniferous wood found in the older deposits of Great Britain is of this type, which is characterised by the rows of glands being disposed, when double, not side by side, as in the common European pines and firs, but alternately (see *Wond.* pp. 625 and 663.). The localities which furnished Mr. Witham with an abundance of specimens, are at *Lennel Braes*, on the banks of the Tweed, near Coldstream, and at Allanbank Mill, in Berwickshire (see *Obs. Foss. Veg.* p. 14.). It may be interesting to mention, that some slices of these woods prepared for the microscope (presented to me by the late Dr. Henry, of Manchester), not only expose the vegetable organization in an admirable manner, but also form beautiful objects for the exhibition of polarization.

In the New Red sandstone several species of an extinct genus of Coniferæ, named *Voltzia*, are found at Soultz-aux-bains, near Strasburg (*Wond.* p. 685.). The Lias contains stems and branches of Coniferæ, with their leaves, and cones. I select for illustration (*Lign.* 40.) a remarkably perfect specimen of *Araucaria*, in the cabinet of the Misses Philpot (figured in *Foss. Flor.*), and which has been so admirably cleared from the Lias in which it was imbedded, that even the surface of the leaves is distinctly visible. It closely resembles a twig of the Norfolk Island pine, the *Altingia excelsa*.

The Oolite formation contains drifted fragments of coniferous wood, associated at Stonesfield with leaves and fruits of Cycadeæ, marine plants and shells, insects, and the bones of reptiles and of mammalia; at Scarborough, with numerous other terrestrial plants; and at Swindon, with ammonites, trigoniæ, &c.

LIGN. 40. Fig. 1.—PART OF A BRANCH OF ARAUCARIA PEREGRINA. *Lias, Lyme Regis.*
2.—CALAMITES NODOSUS, with foliage. *Coal-shale* (see p. 111.).

But the most extraordinary and interesting assemblage of these trees, is that, already alluded to, in the Isle of Portland, where an entire forest of pines appears to have been transformed into stone, in the very spot on which it flourished; the Cycadeæ still shooting up, as it were, between the trunks, and the roots of the trees, though changed into flint, extending into the bed of mould from which they originally derived their support; thus realizing the fable of the petrified city in Arabian story, whose inhabitants were turned into stone, yet preserved the positions which they occupied when alive (*Wond.* p. 361.).

In the Wealden deposits of Sussex, Kent, and Surrey, I have not observed a single fragment of coniferous wood; but the ironstone of Heathfield (*Geol. S. E.* p. 240.) has yielded to my researches branches, stems, and foliage of plants related to the Cypress, or Thuya, collocated with small seed-vessels, apparently of some species of *Restiaceæ*, an order of low rush-like plants, natives of New Holland. These remains, like the fruits of the Zamiæ (*Lign.* 39.) are often invested with hydrate of alumine.

The arenaceous limestones of the Kentish rag in Kent and Sussex, in some localities, abound in water-worn masses of coniferous wood, which are often perforated by various boring mollusca, as teredo, fistulana, pholas, &c. In the Iguanodon quarry of Kentish rag, near Maidstone, which the researches of that accurate and indefatigable observer, Mr. Bensted, have rendered classic ground, large quantities of these remains are found, and also several cones belonging to different species, if not genera. One of these is decidedly a species of Abies, or fir:* it was associated with fragments of trunks and branches, whose internal structure proved their relation to the fruit. Plate V. fig. 2, are microscopic views of transverse and longitudinal sections of this wood; 2 a. shows the cellular tissue in a transverse slice, seen by reflected light; 2 b. a vertical section in the direction of the medullary rays, exhibiting the vessels studded with single rows of glands. This wood occurs both in a calcareous and siliceous state; in some examples the external zones are calcareous, and the inner siliceous; in others the entire branch is changed into black flint, in which the coniferous structure is beautifully preserved.

Near Willingdon, in Sussex (*Geol. S. E.* p. 172.), a bed of sand, immediately beneath the galt, contains a layer of water-worn fragments of stems and branches, generally of small size; they are very commonly perforated by some kind of gastrochæna, and the cavities formed by these depredators are filled with particles of green chlorite sand. The structure of this wood is represented Plate V. fig. 3 a. a transverse, and 3 b. a vertical section, viewed by reflected light. In 3 b. the vessels are seen dotted with two parallel longitudinal rows of very minute

* It is figured and described as *Abies Benstedi*, by the author. Geol. Proc. January, 1843.

glands, arranged alternately, as in the Araucaria; and a fragment of one of the medullary rays remains attached near the middle of the specimen.

In this deposit of coniferous wood, two or more fruits of a Zamia have been discovered; one specimen, five and a half inches long, and of an elongated cylindrical form, covered with rhomboidal eminences, indicating the seeds, is figured and described as *Zamia Sussexiensis* by the author.*

In a bed of fossil coniferous wood, near Hythe, in Kent, a resinous substance has been discovered, partaking of the properties of amber and retin-asphalt; it is characterised by its clear red colour, infusibility, and the difficulty with which it is acted upon by many chemical solvents.†

The White Chalk of England has afforded but few traces of plants of this family, or indeed of a higher order than the Cellulosæ. Fragments of coniferous wood are, however, occasionally found in the state of carbonaceous, or reddish brown friable masses, and when this substance is removed, the surface of the chalk is seen to be marked with impressions of ligneous fibres; sometimes the surface is studded over with little pyriform eminences, which are cretaceous casts of perforations that existed in the wood. These specimens, when all traces of the wood are absent, are very puzzling to those who

* Geol. Proc. 1843.

† Ibid.

are not aware of their origin. Occasionally silicified fragments of wood are found imbedded in flint. An interesting specimen of this kind was observed in a wall of Lewes Priory, and although it must have been exposed to the influence of the weather for nearly eight hundred years, it still beautifully exhibits the coniferous organization.

LIGN. 41. FRAGMENT OF WOOD IN FLINT, FROM LEWES PRIORY.
(*Collected by Miss Mantell.*)

The tertiary formations in some localities abound in coniferous plants and woods: they occur in the Paris basin, associated with bones of mammalia; and several species of pine (*pinus*) and of yew (*taxus*) have been described by M. Brongniart. I have collected vegetable fossils of this kind from the London clay of the Isle of Sheppey, Bracklesham Bay, Bognor, and Newhaven, in Sussex, and in Alum Bay, in the Isle of Wight.

In the sands of the desert of Sahara, in Egypt—among the mammalian bones of the Sub-Himalayas—and in the tertiary deposits of Virginia, associated with Cycadeæ—drifted coniferous wood and stems have been discovered.

Stems of trees of this family, of a highly interesting nature, are found in various parts of Australia and Van Dieman's Land; partly in a calcareous, and partly in a siliceous state. The same trunk often possesses a white friable calcareous external zone, many inches thick, traversed by veins of silex, or opaline chalcedony, while the centre or heart of the stem is a pure silicified mass; in both states the internal organization may be detected. This fossil wood is to be seen in most cabinets, large quantities of the stems having been sent to England by emigrants.* The trees, from which the specimens brought to this country were obtained, appear to have been subjected to the same kind of change as those of the Isle of Portland, for they are described as standing erect to the height of several feet in a bed of arid sand, apparently in the places where they grew; their petrified stems and branches being

* My late friend, Sir Francis Chantrey, had a magnificent specimen, upwards of six feet long, which is now in the British Museum.

scattered around them. They so entirely preserve their natural woody appearance, that one of the colonists mentions among the extraordinary sights he witnessed on his first arrival in New Holland, the burning of trees into lime to manure the ground.*

A fossil Pine forest, on the eastern coast of Australia,† in the inlet called Lake Macquarrie, has very recently been described by the Rev. B. Clarke. At the base of a mountain range, composed of conglomerate and sandstone, with subordinate beds of lignite, terminating on one side of the lake or inlet, an alluvial flat extends to the water-edge, covering the sandstone rock which is found *in situ* beneath. Throughout the whole of this plain, stumps of fossilized trees are seen projecting out of the ground, presenting the appearance of a forest in which the trees are all cut down to the same level. At the distance of some yards from the shore, a reef is formed by vertical rows of the petrified stems, which project above the surface of the water. Many of the fossil trees on the shore, have the remains of roots extending into the sandstone rock below the alluvial detritus; and, like those in the Island of Portland, are in some instances surrounded by an accumulation of sandy rock, which forms a

* The fossil trees of Preservation Island, in New South Wales, described by Mr. Parkinson, are no doubt of a similar character.—*Org. Rem.* Vol. I. p. 381.

† Proc. Geol. Soc. 1843.

mound of a higher level than the rest of the stratum. The trunks stand, generally, about three or four feet above the surface, and are from two to six feet in diameter. The wood is silicified, and veins of chalcedony traverse the substance of the trunks between the concentric rings and medullary rays. In several examples, from 60 to 120 annual circles of growth were observable. Beds of lignite occur both above and below the fossil trees, in the neighbouring hills; and many localities along the eastern coast of Australia are mentioned, as presenting similar phenomena.

The resinous secretions of pines, firs, and other Coniferæ, are occasionally found with their stems. When the tunnel was bored through Highgate Hill, in 1811, many concretionary lumps of a resinous substance were discovered, and excited considerable attention: they proved, upon analysis, to be the resin of some coniferous tree, changed by mineralization. Amber, as I have already mentioned (p.64.), is of a similar origin; and in black amber the bituminous change it has undergone is very apparent. The same origin is ascribed to the diamond (*Wond.* p. 636.). The pollen of Coniferæ has been discovered at Egra, in Bohemia, in a tertiary deposit, which is two miles long, and twenty-eight feet thick; this bed is entirely composed of fossil animalcules and pollen; the first ten feet being infusorial marl, and the remainder animalculites and pollen.

PANDANUS, or *Screw Pine*.—I cannot close this review of fossil Coniferæ, without mentioning the highly interesting discovery of the fruit of a Pandanus, in the lower Oolite, near Charmouth; this specimen is now in the collection of Dr. Buckland, at Oxford. The fruit is of the size of an orange, and its surface is covered with hexagonal tubercles, which are the summits of the cells containing the seeds. The living screw-pines are natives of warm climates, and abound in the groups of islands in the Pacific; they are generally the first important vegetable tenants of the newly-formed coral islands. This extraordinary fossil is fully illustrated in *Bd.* pl. 62, and p. 503.

A few fragments of stems with transverse rings, as if left by amplexicaul leaves, have been found in the Coal; these may have belonged to some species of Pandanus.

PALMACITES, *Fossil Palms*.—The trees of this family, the greater part of which inhabit intertropical regions, are remarkable for their elegant forms and peculiar aspect. They have a single cylindrical stem, which, like that of the arborescent ferns, rises to a great height, and is crowned with a tuft or canopy of foliage; the leaves are often of considerable size, and either pinnated, or fan-shaped, and plaited in regular folds. The Date and Cocoa-nut are well known examples of their fruit. The surface of the stems is scored with transverse scars left by the separation of the petioles. Stems, with the external surface and internal organization preserved, and the leaves and fruits of several species, have been discovered in a fossil state, and for the most part in tertiary deposits. Among the silicified stems which abound in Antigua and other West Indian islands, associated with corals in a similar state of mineralization, are many which decidedly belong to this family (see Plate V. fig. 1.). Some species have been found in the Carboniferous formation, and in the Oolite. *Carpolithes Bucklandi* (see *Lign*. 34, fig. 2.) is supposed to be the fruit of a tree allied to the palms; and two other fruits, from the coal, *Trigonocarpum Olivæforme*, and *T. Nöggerathi*, have probably the same natural affinity; see *Lign*, 34, figs. 3 and 4.

A group of fossil palm trees has very recently been noticed and described by Dr. Owen of New Harmony, in the state of Indiana, in one of the upper members of the Illinois coal-field. From twenty to thirty erect trees were discovered, with their main roots attached and ramifying in the clay, and their stems in the coal and sandstone above, as if submerged on the spot where they originally grew. A carbonaceous crust envelopes the trunks, which are covered with lozenge-shaped scars, having a transverse direction, and presenting a diversity of figure in the petioles, that indicates at least three species of palms.*

* Silliman, Amer. Journ. Science, October 1843.

But it is not until we arrive at the tertiary formations that the remains of palms are found in any considerable number. Stems, leaves, and fruits have been discovered in the Paris basin, by M. Ad. Brongniart (*Bd.* pl. 64, p. 515). Silicified trunks and fruits also occur in many other places on the continent; but no examples surpass in beauty and interest those which are found in Antigua. A slice of a silicified stem from that island (collected by the late Dr. Henry) is represented, as seen by reflected light, in Plate V. fig. 1; it admirably displays the monocotyledonous organization, namely, bundles of vascular tissue imbedded in cellular structure. Silicified stems of monocotyledons, apparently related to the Palms, are very widely distributed, and have been collected among mammalian remains in Ava, and in the Sub-Himalaya mountains.

The stems of a very curious plant, which in structure resemble the palm, were first discovered by me in 1820, in the Wealden of Tilgate Forest, Hastings, and the Isle of Wight, with the bones of reptiles, and fresh-water shells. As their affinity is at present uncertain, they have been placed in the genus *Endogenites*, (*stony-endogenous plants*,) which is formed for the reception of those fossil monocotyledons whose natural relations are uncertain (*Prod. Veg. Foss.* p. 131.).

ENDOGENITES EROSA.—(See *Geol. S. E.* Plate I. figs. 4 and 5, and *Foss. Til. For.* tab. 3).—These stems vary in size, from a few inches to two feet in circumference, and from one to five or six feet in length. They are of a very irregular and varied shape, and present no indications of branches; some specimens taper at both ends, while others are of a clavated or club-form, like some of the Cacteæ, or Euphorbia. They are silicified, and permeated with numerous tubular cavities, which extend, in a tortuous and irregular manner, in a longitudinal direction. These channels, which are often lined with quartz crystals, pass over the surface, as well as penetrate the substance of the stems, and thus produce an eroded appearance, whence the specific name, *erosa*. When found in beds of clay, or marl, they are enveloped in a friable carbonaceous crust, which soon flakes off, and exposes the stony surface. Under the microscope there are indications of monocotyledonous structure, but of no decided character.*

Fossil Palms, *and other Vegetables of the Isle of Sheppey*.—The most important deposit of fossil

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* When the face of the cliff, immediately behind Pelham Place, Hastings, was cut away, in the course of the building operations, some years since, I observed several layers of lignite, in which were long portions of these curious stems. Very large masses of this endogenite are often thrown up by the waves on the shore between Hastings and St. Leonard's.—(See Dr. Fitton's delightful "Guide to the Geology of Hastings.")

fruits of the Palm tribe, and of numerous other plants, is the Island of Sheppey; and I purpose describing in this place, not only the remains of the Palms, but also of some of the most interesting vegetable fossils with which they are associated in that celebrated locality.

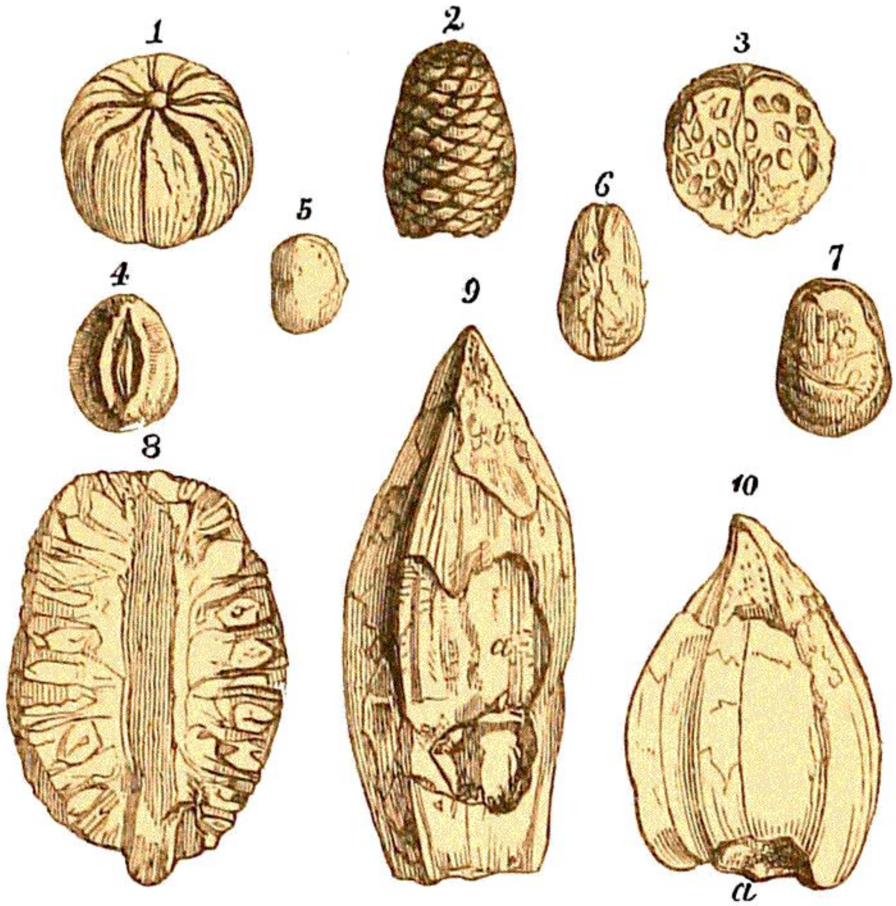
This island, which is situated in the mouth of the Thames, is entirely composed of the London clay, with layers of the septaria, or clay nodules, so common in that deposit. On the north, there is a range of cliffs, about two hundred feet high, which is continually undermined by the waves, and large masses of the clay are thrown down upon the shore, and innumerable fruits, seeds, branches and stems of trees, and other fossils, exposed. The vegetable remains are strongly impregnated with iron pyrites, and as this mineral speedily undergoes decomposition, when exposed to the atmosphere, the choicest examples often fall to pieces, even when preserved in a dry cabinet. Mr. Bowerbank, who possesses an unrivalled collection of these fruits, keeps them in stopper-bottles filled with water, placing the different species separately, and labelling the phials. I have successfully employed mastic varnish, first wiping the specimens dry, and removing any saline efflorescence, by means of raw cotton, and then brushing in the varnish with a stiff hair-pencil.

The fruits, or seed-vessels, occur in such profusion, that a large collection can easily be made.

They (see *Excursion to the Isle of Sheppey*) comprise several hundred species, few of which have been scientifically investigated. Mr. Parkinson has given several admirable figures, particularly of the large palm-like fruit, called "petrified figs." (*Org. Rem.* Vol. I. pl. 6 and 7). M. Ad. Brongniart has named several in his *Prodrome;* but without figures the descriptions are not easily comprehended. Mr. Bowerbank has alone done justice to the subject, by the publication of figures and descriptions, under the title, "History of the Fossil Fruits of the London Clay;" of this excellent work, but one part, with seventeen plates, has yet appeared, from which I shall select a few subjects for illustration.

The fruits already determined by Mr. Bowerbank are the following.

1. Fruits of vegetables, having a downy structure, like the cotton plant.
2. Seeds of some plant of the cucumber family. *Lign.* 42, figs. 1 and 3.
3. Cones of a tree allied to the *Petrophila*, of New Holland. *Lign.* 42, figs. 2 and 8.
4. Seeds of the bean family, some of which resemble those of the scarlet runner. *Lign.* 42, figs. 5, 6, 7.
5. *Wetherellia*, an unknown genus. *Lign.* 42, fig. 4.



LIGN. 42. FOSSIL FRUITS FROM THE ISLE OF SHEPPEY.

(*Mr. Bowerbank.*)

Fig. 1 and 3.—*Cucurmites variabilis:* fig. 3, is a vertical section, showing the seeds. *Lign.* 43, fig. 6—½ *nat.*

2 and 8.—*Petrophiloides Richardsoni:*—⅓ *nat.* fig. 8, is a vertical section, showing the disposition of the seeds in the cells formed by the confluent scales—½ *nat.*

4.—*Wetherellia variabilis:* a section of the fruit, in which state it is called coffee-berry by the collectors—⅓ *nat.*

5 and 6.—*Faboidea semicurvilinearis:* fig. 5, side view—¼ *nat.*

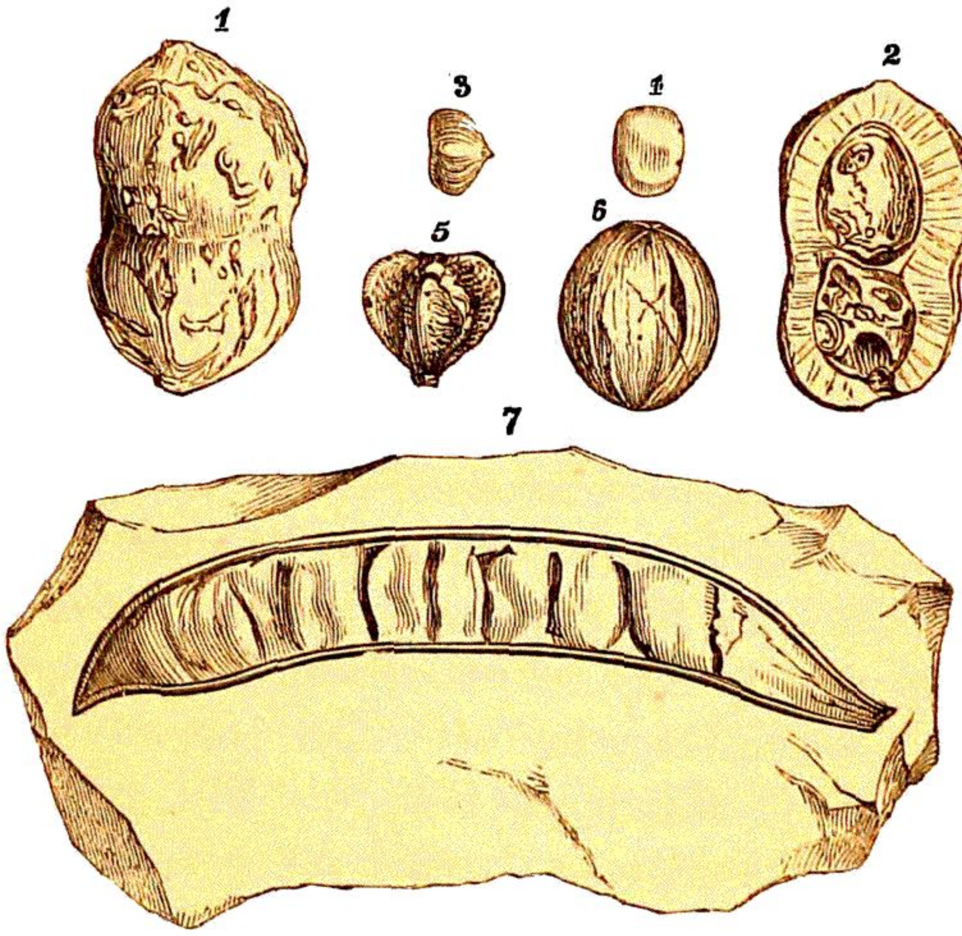
6.—Is the face of a similar seed—⅓ *nat.*

7.—*Faboidea bifalcis:* side view—⅓ *nat.*

9.—*Nipadites lanceolatus:* *a*, the seed; *b*, the shell, or pericarp—½ *nat.*

10.—*Nipadites cordiformis:* *a*, the extremity of the seed, imbedded in the shell—⅓ *nat.*

6. Fruits allied to the Palm tribe. (*Nipadites*). *Lign.* 42, figs. 9 and 10.
7. Fruits of leguminous plants, differing from any known recent. *Lign.* 43, figs. 1, 2, 3, 4.



LIGN. 43. FOSSIL FRUITS FROM THE ISLE OF SHEPPEY.

(*Mr. Bowerbank.*)

Fig. 1 and 2.—*Zulinosprionites latus.* 2. A section, showing the receptacles for two seeds. — $\frac{2}{3}$ *nat.*

3.—*Leguminosites dimidiatus;* side view. — $\frac{1}{2}$ *nat.*

4.—*Leguminosites subquadrangularis;* side view. — $\frac{1}{2}$ *nat.*

5.—*Cupanoides lobatus.* — $\frac{1}{2}$ *nat.*

6.—*Cucurmites variabilis.* — $\frac{1}{2}$ *nat.*

7.—*Mimosites Browniana;* from Ossington, Suffolk. A seed-pod of an *Acacia*, or other plant of the Mimosa family. — $\frac{2}{3}$ *nat.*

8. Seeds, allied to the *Amomum*, or Cardamom tribe. *Lign.* 43, fig. 5.
9. Seeds of *Cupressinites*, or plants related to the Cypress.
10. Seeds resembling those of the Laburnum.
11. Seed-pod of a species of Acacia, or Mimosa. *Lign.* 43, fig. 7.—$\frac{2}{3}$ *nat.*

The most remarkable fruits in the above catalogue are those which, from their appearance when compressed, are commonly known by the name of "petrified figs" (*Lign.* 42, figs. 9, 10.). Some specimens attain a considerable size, and are from five to seven inches long. These fossils were referred to the *Cocos* by Mr. Parkinson, but Mr. Bowerbank has shown that they are nearly related to the genus NIPA; several species of which abound in the Molucca and Philippine Islands. The Nipæ are low, shrub-like plants, having the general aspect of palms; they grow in marshy tracts, at the mouths of great rivers, particularly where the waters are brackish. They are allied to the cocoa-nut tribe, on the one hand, and to the screw-pine, or pandanus, on the other.

Mr. Bowerbank has also, by a microscopical examination of some stems from Sheppey, in which the vascular tissue was preserved, detected a species of *Piper*, or pepper-plant.

The masses of fossil wood found in the Isle of Sheppey, consist of portions of the stems of palms, coniferæ, and dicotyledonous trees. Large water-worn fragments, perforated by teredines, and containing portions of their shelly tubes, are abundant, as at Bognor, Bracklesham, and most other localities of the London Clay. The tortuous channels made by the borers, are frequently lined or filled up with calcareous spar, of various shades of grey, blue, and amber colour, while the fibrous structure of the wood is of a deep brown, or light fawn; the surface of polished slabs of this fossil wood present, therefore, a beautiful figured appearance from the sections of the sparry tubes.*

LILIACEÆ.—This family of endogenous plants comprises many of the most beautiful species; those with annual stems, as the lily, hyacinth, tulip, &c. are celebrated for the variety and splendour of their blossoms. Some of the arborescent forms, as the tulip-tree, attain a large size; but the flowers of this division are proportionably small. In a fossil state, stems, leaves, fruits, and even the imprints of the flowers, have been discovered. Among these are species related to Sagittaria (arrow-head), Smilax (bind-weed), and Convallaria (lily of the valley). Some liliaceous leaves have been found in the carboniferous strata, and may possibly belong to the same plants as the trigonal fruits we have

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* Slabs of this kind are generally kept by the lapidaries at Bognor, Worthing, &c. and sold at 2*s*. or 2*s*. 6*d*. each.

referred to the palms. A few large stems, approaching in their external characters to the Yucca, or Dracæna, occur in the coal, as previously noticed. The Stonesfield slate has yielded some examples of plants of this family; a beautiful stem from that deposit is figured by Count Sternberg (*Flor. der Vorwelt*, plate 30.). One of the most remarkable liliaceous plants of the British strata was discovered by myself, associated with bones of large reptiles, in Tilgate Forest, nearly thirty years since.* M. Brongniart considers it to be generically distinct from all known recent and fossil plants.

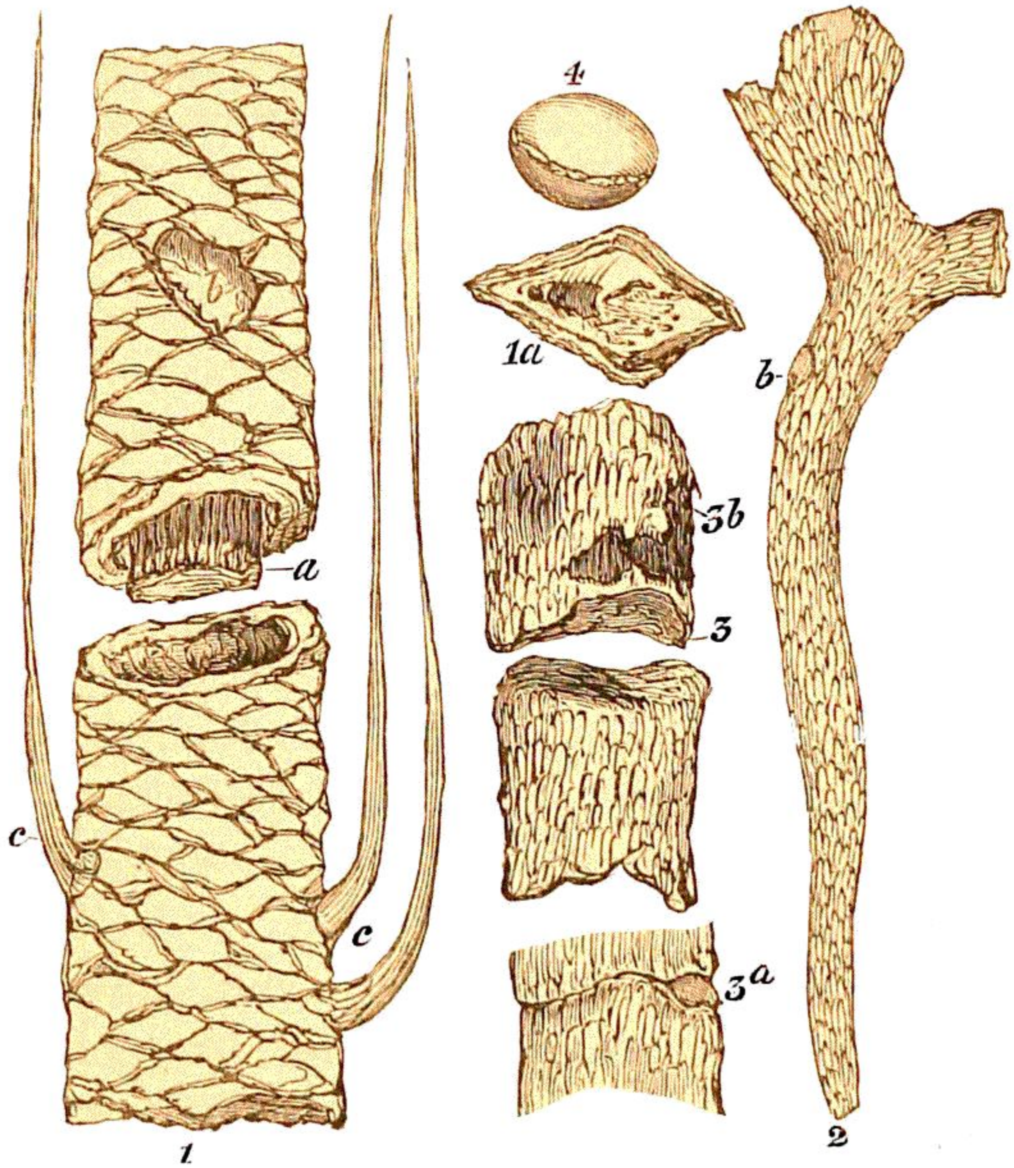
CLATHRARIA (*latticed-stem*).—Stem composed of an axis having the surface covered with reticulated fibres, and of a false bark formed by the union of the consolidated bases of the petioles, whose insertions are rhomboidal and transverse.

Of this plant (which I have named *C. Lyellii*), the trunk, and its axis, roots, leaves, and probably the fruit, have been discovered.† The external surface of the stem is covered with transverse, lozenge-shaped, elevated scars, separated by lateral depressions. In young specimens these scars are arched above, and angular below, and there is much

* It is described and figured in the Fossils of Tilgate Forest, Plates 1, 2, and 3.

† A fine suite of specimens collected by me in Tilgate Forest is now in the British Museum.

irregularity of form, the shape varying from a true rhomboid to an elongated lozenge. The outer por-



LIGN. 44. CLATHRARIA LYELLII. (G. A. M.) *Tilgate Forest.*

Fig. 1.—A stem, with rhomboidal transverse scars, left by the petioles; broken and separated, to show the internal axis at *a*, which, if the pieces were united, would be received in the cavity below. The depression, or cicatrix, on the middle of the upper portion, *b*, was probably the situation of a resinous secretion, like the dragon-blood in the Dracæna: *b*, in fig. 2, shows a similar spot. The outlines, *c c*, point out the form and mode of attachment of the leaves, as shown in some specimens imbedded in stone and clay.

Fig. 1 a.—One of the cicatrices of the petioles, natural size.
2. — An inner axis, showing the branched character of the original. This specimen is three and a half feet long.
3. — Two portions of an internal axis which fit together; the lower is convex at the line of junction, the upper concave; a lateral opening is left when they are united, as shown at 3 a, which indicates a *floral* axis, or pannicle, as seen by the transverse direction of the fibres in the lower piece of fig. 3.
3 b.—The remains of a zone of vascular tissue attached to the internal axis.
4. — A small nut, or fruit (*Carpolithes Mantelli, Ad. Br.*), often found with the stems of the Clathrariæ, and supposed to belong to those plants.

tion of the stem, in adult specimens, will sometimes separate from its central axis, and is then a hollow cylinder of stone (*Foss. Til. For.* pl. 2.) as shown in *Lign.* 44, fig. 1: while the central axis is solid, and has its surface strongly marked with reticulated, interrupted, longitudinal ridges: this surface has generally adherent to it patches of vascular tissue, (*Lign.* 44, 3 b.), but in so friable and confused a state, that numerous microscopical examinations have thrown no satisfactory light upon its structure. Nor has my investigation of polished sections of the stems been more successful; the only trace of organization detected being cellular tissue, filled up with calcareous spar. In the young plants, the internal axis cannot be distinguished from the outer cortical cylinder, and slices of these stems have only shown confused meshes of cells. Fig. 2 represents a branched specimen of the solid axis. On the clay, and grit, in which the stems were imbedded, impressions of the leaves have often come under my notice; they bear considerable resemblance to the foliage of the Yucca. For the instruction of the student, outlines of leaves are given in *Lign.* 44, fig. 1. *c*, *c*, showing their form, and mode of attachment to the scars on the stem.* In one specimen of the inner axis, the stem naturally separates into two portions; the lower one presenting a convexity, over which the fibres from the outer surface pass, and extend towards the opposite side (see *Lign.* 44, fig. 3.); the corresponding articulation is hollow, and fits close upon the convexity, leaving on the side a cavity, shown at fig. 3[a.]: this marks the origin of a blossom, or floral axis, the axis of the pannicle. On some portions of the stems there are deep pits, which so closely resemble those observable in the Dracæna, where the resinous secretion of that plant (called dragon-blood) is collected, that it is probable they had a similar origin. These plants were nearly related to the Dracæna, or rather to Xanthorrea, (a native of New Holland,) the stem of which has the same structure, as to its essential character, and is sometimes dichotomous, or branched, like the Clathrariæ (*Geol. S. E.* p. 233.). Small fruits, resembling the seeds or kernels of some kind of palm, as the Areca, are found with the Clathrariæ (see

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* In perforating the Weald Clay, near Bletchingly, Surrey, for one of the tunnels of the South Eastern Railway, the engineer, Mr. Simms, discovered a stem with leaves, and many bones of a young Iguanodon.

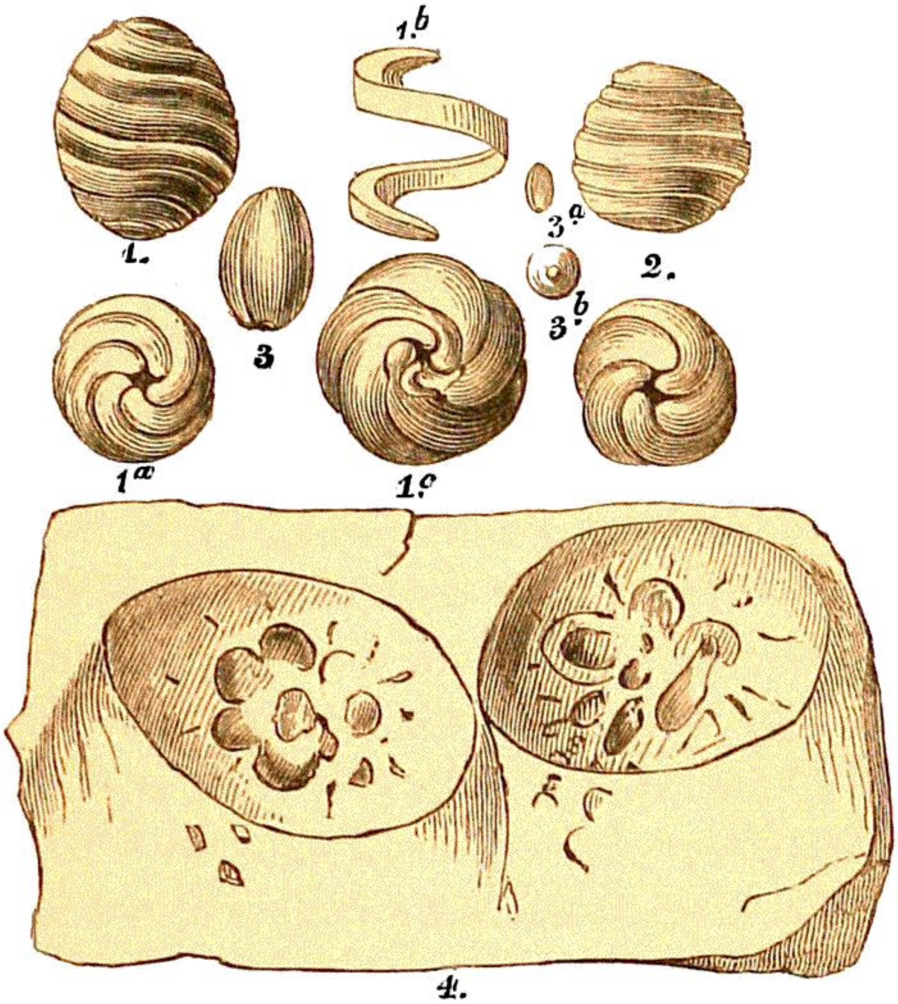
Lign. 44, fig. 4.), and probably belonged to those plants. The remains of the Clathrariæ are generally associated with water-worn bones of reptiles, pebbles, gravel, and other drift, and are often imbedded in the fluviatile conglomerate, which forms so striking a feature in some parts of the Wealden. They appear to have floated down the river with the carcases of the Iguanodon, Hylæosaurus, &c., and at length to have sunk to the bottom, and become imbedded in the silt, sand, and gravel deposited by its waters (see *Geol. S. E.* p. 331.).

The stems of large plants, marked with interrupted annular ridges, indicating amplexicaul leaves, have been found by Mr. Bensted, in the Kentish rag, of his quarry; these are still more nearly related to the Yucca, or Dracæna, than are the Clathrariæ. They are imbedded with the drifted coniferous wood, previously noticed; and being associated with bones of an Iguanodon, may be considered as belonging to the Flora of the Wealden.

FRESH-WATER PLANTS. — The tertiary fresh-water formations often contain abundance of the fossilized aquatic plants, which inhabited the lakes or rivers from whence these deposits were derived; the remains of several species of our common lacustrine plant, the *Chara*, are found in immense quantities in some of the fresh-water limestones and marls of the Isle of Wight, the coast of Hampshire, and of the Paris basin. The shell-marls, still in progress of formation in the lakes of Scotland, in like manner are imbedding the recent species (*Ly.* I. p. 68.); and the travertines precipitated by thermal springs, effect a similar operation.

CHARA. — This common, but very interesting plant, is well known as the inhabitant of every lake, stream, and rivulet in the kingdom. The stems are hollow, and composed of tubes filled with a fluid in which green globules circulate; they form beautiful objects for exhibiting the circulation in vegetable structures. Their fruit consists of minute nuclei, with an external calcareous covering, composed of five spirally twisted plates, which unite at the summit (*Lign.* 45, figs. 1, 2.). These seed-vessels, when first discovered in a fossil state, were supposed to be shells of some unknown mollusca, and a genus was formed for their reception with the name of *Gyrogonites* (*twisted-stones*); a circumstance necessary for the student to bear in mind, as the term is still often employed by geological writers, although the true nature of these bodies is well-known. In Plate III. fig. 5, a branch of the common Chara is represented, with seeds: and figures of the seed-vessels of two fossil species are subjoined (*Lign.* 45, figs. 1, 2.).

NYMPHEA.—Those magnificent aquatic plants, the water-lilies, which adorn our rivers and lakes, with flowers and foliage partaking more of the character of an exotic Flora than any other of our indigenous



LIGN. 45. FOSSIL FRESHWATER PLANTS.

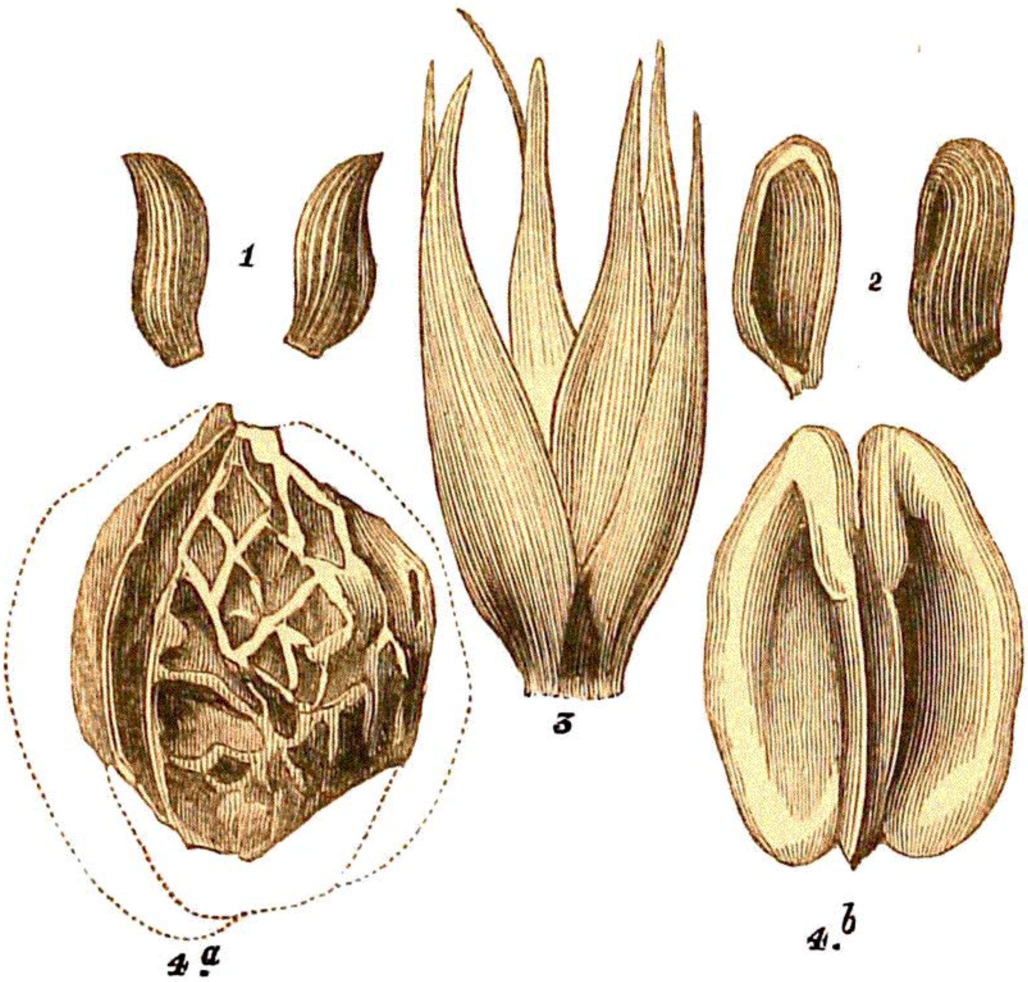
Paris tertiary strata.

Fig. 1.—Seed-vessel of *Chara helicteres* × 10. Side view.
1a.—View of the base of the same.
1b.—One of the spiral valves separated.
1c.—View from above.
2.—Seed-vessel of *Chara medicaginula* × 10. The upper figure is a side view; the lower, a view of the base.
3.—*Carpolithes ovulum*, magnified side view.
3a.—The same, natural size.
3b.—Magnified view of the base of the same.
4.—A piece of fresh-water limestone, with impressions of two stems of *Nymphea arethusa* ×.

plants, are also found in the lacustrine marls and limestones of the tertiary formations of France. But the nature of these remains could only be discovered by a profound botanist, since they consist of the impressions of the internal structure of the stems. The organization is, however, so peculiar, that no reasonable doubt of their origin can be entertained, and I figure two imprints (magnified) from a piece of limestone from Lonjumeau (*Lign.* 45, fig. 4.), presented to me by M. Brongniart. Some minute seed-vessels (*Lign.* 45, fig. 3.) found with these impressions, so closely resemble those of Nympheæ, that there is reason to believe they belong to the same plants (*Class. Vég. Foss.* p. 72.).

Fossil Flowers.—The tertiary limestone of Monte Bolca (*Wond.* p. 251.), so rich in fishes, and other remains of great interest, contains leaves, and even flowers, of liliaceous plants. The specimen figured (*Lign.* 45, fig. 3.) is in the Museum at Paris, and described by M. Brongniart by the name of *Antholithes* (stone-flower) *liliacea;* it consists of the corolla and calyx: the anthers and pistils have not been observed in any example. This specimen may suggest to the collector diligent search for such objects in the tertiary strata of England.

Flowering Dicotyledons.—The fossil remains of dicotyledonous trees and plants, which constitute the grand feature of the existing Flora, next come under consideration; and although our survey of fossil vegetables has partaken more of a botanical than geological arrangement, yet the reader cannot fail to have observed how large a proportion of the



LIGN. 46. FOSSIL NUTS AND FLOWER.

Fig. 1.—*Thalictroides Parisensis:* tertiary strata, Paris.
2.—*Thalictroides Websteri.* Isle of Wight.
3.—*Antholithes liliacea.* Monte Bolca.
4.—*Juglans nux-taurinensis:* fossil walnut, from Turin.
4a.—Portion of the husk of the shell.
4b.—The kernel, formed of calcareous spar.

cryptogamous and endogenous classes, were found in the secondary formations; namely, in the carboniferous, saliferous, oolitic, and cretaceous deposits.

A striking contrast will be presented in the geological position of the mineralized dicotyledons, of existing genera and species. These abound in the tertiary strata, and generally in an inverse ratio to the antiquity of the deposit; while their remains, if we exclude the Coniferæ and Sigillariæ, are rare in the older rocks. Nor have there been discovered in the tertiary, immense accumulations of vascular cryptogamia, as in the carboniferous formations; and we may seek in vain among the secondary, for such beds of fossil dicotyledonous plants as exist in many of the newer tertiary strata.

One of the most remarkable examples of foliage of this class in the older secondary deposits, is a leaf found in the New Red sandstone, near Liverpool. It much resembles the leaf of a thick ribbed cabbage.*

We have already mentioned, that in strata of this epoch, several stems, with leaves, flowers, and fruit of a peculiar genus of Coniferæ, have been found near Strasburgh.

It would be impossible, within the limits assigned to this work, to offer even a general view of the fossil remains of this grand class of vegetables, and it must suffice to point out a few interesting localities and examples. When stems of dicotyledons

* This fossil is named Dictyophyllum crassinervium by Dr. Lindley, Foss. Flor. pl. 201.; and is figured in Mr. Murchison's splendid work, Sil. Syst. p. 43.

only are found, but little certainty can be obtained as to the family to which they belonged; the leaves of many well-known genera offer more certain characters; the flowers are rarely in a state of preservation to afford any valuable data; but the fruits, or seed-vessels, which are frequently well preserved, may enable the botanist to arrive at precise determinations as to generic, if not specific, relations.

The lignite, or brown coal, as we have before stated, is almost entirely composed of dicotyledonous trees, of genera, and of many species, which are still inhabitants of Europe; namely, poplar, willow, elm, chestnut, walnut, sycamore, maple, linden, buckthorn, &c. (See *Bd.* Vol. I. pp. 508—514.).

The tertiary marls of Aix, in Provence, which abound in lacustrine shells, crustacea, and insects, also contain leaves of the cinnamon, and other dicotyledons. (*Wond.* p. 245.).

The deposits of brown coal, on the banks of the Rhine, are literally the carbonized remains of forests, which in some very remote period, were drifted from the interior of the continent into a vast lake or gulf. The trees bear evident marks of transport, and are destitute of roots and branches. The entire mass resembles those rafts of forest-trees, which are daily seen floating down the Mississippi into the Atlantic, where they become engulfed in its profound depths, and probably will be converted into coal or lignite. In future ages, they may be elevated above the waters, become dry land, and contribute to the wants and luxuries of future races of mankind.

The celebrated lacustrine strata of Œningen, of which we shall treat hereafter, contain numerous interesting remains of this class. (*Bd.* pp. 511—514.)

Leaves.—The foliage of dicotyledonous trees are of frequent occurrence, in the tertiary marls and limestones; and in some localities are found in considerable abundance, and in a good state of preservation. Near Bournemouth, on the Hampshire coast, several species are to be met with in a fissile marl, the substance of the leaves being carbonaceous; some of them belong to the *Lauraceæ* and *Amentaceæ*, others to the *Characeæ*.* Some specimens (presented to me by Miss Wollaston) resemble the leaves of *Nerium oleander*.

The red marl associated with lignite at Castle Hill, Newhaven (*Geol. S. E.* p. 54.), contains leaves of a similar kind; a seed-vessel of some coniferous tree has also been found therein.

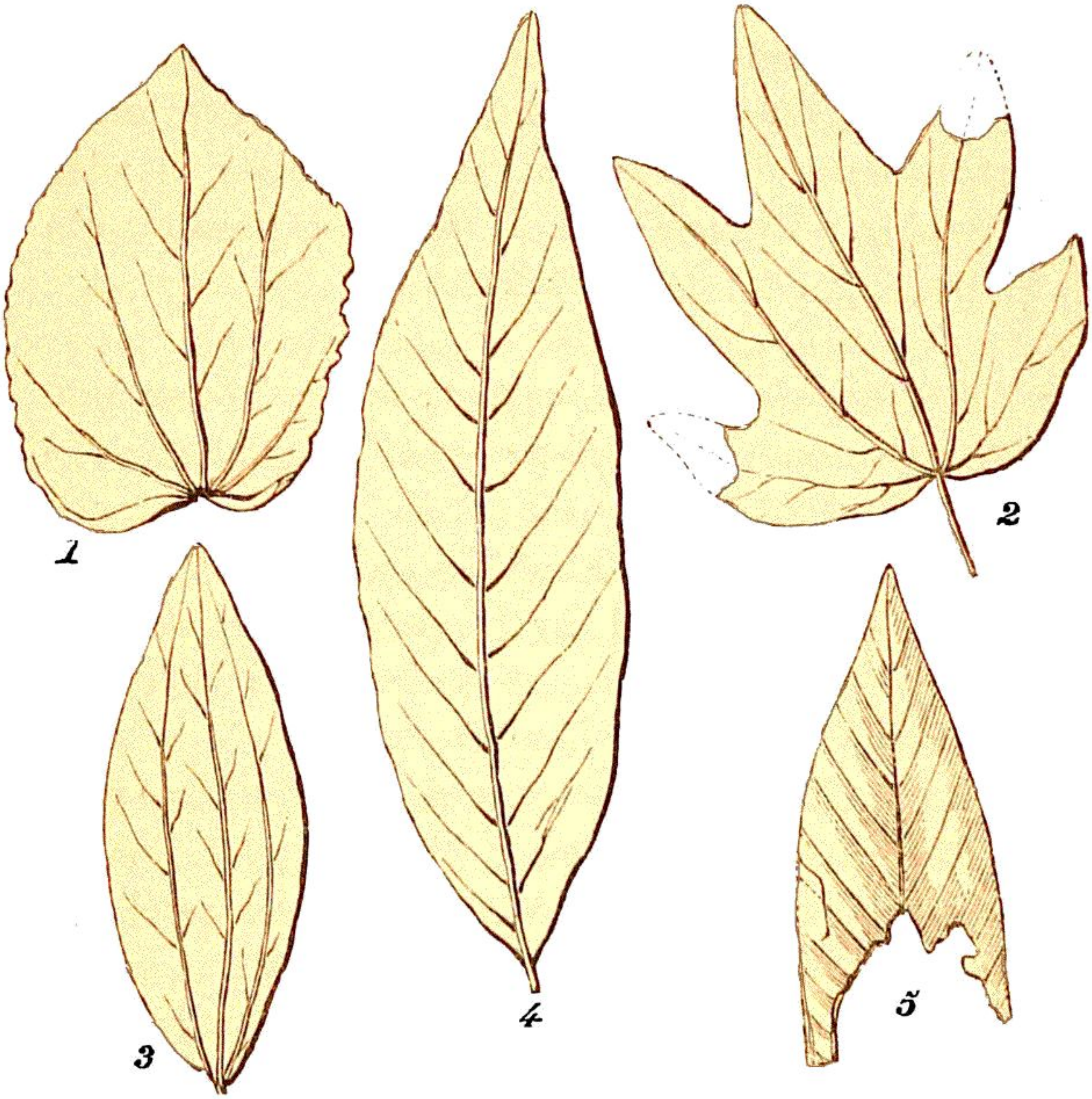
Some of the most interesting examples that have come under my notice, were collected from the sub-Apennine tertiary strata, at Stradella, near Pavia. These leaves belong to several genera of arborescent, or at least ligneous dicotyledons, and most of them

* Rev. J. Brodie. Geol. Proc. III. p. 592.

to species which still grow in Italy. In some examples the substance of the leaves is changed into carbon, and the structure well preserved; but, in general, sharp imprints on the stone are the only traces of the originals. They are found in a gypseous marl, of a cream colour; and, from their perfect state, it is inferred that they were enveloped in the soft matrix immediately after their fall, and were preserved by the rapid crystallization of the gypsum.

Two specimens from my cabinet are figured in Plate III. figs. 4 and 8; and outlines of a few other examples, in *Lign.* 47.

FRUITS.—In my notice of the fossil fruits from the Isle of Sheppey, several kinds of dicotyledons were enumerated. Many species also abound in the lignites of Germany, France, and Italy; in those near Frankfort, seed-vessels of the maple, elm, hornbeam, birch, willow, and walnut, &c. In the environs of Turin, fossil fruits of a species of *Juglans* (*Lign.* 46.) are found in the newer tertiary deposits, and are called Turin-nuts. The ligneous envelope has perished, but the form of its surface, and of the enclosed kernel, are preserved in calcareous stone. These nuts differ, both in the pericarp and in the kernel, from the living species: the lobes are simple (*Lign.* 46, fig. $4^{b.}$), and not subdivided as in the common walnut. Another species has been found at Lons-le-Saulnier, which has mammillated lobes.



LIGN. 47. DICOTYLEDONOUS LEAVES IN GYPSEOUS MARL,
From Stradella, near Pavia.

Fig. 1.—Leaf of Poplar (*Populus græca*).
2.—Maple (*Acer*).
3.—Water-spike (*Potamogeton*).
4.—Willow (*Salix*).
5.—Chestnut (*Æsculus*).

Two species of fruits belonging to plants of the order *Ranunculaceæ*, and related to *Thalictrum* (*meadow-rue*), have been found, one in the Paris basin, (meulière du terrain d'eau douce supériéur,) by M. Alexandre Brongniart, and the other in the Isle of Wight, by Mr. Webster. This last specimen has the pericarp carbonized, and its cavity is filled with clay. Figures of both these seed-vessels are given (*Lign.* 46, figs. 1, 2.).

Carpolithes Smithiæ (G. A. M.). The nature of a remarkable fruit, of which an imperfect specimen, found by me in the chalk near Lewes, and described in the Fossils of the South Downs, has lately been elucidated by an interesting example from the Kentish chalk, collected by Mrs. Smith, of Tunbridge Wells.* These fruits are of an oval form, and flattened by compression. They are of a rich brown colour, mottled with white, from the chalk having permeated their substance, and are studded over with slight eminences, which prove to be the terminations of oblong flattened seeds. Although the internal structure is not preserved, there can be no doubt that the originals were spurious compound berries, having, like the mulberry, the seeds imbedded in a soft pulpy mass.

DICOTYLEDONOUS STEMS.—The occurrence of the trunks and stems of dicotyledons, in a carbonized

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* This interesting fossil is in the choice and extensive collection of Mrs. Smith, and is figured and described in a Memoir by the Author, Geol. Proc. Jan. 1843.

state, has already been described. Like the monocotyledonous and coniferous trees, they are also found silicified in many localities. The most beautiful specimens I have seen are from the Lybian and Egyptian deserts, and were collected by my friend, Colonel Head. In these the most delicate vascular tissue is permeated by chalcedony and jasper, and some of the vessels are injected with silex of a bright vermilion, and blue colour, traversing the cellular structure which is of a rich yellow. Fragments of these silicified trees are scattered everywhere among the sands of the desert; but the most interesting locality is a sterile, irregular plateau, which reposes on marine limestone, considerably above the level of the Nile, about seven miles east by south from Cairo. This district is called the *petrified forest*, from the immense quantities of silicified trees with which it is covered. Many of the trunks are scattered over the surface, among rolled and angular fragments of dark grit, and pebbles of jasper, chert, and quartz. The large trunks occur in greatest numbers on dark-coloured knolls, where they lie, like the broken stems of a prostrate forest, crossing each other at various angles. Two of the largest measured forty-eight, and sixty feet in length, and two and a half, and three feet in diameter at the base. With but two or three exceptions, all the specimens examined microscopically, possess dicotyledonous structure. No traces of seed-vessels or leaves have been detected.* The situation and condition of these silicified trees, indicate great changes in the relative position of the land and sea in that part of Egypt; the trees must have grown on the dry land formed by the elevated bed of a former ocean; this must have been submerged, and covered by beds of sand and rolled pebbles; and, lastly, the whole series of deposits were raised to their present situation, the retiring waters having removed the loose portion of the once continuous strata that were last formed, and dispersed them, with fragments of the petrified trees, over the surface of the Egyptian and Lybian deserts.†

RETROSPECT.

Our limits do not admit of a more extended notice of fossil vegetables; but the preceding survey will afford the student a general view of the subject. Above six hundred species of plants have been discovered in the British strata, according to the recent catalogue of Mr. Morris;‡ among which there are

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* On the Geology of Egypt, by Lieut. Newbold, F.R.S. Geol. Proc. III. p. 782.

† Ibid.

‡ A Catalogue of British Fossils, by John Morris, Esq. F.G.S. 1 vol. 8vo. 1843.

two species of *Poa*, a common tribe of grasses, from Coalbrook Dale, and these are almost the only known examples of any of the *gramineæ* in the ancient fossil Flora.

From this survey of the mineralized remains of the vegetable kingdom, it will be perceived that, from the most ancient fossiliferous deposits, to those which are contemporaneous with man—from the ancient coal-measures to the modern peat-morasses—vegetable matter occurs in all the various states of carbonization; petrifaction, or transmutation into stone, from the infiltration of earthy or metallic substances, being an accidental change, dependent on the character of the deposit in which the remains were imbedded, modified by the nature of the original plants.

Although the complete system of organic life in the vegetable kingdom of the ancient periods of our globe, is not revealed by the fossil remains hitherto discovered, for numerous families may have existed of which no traces have been detected, and if of delicate organization none may be preserved, yet some interesting generalizations are presented for our consideration. And although conclusions of this kind must be regarded in the nature of shifting hypotheses, which may require to be modified with the progress of discovery, yet the characters of the Floras of certain formations, differ in so striking a manner from those of other groups of strata, that it is not probable their essential features will be materially affected. From the data hitherto obtained, the most eminent botanists (Count Sternberg, M. Brongniart, Dr. Lindley, &c.), consider that the Floras of the ancient world constitute three distinct epochs or eras.

The first comprehends the earliest strata in which traces of vegetation appear, and includes the Carboniferous. The plants of this epoch, as we have already shown, consist of fuci, and other cellular tribes; ferns, of various kinds, in great abundance; coniferous trees, related to species of warm climates; of palms, and other monocotyledons; gigantic lycopodia, and trees (*Sigillariæ*) in great abundance, whose precise relations to known forms are not accurately determined. In this Flora the tree-ferns predominate, constituting nearly two-thirds of the whole known species; and the general type of the vegetation is analogous to that of the Islands and Archipelagos of intertropical climates.

The second epoch extends from the New Red, or Saliferous Strata, to the Chalk inclusive, and is characterised by the appearance of many species of Cycadeæ, Zamiæ, and other Coniferæ; while the proportion of ferns is much less than in the preceding period, and the Lycopodiaceous tribes, Calamites, &c. of the carboniferous strata, are absent. A Flora of this nature is analogous to that of the coasts and maritime districts, of New Holland and the Cape of Good Hope.

The third epoch is that of the Tertiary, in which dicotyledonous tribes appear in great numbers; the Cycadeæ are very rare; the ferns in diminished numbers; and the Coniferæ more numerous. Palms, and other intertropical forms, are found associated with the existing European forest-trees, as the elm, ash, willow, poplar, &c. presenting, in short, the general features of our continental Floras.

But we must not omit to notice a remarkable feature in the Floras of the secondary strata, namely, the almost entire absence of the *gramineæ*, or grasses, which form so large a proportion of existing plants. It has been suggested, that the greater or lesser durability of the foliage of certain vegetables, may have occasioned their presence or absence in the carboniferous deposits, and experiments have been instituted with the view of determining this question. But although it was found that, when the foliage of various families of plants was subjected to long maceration, the leaves of dicotyledons and grasses disappeared, while the ferns and Cycadeæ remained, yet this experiment does not meet the exigencies of the case. We have no evidence to show that the fossil leaves were ever placed in similar conditions; on the contrary, there is reason to conclude that they were imbedded under circumstances that arrested the usual progress of decomposition, prevented the escape of the hydrogen and other gaseous elements, and gave rise to the bituminous fermentation by which they were converted into lignite and coal; and we have no proof that, had grasses been associated with the ferns, they would not have undergone a similar change. We have, in fact, at the present time, countries in which the ferns assume the numerical proportion of the grasses of other latitudes; for example, New Zealand, which also presents in its fauna a striking analogy to that of the carboniferous deposits, in the extreme scarcity of indigenous mammalia.

A late writer has the following remarks on this subject:—"Although in its Flora, New Zealand has some relationship with the two large continents between which it is situated, America and Australia, and even possesses some species identical with those of Europe, without the latter being referable to an introduction by Europeans, yet the greater number of species, and even genera, are peculiar to the country. New Zealand, with the adjacent islands, Chatham, Auckland, and Macquarrie, form a botanical centre. It is sufficiently distant from both continents to preserve its botanical peculiarities, and it offers, in that respect, the most striking instance of an acknowledged fact in all branches of natural history, viz. that the different regions of the globe are endowed with peculiar forms of animal and vegetable life. The number of species of plants at present known is 632, of which 314 are dicotyledonous, and the rest, or 318, are monocotyledonous, and cellular. The number of monocotyledonous is very small in comparison with the cellular; there are seventy-six species. The *grasses have given way to ferns*, for the ferns and fern-like plants are the most numerous in New Zealand, and cover immense districts. They *replace the gramineæ, or grasses, of other countries*, and give a character to all the open land of the hills and plains. Some of the arborescent species grow to thirty feet and more in height, and the variety and elegance of their forms, from the minutest species to the giants of their kind, are most remarkable."*

In the accumulations of vegetable matter now in the progress of formation in the morasses, and bays, and creeks of New Zealand, the remains of ferns largely predominate; and I am informed by my son,† that in the estuaries they are associated with shells of the genera terebratula and trigonia.

ON COLLECTING BRITISH FOSSIL VEGETABLES.

From what has been advanced, the student will have anticipated, that to obtain an illustrative collection of the fossil vegetables of Great Britain, different localities must be visited. The fruits, and stems of the palms, Coniferæ, and many species of

* Dr. Dieffenbach's New Zealand.

† Mr. Walter Mantell, of Wellington, New Zealand.

dicotyledons, may be collected in the Isle of Sheppey, and other places where the London Clay is exposed. (See *Excursion to the Isle of Sheppey*, Part III.) Cycadeous stems and coniferous wood may be procured in the Isle of Portland; and the foliage of several species of Zamiæ and ferns, in the carbonaceous deposits of the Oolite, on the Yorkshire coast, near Scarborough, and at Gristhorpe Bay. The Lias near Lyme Regis, Charmouth, and their vicinity, affords stems and branches of coniferous trees, and leaves of Cycadeæ. Ferns, Sigillariæ, Calamites, and the usual species of the carboniferous Flora, may be found in every coal-mine. Fuci, particularly a branched species, Fucoides Targionii (see vignette of the title-page), occur abundantly in the firestone, or upper green sand, at the foot of the chalk-downs, near Bignor, in Sussex; and sometimes in chalk flints.

A list of a few of the most remarkable British localities is subjoined. In addition to the suggestions already given as to the mode of collecting specimens of fossil plants, it may be necessary to state that the dicotyledonous leaves in the tertiary marls and clays, are generally very delicate and friable, and liable to flake off from the stone in the state of a carbonaceous film. This may, in a great measure, be prevented by carefully covering them with a thin coating of mastic varnish, before they are placed in the drawers of the cabinet. In extracting these specimens, a broad chisel will be found the most convenient instrument. In searching for fossils in coal-mines, the collector must remember that the nodules of ironstone often contain very beautiful examples of the leaves of ferns, and fruits of the Lepidodendra. These nodules, when of an oblong shape, as *Lign.* 3, fig. 1, should be split open in a longitudinal direction, with a smart blow of the hammer, and the enclosed leaf will thus be exposed as in *Lign* 3, figs. 2, 3, p. 81.

LIST OF A FEW BRITISH LOCALITIES OF VEGETABLE FOSSILS.

Allenbank, Berwickshire	*Carb.*	Stems of Coniferæ, &c.
Alum Bay, Isle of Wight	*Tert.*	Fruit, leaves, lignite, Charæ, stems, and seed-vessels.
Ashby-de-la-Zouch, Leicestershire	*Carb.*	Coal plants in great abundance.
Bignor, Sussex	*Cret.* *Firestone*	Fuci.
Binstead, Isle of Wight	*Tert.*	Charæ, stems and seed-vessels.
Blackdown, Devon	*Gr. Sand*	Silicified wood—coniferous.
Bognor, Sussex	*Tert.*	Coniferous and monocotyledonous wood; washed up on the shore.
Bolton, Lancashire	*Carb.*	Lepidodendra, Sigillariæ, &c.

Bournemouth, Hants. . . .	*Tert.* . .	Dicotyledonous leaves.
Brook-point, Isle of Wight.	*Wealden*	Cycadeæ, and coniferous wood.
Calbourn, Isle of Wight . .	*Tert.* . .	Charæ, stems and fruits.
Camerton, near Bath . . .	*Carb.* . .	Usual plants of the coal.
Charmouth, Dorset	*Oolite* . .	Coniferous wood, Cycadeæ, fruit of Pandanus.
Clifton, near Manchester .	*Carb.* . .	Coal plants in great perfection.
CoalbrookDale, Shropshire.	*Carb.* . .	Usual plants of the coal, in abundance.
Cuckfield, Sussex	*Wealden.*	Clathrariæ, Endogenites, ferns, and lignite.
Faversham, Kent	*Gr. Sand.*	Fruits of Zamiæ.
Folkstone, Kent	*Galt* . . .	Coniferous wood—bituminous and pyritified.
Glasgow	*Carb.* . .	Coal plants and large trunks of Coniferæ.
Hastings, Sussex	*Wealden.*	Clathrariæ, Endogenites, ferns.
Herne Bay, Kent	*London Clay* . .	Fruits of Coniferæ, and palms: wood.
Kilkenny, Ireland	*Carb.* . . .	Calamites, ferns, &c.
Liverpool	*New Red.*	Fuci.
Lyme Regis, Dorset	*Lias* . . .	Cycadeæ, Coniferæ, &c.
Maidstone, Kent	*Shanklin Sand* . .	Fruits and wood of Abies, Pinus, Dracæna; fuci.
Malton	*Oolite* . .	Fruits, and Cycadeæ.

Newcastle (Jarrow Colliery)	*Carb.*	Coal plants in great variety.*
Newhaven (Castle Hill), Sussex	*Tert.*	Dicotyledonous leaves and fruit—*rarely*.
Portishead (on the shore)	*Millstone Grit*	Sigillariæ, Stigmariæ, &c.
Portland, Isle of	*Wealden.*	Petrified forest of Coniferæ, with Cycadeæ.
Pounceford, Sussex	*Wealden.*	Equiseta, ferns, lignite.
Scarborough	*Oolite*	Ferns, Cycadeæ, Equiseta, &c.
Selmeston, Sussex	*Shanklin Sand*	Coniferous wood, fruits of Zamiæ.
Sheppey, Isle of	*London Clay*	Fruits innumerable, wood, &c.
Stonesfield, Oxfordshire	*Oolite*	Fuci, Cycadeæ, Thuyites, fruits of palms, and Zamiæ, &c.
Swindon, Wilts	*Oolite*	Coniferous wood.
Tunbridge Wells (vicinity)	*Wealden.*	Ferns, several species.

The above list must, of course, be considered merely as suggestive.

* In collecting *Stigmariæ*, the student should particularly direct his attention to the relation existing between these fossils and their supposed stems, the *Sigillariæ;* for although the interesting discovery mentioned in page 143, if accurately described, leaves no doubt on the subject, yet the mode in which the radicles of the Stigmariæ are articulated to the main branches, and the regularity of their distribution, are characters not observable in the roots of other trees, and render the acquisition of additional evidence highly desirable.

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PART II.

PALÆONTOLOGY,

OR

THE FOSSIL REMAINS

OF THE

ANIMAL KINGDOM.

PALÆONTOLOGY,*

OR

FOSSIL ZOOLOGY.

"The very ground on which we tread, and the mountains which surround us, may be regarded as vast tumuli, in which the organic remains of a former world are enshrined."—*Parkinson's Org. Rem.* Vol. I.

THE recent species of the Animal Kingdom exceed one hundred thousand, while those known in a fossil state scarcely amount to ten thousand; yet the latter comprise examples of most of the classes and families, and many of the genera and species, of the beings which still inhabit the lands and waters of our planet. Although our notice of these remains must necessarily be limited to a general survey, we shall describe somewhat in detail the fossils that possess the greatest interest, and also those, which, from their extended distribution, will often be presented to the observation of the student in the course of his personal researches.

* PALÆONTOLOGY—*a discourse on ancient beings.*

Our examination will commence with the minutest animal organisms, and proceed in an ascending order, in accordance with the usual zoological classification; but it will be expedient, as in the botanical section, to comprehend occasionally, under the same head, species and genera of different families, or classes, that may be associated together in particular deposits or localities.

In the preliminary remarks on the nature of Organic Remains (p. 54), the various conditions in which the relics of animals are preserved in the strata, were considered. We may, therefore, at once enter upon the investigation of the specimens selected for the illustration of the subject, from the innumerable relics of the ancient inhabitants of the sea and land, entombed in the solid crust of the earth—the remains of the countless tribes of beings, which have successively appeared on the surface of our planet, flourished for indefinite periods, and then vanished, and been succeeded by other types of organization.

The fossil Animal Kingdom will be considered under the following sections:—

I. INFUSORIA, or Animalcules.

This section will embrace, not only the remains of the animalcules (*little animals*), which, from the constant presence of many genera in vegetable infusions, have received the name of *Infusoria;* but also the relics of other minute beings associated with them, and which cannot be successfully investigated without the aid of the microscope. Some organisms will, therefore, be included in this section, which belong to higher orders than those described in subsequent chapters.

II. ZOOPHYTES; including—

1. AMORPHOZOA (*animals of irregular forms*).—These structures present the most simple condition of animal life; as the *Sponges*.
2. POLYPIARIA, or Coral Animals.

III. ECHINODERMA (*animals with a spiny skin*).—Comprising—

1. CRINOIDEA, or Lily-shaped animals.
2. ASTERIA, or Star-fishes.
3. ECHINIDA, or Sea-urchins.

IV. MOLLUSCA (*animals with soft bodies.*)—Under this head the fossil shells will be considered.

1. BIVALVES; the *Brachiopoda* and *Lamellibranchia.*
2. UNIVALVES; the *Gasteropoda.*
3. CHAMBERED SHELLS; the *Cephalopoda*, including the testaceous genera, and those which are destitute of shells, as the *Sepiadæ*, or Cuttle-fish.

V. ARTICULATA, (*having external jointed cases or skeletons*).—Comprising—

1. CIRRIPEDIA; as the *Barnacle.*
2. ANNELATA, or Red-blooded Worms.
3. INSECTA, or Insects; and *Arachnida*, or Spiders.
4. CRUSTACEA (*having a crustaceous skin*), as Crabs and Lobsters.

VI. PISCES, or Fishes.

VII. REPTILIA, or Reptiles.

VIII. AVES, or Birds.

IX. MAMMALIA (*animals giving suck*).*

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* See Appendix for a tabular view of the binary zoological arrangement of Professor Owen, which is the best classification hitherto proposed.

CHAPTER VII.

FOSSIL ANIMALCULES; INCLUDING THE INFUSORIA, POLYTHALAMIA,* AND FORAMINIFERA.

"Where is the dust that has not been alive?"
YOUNG.

"In the leaves of every forest, in the flowers of every garden, in the waters of every rivulet, there are worlds teeming with life, and numberless as are the glories of the firmament."
DR. CHALMERS.

THAT those infinitesimal forms of existence, whose presence in our lakes, rivers, and streams, can only be made manifest by the aid of the microscope, should be detected in a fossil state, and that their aggregated skeletons should be found to constitute chains of hills, and the subsoil of extensive districts, and that the most stupendous monuments erected by man, should be composed of rocks resulting from the mineralized remains of animalcules, invisible to the unassisted eye, are among the most marvellous of the wonders of Geology.

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* *Polythalamia*, *i.e.* shells having many chambers or cells.

I have noticed in my former work (*Wond.* pp. 565 and 801.), the discovery of infusoria in flint, opal, chalk, and many other rocks, by that eminent observer, M. Ehrenberg. This interesting field of research has since been explored by other naturalists, and in every part of the world the Tertiary, Cretaceous, and other secondary deposits, have been found to contain microscopic fossil bodies in profusion. At present this branch of palæontology is in its infancy, and it offers to the young student an inexhaustible and most inviting department of scientific investigation. It possesses, too, this great advantage over many other subjects, that it is within the reach of every one, for it can be pursued at home, and the materials for investigation are everywhere at hand. Unlike my explorations in Tilgate Forest, in which a few fragments of bones, or teeth, scattered at wide intervals in the rocks, and in localities many miles apart, were often the only reward of a day's ramble, here in the quiet of my study, I may discover in a few atoms of flint, or grains of chalk, picked up by the road-side, skeletons of beings equally interesting and extraordinary as the colossal Iguanodon, and Hylæosaurus.

Living Infusoria, or Animalcules.—That the reader may have an idea of the forms of the living animals whose mineralized remains we are about to investigate, accurate figures of several recent species allied to those frequently found fossil, are given in

Plate IV. Their forms so entirely depend on their durable cases, or framework, that the latter may easily be recognised, even when the coloured soft parts have entirely disappeared. These shells, or cases, in some families are calcareous, and in others consist of a pure colourless transparent silex or flint. But many have a naked and flexible skin, or epidermis, and these of course are not known as fossils; the loricated (having an armour or shell) animalcules, whose shields are constructed of silex, lime, or iron, alone leave enduring memorials of their existence.

XANTHIDIUM (Plate IV. figs. 1, 2, 3, 4, 5.).—The carapace (case, shield, or shell) of this genus of animalcules, consists of a hollow, siliceous globe, in which the body is contained, beset with tubular spines, that probably contained tentacula; but these have not been observed. Like most of the infusoria, the *Xanthidia* increase by self-division; hence the double appearance in the figures, all of which represent individuals in the progress of separation; they are very stationary animals. Mr. Hamlin Lee has collected several species in the ponds on Clapham Common; and Dr. Bailey (of the Military College, West Point, New York) has sent me recent specimens, which closely resemble a fossil species of our chalk flints.

PYXIDICULUM (Plate IV. fig. 2.).—The carapace is a little saucer-shaped box or case, in which the body is contained; and is invested by a membrane (?). It occurs fossil in flint.

BACILLARIA (Plate IV. fig. 6.).—A simple siliceous shell, of a prismatic shape, forming a brilliant chain, which often appears in zig-zag, in consequence of incomplete self-division: each link is an individual animalcule. An immense number and variety of forms are placed in this family, with a multitude of generic and specific names. The fresh-water species inhabit every pond and lake, and the marine every sea. Fossil species have been found in the Isle of France, Virginia, &c.

COCCONEIS (Plate IV. fig. 7.).—This is a very elegant kind of *Bacillaria*, and consists of a simple or bivalve siliceous carapace, with a central opening; it never occurs in chains like the former. It has been found fossil near Cassel.

NAVICULA (Plate IV. figs. 8, 9, 14, 15.).—This beautiful free animalcule, has bivalve siliceous shields, with six openings; they are never found in chains. Figs. 8 and 9. show a living *Navicula*, viewed in front, and in profile; the spots in the centre indicate the cells of the stomach: in fig. 9, the currents produced when the animal moves through the water are represented. Fossil *Naviculæ* abound in the Tertiary marl of Virginia.

GAILLONELLA (Plate IV. figs. 10, 11.).—These animalcules are free, and their cases bivalve, and of a cylindrical, globular, or discoidal form; they occur in chains, in consequence of their self-division being imperfect, and the new individuals remaining attached to the old. The *Gaillonellæ* are among the most abundant and prolific of animal organisms, and are to be found in every pool, stream, and lake: fossil species occur abundantly in the Virginian marl and other strata.

SYNHEDRA (Plate IV. fig. 12.).—The shield is siliceous, and of a slender, elongated form. The animal is attached by the base (fig. 12 *a.*) in youth, and afterwards becomes free. It is found fossil in the Mountain-meal of Santa Fiora, &c.

PODOSPHENIA (Plate IV. fig. 13.).—The carapace is cruciform, or wedge-shaped, and is attached in youth by the small end, but afterwards becomes free. These animalcules are often found arranged in clusters, as in the figure. M. Ehrenberg states that they inhabit the sea, and not fresh-water; but Mr. Lee has discovered specimens in streams communicating with the Thames, so closely resembling the figures of M. Ehrenberg, both in the individual forms, and in the mode of grouping, as evidently to belong to the same genus, if not species. The *Podosphenia* occurs fossil in the polishing slate of Bilin.

EUNOTIA (Plate IV. figs. 16, 17.).—The carapace is siliceous, and either simple or bivalve; flat below, and convex, and often richly dentated above. An empty carapace is shown fig. 16; and a group of living *Eunotiæ* attached to a stem of conferva fig. 17. Several fossil species have been discovered at Santa Fiora.

That the general reader, whose attention is for the first time directed to these inquiries, may be in some measure prepared for the vast accumulation of fossil animalcules which are found in some formations, I subjoin the observation of Dr. Bailey on one species, an elegant fragile animalcule, which hangs in clusters together, appearing like spiral chains, and is about $\frac{1}{20}$ of a line in diameter.

"This fresh-water infusoria (*Meridion vernale*) is seen in immense quantities in the mountain brooks around West Point, the bottoms of which are literally covered in the first warm days of spring with a ferruginous-coloured mucous matter, about a quarter of an inch thick, which, on examination by the microscope, proves to be filled with millions and millions of these exquisitely beautiful siliceous bodies. Every submerged stone, twig, and spear of grass, is enveloped by them; and the waving plume-like appearance of a filamentous body covered in this manner, is often extremely elegant. Alcohol completely dissolves the endochrome (*soft* *colouring matter*) of this species, and the frustrules (shields or cases) are left as colourless as glass, and resist the action of fire."*

The yellow, or ochreous scum observable in ponds, ditches, and stagnant pools, is an aggregation of animalcules, whose shells are ferruginous, and which are of such extreme minuteness, that one cubic inch must contain a billion of their cases or skeletons.

FOSSIL INFUSORIA, OR ANIMALCULITES.—From this notice of a few recent forms of Infusoria, we proceed to the investigation, not only of the fossil remains, which strictly belong to this class, but also of other minute animal organisms with which they are associated, and being invisible to the naked eye, will be conveniently examined under this section. These are the *Polythalamia* (*many-chambered shells*) and the *Foraminifera* (*covered with pores*), the siliceous and calcareous cases of animals bearing a general affinity to the Mollusca (commonly known as shell-fish), of whose fossil relics we shall treat in subsequent chapters.

In peat-bogs and swamps, both of modern and ancient date, masses of a white marly, or siliceous paste (*hydrate of silica*), are often observed, and these are wholly made up of the carapaces of infu-

* Trans. Amer. Assoc. Geolog. 1843, p. 152.

soria, of the genera *Navicula, Bacillaria, Gaillonella*, &c. Many of the peat-bogs of Ireland contain layers of a white earthy substance, which, when dry, is of the appearance and consistence of friable chalk, and this consists of the siliceous cases of animalcules. At Lough Island, Reavey, near Bryansford, not far from Newcastle, an infusorial deposit has been noticed, which is extremely rich in these remains.* In New England and New York, Dr. Bailey has discovered similar deposits in numerous localities; and the pages of that excellent scientific periodical, Silliman's Americal Journal of Science, are enriched with an elaborate account of his successful researches. But many of the tertiary deposits far surpass, in the extent and multiplicity of forms which enter into their composition, any of the modern infusorial strata hitherto examined.

The marine sands of the Paris basin are, in some localities, so full of microscopic forms, that it is calculated a cubic inch of the mass contains sixty thousand *foraminifera* and *infusoria*. The sand from Grignon, near Paris, abounds in these organisms; and, as the shells from that locality are very common, and usually full of debris, the student may readily obtain specimens for examination.

The greenish sand at Bracklesham Bay, on the western coast of Sussex, is rich in foraminifera, and some layers are formed of *Nummulites* (*Wond.*

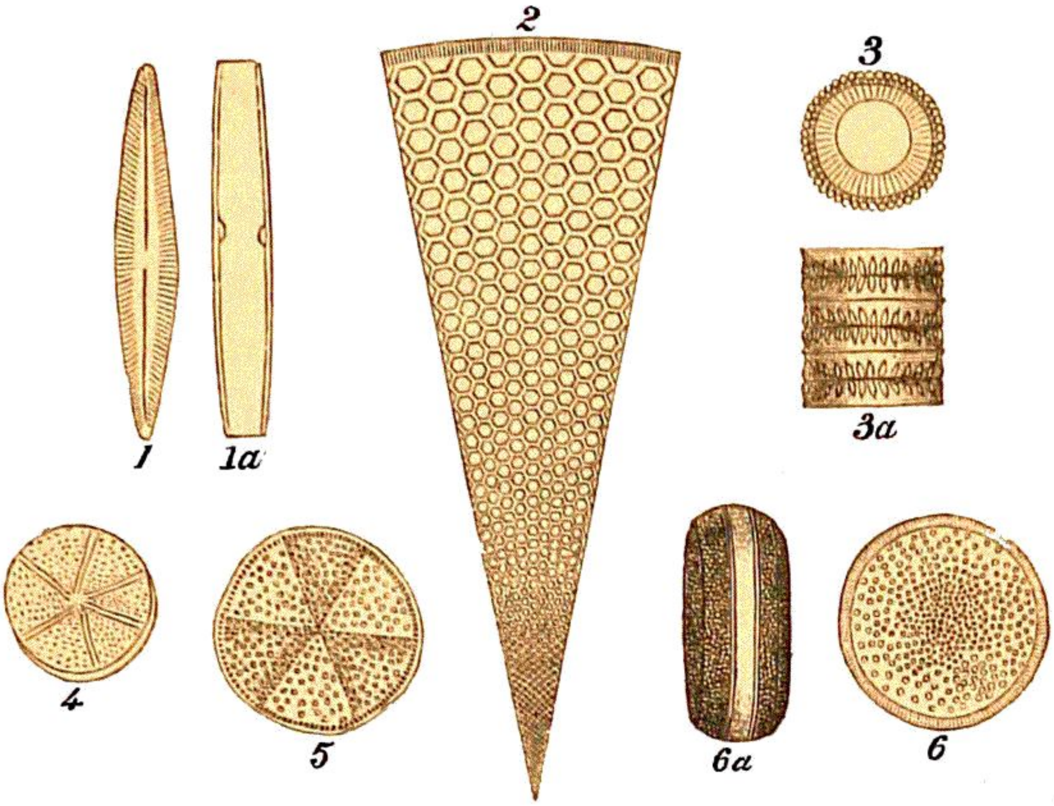
* Dr. Drummond. Mag. Nat. Hist. for 1839, p. 353.

p. 234.), not larger than a grain of sand. In short, the tertiary sands and marls, very generally contain immense numbers of this class of organic remains. But no specimens of the British tertiary that have come under my notice, are at all comparable with those of Germany, and other countries on the continent, and in the United States.

The POLIERSCHIEFER (*polishing-slate*) of Bilin, is stated, by M. Ehrenberg, to form a series of strata fourteen feet in thickness, entirely made up of the siliceous shells of *Gaillonellæ*, of such extreme minuteness, that a cubic inch of the stone contains forty-one thousand millions! The *Berghmehl* (*mountain-meal*, or *fossil farina*) of San Fiora, in Tuscany, is one mass of animalculites. In Lapland a similar earth is found, which, in times of scarcity, is mixed by the inhabitants with the ground bark of trees, for food; some of this earth was found to contain twenty different species of fossil animalcules. In the district of Soos, near Egra, in Bohemia, a fine white infusorial earth occurs, about three feet beneath the surface; this substance, when dried, appears to the naked eye, like pure magnesia, but, under the microscope, is seen to be entirely constituted of an elegant species of infusorial carapace, (named *Campilodiscus*,) of which figures are given, *Lign.* 51, figs. 1, 2.*

* I am indebted to H. Hopley White, Esq. of Clapham, for specimens of this and other infusorial earths from Germany.

INFUSORIAL MARL OF RICHMOND, IN VIRGINIA.— The town of Richmond, in Virginia, is built on strata of siliceous marls of great extent, which



LIGN. 48. ANIMALCULITES OF THE RICHMOND EARTH, VIRGINIA.
Inv. × ×
(*Presented by Dr. Bailey.*)

Fig. 1.—NAVICULA. 1*a*. Side view.
2.—COSCINODISCUS RADIATUS; a portion of the circular shield.
3.—GAILLONELLA SULCATA. The upper figure shows the face of one of the joints or animalculites.
3a. Three of these animalculites united.
4, 5.—ACTINOCYCLUS. Two species.
6.—COSCINODISCUS PATINA. Front and side views.

have a total thickness, beneath and around the town, of more than twenty feet. These marls, whose composition was first detected by Professor

W. B. Rogers, are referred, by that eminent American geologist, to the older tertiary (*eocene*, or *miocene*) formations. They occupy considerable districts, spreading out into sterile tracts, along the flanks of the hills, their siliceous character rendering them unfavourable to vegetation. The investigations of Dr. Bailey have shown that the siliceous skeletons, so abundant in this earth, consist of several species of *Navicula* (*Lign.* 48, fig. 1, 1 *a.*), *Gaillonella* (*Lign.* 48, fig. 3, 3 *a.*), *Actinocyclus* (*Lign.* 48, figs. 4, 5.), &c.

The most remarkable forms are saucer-shaped shells or discs, having their surfaces elaborately ornamented with hexagonal spots disposed in curves, presenting some resemblance to the engine-turned case of a watch. *Lign.* 48, fig. 2, is a small segment of a disc, very highly magnified. These discs vary in size from $\frac{1}{100}$ to $\frac{1}{1000}$ of an inch in diameter: they are named *Coscinodiscus* (*sieve-like disc*), and there are several species: one less richly sculptured, *C. patina*, is figured *Lign.* 48, fig. 6.

Circular bodies, with five or six lines radiating from the centre to the circumference, like the spokes of a wheel, hence named Actinocyclus, (*Lign.* 48, figs. 4, 5.), are also abundant; and spicula of sponges, *Alcyonia*, and probably of *Actiniæ*.

When a few grains of this marl are prepared, and mounted on a glass, almost all these varieties will be manifest, so largely is this earth composed of the skeletons of animalcules; in fact, very few inorganic particles are intermixed with the organisms. The merest pellicle or stain, left by the evaporation of a drop of water in which some of the marl has been mixed, teems with the most beautiful infusorial structures.

At Petersburg, in Virginia, an infusorial sandy marl occurs, interstratified with deposits which, from their shells, are referred to the older tertiary formations. Probably this marl is a continuation of that of Richmond, but it is full of many new forms, associated with those common in the earth of the latter locality. Dr. Bailey has favoured me with specimens which surpass, in the variety, elegance, and interest of their fossil contents, any infusorial deposits I have examined.*

Mr. Edwin Quekett, whose talents and acquirements as a naturalist are of the highest order, has detected in a recent state, attached to some zoophytes preserved in spirits, and brought from Melville Island by Sir Edward Parry, several discs resembling the *Coscinodiscus radiatus*, figured *Lign.* 48. These are in pairs, and there is no doubt that the fossil cases, like the recent, belonged to bivalve infusoria. Gaillonellæ, Pyxidiculæ, Naviculæ, and other forms resembling those of the Richmond earth, were also

* Dr. Bailey, with great liberality, has so amply supplied myself and other observers with specimens of this deposit for examination, that the fossils above described are now familiar to the British microscopists.

found, and a tri-radiate spiculum of a sponge.* Dr. Bailey has also observed two kinds of living Gaillonellæ, which are identical with fossil species. Hence it appears, that in the northern seas of the present day, there exist minute animals precisely similar to those which lived in a much lower latitude, at some very remote period.

The prevalence of marine and fresh-water animalcules in the same deposit is not unusual; and the remarks of Dr. Bailey on this subject are so just and pertinent, that I am induced to insert them, as a salutary caution against hasty generalizations. Dr. Bailey, after describing a species of Gaillonella (*G. moniliformis*), as an inhabitant only of salt and brackish water, and stating that he had also found it sixty miles up the Hudson River, near West Point, observes—"The Fauna and Flora of the Hudson at this place would, if in a fossil state, be rather puzzling to the geologist, on account of the singular mixture of marine and fluviatile species. While *Valisneria* and *Potamogeton* (two common fresh-water plants), grow in such vast quantities, in some places, as to prevent the passage of a boat; and the shore is strewn with fluviatile shells (such as Planorbis, Physa, &c.) in a living state; yet we find the above plants entangled with Algæ (sea-

* Microscopical Journal, Plate XV. contains figures of these objects.

weeds), and marine parasitic zoophytes, and infusoria; while the rocks below low-water mark, are covered with Balani (*barnacles*) and minute corallines, and the marine Flora is represented by vast quantities of very elegant sea plants."*

ANIMALCULITES OF THE CRETACEOUS FORMATION.—It has long been known, that a large proportion of the purest white chalk consists of minute chambered shells, and corals. Mr. Lonsdale, some years since, called attention to the subject, and showed that, by brushing chalk in water, and examining the residuary deposit, *Polythalamia, Foraminifera*, and *Polyparia*, might be obtained in great abundance. But the recent observations of M. Ehrenberg have demonstrated that even these atoms must be considered as colossal; and that each cubic inch of chalk may contain upwards of one million of well-preserved animalculites and shells. The larger species of these fossil bodies may be obtained from the sediment produced by brushing the chalk in cold water; but the entirely microscopic forms continue a long time suspended in the liquid, and can only be procured by a peculiar process, described at the end of this chapter.

Chalk, therefore, must be regarded as an aggregation of exceedingly minute organisms, and of

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* American Journal of Science, Vol. XLI.

inorganic particles. The yellow, soft, writing chalk of the north of Europe, is composed of about half its bulk of fossil bodies; but in the chalk of the south of Europe, the organic remains largely predominate. The inorganic matter of the chalk does not arise from a precipitate of lime previously held in solution in water, but from a disintegration of the assembled microscopic organisms, into more minute calcareous particles, which have been reunited by a crystalloid action, into regular, elliptical, granular laminæ. In like manner it is inferred, that the compact nodules of flint have originated from an aggregation of pulverulent particles of siliceous infusoria. Upon this hypothesis M. Ehrenberg explains the absence of flint nodules, and the abundance of siliceous infusoria, in the beds of marl that alternate with the chalk in the south of Europe; and their presence in the chalk of northern Europe, in which the infusorial marls are wanting. In other words, it is supposed, that in the former case the siliceous shells of the animalcules were deposited in layers or strata; and in the latter were aggregated together in nodular masses. This opinion should, however, be received with much reservation; for, although the animal origin of lime, flint, and iron, must be admitted to a great extent, yet the deposition of flint, and lime, from aqueous solutions is carried on at the present moment upon an enormous scale; and it cannot be doubted that the same process contributed largely to the formation of the nodular layers, dikes, and veins of flint, which prevail in many beds of the chalk, and other formations.

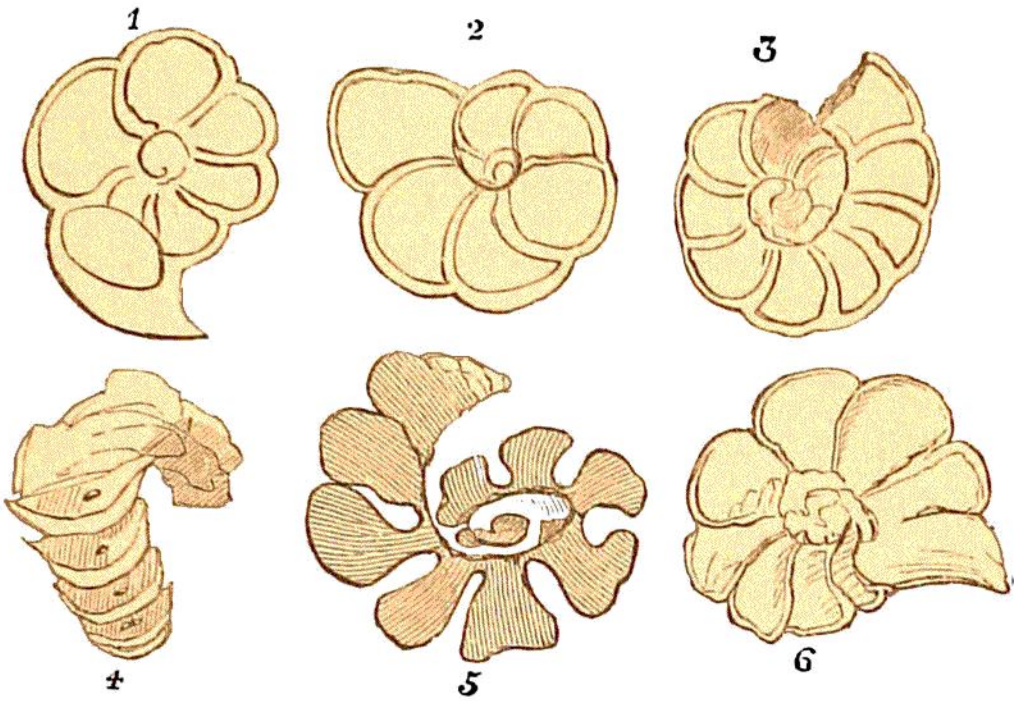
The most abundant microscopic animal forms in the English chalk and flint which I have examined, are two kinds of *Polythalamia*, called *Rotalia*, and *Textularia*. Immense numbers of minute *Foraminifera* also occur, and many shells, which are unquestionably the young of the testaceous Cephalopoda (as the Nautilus, Ammonite, &c.), that prevail in the cretaceous strata. Spines of sponges, and of echinoderms, and the scales and teeth of fishes, also frequently appear in the field of the microscope: and a spongeous structure is so common in flint, that an eminent observer (Mr. Bowerbank) conceives that all the flints, both nodular and tabular, have originated from sponges ;* an hypothesis which is altogether inadmissible. The assertion that the chalk almost wholly consists of organic bodies which can be rendered visible, is likewise to be accepted with some limitation. The assiduous observer who searches for hours the chalk and flint, carefully prepared, and with the aid of an excellent microscope, although he will meet with immense numbers of organisms, will find a far greater proportion of atoms without any traces of structure. Neither is

* See Memoir on the Siliceous bodies in the Chalk, Greensands, and Oolite, by J. S. Bowerbank, Esq. F. R. S. &c. Geol. Trans. Vol. VI. p. 181.

there much variety in the easily recognizable forms of the English chalk (I write from my own limited experience); many of the species described by M. Ehrenberg, and others, are few and far between; and the rest I (and several friends who are expert observers) have not been so fortunate as to detect. These remarks are offered, that the student may not be discouraged, if, after perusing the account of the discoveries of M. Ehrenberg, he should not be more successful than myself. At the same time, it must be remembered, that, as the fossil remains of animals and plants, of large size, are very commonly associated together in particular localities, while in other districts, traversed by similar strata, they are altogether wanting; in like manner, some deposits, as those of Richmond, may be made up of the skeletons of animalcules, while in other spots they may be sparingly distributed, or even entirely absent.

The mode of preparing the chalk for examination, together with such directions for its manipulation as experience has shown to be useful, will be given at the end of this chapter. Many of the larger corals and shells, may be seen on the surface of a piece of chalk recently broken, and viewed by reflected light; always beginning the examination with a low power (two inch object-glass), and ascending to the higher; for flint, the thinnest possible chips, immersed in oil of turpentine, will suffice.

POLYTHALAMIA OF THE CHALK. *Rotalia* and *Textularia*.—The genus *Rotalia* comprises those minute chambered shells which resemble the nautilus in their general contour, but are essentially distinct, for the inner cells are occupied, in a recent

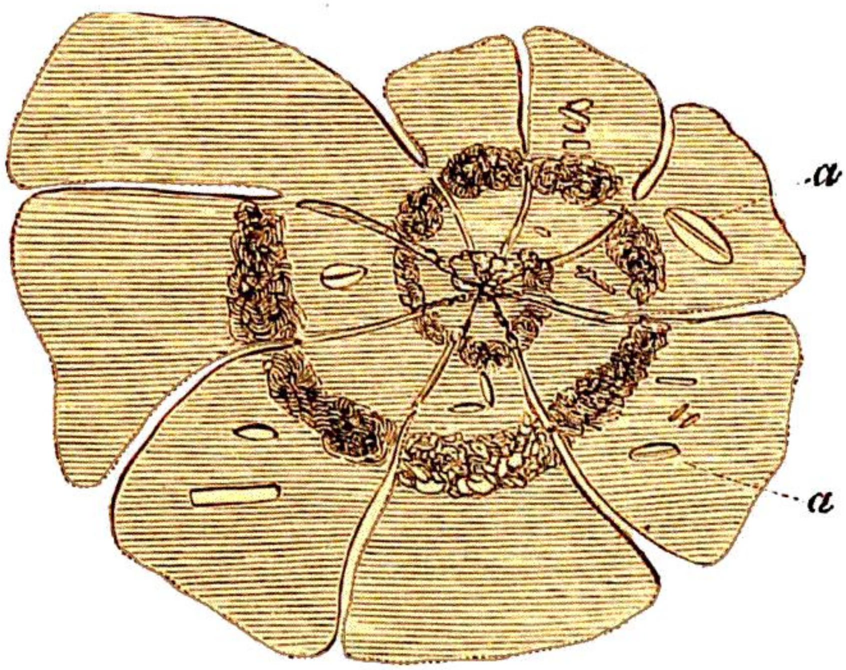


LIGN. 49. POLYTHALAMIA IN FLINT AND CHALK. *inv.* × ×.

Figs. 1, 2, 3, 6.—Different forms of Rotalia.
2.—Resembles the recent *Rotalia stigma*, (Ehrenberg), from the North Sea, near Cuxhaven.
4.—Portion of a Nautilus, showing five chambers, partially separated, each pierced by the siphon: in flint, from Ireland.
5.—Shows the internal body of a Rotalia in flint, the shell having disappeared.

state, by the digestive apparatus of the inhabitant; and the shell is traversed by perforations, through which minute tentacula extend. *Lign.* 49, figs. 1, 2, 3, 6, represent different species, from the chalk and flint of Surrey.

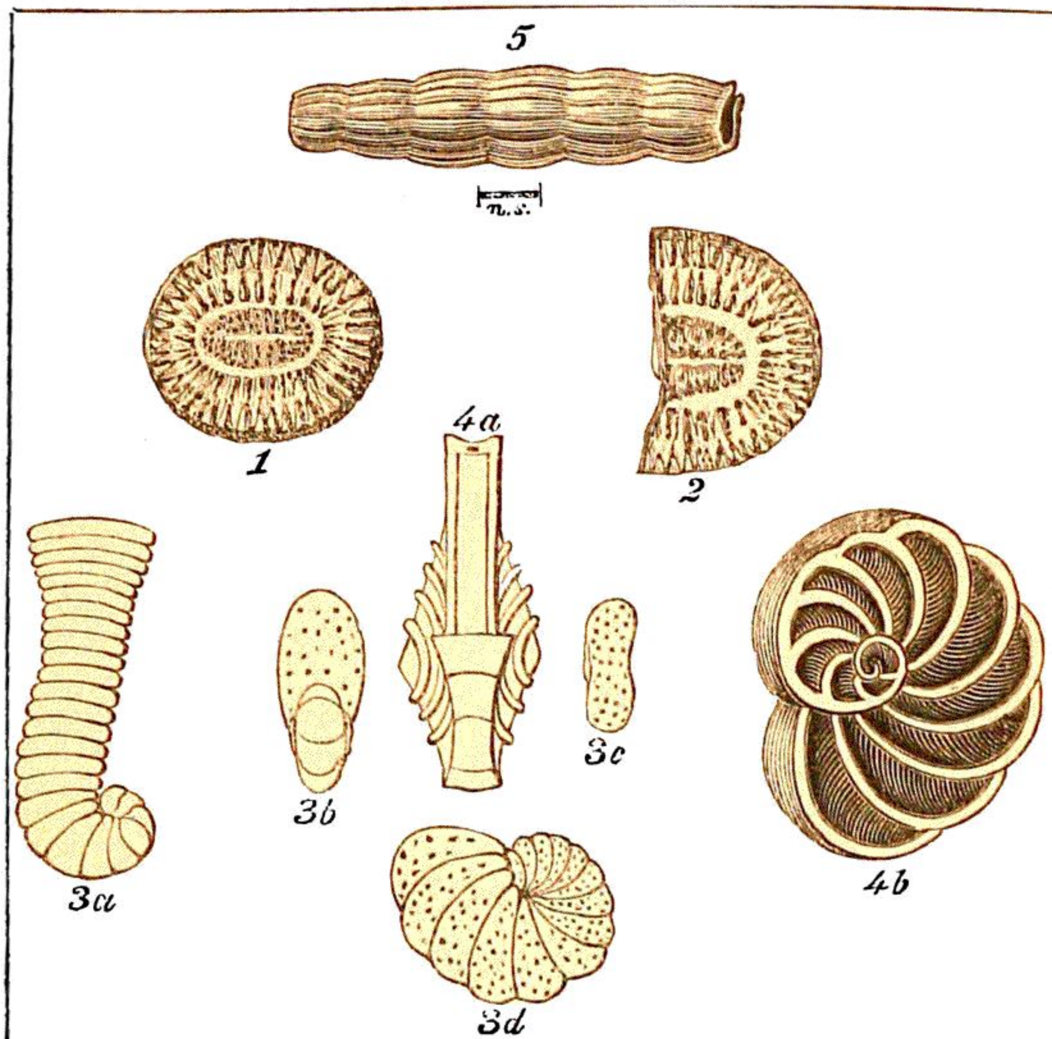
To illustrate the nature of these specimens, the figure of a recent marine Polythalamian, from Cuxhaven, is annexed (*Lign.* 50.), which M. Ehrenberg



LIGN. 50. NONIONINA GERMANICA, × 290.

A recent polythalamian animal, from the North Sea, near Cuxhaven. In some of the chambers, (*a*, *a*,) naviculæ, and other infusoria swallowed by the animalcule, are seen. (Ehrenberg.)

considers to be intimately related to the Rotalina. The body of this animal is enclosed in the shell, and occupies not only the outer chamber, but also all the cells contemporaneously. The shell is pierced all over with minute pores, like a sieve, through which tentacula protrude: it has also several long, soft, transparent contractile feelers, called pseudopodia (*false-feet*). The shell is calcareous, and in the specimen before us, *Lign.* 50, has been removed by weak hydrochloric acid; the soft body of the animal is thus exposed, and is seen to extend to the innermost cell. Several minute infusoria, which it has swallowed, are shown lodged in some of the cells (*Lign.* 50, *a*, *a*.). The connecting tube, which occupies the place of the siphunculus of the Nautilus, is the intestinal canal. I have selected this figure, in preference to one of the perfect shell, to illustrate the nature of the remarkable fossil, *Lign.* 49, fig. 5, which is evidently either the soft body of a Rotalia preserved in silex, or a cast of the interior of the shell; whichever it may be, a more interesting example could not be found, to prove how entirely those animals differed in their internal organization from the Nautilus, which in their external aspect they so much resemble. The septa of a very minute Nautilus in flint, *Lign.* 49, fig. 4, form an excellent object for comparison. Fig. 5 is in the cabinet of Mr. Hamlin Lee; and I have a similar specimen, discovered by the Rev. J. B. Reade. I have Rotalia from Alabama (collected by Dr. Bailey), in which the body of the animal appears to be covered by papillæ, as in the recent *Nonionina*. The student must be prepared to meet with these Polythalamia under very different aspects, according to the position in which they happen to be presented. In a foreshortened view they resemble two



LIGN. 51. POLYTHALAMIA, AND SHIELDS OF ANIMALCULITES.

Fig. 1 and 2.—CAMPILODISCUS; a perfect shield and part of another, seen from above; from Egra in Bohemia. × × Drawn by Mr. Mounsey.

3.—LITUOLA NAUTILOIDEA. Chalk, near Chichester. (By Mr. Walter Mantell.)

3a.—Side view, × 8.

3b.—Front view of the last cell of *3d*, to show the foramina with which it is pierced.

3c.—The last cell of *3a*.

3d.—Side view of a young shell before the produced, or straight part appears. × 20.

4.—FLABELLINA BAUDONINA. Chalk. M. D'Orbigny.

4a.—A young individual seen in profile. × 12.

4b.—The same, viewed laterally, to show the spiral structure.

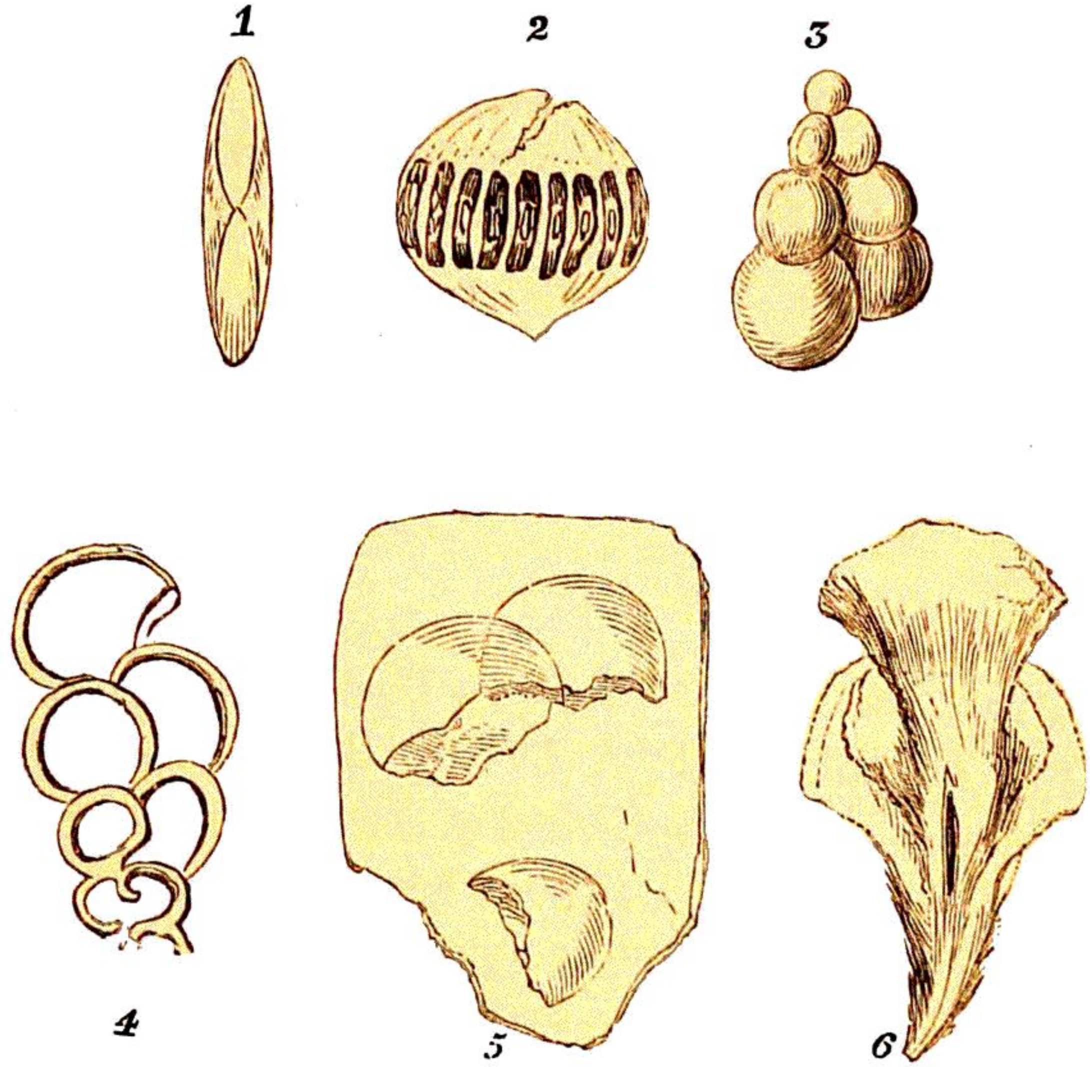
5.—NODOSARIA. Chalk, Chichester. (By Mr. Walter Mantell.) The line below indicates the natural size.

oblong spheroids, as in *Lign.* 52, fig. 1; and when seen obliquely, appear like a cluster of globular bodies: by a little practice they are easily recognised in the various phases they assume.

LITUOLA (*crosier-like shell*).—Another common species of foraminiferous shell in the chalk, is the elegant fossil called *Lituola*, *Lign.* 51, fig. 3, which in its young state is of a discoidal involute form, fig. 3 *b*, 3 *d*; but with age it becomes produced, and assumes the shape of a crosier, fig. 3*a*.; its perforated surface affords a good example of the structure of the foraminifera.

FLABELLINA (*fan-shaped animalcule*).—I am induced to figure an example of another genus of this family, which is very common in the chalk of France, and also occurs in that of England, that the student may be familiar with the dissimilar forms in which these fossil bodies appear, when viewed in different aspects. Seen in profile, (*Lign.* 51, fig. 4*a*.) it is fan-shaped; but viewed laterally, it presents a spiral and chambered structure, as shown in fig. 4*b*. One of the larger coralline bodies, (*Nodosaria*,) often associated with the above, is represented *Lign.* 51, fig. 5.

TEXTULARIA (*entwined animalcule*).—Another common form of Polythalamia, collocated with the Rotalina, generally resembles the vertical section of a spiral univalve shell, as in *Lign.* 52, fig. 4, which is a remarkably distinct specimen in flint. Like the Rotalia, all the chambers were occupied by the viscera



LIGN. 52. MICROSCOPIC FOSSILS IN FLINT AND CHALK: *inv.* × ×.

Fig. 1.—Fore-shortened view of a Rotalia, (resembling the recent Nonionina).
2.—Pyxidicula Leeana (G. A. M.) in Boulogne marble.
3.—Textularia globulosa, in marl: Mount of Olives.
4.—Textularia, in flint: Surrey.
5.—Pyxidicula Readeana, (G. A. M.), in flint: Brighton.
6.—Unknown fossil, in flint. Cabinet of Mr. Hamlin Lee.

of the animal. In many specimens the appearance is that of a cluster of globules, spirally entwined, and diminishing in size from the base to the apex, as in *Lign.* 52, fig. 3, from the Mount of Olives.

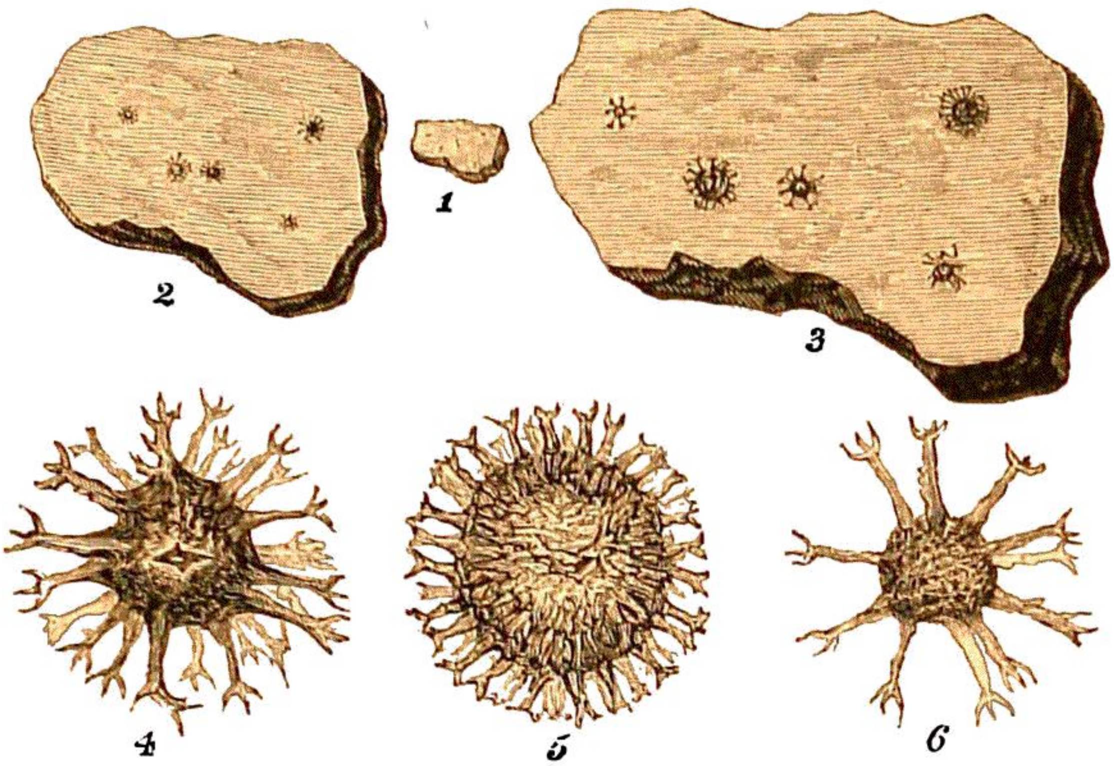
The two families, *Rotalina* and *Textularina*, are most extensively distributed. Dr. Bailey has sent me specimens of limestone from Beyrout, Damascus, the Mount of Olives, Anti-Libanus, &c., all of which contain one or more species apparently identical with those of our English chalk; and Dr. Bailey informs me, that in the calcareous marls of the upper Missouri river, extending nearly to the Rocky Mountains, the same fossils prevail; the predominant species are *T. globulosa*, and *R. globulosa.*

PYXIDICULA (*little box*).—The carapace of the recent animalcule, Plate IV. fig. 2*a.* *b.*, consists of a globular or hemispherical siliceous case, in which the body was contained. The durable shields of these infusoria are often found in chalk flints. I have a slice of flint from Brighton, (discovered and presented to me by the Rev. J. B. Reade,) which contains a group of twenty individuals; a portion of this specimen, including three of the cases viewed by transmitted light, is figured in *Lign.* 52, fig. 5. It is an exceedingly delicate species, very transparent, and has a smooth surface; the cases appear as if floating in the transparent siliceous medium. The Richmond earth, so prolific in infusorial relics, contains a pyxidicula, the surface of which is richly granulated.

The most beautiful fossil carapace, apparently belonging to this genus, which I have seen, was discovered by Mr. Hamlin Lee, in a few grains of the Napoleon marble of Boulogne, which he examined at my request. This exquisite animalculite, is a hollow spherical body, begirt with a broad zone of slightly convex, vertical, perforated bands, or ribs, of a very dark chocolate colour. The figure, *Lign.* 52, fig. 2, has been carefully drawn, and faithfully portrays the original × 250.

The same lignograph, fig. 6, represents a very singular fossil in flint, viewed by transmitted light, the nature of which is unknown to me; but the appearance is so peculiar, that it is desirable some record of it should remain: the light parts are of a delicate amber colour, the darker of a rich chocolate brown.

XANTHIDIUM.—We have now to examine some of the most elegant and abundant of the minute organisms preserved in the chalk flints. Several living species of these animalcules are represented Plate IV. figs. 1, 2, 3, 4, 5. When the animals die, their soft parts rapidly decompose, and their siliceous cases remain, appearing as spheroidal or globular bodies, beset with tubular spines. Some of the flint nodules swarm with Xanthidia: in others they are rare. Mr. H. Lee discovered a group of twenty in an area scarcely a line in diameter; and every chip, of some flints, contains several. One of the most interesting groups of Xanthidia was discovered by my son, Reginald Neville Mantell, in a fragment chipped off a flint pebble, by a smart



LIGN. 53. XANTHIDIA IN FLINT.

Fig. 1.—A thin translucent chip of flint: *nat.*
2.—The same magnified, and viewed by transmitted light; showing a group of five Xanthidia.
3.—The same, more highly magnified.
4.—XANTHIDIUM RAMOSUM; one of the animalculites seen in fig. 3, very highly magnified.
5.—XANTHIDIUM REGINALDI; one of the same group.
6.—A variety of XANTHIDIUM RAMOSUM; another of the same cluster of Xanthidia.

blow of a hammer; and I will here describe the mode by which these bodies were detected, as it affords a good practical lesson for the young investigator.

These bodies vary from $\frac{1}{300}$ to $\frac{1}{500}$ of an inch in diameter. The chip of flint, of the natural size, is represented in *Lign.* 53, fig. 1. It was immersed in oil of turpentine for a short time, and then placed on a piece of glass, and examined with a moderate power, by transmitted light, the turpentine having rendered the translucent flint almost as transparent as glass ; this appearance is shown fig. 2. The half-inch object-glass was now employed, and fig. 3 is the result. The quarter-inch object-glass, and a corresponding eye-piece, were then substituted, and by the adaptation of a camera lucida, figs. 4, 5, and 6 were delineated. Fig. 5, proved to be a new species, and has therefore been named after the discoverer. Other forms of Xanthidia are figured in *Wond.* pp. 565, 801 ; and also in the Annals of Natural History for 1838, by the Rev. J. B. Reade, who was the first in this country to follow up the investigation of the chalk and flint, in the manner recommended by M. Ehrenberg.*

Besides the prevalent forms above described, M. Ehrenberg states that numerous animals of the *Bryozoa*, (*moss-corals,*) related to *Flustra*, and *Eschara*, abound in the chalk. A beautiful specimen of a coral-polype, discovered by the Rev. J. B. Reade, in flint, is represented *Wond.* p. 565, fig. 2.

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* H. Hopley White, Esq., has contributed an elegant Memoir on Xanthidia, which is published in the Transactions of the Microscopical Society of London, Vol. I. p. 77.

Several of the minute chalk corals will be figured and described in the next chapter. But one of the most unexpected results of M. Ehrenberg's labours, is, that numerous shells, corals, and infusoria, found in the most ancient cretaceous deposits, are identical with existing species. In sea-water, from Cuxhaven and other places, he has detected twenty-one genera and forty species, which he considers as differing in no respect from fossils that occur in the chalk.

NUMMULITE ROCK.—A large species of foraminiferous polythalamia, is well known by the name of *Nummulites* (fossil-money), from bearing some resemblance in form to a coin. These fossils are of a flat discoidal form, (see *Wond.* p. 234. *Ly.* I. 410.), slightly convex, and smooth externally; upon splitting them transversely, or rubbing them down, numerous cells or chambers are exposed, arranged in a discoidal spire, and on the same plane. In some of the tertiary strata they are very abundant, and still more so in the chalk of the southern parts of Europe, and in Asia and Africa. The cretaceous formation at Bayonne, and of the Pyrenees, consists of beds of compact crystalline marble composed of nummulites.* The limestone of which the great pyramid of Egypt is in part constructed, is an aggregation of nummulites, and microscopic animalculites, that serve as a cement to the larger

* Ly. I. p. 410.

fossils.* In the United States, a range of mountains near Suggsville, three hundred feet high, is entirely composed of one species of nummulite.†

A large proportion of the sand of the Lybian desert consists of microscopic fossil remains. Below the chalk formation some deposits also abound in animalculites. But in the Wealden limestones, sandstones, and clays, I have not succeeded in detecting any trace of infusoria, although, from the abundance of several species of the minute fresh-water crustaceans, called *Cypris* (*Wond.* p. 380.), it might be expected that the carapaces of Bacillariæ, Naviculæ, &c. on which the living Cyprides feed, would occur in immense quantities. Messrs. Reade, White, Deane, H. Lee, and other observers, have obliged me by repeated examinations of the Wealden rocks, but hitherto without success. I have inspected the Sussex and Purbeck marbles by every method, but have detected nothing except fragments of bones, vegetable matter, and cases of Cyprides, broken or entire, with which the cavities of the shells (*paludinæ*) composing those limestones, are literally crammed. In the fresh-water beds

* An interesting fact was mentioned to me by a friend who lately descended the Nile; namely, that the nummulite limestone rocks are in some places washed down and disintegrated, and the loose nummulites re-deposited in the recent detritus, or mud of the river.

† See Dr. Morton. Cret. Form. of North America.

which overlie the petrified forest of Portland, no infusoria have been discovered. The Stonesfield slate, and the mountain limestone of Derbyshire, when sliced and polished, exhibit numerous microscopic Polythalamia, and other shells.

INSTRUCTIONS FOR THE MICROSCOPICAL EXAMINATION OF CHALK, AND OTHER LIMESTONES; FLINT, ETC.

The following method is that recommended by M. Ehrenberg. Place a drop of water upon a plate of thin glass, and put into it as much scraped chalk as will cover the fine point of a knife, spreading it out, and leaving it to rest a few seconds; then withdraw the finest particles which are suspended in the water, together with most of the liquid, and let the remainder become perfectly dry. Cover this dried spot of chalk with Canada balsam (the turpentine of *Abies balsamea*), and hold the plate of glass over the flame of a lamp, until the balsam becomes slightly fluid, without froth or air-bubbles; it should be maintained in this position (the glass being kept as hot as the finger will bear) for a few minutes, until the balsam is found to have thoroughly permeated the substance to be examined. It is preferable to place a piece of very thin glass upon the balsam, and gently press it down, and allow it to remain. (Glass for this purpose may be obtained of Mr. Drake, Jermyn-street, St. James's, London. The thinnest is $\frac{1}{100}$ of an inch thick, and is 3*s.* 6*d.* per ounce; the thicker kind is $\frac{1}{80}$ of an inch, and is cheaper.) The best flatted crown-glass should be used for placing the chalk or other objects on. It is convenient to have the slips of glass of one size, or the specimens will require different boxes for their reception; three inches by one inch, is that usually employed. These objects require to be viewed with a power magnifying three hundred times linear, that is, in diameter; and if the process has been properly conducted, it will be seen that the chalk is chiefly composed of well-preserved organisms. In these preparations all the cells of the Polythalamia appear at first black, with a white central spot, which is caused by the air contained in those cavities, for air-bubbles always appear under water as black annular bodies; but, by degrees, the balsam penetrates into all the single cells, the black rings of the air vesicles disappear, and the structure of the originals is beautifully displayed.*

Calcareous Sandstone and Marl, may be examined by the same process; but if it be of loose texture, Dr. Bailey spreads some of the sandy powder very *thinly* on a plate of glass, with or

* Ann. Nat. Hist. June, 1841. From a masterly abstract of M. Ehrenberg's Memoir on the Microscopical Structure of Chalk, &c. by Mr. Weaver.

without water, and by the aid of a lens of moderate power, selects and picks up, with fine forceps, or the point of a needle, the roundish grains, and transfers them to another piece of glass, having on one spot a thin coat of Canada balsam. This should be gently heated over a spirit lamp, and the balsam will penetrate the grains, and render them transparent; by this process the minute Polythalamia, &c. may be detected. For a hasty exploration, the dust may be rendered transparent by a drop or two of oil of turpentine.

In sandy calcareous marls, as some of the infusorial earths of Virginia, the same accurate observer directs that a few grains should be diffused in water in a watch-glass, the lighter portion will be thus suspended in the fluid, which should be dropped on glass, and when dry prepared with Canada balsam, as above.

Flint, and other siliceous stones, require no preparation, but may be examined in the manner already pointed out in the description of the fossil Xanthidia, by chipping off very thin fragments, and immersing them in oil of turpentine. A clear, translucent flint should be selected, from which the slices should be chipped by smart blows of a hammer, over a sheet of white paper: the most transparent flakes are to be preferred, and these should be put in oil of turpentine, in a wide-mouth glass bottle. Take out the pieces for examination with forceps, and inspect them as transparent objects, by transmitted light. When good specimens are discovered, they should be mounted in Canada balsam. It is hazardous to entrust these fossils to the lapidaries; the interesting group of twenty Xanthidia, presented to me by Mr. Lee, was reduced to ten, by one of our best workmen, in whose hands it was placed for polishing, with the view of rendering it more transparent.

CHAPTER VIII.

FOSSIL ZOOPHYTES; COMPRISING THE AMORPHOZOA AND THE POLYPIARIA.

THE extraordinary beings whose mineralized skeletons are the subject of our present investigation, have largely contributed to the formation of the solid materials of the crust of the earth. In the earliest, or most ancient strata in which traces of animal organization can be detected, Zoophytes hold a conspicuous place; and in the deposits which are in progress at the present time, along the shores, and beneath the seas of warm and tropical climates, the coral animalcules are laying the foundations of new islands and continents, and producing reefs of rock hundreds of miles in extent, which, when elevated above the waters in future ages, will rival in magnitude and extent the mountain chains of modern Europe. The reader who is unacquainted with the natural history of these marvellous creatures, will find a familiar account of their nature and economy, in the sixth lecture of the *Wonders of Geology*, Vol. II. p. 503; and a lucid sketch of the physical changes produced on the earth's surface by their agency, in Mr. Lyell's *Principles of Geology*, Vol. III.; and to these works the student is referred, that more space may be allotted for the examination of the fossil species.

1. Fossil Sponges.—The terms *Amorphozoa*, (*signifying animals of indeterminate forms*), and *Porifera* (*animals beset with pores*), are employed by modern naturalists to designate the Sponges, and other analogous structures, which occupy the boundary line that separates the animal and vegetable kingdoms. The true nature of the Sponges, is still a disputed question; for, while many distinguished naturalists contend for their animal organization, others equally eminent affirm, that neither in structure nor functions, do they differ from vegetables in any essential particular. Thus Professor Owen remarks, "that if a line could be drawn between the animal and vegetable kingdoms, the Sponges should be placed upon the vegetable side of the boundary." But I concur in the opinion of the author of a beautiful and charming work on British Sponges,* that there is nothing to forbid the belief,

* A History of British Sponges, &c. by Dr. George Johnston, Edinburgh. 1843. One vol. 8vo. with twenty-five plates. A previous work of Dr. G. Johnston, "A History of British Zoophytes," with forty-four plates, from drawings by the accomplished lady of the author, cannot be too highly commended.

that these bodies hold an intermediate place; that they are, in fact, the true *Zoophytes*, or animal-plants. In some forms, as the green *Spongilla* of our lakes, the vegetable nature prevails; while in others, as the keratose (*horny*) sponges, filled with mucilaginous slime, and the fleshy *Tethya*, whose oscula, or pores, exhibit signs of irritability, the animal character predominates. We shall therefore consider the fossil Sponges as the mineralized remains of the lowest grades of animal organization.

Sponge consists of a living mass, covered with numerous pores of various sizes, connected internally by anastomosing channels, and coated with a gelatinous slimy film. The skeleton, or framework, in some kinds, is a fibrous, horny, flexible, or rigid tissue, which in many species is strengthened by calcareous or siliceous spicula (*spines*); while in others the entire substance is calcareous, or siliceous, constituting a web of transparent rock crystal, or flint, resembling spun glass.* The gelatinous matter lines all the cavities, and forms the margins of the openings. Currents of water constantly enter the pores, traverse the inosculating canals, and issue

* I particularly allude to a siliceous Sponge from Barbadoes named, by Mr. Stutchbury, of the Bristol Institution, *Dictyochalix pumicea*. This specimen is of a fungiform shape, and appears to the naked eye as if formed of pumice stone, but under the microscope is literally a tissue of transparent silex.

from the larger orifices, which often project above the surface in perforated papillæ. By the circulation of the water through the porous structure, the nutrition of the animal mass is effected; and the modifications observable in the number, size, form, and disposition of the pores, channels, and orifices, in different species, appear to be subservient to this especial function.

Fossil sponges are numerous in the cretaceous deposits, and generally in the flint nodules; they also occur in the white Chalk, and Chalk-marl, and are often mineralized by pyrites: the detached spicula are very abundant, particularly in some layers of the Shanklin Sand, and Kentish rag. In certain localities, entire strata are almost wholly composed of Sponges.

But associated with the true Sponges, are numerous Zoophytes which resemble them in form, but are of a nature altogether different; and it is important that the student should be able to discriminate them. These are the fossil remains of Polypiaria (*having polypes*), and are the skeletons or framework of aggregations of animalcules, or polypes; each individual of which had an independent existence, although the whole were united by one common living base.* The *Alcyonium*, called dead-

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* A polype generally has a cylindrical or oval body or sac, with an opening at one extremity, around which are long feelers, or tentacula (*Wond.* p. 518.).

men's-fingers, so commonly attached to oysters and other shells, presents an example of this type of zoophytal organization.*

In collecting fossil zoophytes, from the Chalk, for example, the specimens may be easily separated into two groups; namely, those which have a porous structure, like the Sponge, and those in which regular cells, or polype-cavities, are discernible. The hard corals may be readily known by their calcareous, crystalline structure.

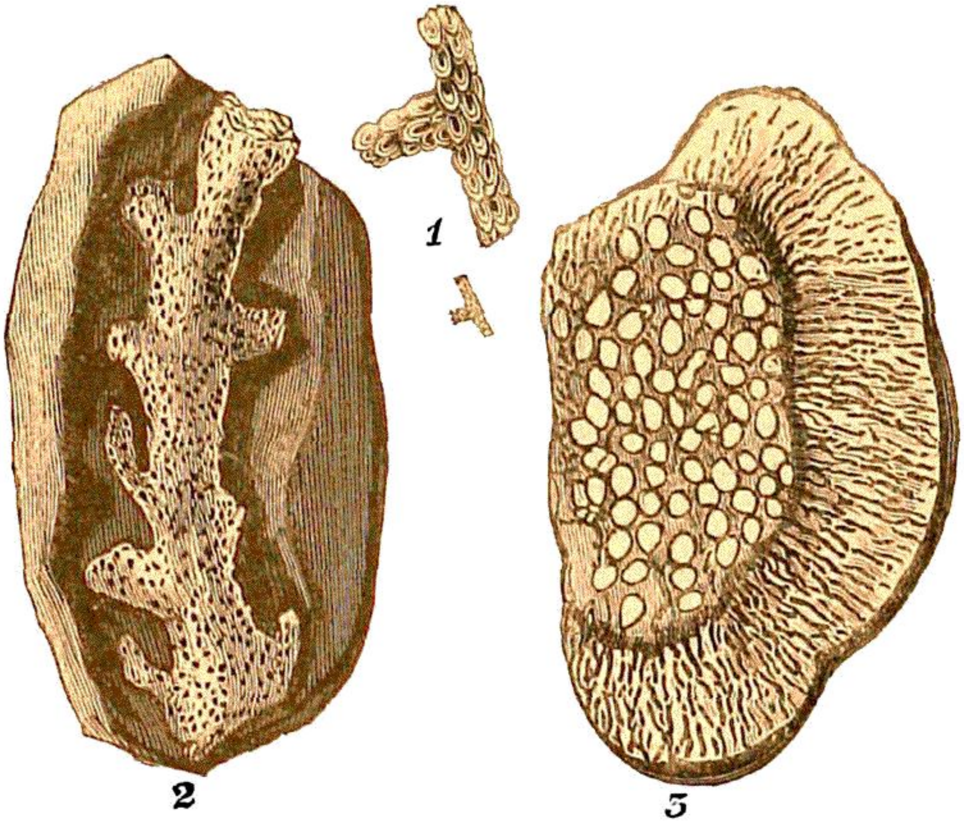
There is much confusion in the names by which the fossil bodies of this family are distinguished; and this has originated, in part, from different states of the same species having been described by different names, and also from the common and reprehensible practice of changing, without sufficient reason, the names assigned to species by the original discoverers.

SPONGITES. — Mass polymorphous; structure porous, and destitute of regular tubes or canals. As a generic name, *Spongites*, may serve to distinguish those fossils whose identity with the recent Sponges is apparent. The Chalk often contains cyathiform (*cup-shaped*) flints, which enclose a funnel-shaped sponge (*Spongites Townsendi. Foss. South D.* Tab. XV. fig. 9.). A common ramose species some-

* See Dr. George Johnston's Brit. Zooph. plate 26; and Wond. Plate V. fig. 8.

times attains a large size; being from twelve to fourteen inches in length, and spreading into numerous branches, which terminate in porous papillæ. In some instances this sponge is permeated throughout with silex, and the structure can then only be detected by fracture; but occasionally branches, which appear to have been saturated with liquid chalk before their immersion in the flint, may be detached; as in the beautiful specimen figured *Foss. South D.* Tab. XV. fig. 11. A small branched species is very abundant in flints, particularly in those from the Wiltshire Downs. Several examples are figured in the elegant Memoir on Wiltshire Fossils, by Miss Etheldred Benett, of Norton House. These sponges are generally of a chalky texture, and lie loose in the flints; probably from the decomposition of their gelatinous investment, after they were enclosed in the siliceous mass. A specimen of this kind, discovered by breaking a flint, is figured *Lign.* 54, fig. 2: the surface of the Sponge is beset with loose acicular spines (see *Lign.* 58, fig. 5.).

Flints of a sub-hemispherical and inversely conical form, are exceedingly common in the Lewes chalk, having the upper surface almost flat, and marked with flexuous anastomosing depressions, surrounded by a circular or elliptical groove, that forms the outer margin. These markings are produced by the sponge enveloped in the flint (*Lign.* 60, fig. 5. *Foss. South D.* Tab. XV. fig. 7.). Upon breaking them, the structure of the Zoophyte is displayed; but in many examples it has perished, and the cavity thus produced is partially filled with stalactitical chalcedony, or lined with quartz crystals: these flints vary in magnitude from the size of a walnut to that of an orange.



LIGN. 54. CORAL AND SPONGES IN CHALK AND FLINT. *Sussex.*

Fig. 1.—RETEPORA. The lower figure *nat. size.* *Chalk, near Chichester.* (*Mr. Walter Mantell.*)

2.—Fragment of a branched Sponge in the hollow of a flint. *South Downs.*

3.—SIPHONIA MORRISIANA.* (G. A. M.) A transverse polished section of a pebble, *from Brighton beach.*

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* The specific name of this Siphonia is to commemorate the important services rendered to British geology, by the author of the "*Catalogue of British Fossils;*" John Morris, Esq.

In the Yorkshire chalk, at Flamborough Head, there are numerous cup-shaped Sponges, having the external surface thickly covered with elevated, porous, perforated papillæ. A specimen in my cabinet, mineralized by pyrites, is frosted over the surface with minute crystals of carbonate of lime, with which many of the cavities of the papillæ are also lined.*

But the strata which offer the greatest number and variety of fossil Sponges, are those of the Shanklin or Green sand, in the vicinity of the town of Faringdon, in Berkshire (*Wond.* p. 561.). These deposits consist of an aggregation of sand impregnated with iron, and comminuted shells and corals, containing myriads of perfect shells, with Sponges, and other Zoophytes; many of these are of great beauty. A cup-formed sponge, called by the workmen petrified *salt-cellar* (*Wond.* Tab. 106.), occurs in a remarkably perfect state; as well as many other interesting species belonging to various genera (*Wond.* p. 560.). The most common are the following:—

Manon.—The mass is composed of reticulated fibres, and the upper surface covered with distinctly circumscribed orifices. *Wond.* Tab. 105, fig. 1, represents *Manon peziza*.

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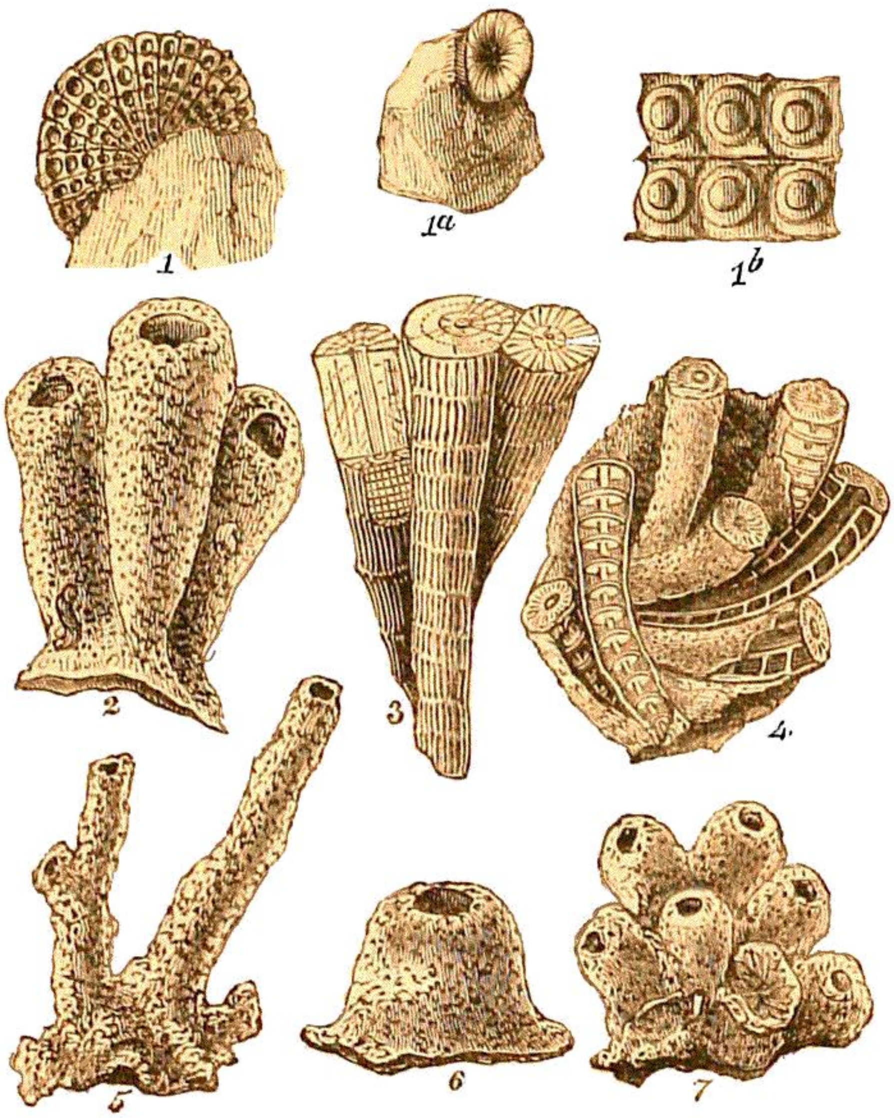
* The rich collection of Mr. Bowerbank contains a fine series of this species of Spongites.



LIGN. 55. FOSSIL POLYPARIA AND AMORPHOZOA.

Fig. 1.—LUNULITES RADIATUS. *Preston Chalk-pits;* view of the convex side. × (*Mr. Walter Mantell.*)

1a.—Front view; *nat.*

1b.—Portion of the surface of fig. 1, × ×.

2.—SCYPHIA INTERMEDIA. *Faringdon.*

3.—LITHODODENDRON SOCIALE: the left-hand branch shows a vertical section at the upper part, displaying the internal structure. *Mountain Limestone, Yorks.*

4.—VERTICELLIPORA ANASTOMOSANS. *Faringdon.*

5.—SCYPHIA RAMOSA. *Faringdon.*

6.—SCYPHIA FORAMINOSA. *Faringdon.*

7.—CNEMIDIUM ASTROPHORUM. *Faringdon.*

CHENENDOPORA.—The mass, cup or funnel-shaped, and the external surface furrowed, or mammillated: the internal surface porous. *Wond.* Tab. 106, represents *C. fungiformis, prov.* "petrified salt-cellar."

SCYPHIA.—Mass cylindrical, simple or branched, fistulous, terminating in a rounded pit, entirely composed of a firm reticulated tissue. *Lign.* 55, figs. 2, 5, 6.

CNEMIDIUM.—Mass turbinated, sessile, composed of close fibres and horizontal canals, diverging from the centre to the circumference; a central pit above, porous at the exterior, radiated at the margin. *Lign.* 55, fig. 7.

Among the shingle, formed of water-worn flint pebbles, (as at Brighton, Margate, Dover, &c.) fossil sponges may frequently be discovered. The flint nodule having been broken, and the calcareous matter of the enclosed sponge washed away by the action of the waves, a delicate silicified tissue remains. Many of the large, solid pebbles, are portions of silicified sponges, and when cut and polished, expose beautiful sections of the tubes and pores of the enclosed zoophytes. Specimens of this kind have been microscopically examined by Mr. Bowerbank, with great success.*

* See the highly interesting and elegant Memoir "On the Spongeous Origin of Moss Agates, and other Siliceous Bodies."—*Ann. Nat. Hist.* Sept. and Oct. 1842.

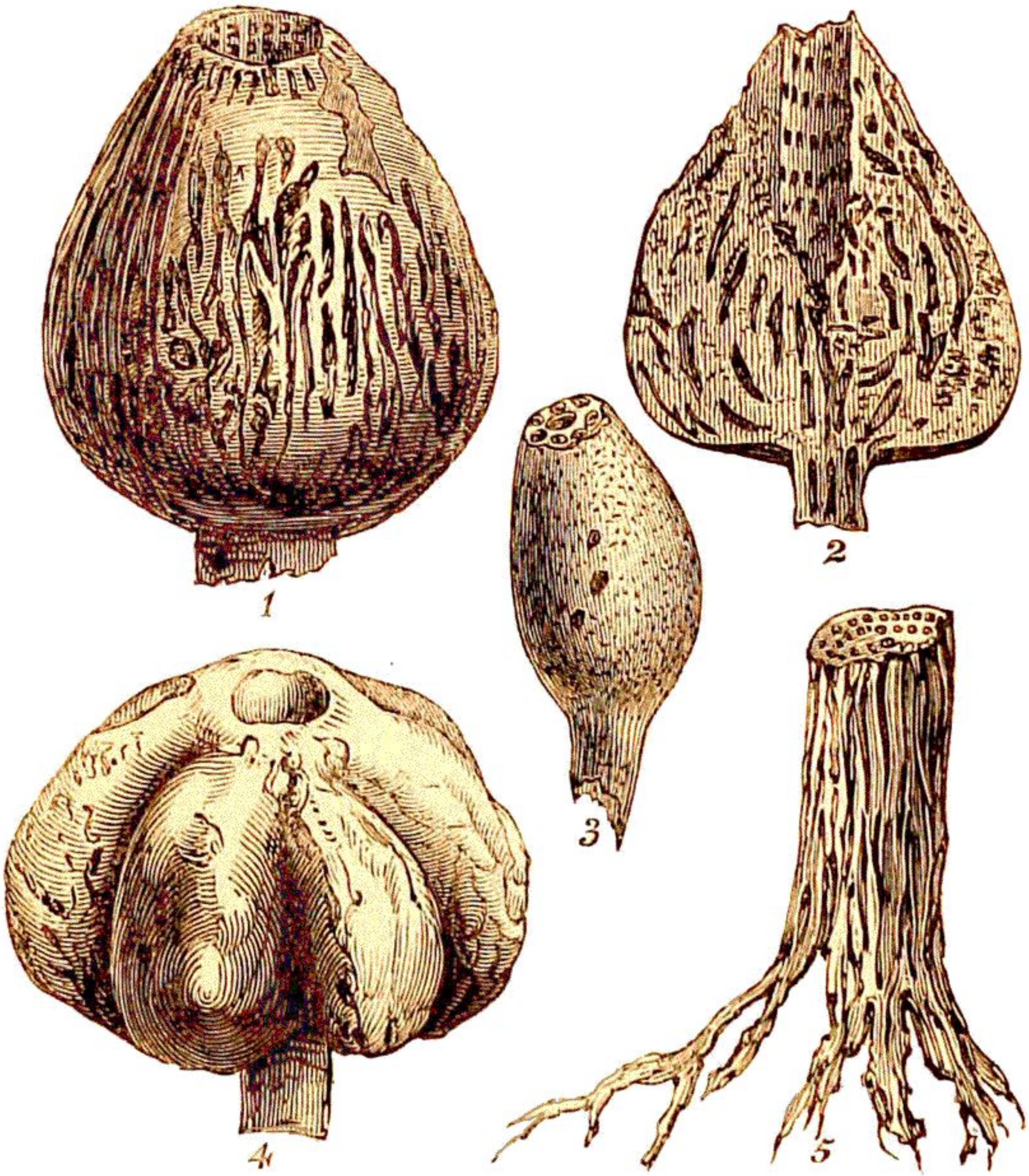
SPINES OR SPICULA OF SPONGES (*Lign.* 58. fig. 5.).—We have already alluded to the spicula which enter into the structure of many of these zoophytes. They are hollow, and of various shapes; some are simple acicular spines; others stellate or radiate, and tri-radiate; and some have the form of a trident; a few of these bodies are figured, *Lign.* 58, fig. 5.

As *Actiniæ* (*sea-anemones*), and *Alcyonia*, also possess spicula, it is possible that some of the fossil spines may have been derived from those animals. The larger spines may be discovered with a lens of moderate power, or even by the unassisted eye; but all will repay a microscopical examination, and the minutest can only thus be detected.

SIPHONIA (*Lign.* 56.).—Structure porous; upper part bulbiform, having a central cavity studded with pores regularly disposed, and supported on a stem composed of parallel longitudinal tubes or vessels; the base fixed; often by radicle processes.

This genus comprises a very numerous group of fossil Sponges, which possess regular tubes or channels, that permeate the spongeous mass, and communicate by openings into a central cavity above. Their forms, although variable, are more definite than the simple Sponges, and altogether their organization appears to be more advanced.

One of the most elegant and well-known species is the *Siphonia Websteri*, of the Shanklin Sand



LIGN. 56. SIPHONIÆ, FROM THE SHANKLIN SAND.
Wilts, and Isle of Wight.

(*Drawn by Miss Murray.*)

Fig. 1.—SIPHONIA WEBSTERI; the body or upper part.
2.—Vertical section of the same, showing the internal structure, and the upper central cavity.
3.—Specimen of S. Websteri in a young state.
4.—SIPHONIA LOBATA, *Warminster;* by Miss E. Benett.
5.—The lower part of the stem, with the radicles, of S. Websteri.

strata, *Lign.* 56, figs. 1, 2, 3, 5, which was first figured and described by that eminent geologist, Mr. Webster, from specimens collected in the Isle of Wight, where it occurs in profusion, near Ventnor, and the Western lines. I have seen specimens fourteen inches long; and imbedded in the siliceous sandstone, or rag, forming the face of the cliffs near Ventnor, fragments of stems which indicate much larger proportions. This zoophyte has a pyriform body, *Lign.* 56, fig. 1, with a cylindrical shallow cavity, supported upon a slender elongated stem, the base of which is fixed by a pedicle or root-like process, *Lign.* 56, fig. 5; the fractured surface shows sections of the longitudinal tubes. This species has been found in numerous localities of the Shanklin Sand, and may be regarded as a very characteristic fossil.*

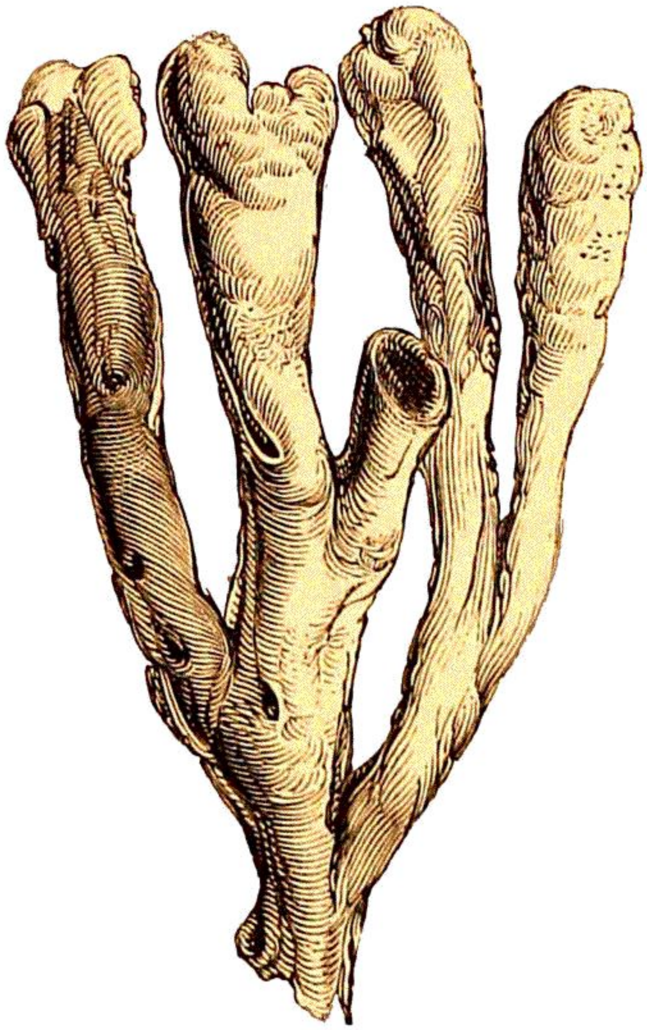
The Portland limestone also contains numerous remains of a Siphonia closely resembling *S. Websteri*, if not of the same species; and varied sections of its stems, produce the white markings so commonly observable on the slabs of stones, forming the steps and pavements in, and around, the metropolis.

An interesting series of fossil Sponges from the Green Sand, near Warminster, figured and described by Miss Etheldred Benett,† under the name of

* Dr. Fitton's figures of this zoophyte, Geol. Trans. Vol. II. Plate XV. *a*, are very beautiful and accurate.

† An elegant Memoir on the Wiltshire Fossils, by this accomplished lady, appears in Sir R. C. Hoare's "Wiltshire,"

Polypothecia, belongs to this genus. These remains are in the same state of mineralization as those of the Isle of Wight, and possess considerable diversity of figure. One of the lobed forms is delineated in *Lign.* 56, fig. 4; and a branched species in the annexed lignograph.



LIGN. 57. SIPHONIA DICHOTOMA. *Warminster, Wilts.*
(*Drawn by Miss Murray.*)

Upon breaking the stem of the "Polypothecia" transversely, sections of parallel longitudinal tubes

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with numerous excellent figures of the zoophytes, &c., from Warminster.

are obtained, as in *S. Websteri.* Miss Benett enumerates upwards of twenty species from South Wiltshire.

The Kentish rag contains large ramose spongeous bodies, which I have no doubt are *Siphoniæ;* and Mr. Bensted has discovered in his quarry, numerous specimens of a polymorphous lobed zoophyte, with a porous structure and spicula, denoting its spongeous character. In the firestone of Southbourne, Steyning, and Bignor in Sussex, I have observed large pyriform and cylindrical Siphoniæ. The organization of these zoophytes was clearly adapted for the free circulation of sea-water, in a more perfect and definite manner, than in the irregular porous tissue, of the simple sponges.

The flint pebbles on the Sussex coast abound in remains of Siphoniæ, especially those near Brighton, which have been washed out of the chalk cliffs; for the cretaceous strata are peculiarly rich in these remains, in some localities near that town. There were several chalk-pits in Edward-street, (now, I believe, filled up and the area built upon,) every flint in which enclosed a Sponge or Siphonia; and many specimens were mineralized by pyrites, and most beautifully exhibited the structure of the originals. I have figured a polished slice of a pebble from Brighton (*Lign.* 54, fig. 3.), whose markings are derived from the transverse section of an enclosed Siphonia, apparently of an undescribed species: scarcely more than half the area is preserved, but it displays the centre filled with numerous parallel openings, the sections of longitudinal tubes, which are surrounded by a broad zone of spongeous tissue.

Among the chalk flints the collector will find numerous specimens, whose forms depend on the enclosed sponges, and other related *Amorphozoa*. Some are of a large size, and of a globular or spherical shape; others are irregularly branched, the surface presenting the usual white calcareo-siliceous coating of the flint nodules, and feeling rough to the touch; and, wherever an opening or fracture appears, indications of the porous texture will be discovered. This class of fossils is at present so imperfectly investigated, that names can be assigned but to few of the common examples, and these would afford no guide to the collector, without the aid of numerous figures, which our space will not permit.* Porifera of the same genera, if not species, as those above described, exist also in some of the secondary strata below the chalk.

CHOANITES.—Form various, generally spherical, funnel-shaped, or globular, with a central opening in the upper part; the original substance carneous, or gelatinous, and capable of imbibition and contraction: base fixed.

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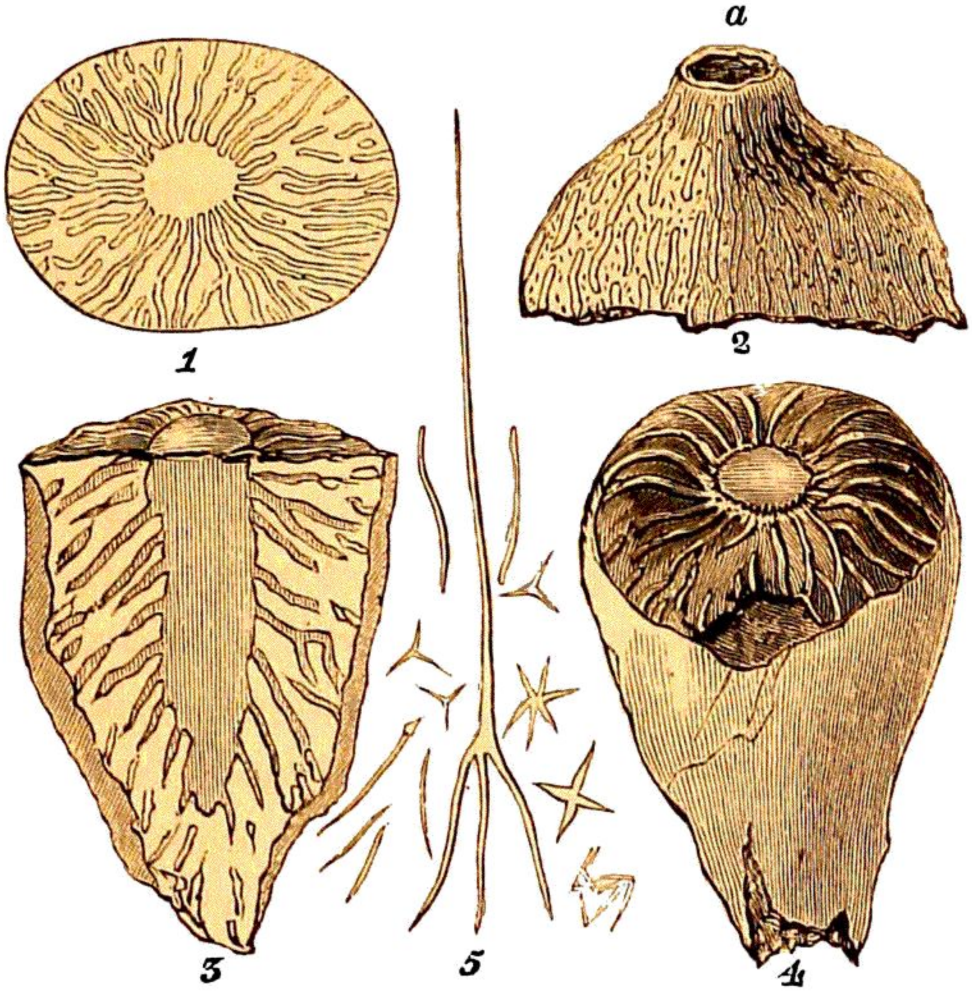
* Several kinds are represented in the Geology of Sussex, Tab. XV.

The fossils which I have placed under this genus,* are closely related to a recent zoophyte (*Alcyonium*



LIGN. 58. CHOANITES KÖNIGI. (G. A. M.) *Chalk, Lewes.*

Fig. 1.—Transverse section of a siliceous specimen.

2.—Upper portion of a *Choanite*, in chalk, showing the mouth or opening into the ventral cavity at *a*.

3.—Vertical section of a *Choanite*, in flint, exposing a section of the body, and tubes passing obliquely from the central cavity, through its substance.

4. *Choanite* in flint; the usual appearance of these fossils.

5. Various kinds of SPICULA of fossil sponges × ×.

ficus of Linnæus), which is described as having the

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* See Foss. South D. p. 178.

form of a fig, with the upper part flattened, and possessing a central cavity; the lower and smaller end fixed by root-like processes. It is of a rich brown colour, and its substance, when dried, appears like that of nut-galls.* There are several species of Choanites in the chalk formation, but the most remarkable is that figured in the annexed lignograph 58, and which may be considered as the type of the genus. This zoophyte frequently occurs in the semi-diaphonous pebbles on the Sussex coast, and gives rise to such beautiful and varied markings, that polished sections are mounted for brooches and other ornaments, being termed by the lapidaries, *petrified sea-animal flowers.*† Among the shingle on the shore at Bognor, Worthing, and other places, very fine examples may be obtained. *Lign.* 58, fig. 4, represents the usual appearance of a siliceous Choanite. Fig. 2. is the upper part of a Choanite preserved in chalk, and richly coloured by iron; the opening at the summit *a*, is the orifice of the central cylindrical cavity, which is filled up by chalk; and in flint specimens, with silex of a different colour to that of the surrounding mass. If fig. 2. were placed on the top of fig. 4, the general shape of the zoophyte would be represented. The opening at the base of fig. 4, marks the spot from

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* Org. Rem. Vol. II. p. 96, Pl. IX. and XI.

† A coloured vertical section is figured in "Thoughts on a Pebble," Pl. 2.

which root-like processes of attachment proceeded. The vertical section of a flint, similar to fig. 4, is shown at fig. 3; and in this example are seen the central cavity, and a section of the substance of the zoophyte, which is traversed by numerous tubes, that commence in the opening, on the inner wall of the central cavity, or digestive sac, and ramify in the mass of which the body was composed. A transverse section of a similar flint is delineated in fig. 1; the central spot indicates the sac filled with white flint, and tubes or canals are seen radiating from it through the substance of the zoophyte; a powerful lens shows the interstitial structure to be granular. From the perfect transparency of the body when silicified, and the rich tints it has acquired from metallic solutions, and the compressed state in which it is often found, it seems probable that the original was composed of a soft, glutinous substance, like the *Actiniæ*, strengthened by spicula; for numerous tri-radiate spines, like those on the left hand of fig. 5, *Lign.* 58, occur occasionally in chalk specimens.*

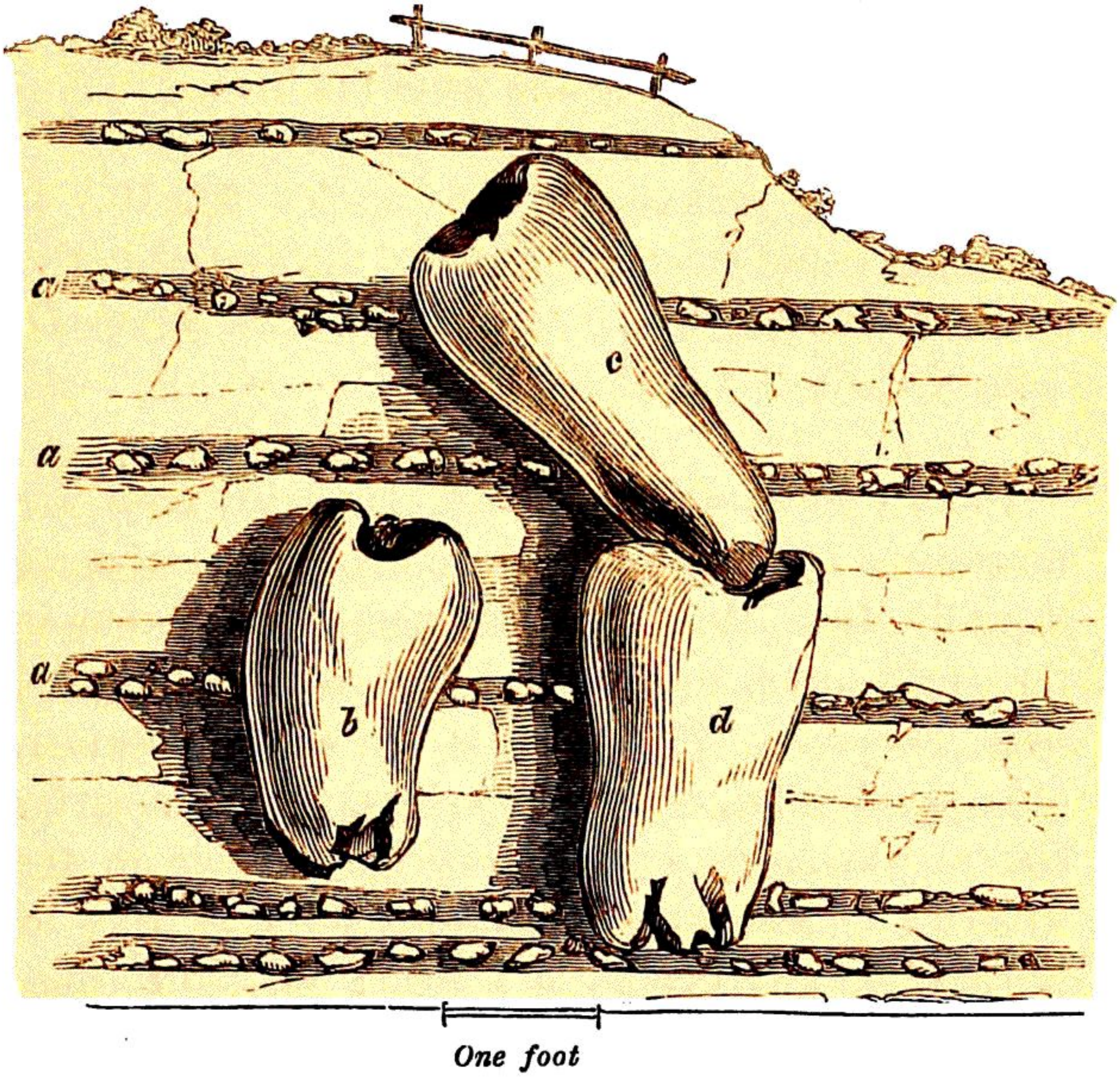
A smaller species, of a subrotund form (*C. subrotundus*), that occurs in groups of three or four (*Foss. South D.* Tab. XV. fig. 2.), is not uncommon in

* Miss E. Benett was one of the earliest investigators of these interesting fossils, and my attention was first directed to the subject by specimens from her choice collection; for this species is abundant in the Wiltshire chalk.

the chalk of Sussex and Wiltshire; and is often found associated with a turbinated zoophyte, apparently of the same genus (*Lign.* 60, fig. 1.). The latter has a shallow central cavity, with a broad smooth margin, a reticulated external surface, and radicle processes proceeding from the base.

CHOANITES FLEXUOSUS (*Lign.* 60, fig. 10.) is cyathiform, and has the margin of the central cavity marked with flexuous indentations (*Foss. South D.* Tab. XV. fig. 1.).

PARAMOUDRA.—This vernacular Irish term was introduced by Dr. Buckland, in his account of some gigantic flints, thus popularly named, that occur in the chalk near Belfast, and also at Whitlingham, near Norwich. These fossils are of an irregular, oblong, spherical, or pyriform shape, having a cavity above, which, in some specimens, extends to the bottom; at the base indications of a pedicle, or process of attachment, are seen; in short, they closely resemble, upon a large scale, some of the funnel-shaped sponges, so frequent in the flints of the South Downs. Their general appearance is represented *Lign.* 59, from Dr. Buckland's illustrations: *b.* is a single specimen, partly imbedded in the chalk, and *c, d.* two of the fossils in contact, the pedicle of the upper lying in the cavity of the lower; but this position appears to be accidental. They are from one to two feet or more in length, and from six inches to a foot in diameter. The appearance, both of the outer and inner surfaces, is that of the usual white calcareo-siliceous crust of



LIGN. 59. PART OF A VERTICAL SECTION OF A CHALK-PIT, *near Moira*.
(*Rev. Dr. Buckland.* Geol. Trans. Vol. IV.)

a, a, a. Layers of flint nodules, alternating with chalk strata.
b. A Paramoudra, imbedded in the chalk.
c, d. Two of these bodies in contact.

spongitic chalk-flints. Upon breaking them, no traces of structure are perceptible; but here and there are patches of reddish and bluish chalcedony, resembling those observable in parts of the Ventriculites and Spongites in the chalk-flints of Sussex. They were probably gigantic goblet-shaped zoophytes, allied to the sponges, but of too perishable a texture to leave any trace but their general outline. Specimens may, however, yet be found with the structure preserved, for it was many years before I detected the true nature of the fossils next to be described.

FOSSIL POLYPIARIA.

The fossil zoophytes included in this section present innumerable varieties of form and structure, but all possess this important character, namely, that they have originated from those aggregated families of minute beings termed POLYPES (*many-feet**). The common *Hydra* (*Wond.* p. 518, Tab. 98.), or fresh-water polype, that inhabits pools and streams, is a familiar example of a free, independent animal of this kind, consisting of a mere cellular gelatinous substance, in the form of a short tube, surrounded at the upper margin by long tentacula, or feelers, which appear to the naked eye like delicate threads. The Polypiaria, properly so

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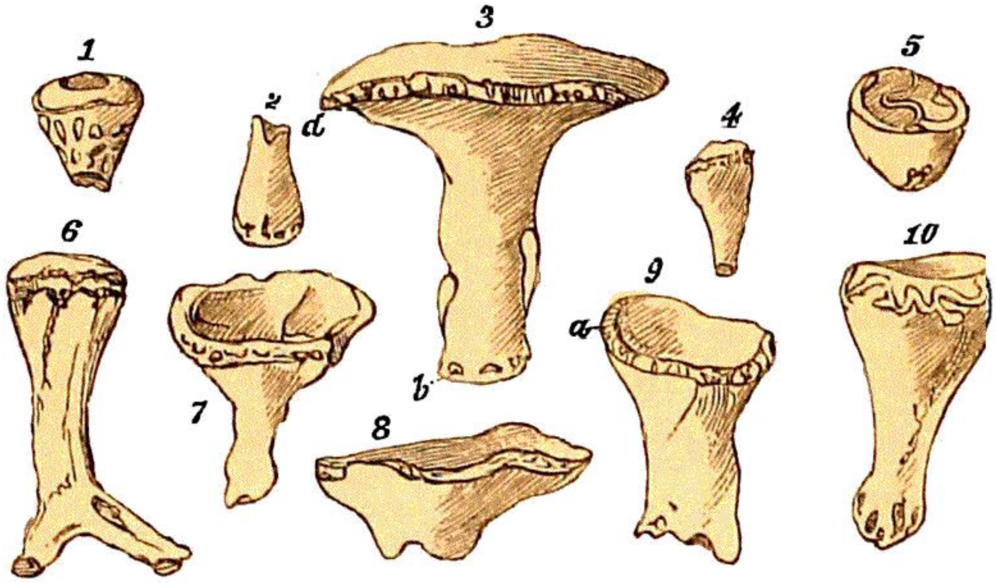
* This name is derived from the tentacula, or processes, which in some species serve for prehension, and in others for respiration.

called, are groups of animalcules or polypes, permanently united at their base, and arranged side



LIGN. 60. FLINTS, DERIVING THEIR FORMS FROM ZOOPHYTES.

From the South Downs, near Lewes. $\frac{1}{6}$ *nat.*

Fig. 1.—CHOANITES TURBINATUS.

2, 3, 4, 6, 7, 8, 9.—FLINTS, whose forms are derived from VENTRICULITES, provincially called "*petrified mushrooms.*"

5.—SPONGITES LABYRINTHICUS.

10.—CHOANITES FLEXUOSUS.

by side, each having an individual existence. A common support, or skeleton (*polyparium**) is

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* The basis, framework, or skeleton, of these groups of animalcules is termed polyparium, or polypidom (*polype-habitation*); and those of a stony hardness are familiarly known as *corals;* these names, therefore, refer to the durable substance of the Polypiaria, and not to the Polypi themselves; but in familiar writing, the term *coral* is often used to designate the entire living mass. The red coral forms a distinct genus called *Corallium.* In fossils, the *Polyparium* alone remains, except in very rare instances.

secreted by the uniting medium, which varies in its nature from a mere gelatinous, or horny material, to an earthy, calcareous, and even siliceous frame-work, that remains when the polypes die, and their soft parts decompose. All the beautiful varieties of corals, &c. are nothing more than the solid skeletons of aggregated masses of polypes. But I must refer the reader to the Sixth Lecture in the *Wonders of Geology* for a familiar exposition of this subject, and of the nature and economy of the living coral-animals.

It may here be necessary to notice a prevailing error, regarding the mode in which the substances called corals are produced. It is very generally supposed that corals, particularly those covered by stars and cells, have been constructed by the polypes, in the same manner as the honey-comb, by the Bee; and the expressions often employed by naturalists, of "the coral animalcules building up their rocky habitations," and "constructing their cells in a particular manner," have contributed to perpetuate this error. But the cases are in no respect similar: the Bee, under the guidance of an unerring instinct, resulting from its peculiar organization, does mechanically construct its cells; but the polype is incapable of forming, or even modifying, its support or cell in the slightest degree. The frame-work, or skeleton, is *secreted* by the animal tissues, in the same manner as are the bones and other structures, in the higher order of animals, without the individual being conscious of the process. If a piece of white coral be immersed in dilute hydrochloric acid, the calcareous part will be removed, and the secreting membrane, in the form of a flocculent substance, be seen attached to the undissolved part; and even in some coralline marbles, although of incalculable antiquity, the animal membrane may, in like manner, be detected.*

We will now examine some of the principal examples of this interesting class of fossil organisms, and commence with those which possessed a soft or flexible substance, like the *Alcyonium digitatum*. It will be obvious that, from the delicate and perishable nature of many of the gelatinous polypiaria, numerous tribes may have inhabited the seas, which deposited the fossiliferous strata, and yet no indications of their existence remain; while, of others, but obscure traces of their structure may be discernible.

VENTRICULITES, (*Lign.* 60, 61.).—Polyparium inversely conical, or fungiform; external surface reticulated; inner surface covered with polypiferous cells; base fixed.†

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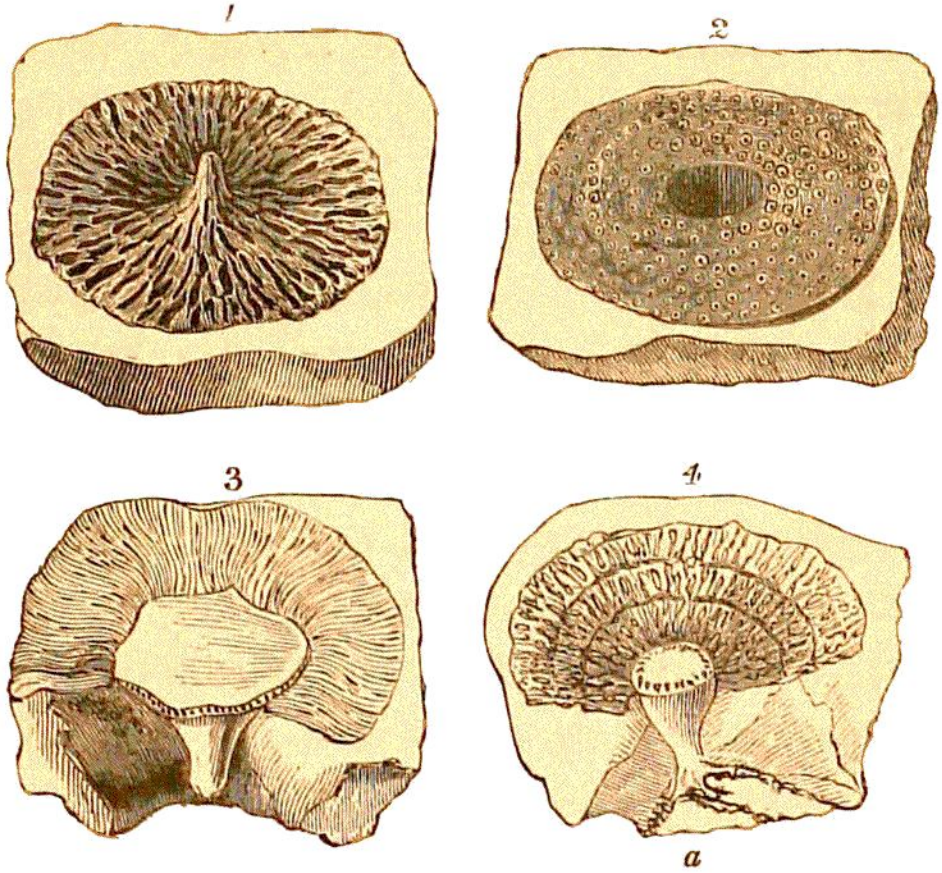
* Org. Rem. Vol. II. Plate I. fig. 3.

† In my former works I have described the fossils referred to this genus, as individual zoophytes; but more accurate investigations have convinced me that the originals were POLYPIARIA, as the late Mr. Miller suggested to me long since.

Among the flints whose forms depend on the organic bodies which they enclose, are many bearing so close a resemblance in shape to fungi, that they have received the common appellation of "PETRIFIED MUSHROOMS;" and a specimen with this denomination, in the cabinet of a friend, first drew my attention to this interesting class of fossils. In *Lign.* 60, figs. 2, 3, 4, 6, 7, 8, 9, several kinds are represented. Figs. 3, 6, 8, are fungiform; fig. 7, is the upper part of a specimen, the stem having been broken off; figs. 2 and 4, are examples of the lower part of the stirps, or stem. In all, there are openings at the base, and a groove on the margin or edge of the upper part, in which the structure of the enclosed fossil body is visible; upon breaking these flints, sections of a funnel-shaped polyparium are obtained.

The origin of these siliceous bodies will be understood by reference to the four interesting specimens delineated in *Lign.* 61. In fig. 3, a fungiform flint, resembling fig. 6, of *Lign.* 60, is seen in the lower part of a Ventriculite; while above, and surrounding the flint, an impression of the reticulated outer surface of the zoophyte, deeply coloured by a ferruginous tinge, remains. In fig. 4, *Lign.* 61, a small turbinated flint, resembling fig. 4 of *Lign.* 60, occupies the base of a Ventriculite, and three root-like processes are seen emerging from it at *a.* In *Lign.* 62, fig. 1, in which the chalk has been removed so as to expose the outer surface of a Ventriculite, a flint fills up the centre at *c*; while above, the radiating reticulated structure is spread out on the chalk, *a*; and the base, with its radicles, is shown at *b*.



LIGN. 61. VENTRICULITES RADIATUS. (G. A. M.)

Chalk, near Lewes. $\frac{1}{6}$ *nat.*

Fig. 1.—A perfect specimen in chalk, inverted, and showing the external reticulated surface.

2.—Specimen expanded, displaying the inner surface, covered with the openings of the polypiferous cells.

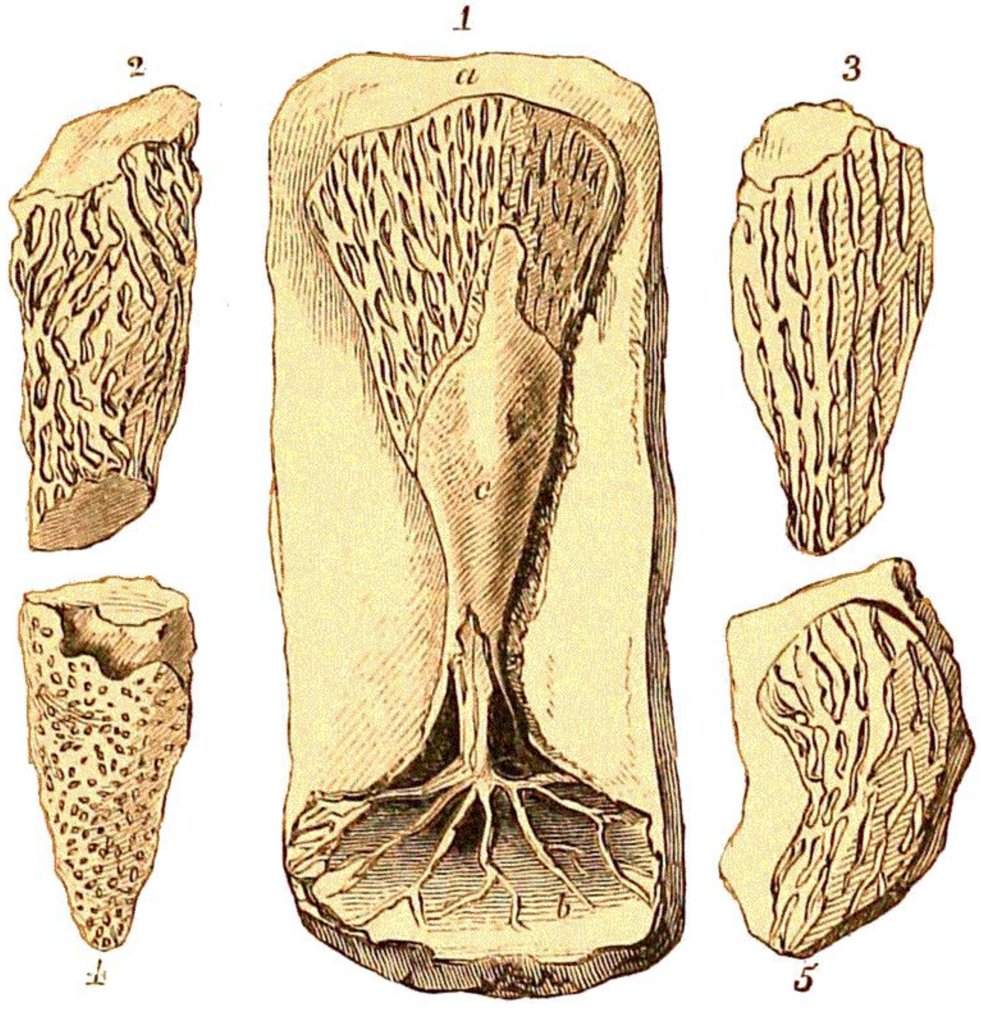
3.—A VENTRICULITE in chalk; the lower part enclosed in flint.

4.—Portion of a VENTRICULITE; the stem, towards the base, enveloped in flint, and three radicle processes spreading from it into the surrounding chalk at *a*.

These specimens demonstrate that all the flints referred to, have been moulded in the cavities of

Ventriculites; and that their diversity of figure has arisen from the quantity of silex that happened to permeate the zoophyte; if but a small portion, then flints, like fig. 4, were produced; if the quantity were more considerable, fungiform flints, as *Lign.* 60, fig. 3, and *Lign.* 61, fig. 3, were the result.

The original form of the Ventriculite was that of a funnel, or hollow inverted cone, terminating in a point at the base, whence numerous fibres proceeded, by which it was attached to other bodies. The outer integument was reticulated, that is, disposed in meshes, like net-work; and the inner surface studded with regular openings, the orifices of tubular cells, each of which was probably occupied by a polype. The substance of the polyparium, or frame-work, of this aggregation of animalcules, appears to have been analogous to that of the soft alcyonia, and seems to have possessed a common irritability, and been able to expand and contract. This opinion is based on the circumstance, that specimens occur in which the zoophyte is in the form of a nearly flat, circular disc; and others in that of a sub-cylindrical pouch. In the former state the outer reticulated structure is elongated, while in the latter, it is contracted and corrugated. The polype-cells are cylindrical, and very regular; the flints often present beautiful casts of them, which appear like rows of minute pillars on the inner surface. When the flint that fills up the cavity of the Ventriculite can be extracted, it is a solid cone, studded with minute papillæ, which are the casts of the orifices of the polype-cells, as in *Lign.* 62, fig. 4.*



LIGN. 62. VENTRICULITES, *from the Chalk, near Lewes.*

Fig. 1.—A specimen, in which the middle is enclosed in a flint *c*; the radiated structure of the Ventriculite is seen at *a*, expanded on the chalk; and the radicles, or processes of attachment, emerging from the flint below at *b*. The figures are one-fourth the size of the originals.

2, 3, 5.—Chalk specimens, showing the radiated external surface of stems of Ventriculites.

4.—A siliceous cast of the cavity of a Ventriculite covered with papillæ, moulded in the orifices of the polype-cells.

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* Org. Rem. Vol. II. Pl. X. fig. 12, represents a specimen of this kind. The figure of a split pebble immediately beneath

In the flints, the substance of the Ventriculite is very generally as translucent as that of the Choanite, and distinguishable from the surrounding silex by a purple, reddish brown, or pale-grey colour; but towards the base and margin it is more or less calcareous; and in many examples the whole, or a large portion of the polyparium, is in that state. But this fact does not invalidate the inference that the original was flexible; for, like the Sponges, it may have been partially imbued with the fluid chalk before its envelopment in flint.* The chalk specimens are commonly as friable as the surrounding stone, from which they are only distinguishable by their ochreous or ferruginous colour.

The constant presence of a ferruginous stain throughout the tissue of the chalk Ventriculites, and other flexible zoophytes, while the surrounding stone is of a pure white, can only be explained by the chemical changes to which the decomposition of animal matter would under such circumstances give rise. If sulphuretted hydrogen were evolved from the putrifying zoophytes imbedded in calcareous

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it (fig. 16), is the base of the stem of a Ventriculite, and the three or four orifices on the top have been produced by the transit of the radicle processes; the fossil is drawn in an inverted position; a very common error before the true origin of these flints was ascertained.

* A piece of sponge dipped in liquid plaster of Paris, and afterwards enclosed in a transparent substance, as glass, would present such an appearance.

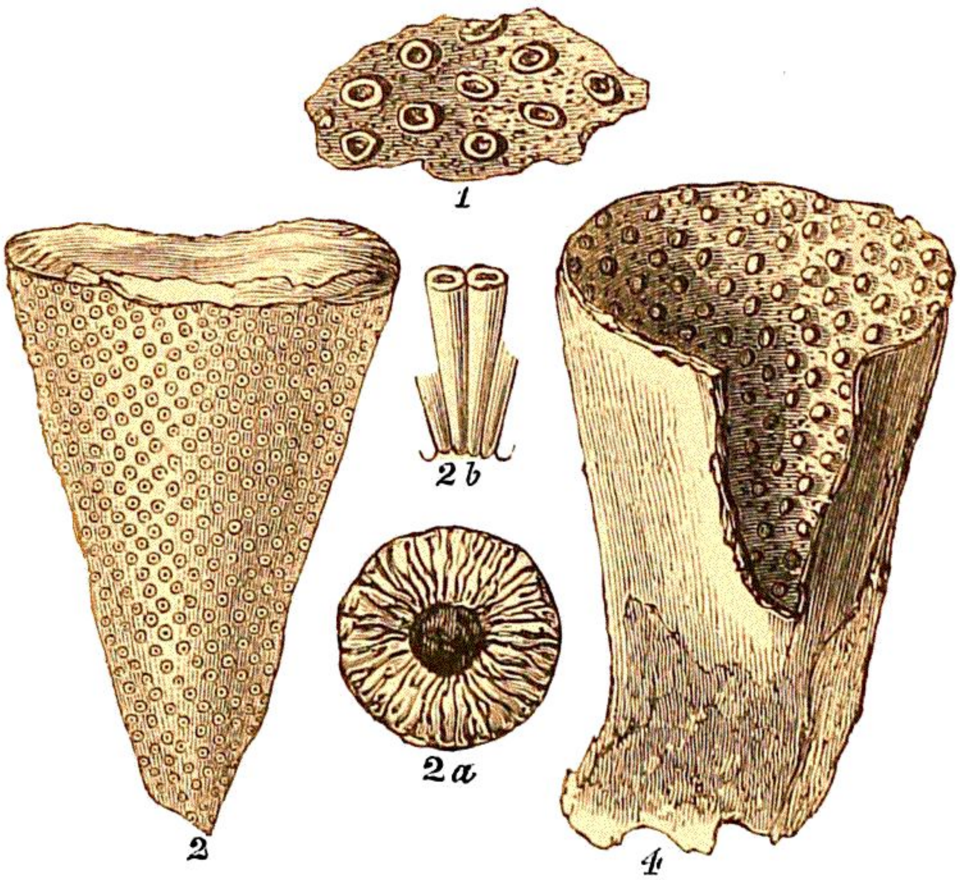
mud containing iron in solution, the sulphur would enter into combination with the iron, the hydrogen escape, and a sulphate or sulphuret of iron be deposited, atom by atom, and thus impart colour and permanence of form to the original. When the enclosed polyparia in flint nodules have perished, chalcedony, quartz crystals, or crystallized pyrites, sometimes of great beauty, are found occupying the cavities. In short, numerous modifications of the petrifactive process, are beautifully exhibited in these common, but highly interesting fossil remains.

The species of Ventriculite to which the previous remarks especially refer, is named *V. radiatus*; from the radiated character of the reticulated external integument. Some of the expanded specimens are more than one foot in diameter.

A small and very elegant species (*V. Benettiæ*), is common in the Wiltshire chalk.* It may be added that a memoir by the author on the Ventriculites (under the name of *Alcyonium chonoïdes*), with four beautiful plates, was published in the Linnean Transactions, Vol. XI. The Ventriculites are the only fossils figured in Messrs. Conybeare and Phillips's Geology of England and Wales (p. 76.).

* The reader interested in these remains should consult Foss. South Downs, p. 167, and Plates X., XI., XII., XIII., XIV.; or Geol. S. E. p. 97.

OCELLARIA. *Lign.* 63.—Polyparium calcareous; the surface covered with polype-cells, disposed in quincunx order, on both surfaces; the form various.



LIGN. 63. OCELLARIA IN FLINT. *Chalk, Lewes.*

Fig. 1.—Portion of the surface of fig. 2, magnified.
2.—*Ocellaria inclusa;* extracted from the flint, fig. 4.
2*a*.—Transverse section of the same, showing a central spot of flint, surrounded by radiating cells.
2*b*.—Two of the polype-cells of fig. 2*a*, highly magnified.
4.—A hollow flint, from which fig. 2 was extracted; the papillæ on the surface, are casts of the orifices of cells.

Under the name of *Ocellaria inclusa*, Mr. König* has figured and described an elegant fossil body, not

* Icones Foss. Sect. fig. 98.

uncommon in the chalk and flints. This species is inversely conical, or funnel-shaped, and somewhat resembles the cast of the cavity of a Ventriculite, *Lign.* 62, fig. 4. But a little attention will enable the collector to distinguish it. The flint that is moulded in a Ventriculite, is surrounded by the substance of the zoophyte, and if found detached, and all the investing material removed, shows no trace of structure, but simply a surface covered with minute papillæ. The *Ocellaria* is generally included in a flint, and by a slight blow readily separates from the surrounding stone, presenting the appearance of a white calcareous cone, beset with regular cells (*Lign.* 63, fig. 2.); leaving a conical cavity in the flint (*Lign.* 63, fig. 4.), which is covered with corresponding eminences, or papillæ. Upon breaking the cone itself, it is found to consist of the calcareous polyparium, from one-eighth to a quarter of an inch in thickness, (*Lign.* 63, fig. 2 *a.*), investing a solid nucleus of flint, the surface of which is also dotted with minute points, but not so distinctly as that of the cavity of the outer case. The specific name, *inclusa*, has been given from this character, which, however, is only accidental, for the specimens that are imbedded in chalk, are simply surrounded by the stone. It is the calcareous nature of the polyparium, that renders it so easily separable from the investing flint, while its little cells afford numerous points of attachment, and these remain on the surface of the hollow case. I have not observed the same regularity of structure on the inner, as on the outer surface of the Ocellaria.

In proceeding with our survey of the fossil zoophytes, we find, at almost every step, the difficulty of following with precision the zoological arrangement of the living types, for this is based on organs (as those of digestion) of which no traces remain; and external form, with oftentimes obscure indications of the structure of the polyparium, afford the only clue to guide us through the labyrinth, and lead to satisfactory results. Numerous genera and species, characterised by the external form, and the shape and disposition of the cells and pores, have been established by various writers; yet a little attention to this class of fossils, discloses structures which differ from any of those previously classified, and new genera and species require to be added to the already very extended catalogue. But the student must be satisfied to arrange many of his specimens in certain groups or families, and not distract his attention with minute distinctions.

FLUSTRA (*Sea-mat*). *Lign.* 64, figs. 4, 5.—Polyparium membranaceous, flexile, or calcareous, encrusting or foliaceous, formed of cells, arranged in several series and in juxtaposition, more or less quadrangular, flat, with a distinct border.* This is one of the most common genera of the encrusting and frondescent zoophytes. The *Flustra* consists of a cluster, or aggregation of polypes, invisible to the naked eye; under the microscope, the polype is found to be a transparent gelatinous body, with a sac, or digestive cavity, the external margin of which terminates in eight or ten feelers, or tentacula, and the whole is surrounded by a firm wall, constituting a cell, that contains the body, and from which the animal can protrude its tentacula and upper parts. Figures of the living polypes, cells, &c. of the Flustra, are given *Wond.* p. 522, Pl. VI. figs. 3, 9.

Numerous species of fossil *Flustræ* occur in the British strata: the encrusting forms are attached to echinites, shells, &c.; the foliaceous imbedded in

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* The Flustra, Eschara, &c. belong to the polypes called *Bryozoa* (moss-animals, so named because their aggregated masses encrust other bodies like moss), which, although exceedingly minute, almost all being microscopic, are highly organized; their digestive organs are more developed than in the other classes, and are as complicated as those of birds. The class of polypes, whose calcareous skeletons principally constitute the coral reefs of tropical seas, are of a lower organization, and are called *Anthozoa* (*flower-animals*), the polypes of which resemble the common Actinia, or sea-anemone. The lowermost class are the *Hydrozoa* (hydra-animals, that is, resembling the common fresh-water polype or hydra); in them digestion is performed by a simple sac or pouch. See the admirable Lectures on Comparative Anatomy, by Professor Owen. Lecture VII. *Polypi.*

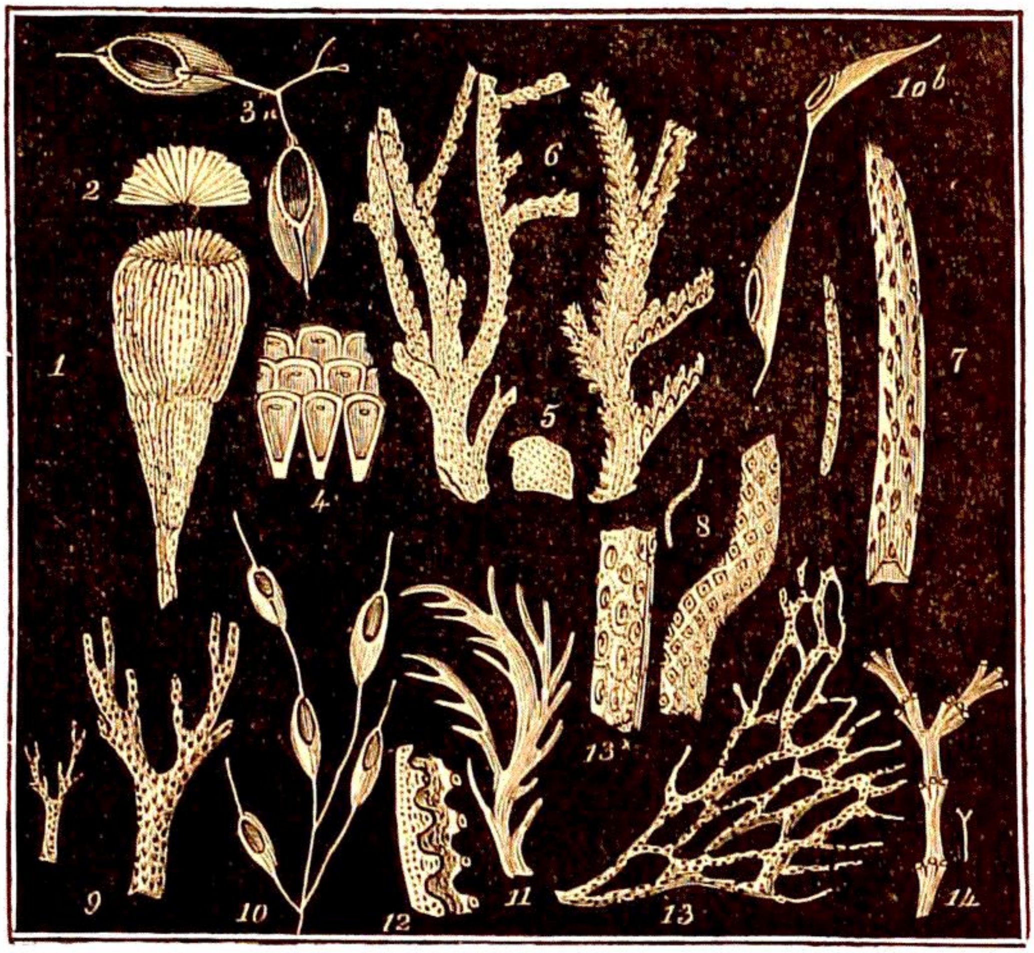
chalk, sand, sandstone, &c. In Mr. Morris's catalogue of British fossils, ten species are enumerated, but none are named from formations below the Cretaceous. A foliaceous Flustra is abundant in the Sussex and Kentish chalk, and often appears in flexuous folds, assuming a quadrangular form.* This species is generally of a ferruginous colour, and from its texture being that of the chalk, the original may be presumed to have consisted of a horny or membranaceous substance. Specimens sometimes cover several square inches of the chalk. It is common in the chalk-pit at Offham, near Lewes. I have selected for illustration a Flustra attached to an echinite from the chalk. *Lign.* 64, fig. 5, represents a patch of this zoophyte of the natural size; and fig. 4, a minute portion magnified, to show the form and arrangement of the cells.

ESCHARA.†—*Ly.* I. p. 391. Polyparium encrusting, foliaceous, calcareous, brittle; cells thickened on their outer surface, with a small, *depressed*, round orifice.

Species of this zoophyte are found in flints, or attached to echinites, and other bodies. They have the appearance of patches of Flustræ, but, with a lens, the latter may be distinguished from them by the regularity and juxtaposition of their cells.

* In my South Down Fossils, Plate XV. fig. 6, a specimen of this kind is described as a Ventriculite.

† *Eschara*, from the supposed resemblance to an eschar.



Ellen Maria Mantell, ad. nat. delt.

LIGN. 64. CORALS FROM THE CHALK AND MOUNTAIN LIMESTONE.

Fig. 1.—CARYOPHYLLIA CENTRALIS: *nat.* (G. A. M.) *Cret. Lewes.*

2.—Front view of half the disc of the same.

3.—Two cells of CRISIA JOHNSTONIANA. × ×.

4.—Magnified view of six cells of the Flustra, fig. 5.

5.—A portion of an encrusting Flustra: *nat. Cret. Chichester.* (*Mr. Walter Mantell.*)

6.—IDMONEA DIXONIANA: *nat.* (G. A. M.) *Cret. Lewes.* The figure on the left shows the under surface; that on the right, the upper surface, with a row of polype-cells on each margin: a portion magnified is given fig. 12.

7.—MILLEPORA RHOMBIFERA. × ×. *Mt. L. Ph. Yorks.* The small figure on the left is of the natural size.

8.—RETEPORA GUALTERIANA. × ×. (G. A. M.) *Cret. Chichester.* (*Mr. Walter Mantell.*) The small figure on the left, *nat.*

9 —MILLEPORA DICHOTOMA. × ×. *Cret. Dover.* (*Mr. Reginald Mantell.*) The left hand figure, *nat.*

10.—CRISIA (?) JOHNSTONIANA. (G. A. M.) × 250 linear. *S. s. Maidstone.*

Fig. 10^b.—Two cells of fig. 10, seen in profile. × ×.
11.—RETEPORA FLEXUOSA: *nat. Cret. Lewes.*
12.—IDMONEA DIXONIANA; a portion of fig. 6. ×.
13.—RETEPORA LAXA. *Mt. L. Ph. Yorks.*
13*.—A portion of the same ×.
14.—IDMONEA COMPTONIANA. × ×. (G. A. M.) *Chalk, Chichester.* (*Mr. Walter Mantell.*)
The small figure on the right is of the natural size.

CRISIA (*separated cells*). *Lign.* 64, figs. 3, 10.—The minute recent corals thus designated are allied to *Flustra*, but separated from that genus by the cells being disposed in a single series, and united by connecting tubes. I notice this genus to direct attention to a curious polypidom from the Shanklin sand (*Lign.* 64, figs. 3 and 10.). The specimen is attached to a fragment of shell. The cells, five of which are represented, fig. 10, are elliptical, with the aperture above, and towards one extremity. They are united by very slender, hollow filaments. Fig. 3, two of the cells seen from above × 250 linear; fig. 10^b. the same seen in profile.* I have named this species *C. Johnstoniana*, as a tribute of respect to the author of the works on British Zoophytes, previously recommended to the student.

The detritus of numerous minute and elegant calcareous polyparia, constitutes a considerable portion of the mass of some of the cretaceous beds.

* I refer this fossil to the genus *Crisia*, with some hesitation; perhaps *Hippothoea* would be more correct, but all the described species of the latter are branched.

Attached to the surface of shells, &c., and sometimes standing erect in little crannies, or hollows, of the flints, many beautiful species may often be detected with the aid of a lens. By brushing chalk in cold water, and examining the deposit, in the manner previously recommended, the student will be able to obtain many of the species figured in *Lign.* 64.

Fossil species of the flexible zoophyte, *Gorgonia*, or Venus's Fan, are occasionally met with, and very fine specimens may be obtained from the loosely aggregated sandstone of Maestricht. (*Wond.* p. 307, Tab. 50.)

RETEPORA (*porous net-work*).—Polyparium stony, disposed in meshes; foliaceous, or branching; cells opening only on the upper or inner side.

These are elegant corals; several fossil species are figured and described, from the Chalk formation of Maestricht, the mountain limestone of Yorkshire, (*Phil. York.*), and the Silurian deposits (*Murch. Sil. Syst.*). It may be useful to state, that in the description of these fossils, the openings in the net-work are called *fenestrules*—the spaces between the ends, *dissepiments*,—and those between the fenestrules, *interstices*.

Three minute species of this genus from the chalk are represented *Lign.* 64, figs. 8 and 11, and *Lign.* 54, fig. 1; and a very delicate Retepora from the mountain limestone of Yorkshire (*R. flexa*), *Lign.* 64, fig. 13.

FENESTELLA.—Cells very small, indistinct externally, with small prominent openings; polyparium stony, fixed at the base, composed of branches, which inosculate by growth, and form a cup. (*Murch. Sil. Syst.* p. 677.). Numerous delicate corals, formerly arranged as *Reteporæ*, have, with much propriety, been placed in this genus by Mr. Lonsdale; and the student, in examining slabs of the Dudley or Wenlock limestone, should remember the distinction.

MILLEPORA.—Pores very minute, perpendicular to the surface, giving the interior a finely striated fracture; form irregular.

There are many fossil species of this genus, some of which are branching, and of considerable size. Two small species are figured, *Lign.* 64; one from the chalk, fig. 9, and another from the mountain limestone, fig. 7. Considerable masses of a polymorphous milleporite, presenting a dense structure, are found in the chalk of Sussex and Wiltshire.

IDMONEA, *Lign.* 64, figs. 6, 14. — Polyparium stony, branched, porous, cells distinct, prominent, arranged in single rows on the inner face only.

A very beautiful coral, figured *nat. size*, *Lign.* 64, fig. 6, is found in the chalk of Kent and Sussex; it often forms a cluster of branches, two or three inches in circumference. The surface of the stems is covered with minute pores, and the cells are distinct, and placed in single rows on the margins; the left-hand figure of fig. 6 shows the plain surface, and that on the right, the opposite and inner, the margins being garnished with a row of cells; this structure is more distinctly shown in the fragment magnified, fig. 12.*

IDMONEA COMPTONIANA,† *Lign.* 64, fig. 14.—This delicate coral is dichotomous, cylindrical, with elongated distinct cells, disposed in triplets, at regular distinct intervals, on one side of the stem.

With the exception of one specimen, to be noticed hereafter, we have now described all the Polyparia figured in *Lign.* 64; and have shown what interesting organisms may be detected in a few grains of calcareous earth. It would be easy to give restored figures of the beings whose stony skeletons are the subject of these remarks, from their close resem-

* I have named this species to commemorate the researches of Frederic Dixon, Esq., of Worthing, who has formed an interesting collection of chalk fossils; and announced a work on the "Zoology of the Chalk Formation," to be richly illustrated with figures of many undescribed organic remains.

† This specific name is in honour of the noble and highly respected President of the Royal Society, the Marquess of Northampton.

blance to existing species; every pore and cell might be represented fraught with life; here the agile inmates, fully expanded, with their little arms, or tentacula, in rapid motion; there retreating within their recesses, and devouring the infinitesimal living atoms that constitute their food; or rapidly shrinking to the bottom of their cells upon the approach of danger; even their varied colours might be introduced, and thus a beautiful and highly interesting picture be presented to the eye, as now to the imagination.

Although, for convenience, I have selected the above examples principally from the cretaceous strata, the collector must not suppose that other formations are not equally prolific in these remains. The Coral-rag of the Oolite, many beds of the Mountain limestone, and those of Dudley and Wenlock of the Silurian System, contain myriads of minute polypidoms associated with the coralline masses, of which those strata are so largely constituted. Exquisite figures of the Silurian corals are given, *Murch. Sil. Syst.* pl. 15, 16, and described by Mr. Lonsdale with characteristic accuracy. A slab of the Dudley limestone often has the entire surface studded with corals, shells, and crustaceous animals, of many species and genera, lying in bold relief, and in the most beautiful state of preservation.

VERTICILLIPORA, (*Lign.* 55.).—Cells poriform, arranged in meshes on the surface of convex imbricating plates round a hollow axis, forming a fixed, irregular, subcylindrical polyparium. *Lign.* 55, fig. 4, represents with great accuracy a very extraordinary coral, common in the sand-pits of Faringdon, (*Wond.* p. 560, Tab. 105, fig. 3.) which is referred by Mr. Morris to this genus.* It is composed of short cylindrical anastomosing branches, or tubes, emanating from an expanded base, divided internally by transverse parallel plates, covered with exceedingly minute pores, or cells, disposed in meshes; the plates enclose a hollow pillar or axis. This structure is well shown in the figure.

LUNULITES (*Lign.* 55.).—Polyparium orbicular, convex above, concave below; concavity radiated; convexity covered with cells, arranged in concentric circles on diverging radii. A species of this coral is often found in the chalk. *Lign.* 55, fig. 1, represents a specimen from the South Downs.

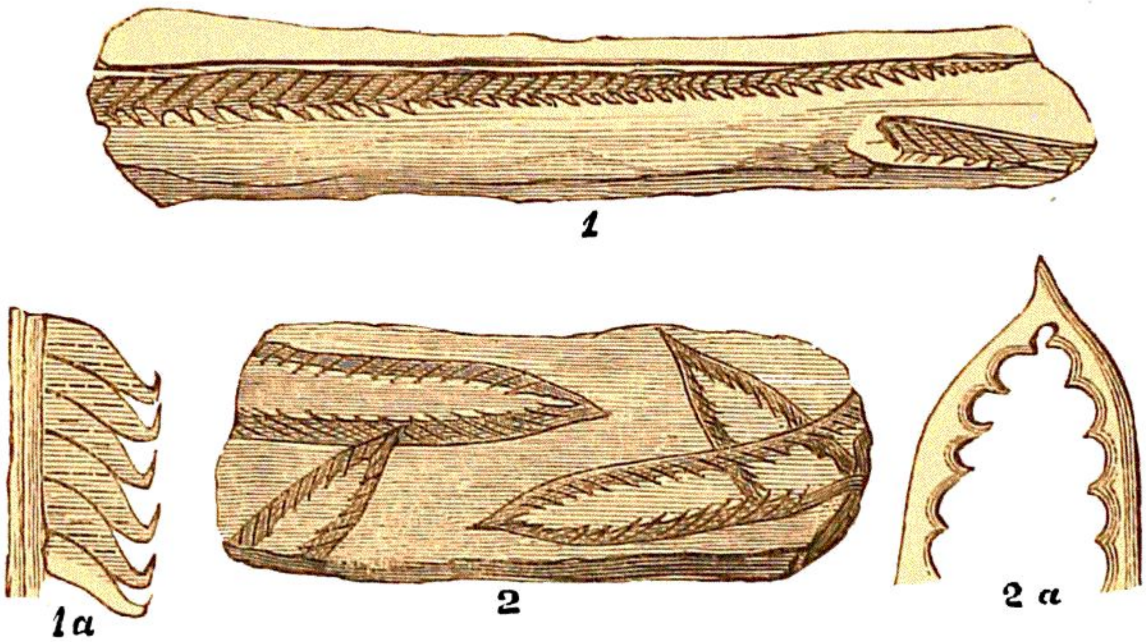
GRAPTOLITHUS (*Lign.* 65.).—Polyparium elongated, undivided, sublinear, acuminated or obtuse, serrated.

These curious bodies abound in some of the Silurian strata, and may be considered as belonging to the characteristic fossils of those ancient deposits. They are the horny central axes, or supports, of zoophytes supposed to be related to the *Pennatula*,

* Catalogue of Brit. Foss. p. 46.

or sea-pen,* and are always more or less flattened from compression.

In a recent state these bodies were probably covered with a soft, or albuminous mass, studded



LIGN. 65. GRAPTOLITES IN WENLOCK LIMESTONE.

(*Murch. Sil. Syst.*)

Fig. 1.—*Graptolithus Ludensis.*†
1*a*.—Magnified view of a portion of the same.
2.—*Graptolithus Murchisoni.*
2*a*.—Magnified portion of fig. 2.

with polype-cells, disposed in rows along the margins of the lateral, curved, grapple-like processes, as in the zoophytes termed *Virgularia*,‡ to which they bear a greater analogy than to Pennatula. It has

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* See British Zoophytes, p. 174, fig. 22.

† *Ludensis*, from Ludlow—to indicate the habitat of the fossils.

‡ See British Zoophytes, Pl. XXIV.

been suggested by some eminent naturalists, that the originals were more nearly related to *Sertularia*, but they appear to me to present close affinity to the family of *Pennatulidæ*. If two specimens of the Graptolithus Ludensis be placed together, so that the elongated smooth edges be in apposition, the united stems will be seen to offer a general resemblance to the axis of *Virgularia mirabilis*.

The species fig. 2, occurs in the lower Silurian rocks, and volcanic grits.* Graptolites have been found in strata of the same age in Norway, Sweden (*Ly*. II. p. 173.), and Scotland. I have received slates literally covered with them, from the Cambrian rocks of the United States, by Benjamin Silliman, jun. Esq.

The distinguished author of the *Silurian System* remarks, that the nature of the strata in which these remains occur in Radnorshire, indicates a condition of the sea well suited to the habits of the family of Sea-pens; for the recent species live in mud and slimy sediment, and the fossils are imbedded in a finely levigated *mud-stone*, which, from its structure, must have been tranquilly deposited. There are six or seven species of Graptolites, all belonging to the most ancient fossiliferous deposits.

I shall next describe some of the single lamellated corals, and then notice those which consist of an

* Murch. Sil. Syst. p. 694.

aggregation of radiated cells, either disposed in solid masses, or frondescent; and also the tubular branched corals, whose cells are radiated or divided by lamellæ, or plates.

FUNGIA (*Wond.* p. 571.).—The corals thus named, from their resemblance to fungi, are of a depressed form, with a scabrous surface beneath; and are divided above by numerous lamellæ, or plates, which radiate from a central, oblong depression, or groove.

When living, the whole polyparium was enclosed by a gelatinous substance, with numerous tentacula around the central cavity, or sac. These zoophytes may be compared to the *Actiniæ*, or sea-anemones; from which they differ only in having a calcareous frame-work, while the Actiniæ have but a stiff albuminous case. (*Wond.* Pl. VI. figs. 2 and 4, represent the living animals, and Tab. 50, fig. 4, and p. 571, fig. 2, two fossil species.)

In the secondary arenaceous strata of the United States, which the researches of Dr. Morton, of Philadelphia, have proved to be the equivalents of the European Cretaceous formation, a single lamellated coral is not uncommon. It is evidently related to the Fungiæ, and is the skeleton, or calcareous support, of an actiniform animal, like our common sea-anemone: a specimen is represented *Lign.* 68, fig. 4. This coral is named by Dr. Morton *Anthophyllum Atlanticum.*

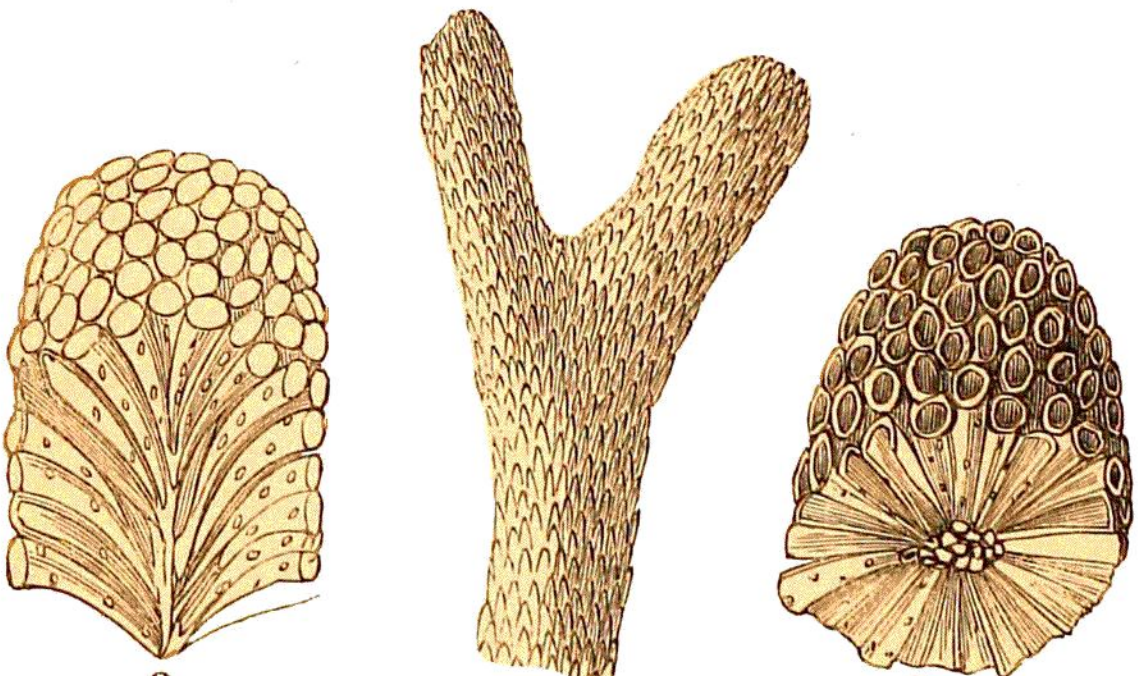
TURBINOLIA (*Wond.* p. 307.).—Polyparium turbinated, detached, base acute, not adhering; cell single, radiated.

This genus occurs in all the fossiliferous deposits: a small, well-marked species (*Turb. Königi*, G. A. M.), from the Galt, of which subdivision of the cretaceous strata it is a very characteristic fossil, is figured *Wond.* Tab. 50, figs. 1, 2.

CARYOPHYLLIA (*Lign.* 64, figs. 1, 2.; *Lign.* 68, fig. 5.). — Polyparium turbinated, or cylindrical, simple or branched, fixed by the base; cells lamellated.

A small recent species of this genus (*C. cyathus*), is common in the Mediterranean, and very frequently seen in collections; it is of a wine-glass form, and the base by which it is attached to other bodies, is broad and spreading. The newer tertiary deposits in Sicily contain this species in abundance. A fossil Caryophyllia, common in the chalk, bears a general resemblance to this species (*Wond.* Tab. 50, fig. 3.); a small specimen is figured *Lign.* 64, figs. 1, 2. Branched Caryophylliæ occur in the Coralline Oolite (*Wond.* p. 571. *Ly.* II. p. 42.), and also in the Dudley limestones (*Murch. Sil. Syst.* pl. 16.). A large proportion of the Coral-rag of the Middle Oolite, is composed of a ramose coral (*C. annularis*) of this genus. *Lign.* 68, fig. 5, represents a specimen from near Faringdon.

Favosites (*Lign.* 66. *Lign.* 68, fig. 3.).—Polyparium stony, polymorphous, solid internally, compact, composed of a congeries of diverging or ascending parallel, contiguous, prismatic tubes, covered by pores, divided by lamellæ, and communicating by lateral foramina.



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Lign. 66. Favosites polymorpha. *Jura Limestone.* (*Goldfuss.*)

Fig. 1.—Portion of a branch of the coral. *Nat.*
2.—Fragment, slightly magnified, with part of the surface broken away below, exposing the central axis, and radiated arrangement of the cells, with their lateral pores.
3.—Another portion, magnified, showing the polype-cells hollow.

This is another tribe of zoophytes that abounded in the Silurian seas, their remains occurring with the other fossil corals of that epoch, in great abundance. I have many beautiful examples from the

Silurian strata of the Ohio, and Niagara, by favour of Dr. Owen, of New Harmony, in which the cells are filled up with calcareous spar. The varied markings on many of the Babbicombe marbles, and Torquay pebbles, are derived from enclosed Favosites (*Wond.* p. 574.*).

Many figures of this beautiful fossil are given by M. GOLDFUSS in his celebrated work on Organic Remains. The specimens selected for illustration (*Lign.* 66.) display the structure so clearly, that further description is unnecessary.

Another species (*Favosites Gothlandica*) occurs in masses of a subconical shape, and is very abundant in some of the Silurian limestones. A fragment, to show the structure, is figured *Lign.* 68, fig. 3.

CATENIPORA, (*Wond.* p. 572, fig. 3.).—Polyparium hemispherical, composed of vertical anastomosing lamellæ ; cells tubular, oval, terminal, united laterally. The oval form of the cells when united laterally, and the flexuous disposition of the lamellæ, give rise in transverse sections to elegant catenated markings, from which appearance the fossil has received the name of *chain-coral.*† The species figured (*C. escharoides*) in *Wond.* is common in the Silurian limestones, and sometimes forms hemispherical masses more than a foot in diameter.

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* The specimen figured is misnamed Caryophyllia.

† Org. Rem. Vol. II. Plate III. figs. 4, 5, 6.

SYRINGOPORA, (*Lign.* 68, fig. 2. *Wond.* p. 571, fig. 5.)—Polyparium arborescent, striated externally, widely attached; cells deep, tubular, radiated by numerous prominent lamellæ.

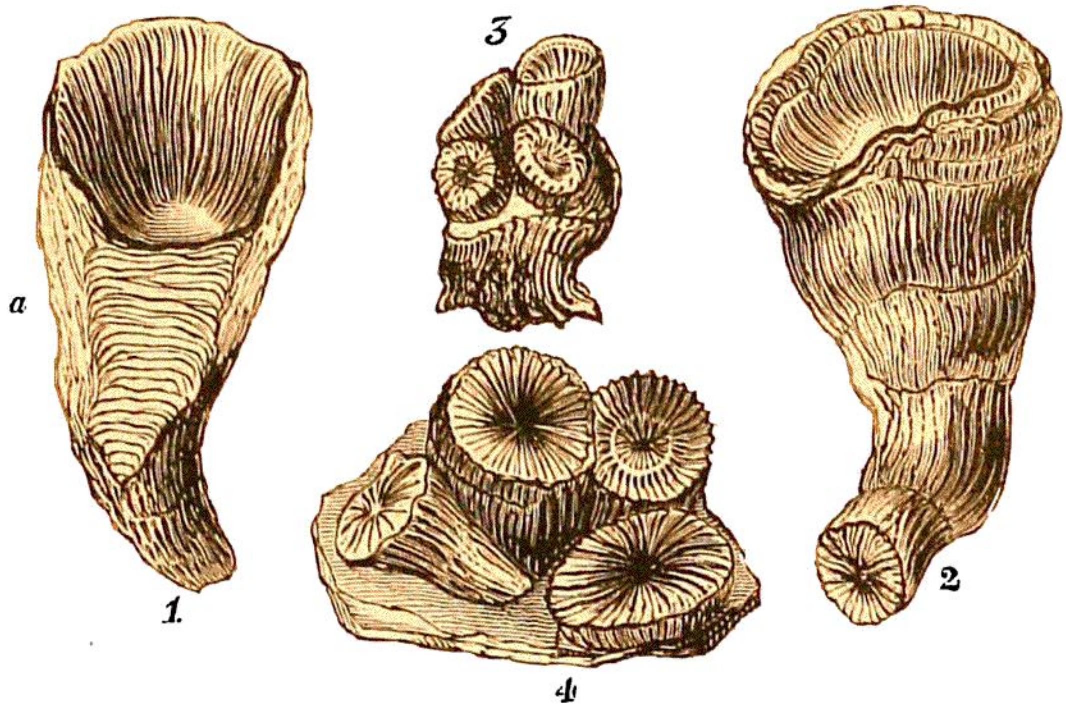
The external appearance of these corallites is that of a cluster of cylindrical tubes, more or less parallel, connected by numerous short hollow transverse processes. They are the *Tubiporites* of Mr. Parkinson, who has given some admirable figures, *Org. Rem.* Vol. II. Plates II. III.; in these fossil corals that ingenious observer first detected the animal membrane. A slab of marble, whose markings are produced by the section of the enclosed tubes of a Syringopora, is represented, *Wond.* p. 572, fig. 2. The Mountain limestones of Derbyshire, and on the banks of the Avon, near Clifton, contain figured marbles of this kind, which are manufactured into vases, tables, &c.

LITHOSTROTION, (*Wond.* p. 571, fig. 8.).—Polyparium massive, solid, composed of aggregated, contiguous, parallel, prismatic tubes; cells shallow, multi-radiate, stelliform.

A species of this genus is common in the mountain limestone, in large masses, which, from the pentagonal form, and parallel arrangement of the tubes, appear like clusters of miniature basaltic columns: hence the name, *L. basaltiforme*.

CYATHOPHYLLUM, (*Lign.* 67, figs. 1, 2. *Wond.* p. 571, figs. 1, 3.).—Polyparium turbinated, simple or compound, internal structure transversely chambered or lamellated; cells polygonal, radiated, depressed in the centre, hollow towards the margin.

The corals of this genus are so abundant in the Silurian rocks, that the seas of that epoch must



LIGN. 67. CORALS FROM THE DUDLEY LIMESTONE.

(*Murch. Sil. Syst.*)

Fig. 1.—CYATHOPHYLLUM TURBINATUM: an oblique longitudinal section, showing at *a* the transverse lamellæ, or cells, of the internal structure.
2.—The same species.
3.—CYATHOPHYLLUM DIANTHUS: a specimen, with four young germs arising from the disc below.
4.—The same species, with four adult cells.

have teemed with these forms of zoophytal organization. The simple turbinated species are sometimes several inches long, and being somewhat curved, have obtained the popular name of "*petrified ramshorns.*"

Upon slitting one of these corals vertically, as in *Lign.* 67, fig. 1, the axis of the polyparium, beneath the cell, is found to consist of thin transverse partitions, constituting a series of chambers.

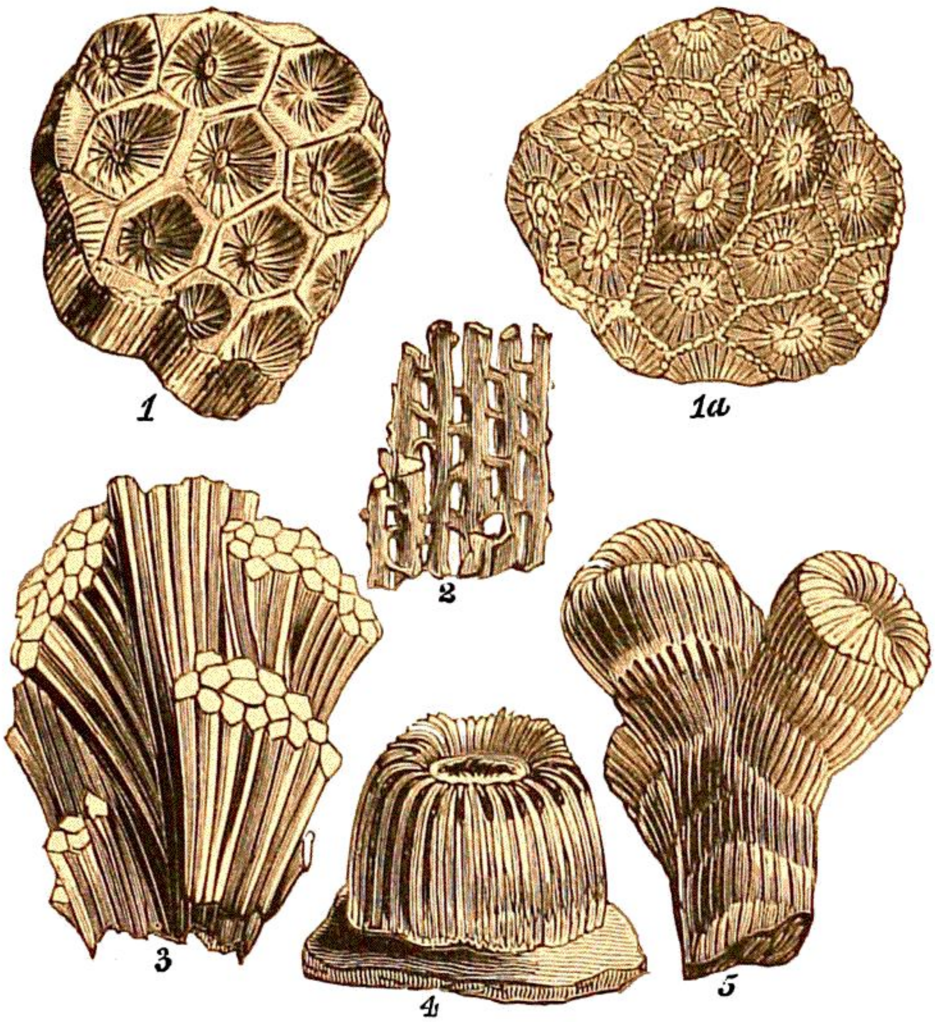
In the compound Cyathophylla, the germs of young cells, occupying the disc of a parent cell, are often met with. Fig. 3 represents a group of four germs on the parent cell, of *C. dianthus*, a common and beautiful coral of the Dudley limestone.

These corals are also abundant in South Devonshire, and many of the most elegant marbles of Babbicombe owe their markings to sections of these polyparia.

Associated with the Cyathophylla in the Silurian rocks, are some corals that attain considerable magnitude, and which are principally distinguishable by their internal structure. Such are *Cystiphyllum*, constructed of bladder-like cells, (*Ly.* II. p. 169); and *Strombodes*, composed of spirally contorted lamellæ, or plates (*Murch. Sil. Syst.* pl. 16 bis., fig. 4.). Other hemispherical masses, presenting on the surface concentric wrinkles, with very minute pores, are common at Dudley, and belong to the genus *Stromatopora*.

Astrea, (*Lign.* 68, figs. 1 and 1*a.*)—Polyparium massive, irregular in shape, or globular, formed by an aggregation of lamellated, radiated, shallow, polymorphous cells.

The species of this genus are also among the most numerous of the corals of the Oolite, and of the older secondary formations, and with the



LIGN. 68. FOSSIL CORALS.

Fig. 1.—ASTREA ANANAS. *Devonshire.*
1*a*.—A polished Slice of Marble, formed of the same species.
2.—SYRINGOPORA RAMULOSA. *Mt. L. Derbyshire.*
3.—A Fragment of FAVOSITES GOTHLANDICA. *Ohio.* (*By Dr. Owen.*)
4.—ANTHOPHYLLUM ATLANTICUM. *Cret. U. States.* (*By Dr. Morton.*)
5.—CARYOPHYLLIA ANNULARIS. *Oolite. Faringdon.*

Caryophylliæ, Cyathophylla, &c., form those coral-line beds, often many feet in thickness, which pervade some of the strata, and are, in fact, coral-reefs, that have accumulated beneath the sea, on the areas they now occupy (*Ly.* II. pp. 42, 43.). The strata of the Oolite, called *Coral-rag* from the abundance of these relics, are literally composed of an aggregation of large corals, the interstices between them being filled with shells, radiaria, &c., either whole, or in a comminuted state. The heaps of stones placed by the road-side, in the N. W. of Berkshire, appear like fragments of an old coral-reef, and attract the notice even of the most incurious observer. I have figured a specimen of Astrea, *Lign.* 68, fig. 1, and a polished specimen, fig. 1*a*, from Clifton, a locality abounding in fine sections of mountain limestone, yielding beautiful examples of coralline marble. The mode of increase of the Astreæ is very curious, a subdivision taking place in the old cells, after the manner of many of the Infusoria; and among the fossils, a star or cell may be seen in progress of division into two, three, or four stars (*Murch. Sil. Syst.* pl. 16, fig. 6.). A living polype of this genus is figured, *Wond.* Pl. VI. figs. 7, 11.

A highly interesting species of Astrea, (*A. Tisburiensis. Wond.* p. 571.) is found in large hemispherical masses, completely silicified, at Tisbury, in Wiltshire. The transverse surface displays, in some specimens, beautiful white radiated stars, on a dark blue ground; and in others, the colours of the stars and ground are reversed. This silicified coral is obtained from a bed of chert, a foot in thickness, which is interstratified with the Portland limestone, this division of the Oolite being largely developed around Tisbury.*

Several species of this and the following genus, perfectly silicified, are found among the pebbles and boulders in Antigua, and other islands of the West Indies, associated with the fossil palms, described in a former part of this work. Some of these corals are of great beauty, and polished sections exhibit the coralline structure most perfectly.

MADREPORA (*Wond.* p. 541, fig. 2.). — Polyparium arborescent or frondescent, porous, fixed; cells deep, prominent, irregularly dispersed on the surface, and accumulated towards the terminations of the coral.

The term madreporite, or fossil madrepore, was formerly applied to all the branched fossil corals with radiated cells, but is now restricted to those which possess the above characters. The recent common species, figured *Wond.* p. 541, will serve to illustrate this genus. The clavated, branched kinds of Madrepore, with polygonal minute cells having twelve rays, are termed *Porites*, and are frequent in the Silurian strata (*Ly.* II. p. 169.).

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* See A Catalogue of Wiltshire Organic Remains, p. iv. by Miss Etheldred Benett, of Norton House, Warminster. 4to. 1831.

LITHODENDRON (*Lign.* 55, fig. 3.).—Polyparium branched, formed of deep, cylindrical, elongated cells, which are terminal, and radiated, with a prominent central axis.

Large masses of several species of this genus, composed of clusters of branches, abound in the Mountain limestone of Derbyshire, Yorkshire, &c.; and a few species occur in the Coralline Oolite; their general configuration will be understood by *Lign.* 55, fig. 3; but in the specimen figured, the margins of the cells are worn off, and do not present the original deeply excavated form.

There is a remarkable specimen of this coral in the Bristol Institution (of which a portion is now placed in the Museum of Economical Geology, in London), that was discovered by Mr. Stutchbury, in a vein of hematitic iron ore. It is a large mass, in which the entire substance of the coral is transmuted into a metallic ore, forming one of the most interesting natural electro-types I have ever seen. In this case, a block of Lithodendron must have lain in a vein or fissure of the stratum, and its animal membrane have resisted the action of the gaseous emanations, or mineral solutions, while the lime was dissolved, and the metallic matter deposited atom by atom, as in the case of pseudomorphous crystals.

Besides those we have specified, there are numerous fossil zoophytes in the British strata, many of which are undetermined; particularly in the Crag, and other tertiary deposits; but without the aid of numerous figures, their description would be useless to the student.

GEOLOGICAL DISTRIBUTION OF FOSSIL ZOOPHYTES.—Although the distribution of the organic remains of zoophytes in the various formations, affords less striking phenomena than those of vegetables, yet some interesting results are presented for our consideration. We perceive that in the most remote geological periods these forms of vitality were in existence, and producing the same effects as the races of the present day.

Nearly 350 species are enumerated in Mr. Morris's Catalogue of British Organic Remains; and it is probable that this list might be largely increased by diligent research.

The Tertiary formations afford numerous Caryophylliæ, Flustræ, Escharæ, Spongiæ, &c.; and the *Crag*, many species of genera that have hitherto been but imperfectly investigated. The older Tertiary, or Eocene deposits, contain Turbinoliæ, Astreæ, Fungiæ, Meandrinæ, and other genera, the recent species of which are inhabitants of tropical seas.

The zoophytes of the Chalk have been presented to the reader somewhat in detail. In the Maestricht deposits, lamelliferous corals, as Astreæ, Fungiæ, Meandrinæ, &c. prevail, and may be extracted from the friable arenaceous limestone in a fine state of preservation. In the White Chalk and Green Sand, of this country, the Spongiæ and allied genera are abundant, and associated with Caryophylliæ, Flustræ, and other forms of the Bryozoa.

But in the Chalk and Shanklin Sand of England, no coral reefs are observable; the zoophytal remains, with but a few local exceptions, occur promiscuously intermingled with the fishes, shells, radiariæ, and other marine reliquiæ; although many layers, or thin seams of chalk and marl, are largely composed of the detritus of Polyparia, like the modern deposits of the Bermudas (*Wond.* p. 69.). These phenomena are in accordance with the general lithological characters of the White Chalk formation of England, and the nature of its organic remains, both of which indicate a profound ocean; and coral reefs are only found at moderate depths. But in other localities, where the sea was shallow, during the formation of the Cretaceous strata beds of coral limestone were produced; and in these strata are also found univalve, and other littoral (*sea-shore*) shells, associated with the usual sponges and other zoophytes (*Wond.* p. 564.).

In the secondary formations immediately preceding the Cretaceous, namely, the Lias and Oolite, coral-reefs, that appear to have undergone no change, but that of elevation from the bottom of the sea, and the consolidation of their materials, evince a condition of the ocean in our latitudes, which is now only met with in tropical climates (*Wond.* p. 569.).

The limestones of the Carboniferous and Silurian systems, also abound in *anthozoan* corals, but many peculiar kinds appear, particularly of Cyathophylla, Lithododendra, Syringoporæ, Cateniporæ, &c.; and are as characteristic of these deposits, as the Sigillariæ and Stigmariæ are of the Coal measures.

The extensive beds of coralline marbles which are found in the Silurian strata wherever they occur, for similar limestones in North America are characterised by the same species of corals as those of England, prove that a more equal distribution of temperature must have prevailed throughout the sea, at that geological epoch, than at the present time, when the geographical distribution of the coral zoophytes is strictly limited by temperature. The reef-forming genera are now confined to waters where the temperature is not below 70°; their most prolific development being 76°. The apparent exception, the occurrence of coral-reefs at the Bermudas, is found to depend upon proximity to the Gulf Stream (*Wond.* p. 55.), which brings down the thermal waters of the tropics, and increases the local temperature of the sea in those localities. The general prevalence of a higher temperature in the earlier ages of our planet, which the reader will remember was indicated by the fossil Flora of the Carboniferous system, thus receives support from the stratigraphical distribution of the fossil polyparia.

On Collecting Fossil Corals.—Few instructions are required for the collection of fossil zoophytes, for as the most important characters of the several kinds have been pointed out in the previous descriptions, the student will be able to select illustrative specimens for his cabinet. The minute corals, &c. of the Chalk, and other limestones, are to be obtained by the same process as that directed for the Infusoria, or animalculites. The large examples should be left attached to a piece of chalk, when practicable, and the surrounding stone removed with a knife or graver, so as to expose as much of the fossil as may be required for the display of its characters, without loosening its attachment to the block. When the investing chalk is very hard, frequently pencilling the specimen with vinegar, or dilute hydrochloric acid, will soften the stone, and render its removal easy, by means of a soft brush: when acid is employed, the specimen must afterwards be well rinsed in cold water.*

The zoophytes that occur preserved partly in flint, and partly in chalk, as the Ventriculites, can

* It may be well to caution the collector against employing sulphuric acid (commonly called *oil of vitriol*) for this purpose, for a white insoluble deposit (sulphate of lime) will thus be formed on the specimen, and its appearance irremediably injured.

rarely be obtained, except through the quarrymen who have been instructed what objects to preserve. The first specimen of this kind ever noticed, was discovered in a mass of chalk which I was breaking up in search of fungiform flints; when, to my great delight, I found the fossil, *Lign.* 61, fig. 3, which at once established the connexion between the flat chalk specimens, *Lign.* 61, figs. 1, 2, and the flints figured *Lign.* 60, figs. 2, 3, 6, 7, 8. Upon showing this fossil to the quarrymen, and exciting their attention by suitable rewards, I obtained the illustrative series now in the British Museum. Much light would probably be thrown on the nature of the organization of other zoophytes of the chalk that have undergone this mode of petrifaction, if due care were taken in their collection, and they were examined before extracted from the stone in which they are imbedded. Loose, delicate specimens, whether from the chalk or tertiary strata, should be affixed, with strong gum-water, to cards, or on pieces of thin board, covered with suitable coloured paper.

The Shanklin-sand Spongites, Siphoniæ, &c. may often be extracted from the rock tolerably perfect, by a well-directed blow of the hammer; but delicate specimens should be left attached to a block, and the surrounding stone be carefully chiselled away, so as to expose the most essential characters.

The Faringdon zoophytes are, for the most part, encrusted by an aggregation of minute polyparia, shells, and detritus, which may be partially removed by washing with a stiff brush, and their cavities cleared with a stout penknife, removing the extraneous matter by *chipping*, not by scraping, or the surface will be injured. In this manner the beautiful specimens figured *Wond.* pp. 560, 561, were developed.

The Corals in the hard limestones can seldom be chiselled out to advantage; for the most part, polished sections are the best specimens for the display of the form and structure of the originals.

The silicified zoophytes of the West Indies, and those from Ava, and the Sub-Himalayas, form beautiful subjects for the microscope; and chips, or sections, should be prepared in the manner recommended for fossil-wood in the same state of mineralization.

LOCALITIES.—The gravels and sands are the most favourable sites for obtaining the Tertiary zoophytes. Mr. Bowerbank has very recently discovered a new species of Astrea (*A. Websteri*) at Bracklesham Bay.

The stone quarries, in that division of the Oolite called Coral-Rag (as in the north-west of Berkshire, Oxfordshire, Gloucestershire, &c.), afford the usual corals of the Oolite.

The Oolite near Bath contains many species, and large masses wholly composed of a minute coral

(*Eunomia radiata*, *Ly.* II. p. 43.), are abundant. The Shanklin Sand gravel-pits, near Faringdon, in Berkshire (see *Wond.* p. 560.), abound, as already mentioned, in many kinds of sponges, and other Amorphozoa; and the quarries of oolitic limestone in the vicinity of that town, yield the usual corals of the formation, in profusion. I know of no locality so rich in these remains.

At Steeple Ashton, in Wiltshire, numerous Caryophylliæ, and other oolitic corals may be obtained. The silicified *Astreæ*, of Tisbury, in the same county, have been particularly described.

Clifton, near Bristol, Torquay and Babbicombe, on the Devonshire coast, are celebrated for their coralline marbles and pebbles. And many of the Derbyshire limestones are equally prolific in similar remains.

Dudley, Wenlock, and Ludlow, are well known, as affording innumerable examples of fossil zoophytes, in great perfection.

I content myself with this brief notice, as the localities of the principal kinds of British zoophytes, have been incidentally mentioned in the course of our previous review.

CHAPTER IX.

FOSSIL ECHINODERMA; COMPRISING THE CRINOIDEÆ, OR LILY-LIKE ANIMALS; STELLERIDÆ, OR STAR-FISHES; ECHINIDÆ, OR SEA-URCHINS.

THE fossil remains of the Echinoderma (*spiny-skin animals*) are found among the earliest traces of animal existence hitherto discovered; for numerous species of the Crinoideæ, and one genus of the *Stelleridæ*, occur in the Silurian deposits.

The animals of this group present the radiated character very decidedly, for their parts are arranged around one common centre; the star-fish and sea-urchin of our coasts are familiar examples of this type of organization. Their external integument or skin is, in most examples, protected by spines (hence the name of the order), and in general perforated by minute foramina for the admission of sea-water, or the protrusion and retraction of minute tubes or hollow tentacula, which constitute their common organs of adhesion and locomotion. The two first families have their skeletons formed of numerous ossicula, or little calcareous bones; the last, of crustaceous brittle plates. These durable parts of the animal fabric occur in immense quantities in the sedimentary deposits; and in many parts of England, and of northern Europe and America, entire mountain-chains are chiefly composed of the bones and detritus of *Crinoideæ*, belonging to numerous extinct species and genera.

Diversified in figure as are the animals arranged in this section, they are naturally related by their organization. The Crinoideæ may be regarded as star-fishes fixed to one spot by a jointed stem; the Star-fishes as free Crinoideæ; and the Echinidæ as star-fishes with the rays coalesced and united together into a globular or spherical case.

FOSSIL CRINOIDEÆ.—The fossil remains of the Crinoideæ, have long since received the name of *Stone-lilies*, from the fancied resemblance of the body of the animal when in a state of repose to a closed lily or tulip; but this appellation is generally restricted to those which have cylindrical or elliptical stems; the term *Pentacrinite*, being applied to those whose support is made up of angular ossicula. One living species only is known, the *Pentacrinus Caput-Medusa*, an inhabitant of the Caribbean Sea (*Wond.* p. 580.). This animal has a long jointed stem, which is fixed at its base by radicle processes, and supports a cup-like receptacle, formed of a series of calcareous plates closely adjusted to each other, in which the body and viscera are contained. The upper part of the receptacle is covered by a plated integument, in which there is an opening for the mouth. From the brim or margin, proceed five jointed arms, which subdivide into branches of extreme tenuity; the upper and inner side of the arms support numerous articulated *cirri*, or feelers. The joints composing the column of support are pentangular, very numerous, and have a central cavity or perforation, and there are side-arms, or articulated tentacula, that radiate from the column in groups of five, at different points. The upper part of the skeleton is figured, *Wond.* Tab. 115.

In a living state the skeleton is covered by the integuments which secrete it; the mouth is situated in the centre of the plated integument of the receptacle, and surrounded by the five arms, which, when spread out, with their numerous *cirri*, form a net for the capture of the prey, and convey it to the mouth. It is scarcely necessary to remark that each Pentacrinus is an individual organism, and not an aggregation of animals, as are the *Polypiaria*, examined in the preceding chapter.

The fossil remains of the Crinoideæ consist of the ossicula, or little bones of the column, arms, and tentacula; of the plates of the receptacle; and of the peduncle, or process of attachment, by which the animal was permanently fixed to the rock. The peduncle is in some species flat and expanded, like that of Gorgonia; in others, it consists of long jointed processes or arms. These several parts of the skeleton are commonly met with more or less detached, and intermingled with the detritus of the strata; and throughout extensive tracts of encrinital limestone, no vestiges of the receptacle are discoverable. But in some localities the skeletons are preserved entire, and spread out on the surface of the layers of shale, clay, or limestone, as if the animals had been enveloped by the soft deposit when alive, on their native sites.

These remarks will afford the reader a general idea of the nature of the animals whose remains are scattered through certain rocks in such inconceivable quantities; for, much as the column may differ in form, the ossicula in their markings, and the plates of the receptacle in their configuration and ornament, the same type of organization will be found to prevail throughout the whole family. This subject is so fully illustrated by Dr. Buckland (*Bd.* plates 47—53.), that I need not enlarge upon it, but shall proceed to describe a few specimens, to guide the student in his investigations.*

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* The best English work is MILLER's Crinoidea, or Natural History of the Lily-shaped Animals. 1 vol. 4to. 1821; with coloured plates;—for, although numerous genera have since been discovered, the principles of Mr. Miller's arrangement are still followed. The Penny Cyclopedia, Art. *Encrinites*, may be consulted with advantage; and I would here

ENCRINITAL AND PENTACRINITAL STEMS AND OSSICULA (*Wond.* p. 517, Tab. 114. *Bd.* plates 49—52.).—The detached bones, and portions of the stems, are so common in many strata, that they attracted the notice of the earlier collectors, by whom the single ossicula were called *trochites* (wheel-stones), and when in an united series, *entrochites*. In the north of England they are called fairy-stones, and Saint Cuthbert's beads. I have found the circular perforated ossicula, which had been worn as ornaments, in tumuli of the ancient Britons.

These bodies present considerable variety in form and ornament, and in the markings on their articulating surfaces, which are often radiated and grooved in floriform and stellular figures (*Lign.* 69, figs. 3, 4.). The central perforation is small in some species, and large and pentagonal in others. The ossicula of the Encrinites often vary in size in the same column, being circular and elliptical, or thick and thin, alternately, as in the upper part of the column of the Lily Encrinite, *Lign.* 69, fig. 6, by which great flexibility and freedom of motion were obtained.

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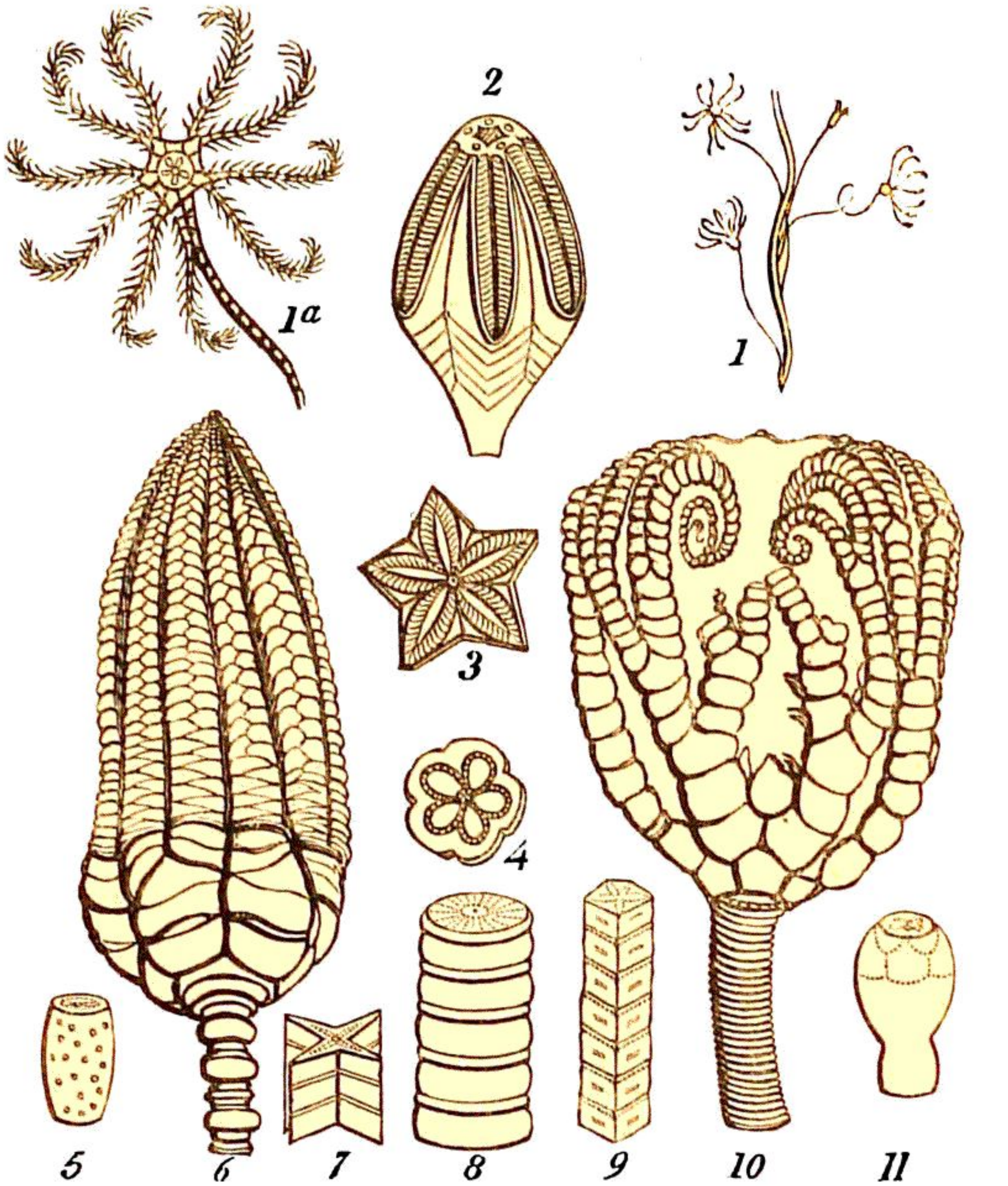
observe, that all the articles on Palæontology in that work are of the highest order, and will afford the student much important and accurate information on the subjects embraced by the science.



LIGN. 69. ILLUSTRATIONS OF CRINOIDEÆ.

Fig. 1.—Group of Living COMATULÆ: *nat.* (*Dr. Thompson.*)
1a.—A Single COMATULA of the same group, magnified.
2.—PENTREMITES PYRIFORMIS. *Ohio.*
3, 4.—Surfaces of two pentepetalous joints or ossicula.
5.—One of the bones of APIOCRINITES. *Chalk.*
6.—ENCRINUS LILIIFORMIS; the body and part of the column attached. $\frac{1}{3}$ *nat. From Brunswick.*
7.—PENTACRINITAL stem of four angles.
8.—ENTROCHITE, composed of five smooth ossicula.
9.—Quadrangular stem of seven ossicula.
10.—CYATHOCRINITES TUBERCULATUS. (*Murch. Sil. Syst.*)
11.—Receptacle of APIOCRINITES; *from the Chalk. Lewes.*

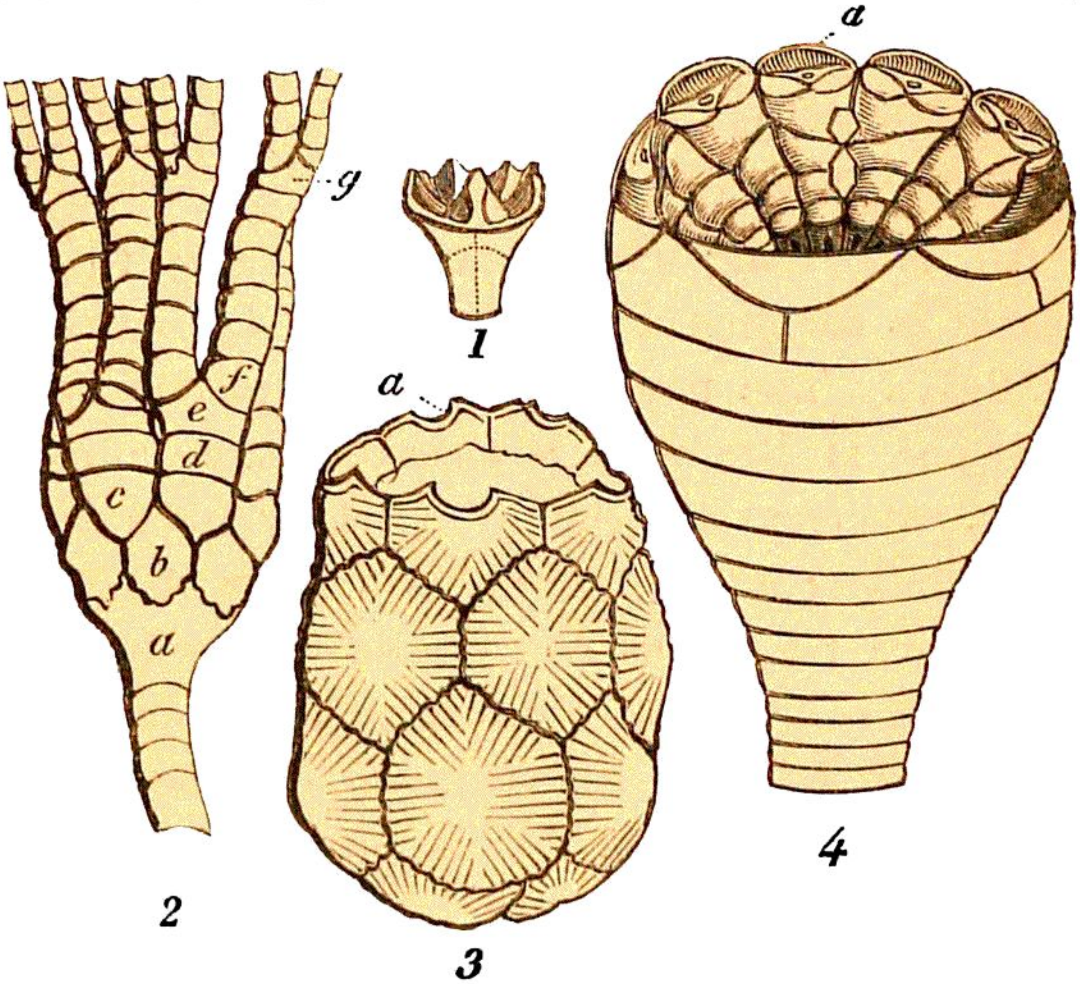
The pentagonal stems also display many modifications; some have five, others but four angles (*Lign*, 69, figs. 7, 9.). In some the angles are acute, in others rounded. Several varieties are figured in *Lign*. 69, and in *Wond*. Tab. 114. The circular, or pentagonal channel formed by the united ossicula of the column, has given rise to the curious fossils called, in Derbyshire, *Screw*, or *Pulley-stones*, which are flint casts of these cavities. They occur in the beds of chert, which are interstratified with the mountain limestone; the siliceous matter, when fluid, filled up the channels, and invested the stems: the calcareous substance has since been dissolved, and removed, and solid cylinders of flint, resembling a pulley (*Wond*. p. 377.), remain. The masses of chert are often impressed with the ornamented articulating surfaces of the ossicula, or trochites. In the quarries on Middeton Moor, near Cromford, Derbyshire, where extensive beds of limestone, composed of crinoideal remains, are worked for chimney-pieces, and other ornamental purposes, beautiful examples of these fossils may be obtained. The cavities of the column and ossicula are often filled with white calcareous spar; while the ground of the marble is of a dark reddish brown colour. In other varieties of the Derbyshire entrochal limestones, the substance of the fossils is white, and the ground dark grey or brown; both kinds, when worked into ornaments, are very beautiful and interesting. Specimens, with the entrochi in relief, and a polished slab of the marble, are figured *Wond.* p. 588, Tab. 120.

The basin, pelvis, or receptacle (*Lign.* 70, fig. 2, *a, b, c, d, e.*), which contained the body, is extremely diversified, and the form, arrangement, and character of the plates that enter into its composition, afford the characters employed for generic distinctions.*

APIOCRINITES ROTUNDUS (*Lign.* 70, fig. 4. *Wond.* p. 583. *Bd.* pl. 47.).—The Pear Encrinite abounds in the limestones and clays of the oolite, near Bradford, in Wiltshire, and is well known to collectors. Mr. Channing Pearce has most successfully investigated the structure of this interesting species, and has obtained specimens with the peduncle, column, pelvis, and arms, complete. In *Wond.* Tab. 117, restored figures of a group of these crinoideans are represented. The column of the Pear Encrinite is composed of round even ossicula, or articulations, with radiated surfaces, and a central opening; it is short, smooth, and cylindrical, and the base ex-

* The generic names are commonly formed of the termination *crinites*, stone-lily, with a term expressive of the peculiar character prefixed, as *Platycrinites*, broad-plated encrinite; *Apiocrinites*, or Pear-encrinite. The old name of *Encrinite* has very properly been retained; but a more appropriate term for the family was suggested by the late Mr. Martin, namely, STYLASTRITÆ, or *column-star*.

panded and permanently fixed. The receptacle is pyriform, and generally found deprived of the arms,



LIGN. 70. FOSSIL CRINOIDEA.

Fig. 1.—EUGENIACRINITES. *Switzerland.*

2.—CYATHOCRINITES PLANUS. *Mountain Limestone.*

a. Basal plate of the *pelvis*, or basin.

b. One of the plates composing the walls of the pelvis.

c. Costal plate.

d. Intercostal plate.

e. Scapula, or ossiculum that receives the arm.

f. First ossiculum of the arm.

3.—MARSUPITES MILLERI (G. A. M.). *Chalk, Brighton.*

a. The semilunar cavity for the arms.

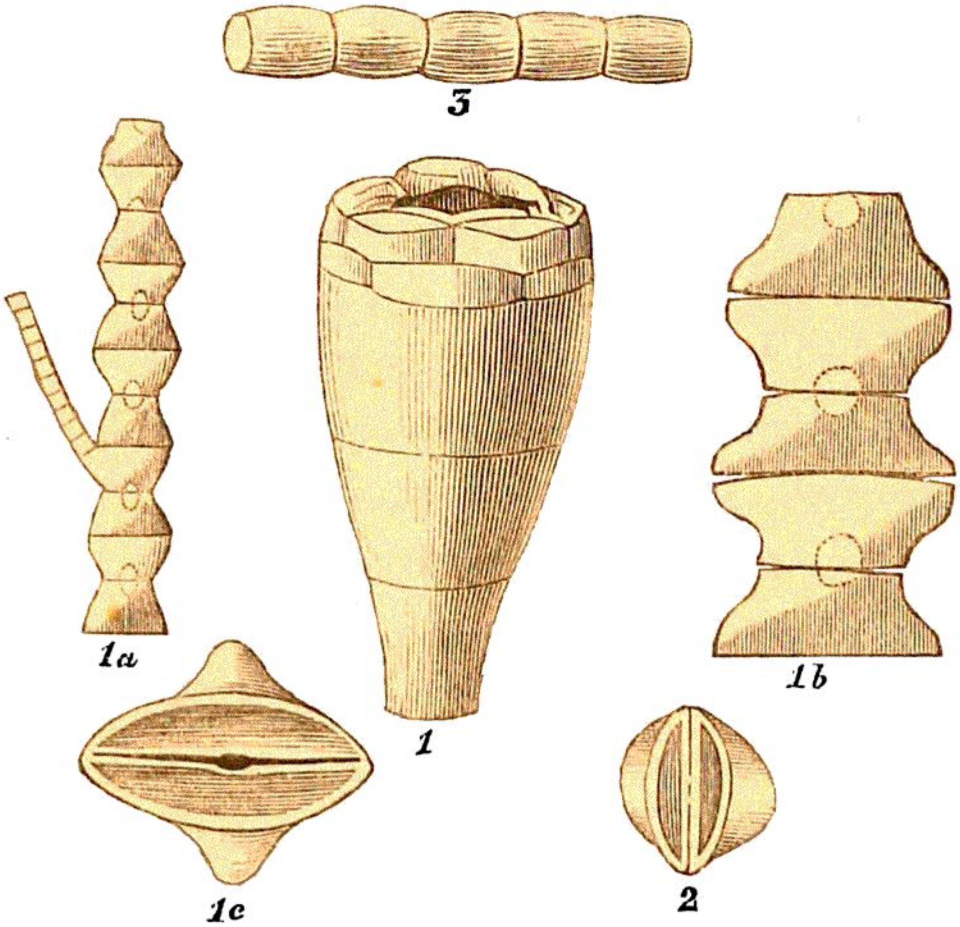
4.—APIOCRINITES ROTUNDUS, or *Pear-Encrinite. Bradford.*

a. First ossicula of the arms.

as in fig. 4, *Lign.* 70. The cavity is closed by small polygonal plates, except in the centre, where the mouth is placed; when living, it is probable that this plated integument could be protruded, like a proboscis, as was certainly the case in some genera. The constituent substance of the fossils is calcareous, and it has an oblique fracture; the colour is generally a light ochre, or a bluish grey.

An interesting circumstance relating to this species is mentioned by Mr. Lyell (*Ly.* II. p. 44, fig. 241.). The upper surface of a bed of oolitic limestone at Bradford, is encrusted with a continuous pavement formed by the stony roots of the Apiocrinites; and upon this is a layer of clay, in which are the stems and bodies of innumerable examples, some erect, others lying prostrate; while throughout the clay are scattered detached stems, arms, and receptacles. This submarine forest of Crinoideans must, therefore, have flourished in the clear sea-water, till invaded by a current loaded with mud, which overwhelmed the living zoophytes, and entombed them in the argillaceous deposit in which their remains are now imbedded.

APIOCRINITES ELLIPTICUS (*Lign.* 71.). — This encrinite is abundant in the White Chalk, and the receptacle is well known to the quarrymen by the name of "*bottle.*" The ossicula composing the column are cylindrical in the upper part, and elliptical and angular in the lower. They are united by a transversely-grooved surface, *Lign.* 71, fig. 1 *c*. The two upper joints are enlarged, and support the pelvis, which is smooth and round (fig. 1.). The column has articulated side-arms, and the base numerous jointed processes of attachment, which, when found detached from the column, have been



LIGN. 71. APIOCRINITES, OR PEAR ENCRINITES. *Chalk. Lewes.*

Fig. 1.—APIOCRINITES ELLIPTICUS, × 3.

1 *a.*—Part of the elliptical portion of the column, with a side-arm.

1 *b.*—Portion of the same, magnified.

1 *c.*—The articulating surface of an ossiculum.

2.—Ossiculum of *A. flexuosus.* (*M. D'Orbigny.*)

3.—Portion of the cylindrical stem.

mistaken for a distinct species, and named "*Stag's-horn Encrinite.*" The specimens figured *Lign.* 71, display the essential characters of this small species. When perfect, this Apiocrinite must have borne a general resemblance to the Bradford species.* I have found several ossicula in the chalk, belonging to other species. *Lign.* 71, fig. 2, is an ossiculum of *A. flexuosus* of M. D'Orbigny.

ENCRINUS LILIIFORMIS (*the true Lily Encrinite*). *Lign.* 69, fig. 6.—This crinoidean is remarkable for its elegance, and the beautiful state of preservation in which it occurs. The column is composed of numerous perforated, round, depressed joints, articulated by a radiated, grooved surface, and becoming somewhat pentangular, and alternately large and small near the pelvis; thus admitting of great freedom of motion. The base of the receptacle is formed of five plates, upon which are placed three successive series of other plates, called *costæ*, or ribs, from which the arms originate. *Wond.* p. 473, represents a specimen of the body partly expanded, so as to expose the jointed *cirri*, or tentacula, attached to the inner surface of the arms; and *Lign.* 69, fig. 6, one in which the arms are closely folded, resembling the bud of a lily or tulip, and with a few ossicula of the column attached to the base. *Bd.* plates 48, 49, present admirable figures of the minute anatomy of this zoophyte.

The remains of the Lily Encrinite have hitherto only been found in that division of the New Red or Trias formation, called in Germany, *Muschel-*

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* A restored figure is given Geol. S. E. p. 111.

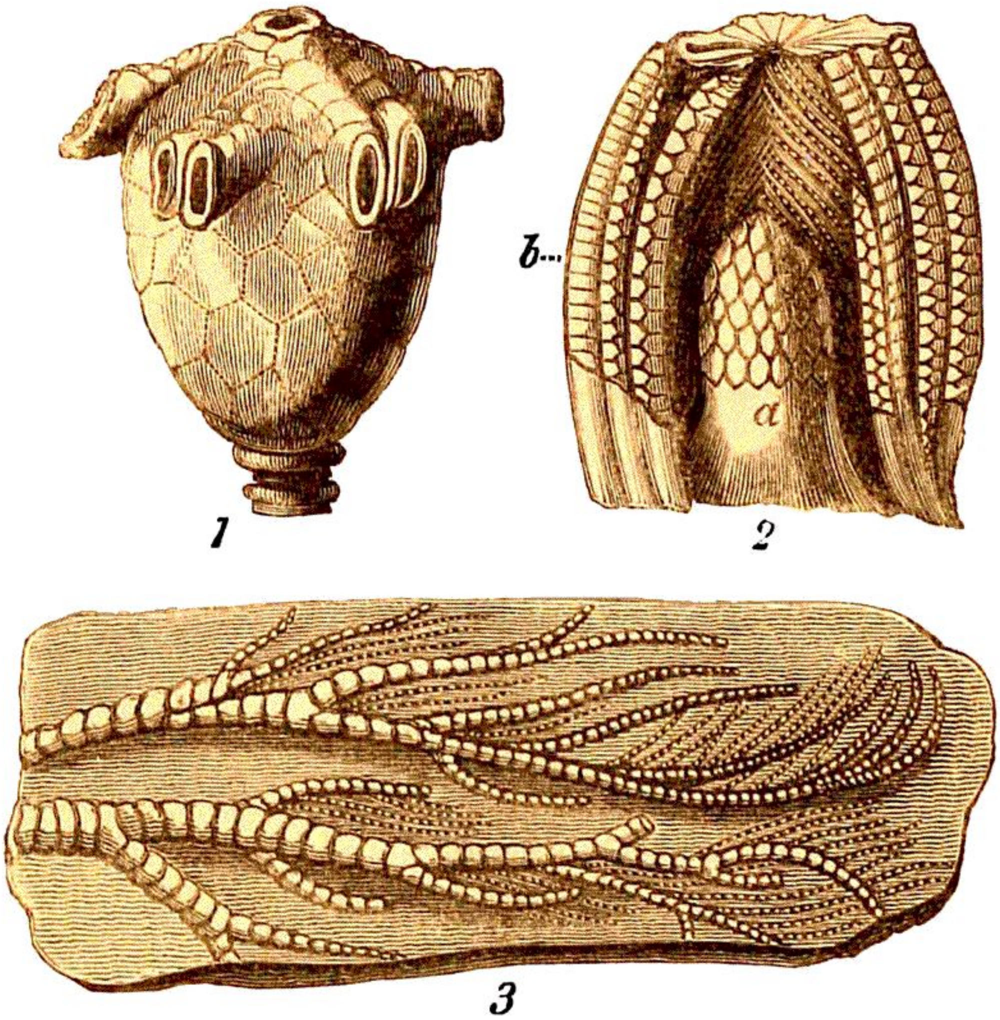
kalk (*Wond.* p. 463.), a deposit not observed in England. Several localities in Lower Saxony, and Westphalia, are mentioned as affording these fossils; but the most celebrated is in Brunswick, near the village of Erkerode, about two miles from the town bearing this name, near a wood called the Elm. The Encrinites are found in a stratum of soft argillaceous cream-coloured limestone, scarcely one foot and a half thick, composed chiefly of trochites, and a few fragile bivalve shells, and corals.*

PENTACRINUS CAPUT MEDUSA. *Wond.* p. 580.—The recent species is thus named from the imaginary resemblance of the body, with its numerous arms, to Medusa's head. Specimens are exceedingly rare; the few known in Europe were obtained from the seas of the Antilles, off Barbadoes, and Martinique. This zoophyte is extremely interesting as an object of comparison with the fossil Crinoideæ. The stem, as we have before stated, is formed of numerous pentangular joints, articulating by pentapetalous, ovate, striated surfaces; and the pelvis is made up of several series, of five plates each; and from the margin of the uppermost ten multiradiate arms, or tentacula, are given off. Fossil stems have been found in the Lias, Oolite, and Chalk of Eng-

* My cabinet contains a splendid specimen from Erkerode, with a portion of the column attached; *Lign.* 69, fig. 6, is an outline of the body, one-third less than *nat.*

land, which closely resemble those of the recent species. Numerous Pentacrinites abound in the Lias and Oolite of Dorsetshire, Somersetshire, &c., where entire strata are composed of their aggregated remains. Slabs of limestone may be extracted with the surface covered with these crinoideans, spread out as if floating in their native element; very commonly they are transmuted into sulphuret of iron, or have a coating of brilliant pyrites. The neighbourhood of Lyme Regis, and Charmouth, is celebrated for these organic remains. A small specimen of the arms of a Pentacrinite on shale, is figured *Lign.* 72, fig. 3.

ACTINOCRINITES (*Nave Encrinite*). *Lign.* 72, figs. 1, 2. *Wond.* p. 585. *Bd.* plate 47.—The column is formed of numerous round ossicula, possesses side-arms, and is fixed by root-like processes. The receptacle is of an irregular subspherical form, the arms passing off at right angles like the spokes from the nave of a wheel; hence the popular name. The base is composed of three plates which support five hexagonals and one pentagonal, and on these are three other series; from the upper margin of the last, five arms are given off, and above the arms the pelvis is covered over with a dome-shaped tesselated pavement (see fig. 2, *Lign.* 72.), on one side of which is an opening for the mouth. The specimen, fig. 1, *Lign.* 72, is the body without a stem, and with a few joints only of the arms remaining, and the dome-like superior termination, and the mouth; this is the usual state in which the fossils are obtained. Fig. 2 shows an Actinocrinite in which part of the brim of the pelvis



LIGN. 72. ACTINOCRINITES, OR NAVE ENCRINITES.

Fig. 1.—ACTINOCRINITES PARKINSONI. (*Org. Rem.* II. Pl. 17.)

2.—Section of an ACTINOCRINITE. (*Miller's Crinoideæ*, Pl. II.)

a. Proboscideal protrusion of the plate and integument.

b. Sections of the folded or closed tentacula.

3.—Arms of a Pentacrinite, on Lias-shale: *Lyme Regis*.

and of the arms has been removed in front, while a portion of the closed arms remains behind; in the middle the central plates are prolonged into a proboscideal form; it is from Mr. Miller's work, and introduced to illustrate the structure of this genus of crinoideans.*

The external surface of the basin, or pelvis, of the Actinocrinites, is generally covered with rugose radiated markings and ridges; so that the detached costal plates of some species, have been mistaken for parts of Marsupites (*Lign.* 70, fig. 3.); see the restored figure of a Nave Encrinite, *Wond.* p. 585. In the specimens figured, *Lign.* 72, fig. 1, this structure has been destroyed, from the fossil having been immersed in strong acid.

CYATHOCRINITES (*cup-like Encrinite*). *Lign.* 70, fig. 2. *Wond.* pp. 585, 587.—The column is formed of round, depressed, perforated joints, articulating by radiated surfaces; pentagonal near the receptacle. The pelvis is cup-shaped, composed of five pieces, succeeded by two successive series of five plates, with intervening plates, and supporting five bifurcating, radiated tentacula.

The Encrinites of this genus have a remarkably light and elegant appearance: the form of the plates composing the pelvis, and of the ossicula of the arms, is carefully delineated in *Lign.* 70, fig. 2; which represents a specimen of *C. planus*, from the magnesian limestone of Somersetshire. The pelvis resembles in shape a depressed vase; its upper part is supposed to have been covered by a plated inte-

* Miller's Crinoid. fig. N. pp. 98—100.

gument, the mouth occupying either the centre, or one side, as in the Actinocrinites.

The Cyathocrinites are found in the Silurian, Devonian, and Carboniferous limestones.

Eugeniacrinites (*clove-like Encrinite*). *Lign.* 70, fig. 1.—From the resemblance of these little fossils to a clove, Mr. Parkinson gave them the foregoing name. They are found at Mount Randen, in Switzerland, in strata (I believe) of the oolitic system: no other part of the animal is known. When perfect this crinoidean must have resembled the Lily Encrinite, but the plates are all anchylosed (that is, fixed together), which, as Mr. Miller ingeniously suggested, may be attributable to an early stage of growth.*

Pentremites pyriformis (*pear-shaped angular Encrinite*) *Lign.* 69, fig. 2.—The column of this very extraordinary echinoderm is cylindrical, formed of perforated ossicula, with radiated surfaces; it has cylindrical, irregular, side-arms. The pelvis is composed of three unequal pieces; two pentagonal, and one tetragonal, surmounted by large plates deeply emarginate, for the reception of the lips of five radiated ambulacra (*grooves with pores*). These diverge from the summit, and each has a longitudinal indented line, and numerous transverse striæ, terminating in a series of pores. The summit is

* Miller's Crinoid. p. 113.

pierced with a central angular opening, surrounded by five foramina. This zoophyte, although resembling the Crinoideæ in having a plated receptacle supported by an articulated column, differs essentially from them in the absence of arms or tentacula. The superior termination in which the ambulacra, the pentagonal aperture, and the five foramina are situated, shows an affinity to the Echinidæ, but the fossil is separated from that family by its stem; it therefore forms a link between the Lily-like animals and the Sea-urchins. There are several species of *Pentremites*, some of which swarm in the cherty limestones of Kentucky. Mr. Say, to whom we are indebted for the first satisfactory investigation of these fossils, mentions that such is their abundance, that he has observed, on a piece of rock not larger than three inches by two-and-a-half, above twenty specimens lying in alto relievo. The same able American naturalist remarks, "that it seems probable the *branchial* (breathing) apparatus communicated with the surrounding fluid through the pores of the ambulacra by means of filamentous processes; these also may have performed the office of tentacula in conveying food to the mouth; or we may suppose that the animal derived its support from the minute animalcules that abound in sea-water, and obtained them in the same manner as the *Ascidia*, with the water."*

* See an interesting Memoir on these bodies, by G. B. Sowerby, Esq. Geol. Journal, Vol. IV.

Seven species are described by Professor Phillips (*Geol. York.* Pl. III.) from the Mountain limestone of Yorkshire. In America these crinoideans abound in strata of the same age, and are considered so characteristic of certain beds, that the term "*pentrametal limestone*" is often employed to designate the mountain limestone of the Illinois.

MARSUPITES MILLERI (G. A. M.), *Lign.* 70, fig. 3. *Wond.* pp. 309, 582.—The fossil skeletons of a genus of Radiaria, related to the Crinoideæ, but separated from them by having no column or support, and being unattached and free, were first noticed and described by the late Mr. Parkinson, as the "*Tortoise Encrinite*" (*Org. Rem.* Vol. II. pl. 13, fig. 24.); but that gentleman, misled by the resemblance of some of the plates to certain species of Actinocrinites, supposed the original was supported by a jointed column. By the examination of numerous specimens obtained from the chalk of Lewes and Brighton, I was enabled to determine its characters, and from the purse-like form when the arms are closed above, proposed the name *Marsupites* (purse-like Crinoidean), which is now generally adopted; the specific name *Milleri*, is in commemoration of the late excellent and able author of the Nat. Hist. of the Crinoidea.

The receptacle of the Marsupite is of a subovate shape, rounded and entire at the dorsal extremity, and composed of a large central plate, and a successive series of pentagonal and hexagonal plates; from the margin arise five arms, which subdivide into ten rays, or tentacula. The opening was covered by an integument, supported by numerous small semi-lunar plates, in the centre or side of which the mouth was placed. The plates of the receptacle are generally more or less radiated, as in *Lign.* 70, fig. 3; but in some specimens their surface is quite smooth. The Marsupites vary in size, from an inch to three inches in length, exclusive of the arms. The receptacle is relatively of great size, compared with that of other crinoideans. The central plate is large, and of a pentagonal form, without the slightest indication of any column or process of attachment: five pentagonal plates are united to the sides of the basal plate, and above these a like number of hexagonals, which receive the five upper plates that constitute the margin; these have each a semilunar depression, to articulate with the first bones of the arms.

Detached plates and ossicula are not uncommon in the chalk near Brighton and Lewes; receptacles more or less entire, and sometimes filled with flint, as in *Lign.* 70, are often found in the same localities; but examples with any portion of the arms are of great rarity (*Wond.* p. 582.); and I believe the Marsupite, with the supra-pelvic plates, those which covered the integument closing the pelvis, figured *South D. Foss.* Pl. XVI. fig. 6, is still unique. The perfect form of the original is given, *Wond.*

p. 309. When living, this animal, like the other crinoideans, could expand its arms or tentacula in the form of a net, capture its prey, and convey it to the mouth.

The Marsupite is exceedingly interesting to the zoologist, for it forms a link that unites the true crinoideans with the star-fishes, called *Comatulæ*, which will be described in the next chapter. The figures we have given will serve to familiarize the student with the usual types; for details of structure, Dr. Buckland's plates, and Miller's *Crinoidea*, should be consulted.

This general survey of the Crinoideæ will prepare the collector for the incredible numbers of their remains that occur in some of the strata, particularly in the Oolite and Lias, and in the Carboniferous and Silurian, systems. The British species exceed one hundred and thirty; and the stems, arms, and receptacles of each, present some peculiarities; and when it is considered that the skeleton of an individual Lily Encrinite is composed of more than twenty-six thousand ossicula, or bones, and that of a single Pentacrinite of upwards of one hundred and fifty thousand, the number and variety of their fossil relics will no longer appear marvellous.

CHAPTER X.

FOSSIL STELLERIDÆ, OR STAR-FISHES.

THE radiated animals, popularly called Star-fishes, from their stellular forms, are so generally diffused through the seas surrounding our island, that the common five-rayed species must be familiar to most of our readers, and will serve as an illustration of the general appearance and structure of this order. This species belongs to that division in which the rays are elongated, and far exceed in length the diameter of the disc; in the other group the body is angular, and the lobes or rays are short, and not longer than the diameter of the body.

The external surface of this species is soft, and attached to a tough coriaceous integument, supported by a skeleton composed of numerous calcareous ossicula, which are arranged in series along the margins of the rays. Each ray has a longitudinal furrow, or groove, called *ambulacrum*, the sides of which are perforated by alternating rows of pores or foramina, through which are protruded or retracted tubular tentacula. The mouth is situated in the centre of the under surface. Now, if we imagine a Star-fish placed with the mouth upwards, its five rays fringed with long articulated tentacula, and fixed by the centre of the under or dorsal surface on a jointed stem, we shall have the essential character of a Crinoidean ; and the animals of one recent genus of *Stelleridæ* are actually in this condition in the earlier stage of their existence : these are the *Comatulæ*, or feather-stars.*

It has been well remarked by Professor Forbes, that from the vast importance of the Crinoideæ in the economy of the ancient world, the history of the only crinoidal animal at present inhabiting the British seas, which at one time swarmed with those beautiful and wonderful creatures, must present many points of interest even to the general observer. The receptacle of the soft body of the *Comatulæ*, like that of the crinoideans, consists of a cup-shaped calcareous base, which sends off five arms, that quickly subdivide, and are beset on each side with rows of articulated pinnæ ; on its convexity there are also numerous slender-jointed simple tentacula. The mouth is situated in the centre of the area, surrounded by the arms, and is capable of being elon-

* The reader interested in this subject should peruse the elegant and charming volume on British Star-fishes and other Echinoderma, by Professor Forbes. 1 vol. 8vo. John Van Voorst. 1841.

gated into a proboscis. In the young state, the Comatulæ are attached by a jointed stem to other bodies, as shown in *Lign.* 69, fig. 1, which represents several of the natural size: fig. 1[a.] is an enlarged view of an individual, and closely resembles an expanded Crinoidean. The stem is composed of about eighteen joints, which are pentangular. After a few weeks the Feather-star becomes detached from its peduncle, and ranges the sea in freedom.*

Four fossil species of Comatula have been discovered in the Solenhofen slate; and it is not improbable that some of the numerous Crinoideans may be Stelleridæ in a young state.†

OPHIURA (*serpent-like Star-fish*) *Lign.* 73, fig. 1.—The Star-fishes thus denominated have very long, slender, serpentine rays, without grooves and tentacula. These rays are extremely flexuous, and in some species armed with spines, by which they

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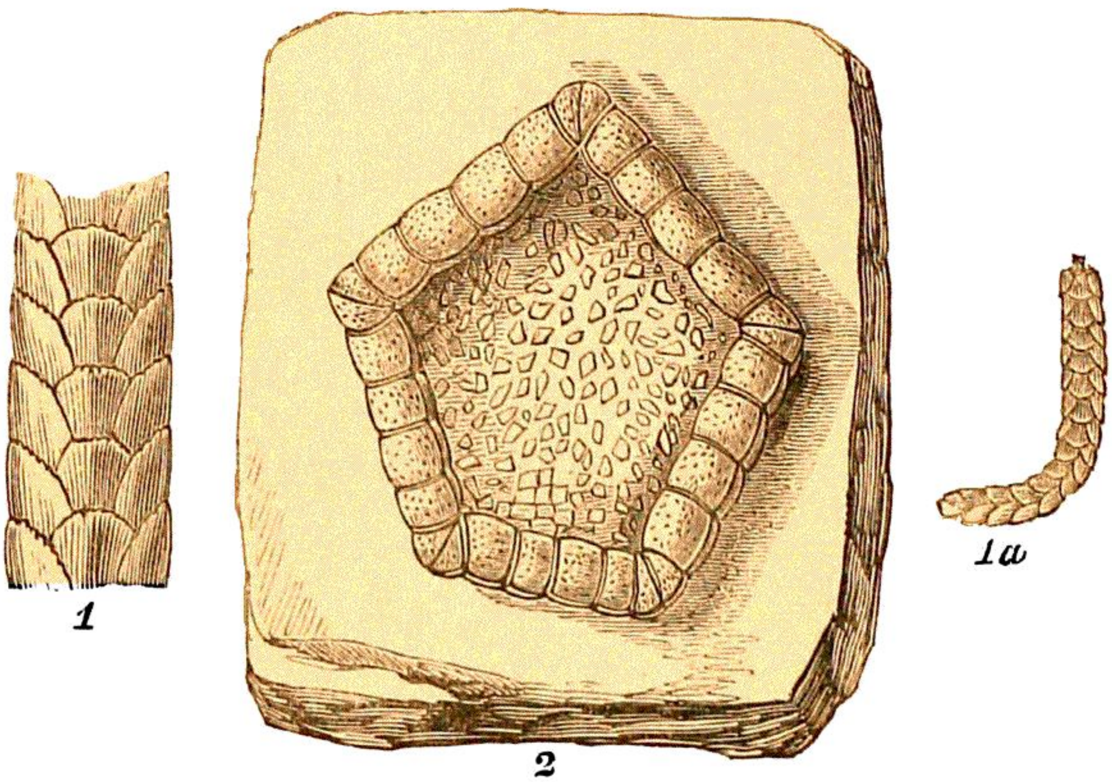
* The researches of J. V. Thompson, Esq. brought to light these interesting facts in the Natural History of the Comatula; this eminent naturalist first discovered the pedunculated Comatulæ in the Cove of Cork.

† When the discovery of Mr. Thompson was first made known to me, I suspected that the Marsupite might have been pedunculated when young; but as very small specimens are equally free from all traces of a peduncle as the adult, I was led to relinquish that opinion: still the collector should bear in mind the possibility of this having been the case, in searching for Crinoidean remains.

can entwine round, and seize their prey.* The structure of these rays is shown in the fragment from the Sussex chalk, *Lign.* 73, fig. 1. Several species of this genus are found fossil, and often in the most perfect state, although, from the extreme fragility of some recent species, this could scarcely



LIGN. 73. STAR-FISHES FROM THE CHALK.

Fig. 1 *a.*—Part of the ray of an OPHIURA; *nat. Preston.* (*Mr. Walter Mantell.*)

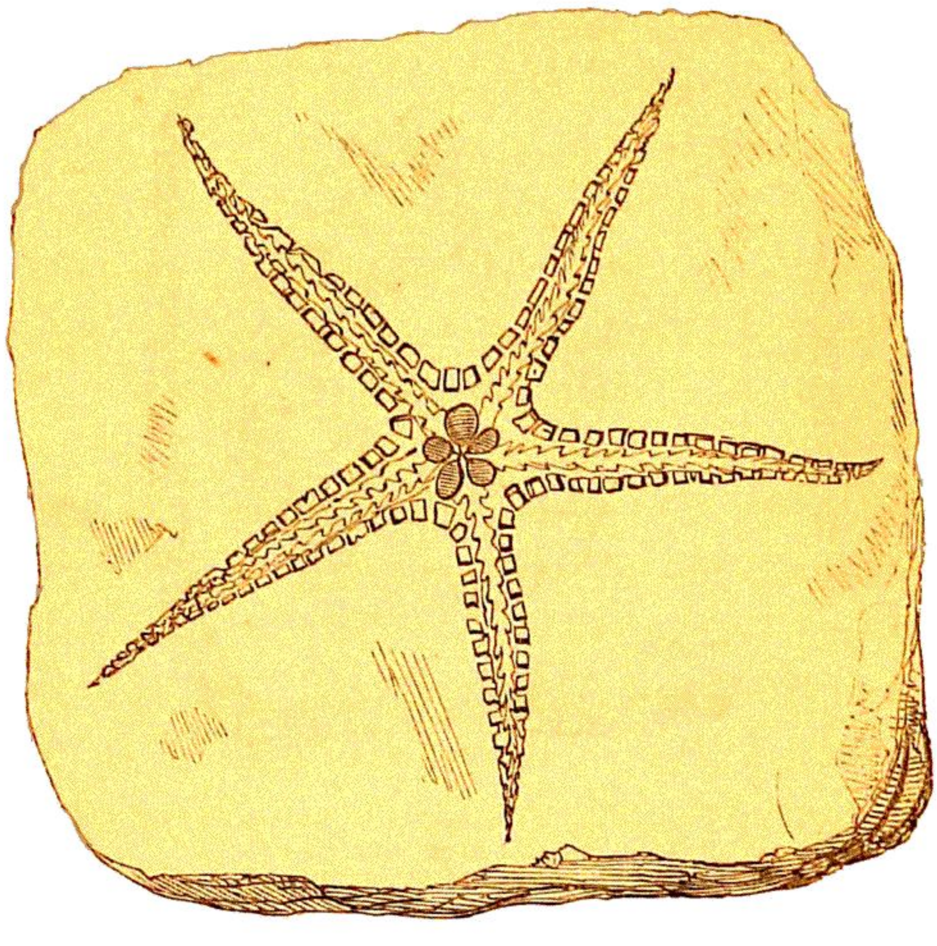
1.—Portion of the same magnified.

2.—GONIASTER REGULARIS. *Chalk. Gravesend.*

have been expected. One species has been found by our distinguished countryman, Professor Sedgwick, in the lowest Silurian deposits; and other

* See Prof. Forbes's Star-fishes, p. 22.

forms occur in all the succeeding fossiliferous formations, up to the most recent. The Lias, in the neighbourhood of Lyme Regis and Charmouth, has yielded several beautiful examples of *Ophiura Egertoni*, and other species. Professor Phillips



LIGN. 74. FOSSIL STAR-FISH. *Lias. Wirtemberg.*

ASTERIAS PRISCA. (*Goldfuss.*)

has figured a species (*O. Milleri.* Geol. York. Pl. XIII. fig. 20.) from the marlstone of Yorkshire; another (*O. Prattii*) occurs in the Oxford clay; and two or more species have been found in the Chalk, and London clay.

There is a recent genus of Star-fishes, called *Euryale*, which, in the multi-radiate character of the articulated dichotomous arms and their curious extremities, approaches very closely to the Crinoideæ, which it seems to connect with the Ophiuræ.

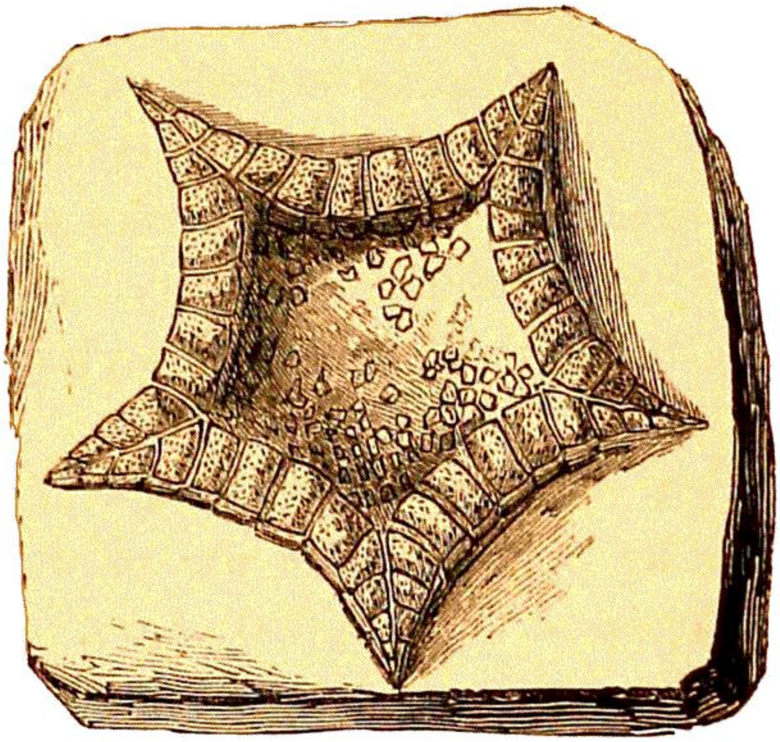
The *Asterias* are stellate in form; the rays are flat, and extend from the body, of which they are a prolongation, and have deep grooves bordered with marginal plates, extending to their extremities.

The Lias of Germany contains several species of Asterias (*Lign.* 74.). A large species occurs in the cornbrash of the oolite of this country; and our chalk has also yielded some beautiful examples.*

Goniaster (*Cushion-star*). *Lign.* 73 and 75.— The Stelleridæ of this genus are of a pentagonal form, and bordered by marginal plates. The recent species are beset by spines; and, although I have observed no trace of such appendages in the fossils, I am induced to refer the species most common in the chalk to this genus, from the close analogy of their skeletons, both in form and structure, to the recent. The two species figured are well known, and were described by Mr. Parkinson (*Org. Rem.* Vol. III. Pl. I. figs. 1 and 3.). The detached ossicula of the

* A remarkably fine specimen of Asterias in Chalk, almost as perfect as if recent, has been discovered by Mrs. Smith, of Tunbridge Wells, and is preserved in that lady's choice collection.

Cushion-stars are frequent in the White Chalk; and the large central ossiculum, called the *madrepori-form tubercle*, which is present, more or less developed, in the dorsal aspect of all species, is often found, and may be mistaken for the base of a crinoidean receptacle. There are thin layers in the



LIGN. 75. FOSSIL STAR-FISH. *Chalk. Kent.*

GONIASTER SEMILUNATA. (*Parkinson.*)

Sussex chalk, particularly at Burpham, near Arundel, that are composed of an aggregation of detached ossicula of star-fishes. The chalk-flints occasionally have adhering to them very fine specimens, and frequently retain sharp imprints of the Goniasters. The siliceous whetstones of Devonshire also contain similar fossils. I have found ossicula in the London clay of the Isle of Sheppey.

I must here conclude this brief notice of the Stelleridæ—animals that, from their structure, and relations to other families of Radiaria, are of great zoological interest, but which have not contributed in any appreciable degree to the formation of the solid materials of the earth.

CHAPTER XI.

FOSSIL ECHINIDÆ, OR ECHINITES.

LIGN. 76. TURBAN ECHINUS, WITH ITS SPINES. *Jura limestone.* (*Hemicidaris crenularis*, Agassiz.)

THE fossils we have now to examine are among the most familiar of the objects commonly known as petrifactions. Their enveloping cases, or crusts, possessing considerable durability, they have served as moulds into which the flint, calcareous spar, limestone, and other mineral substances, when in solution, or in a semi-fluid state, have flowed, and upon consolidation formed sharp and enduring casts, exhibiting the forms of the plates, and the disposition of the pores, striæ, &c. of the original structures.

The common Echinus of our sea-coasts (*Echinus sphæra*), known by the name of Sea-egg, Sea-urchin, or Sea-hedgehog, presents the usual characters of this type of animal organization, which differs from the other Echinoderma in the absence of arms.

The globular envelope, or shell of the Echinus, as it is popularly called, is composed of numerous calcareous, polygonal plates, exquisitely adapted to each other, and arranged in regular and elegant patterns; appearing in the globular and spherical forms, like the lines of the meridian on a globe. The plates are disposed in vertical series, united by finely serrated sutures, and forming quinquepartite sections, into which the envelope very commonly separates upon the decay of the investing integument. Each section is divisible into four vertical rows; two large, termed *areæ* (spaces), see *Lign.* 84, fig. 3, *c*, the plates of which are ornamented with papillæ, or tubercles; and two smaller, called *ambulacra* (avenues), which are analogous to the grooves or furrows of the Star-fishes (*Lign.* 84, *a.*); and these are perforated by numerous pores, for the exsertion of tubular feet, or tentacula. Besides these rows of minute openings, there are two principal apertures, the *mouth* and *outlet;* and also a few large pores on the summit, for the exclusion of the ova, or for the free admission of water. The form and disposition of the parts here described, afford characters for the numerous genera into which the order is divided. The mouth, which is situated on the lower part, is in some species furnished with five sharp angular teeth, which are attached to a calcareous frame-work that admits of being protruded; this apparatus, when extracted entire, is commonly called "*Diogenes' lantern.*" The papillæ on the surface of the plates vary in size from mere granules, to large mammillated tubercles; they serve for the attachment of moveable spines, which also present great variety of form and ornament. The spines have a cavity at their base which fits on the papillæ, and are only supported by the capsular envelopment of the common integument, in many species; but in others, the large spines are attached by a ligament which passes from the centre of the socket, and is received in a perforation of the papilla of each tubercle, in the same manner as in the head of the human thigh-bone.

Transverse slices of the spines, exhibiting their cellular structure, form beautiful objects under the microscope. There are also minute prehensile appendages to the integument, called *pedicellariæ*, but I have not observed any traces of them, even in the best preserved fossil echini.

This general view of the structure of the recent species is necessary to enable the student to understand the nature of the fossil remains; for all the parts above described are found more or less perfectly preserved, either in their natural arrangement, or dispersed throughout the strata. The habits of these animals, of burrowing in the sand, were favourable to their preservation in a mineralized state. It was my intention to have given figures of all the genera into which the numerous fossil species have been divided by modern observers; but I found the attempt hopeless, from the changes in nomenclature and arrangement which are constantly taking place.*

CIDARIS (*Turban-Echinus*).—The first family of the Echinidæ are termed Cidarites, which includes the globular, spherical, and depressed species, having the mouth in the centre below, and the outlet, or vent, opposite, on the summit. The shell is com-

* M. Agassiz has commenced a work on recent and fossil Echinidæ; of which only two livraisons have appeared. It is to be regretted that this eminent naturalist has applied not only new generic, but also specific names, to almost every species he has figured. M. D'Orbigny's *Paleontologie Française*, is a refreshing example of the avoidance of this censurable and unnecessary practice; for, although some generic terms must be changed with the progress of science, and new ones adopted, the specific names affixed by the earliest observers, ought to remain, unless palpably absurd or leading to error.

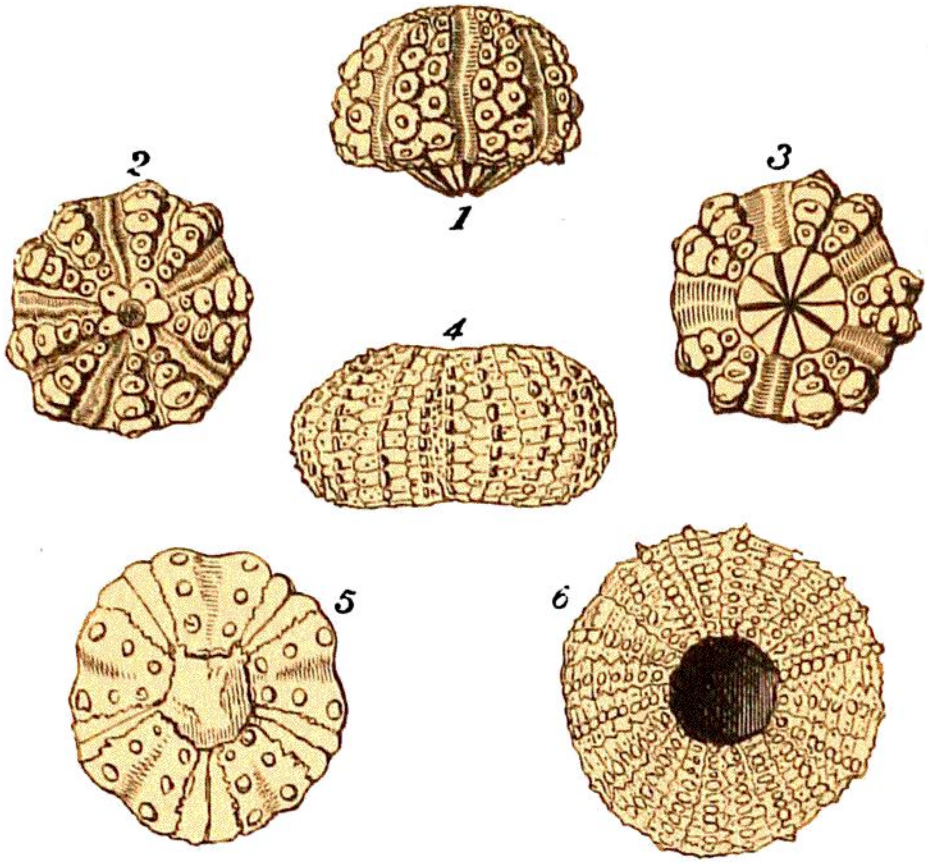
posed of twenty vertical series of plates, the ambulacra, or porous gooves, forming continuous bands from the summit to the mouth, which is armed with five angular teeth. This group comprises many of the most elegant fossil species; those which, from their shape and beautifully ornamented surfaces, have received the popular names of fairy's night-caps, and turbans. The genus Cidaris, which is characterized by the spinous tubercles being perforate, affords the most beautiful examples; and these are occasionally found with the spines in contact, occupying their natural situation. This is, however, a rare circumstance, as will readily be conceived, when the nature of their attachment is considered; for, upon the decomposition of the integument, and the ligaments which sustain the spines in a living state, those appendages quickly separate, even in recent specimens. The interesting fossil figured *Lign.* 76 (from M. Agassiz's work), is a choice example of a Cidarite with the spines attached. This species (*Hemicidaris crenularis, Agassiz.*) of mammillated Echinus is common in the oolite of this country, and is considered to be characteristic of the Upper Jura limestone. It is said to be the same as that figured by Mr. Parkinson, under the name of *Cidaris mammillata* (*Org. Rem.* Vol. III. Tab. 1, fig 6.), from Calne, in Wiltshire; but I have never observed spines like those of *Lign.* 76, in the English oolite. These spines are not homogenous throughout, but their central part appears to have been of a softer texture than the external crust, as may be seen in the figure where the spines are imperfect. This difference of texture is not observable in the spines of the depressed Cidarites (*Lign.* 77, fig. 4.), but is constant in all the species which M. Agassiz has arranged under the genus *Hemicidaris*, of which the present fossil is the type. The original is twice the size of the figure.

CIDARIS BLUMENBACHII (*Lign.* 77, fig. 1, and *Lign.* 91, fig. 3.).—This is another beautiful and common tuberculated Echinite of the Calne oolite: the tubercles are very large and prominent, and the spines remarkably neat, being covered with granulated longitudinal striæ; they are of an elongated, cucumerine form, and homogenous in structure (*Lign.* 91, fig. 3.).

These echinites are found in immense numbers in the oolite, at Calne and Chippenham, in Wiltshire; Faringdon, in Berkshire; Yeovil, in Somersetshire, &c. I have seen slabs of limestone from Calne with upwards of fifty specimens of this Cidaris imbedded on its surface; and the spines may be obtained by hundreds.

An elegant Cidarite is found associated with the above species; it is of a depressed form, and has very long slender subcylindrical spines: it is named *Cidaris sceptrifera*. I have a specimen from Calne, with upwards of fifty spines attached to the shell, and spread out on the surrounding stone.

Several species abound in the White Chalk, and specimens are occasionally found with the teeth and



LIGN. 77. CIDARITES FROM THE OOLITE AND CHALK.

Fig. 1.—CIDARIS BLUMENBACHII; view in profile, showing the teeth projecting: $\frac{1}{3}$ *nat. Calne.*

2.—The same seen from above, displaying the outlet, and surrounding pores.

3.—The same, view of the base, displaying the mouth, surrounded by five angular bipartite teeth.

4.—CIDARIS DIADEMA (Diadema rotulare, *Agass.*) *Upper Chalk, near Lewes.* Viewed in profile: *nat.*

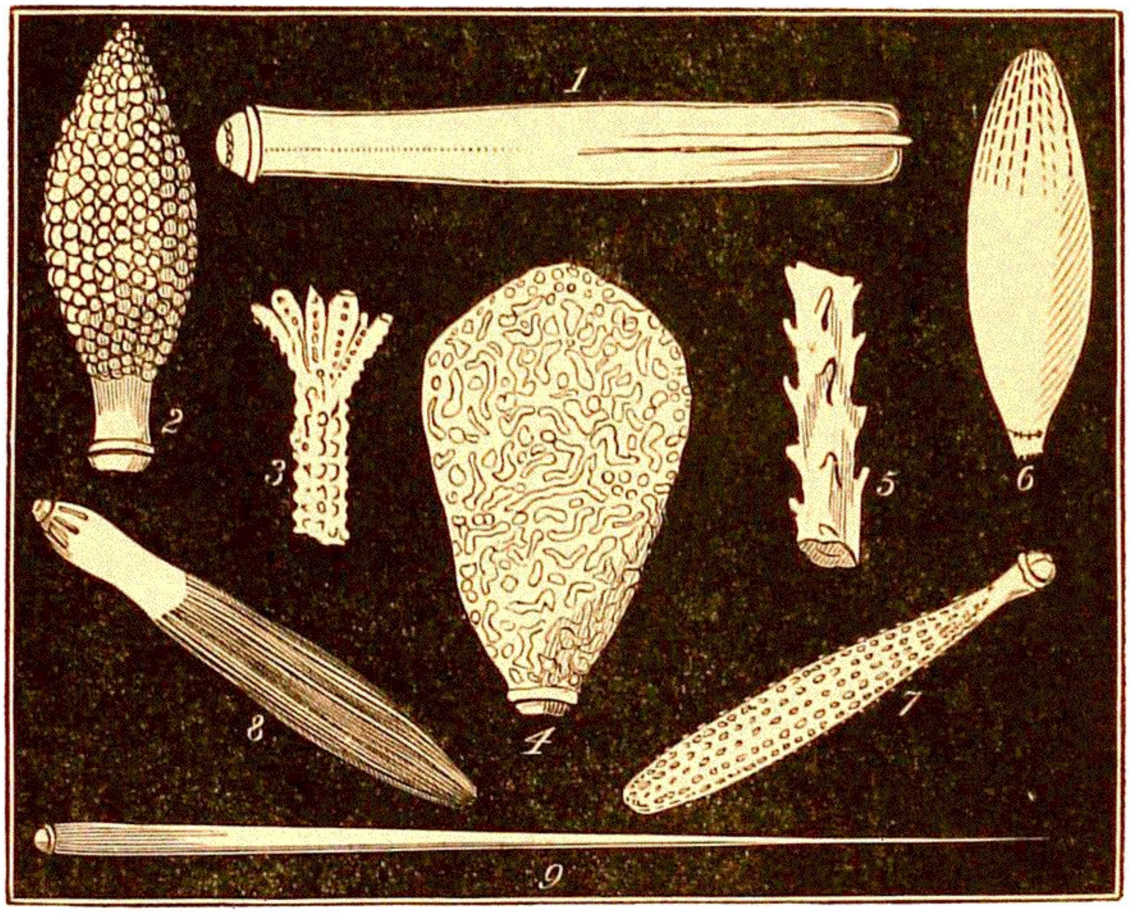
5.—A siliceous cast of the same species. *South Downs.*

6.—View of the base of C. DIADEMA. This species occurs in the Neocomian formation of France.

spines attached. The Chalk of Gravesend, Charlton, Purfleet, and other localities in Kent, are prolific in these fossils; the softness of this rock renders their development easy. The two common species are CIDARIS CRETOSA (*Org. Rem.* Pl. I. fig. 21.), with elongated spines, and C. CLAVIGERA, with short, club-shaped spines.

CIDARIS DIADEMA (*Lign.* 77, fig. 4.).—A small depressed species is also frequent in the Chalk; it was formerly known as *C. diadema;* but now forms the type of M. Agassiz's genus *Diadema.* A flint cast of the interior of a shell of this kind is figured *Lign.* 77, fig. 5. These casts, together with those of the larger Cidarites, are often met with on the ploughed lands, in beds of gravel, and among the shingle of the sea-shore of chalk districts; appearing as flattened round bodies, with a circular protuberance at each pole, and vertical rows of rounded projections. The imprints of the external surface of the shells are also frequent in chalk flints, and present exquisite casts, in intaglio, of the mammillated tubercles, and ambulacral grooves. A fragment of a flint, bearing the imprint of a portion of a Cidarite, is represented *Lign.* 82, fig. 2. The holes around the impression indicate tubular cavities in the flint, formed by the spines; proving that these processes were attached to the shell when enveloped by the fluid silex; both having since perished, and left only their imprints. The shells of the genus Echinus resemble those of Cidaris, but the tubercles are imperforate; more than twenty-five species of fossil Echinus are described.

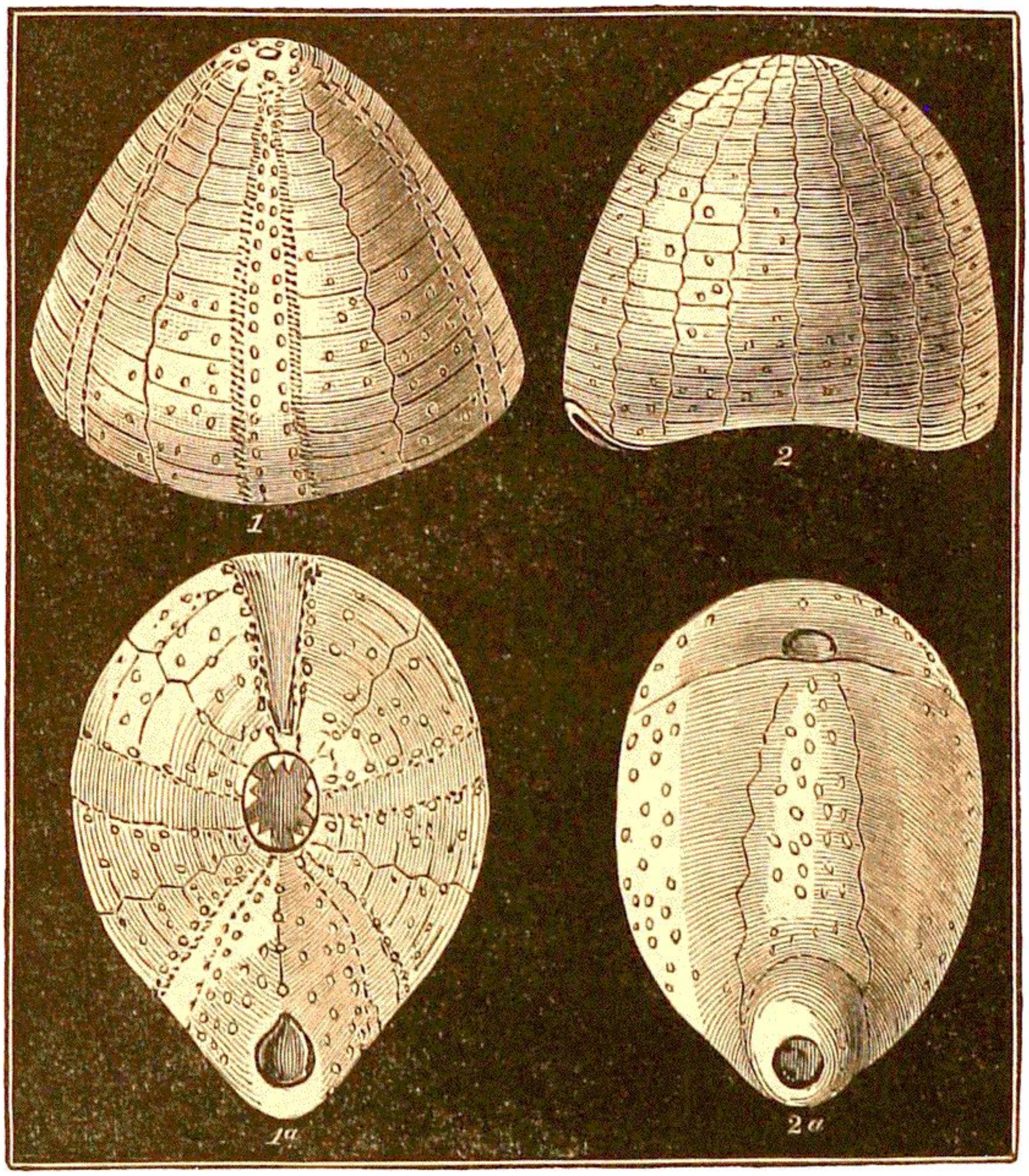
I have selected a few spines of different species of the Turban Echinites, or Cidarites, to serve as objects of comparison; they are figured in *Lign.* 78.



LIGN. 78. FOSSIL SPINES OF CIDARITES.

Fig. 1.—Spine of ACROCIDARIS nobilis (*Agassiz*).
2.— . . . . CIDARIS cucumifera.
3.— . . . . stemmacantha.
4.— . . . . meandrina.
5.— . . . . spinosa.
6.— . . . . clunifera.
7.— . . . . cretosa.
8.— . . . . Parkinsoni.
9.— . . . . sceptrifera.

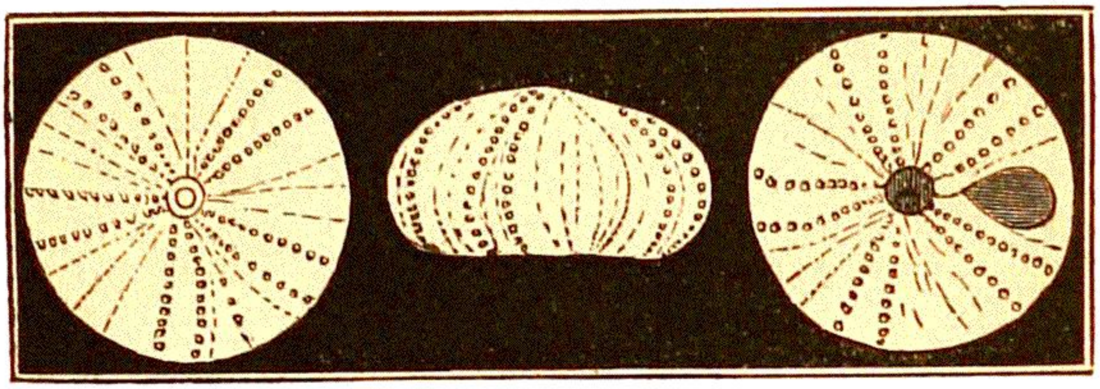
GALERITES (*cap-shaped Echinite*) CRETOSUS. *Lign.* 79.—The Galerites are only known in a fossil state. They are characterised by their regularly circular or polygonal shell, which is flat below, and convex or conical above, and formed of



LIGN. 79. ECHINITES FROM THE CHALK. *Lewes.*

Fig. 1.—GALERITES CRETOSUS: *nat.*
1a.—Base of the same, with the five teeth.
2.—ANANCHYTES OVATUS: ½ *nat.*
2a.—Base of the same.

dissimilar plates covered with minute tubercles. The ambulacra are narrow, and vary in number from four to five or six in different species; they pass from the summit to the mouth, which is central; the outlet is below, towards the margin. The *Galerites*, formerly called *Conulus*, from the conical shape of several species, are very numerous, particularly in the chalk formation, and prevail in some localities in incredible numbers. The species figured *Lign.* 79, fig. 1. (which was formerly named *Albogalerus*, from a supposed resemblance to the white conical caps of the priests of Jupiter), occurs in

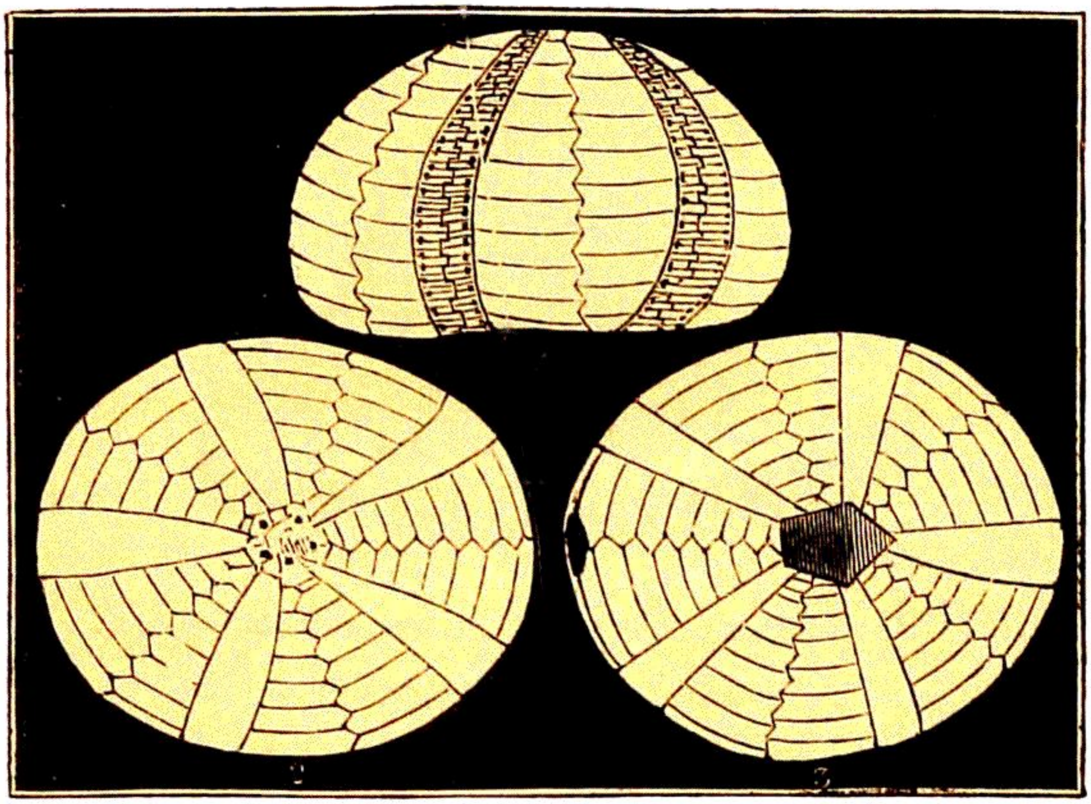


LIGN. 80. DISCOIDEA INFLATA. *Oolite. Portland.*

The left-hand figure shows the summit; the middle figure a profile; and the right hand, a view of the base, with the mouth in the centre, and the outlet towards the margin. (*M. Agassiz*).

great perfection in the Kentish chalk; it is less common in that of Sussex. The siliceous casts are constantly found among the drift and gravel, and strewn over ploughed lands of chalk districts; they are popularly termed shepherd's crowns, or sugar-loaves. The specimens obtained from the chalk, when filled with flint, yield exquisite casts, if the shell be dissolved in dilute hydrochloric acid; by this means the form of the plates, and casts of the minutest pores of the ambulacra are obtained. The common species *Galerites vulgaris*, has five ambulacra; *G. sexfasciata* has six.

The Galerites, which have a decagonal, or rather circular, mouth, and in which the tubercles are disposed in vertical rows, like the Cidarites, instead of being uniformly spread over the surface, are separated into the genus *Discoidea* by M. Agassiz (*Lign.* 80.)



LIGN. 81. GALERITES CASTANEA. *Chalk.*

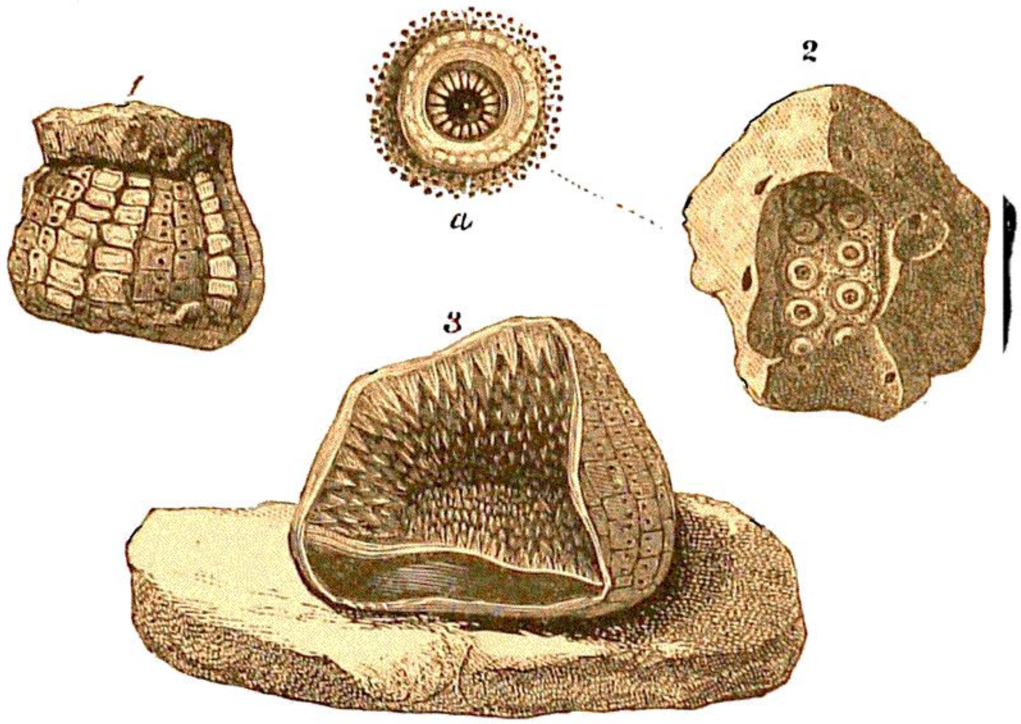
Fig. 1.—Profile. The pores and plates of the ambulacra are only inserted in this figure.

2.—View from above.

3.—The base, showing the central pentangular mouth, and the vent in the margin.

Another closely related species, but in which the mouth is pentagonal, and the outlet in the margin, occurs in the Cretaceous strata of the Alps, and in the Chalk marl of Sussex. It is *Nucleolites castanea* of M. Brongniart (*Lign.* 81.).

ANANCHYTES (*helmet-shaped Echinite*) OVATUS. *Lign.* 79, fig. 2.—This genus is the most charac-



LIGN. 82. ECHINITAL REMAINS IN FLINT. *Chalk. Lewes.*

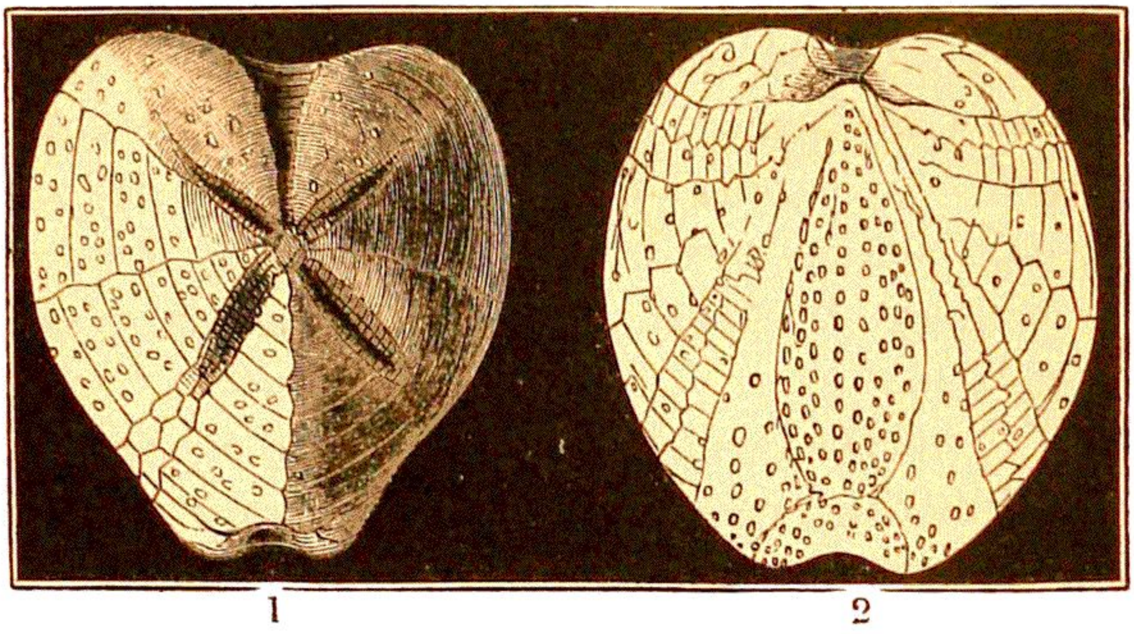
(*One-third the natural size.*)

Fig 1.—*Cast of Ananchytes*, showing the form of the plates.
2.—Imprint of a segment of a Cidarite on a pebble.
a.—One of the impressions of a spinous tubercle: *nat.*
3.—Portion of an Ananchyte, having the cavity covered at the bottom with flint, and above with crystals of carbonate of lime.

teristic of all the echinites of the upper chalk, and has not been found in any other formation. The *Ananchytes* are readily distinguished by their elevated, helmet-like form; by the elliptical vent being placed below and towards the posterior margin, and the mouth, which is lipped, near the opposite border. The vernacular names of "*Shepherd's Crowns*," and "*Paris Loaves*," indicate the common form of the most abundant species, figured *Lign.* 79, fig. 2. The shell is oval in its longest diameter; flat, or nearly so, below; and rounded, conical, and somewhat laterally compressed towards the summit. The ambulacra are five, between double lines of pores. The tubercles are minute and scattered. The substance of the shell is of great thickness. More than twenty species are known.

The helmet Echinites, like those of the preceding and following genera, give rise to innumerable siliceous casts, which are found associated with the latter, in drift, on the ploughed lands, or among the shingle on the sea-shore, and must be well known to the collector: they are often placed as ornaments on the mantel-shelves of the cottagers. A flint cast of an Echinite in which the plates were partially separated, is represented *Lign.* 82, fig. 1. The shells of this and the following genus are generally filled either with chalk or flint, and sometimes with pyrites; but occasionally they are found partially or entirely empty, or with a lining of crystals of calcareous spar, symmetrically arranged in rows, in accordance with the direction of the ambulacral pores. *Lign.* 82, fig. 3, is a remarkable example, in which flint occupies the floor of the shell, while the upper surface is frosted over with crystals of calcareous spar.

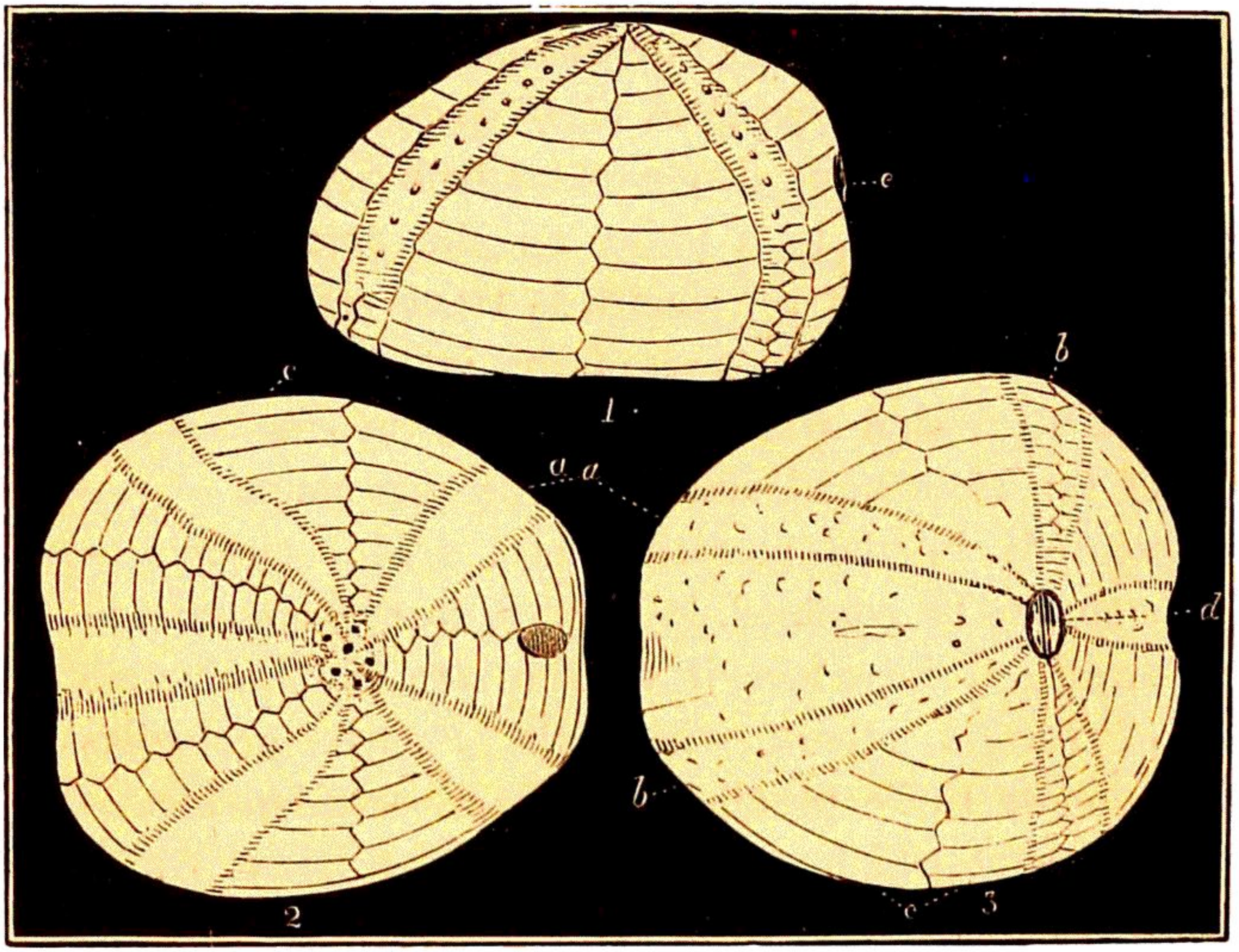
SPATANGUS COR-ANGUINUM (*Snake-heart Echinite*). *Lign.* 83.—This is another genus of fossil echini, of which there are many species in the



LIGN. 83. HEART-SHAPED ECHINITE. *Chalk. Lewes.*

Fig. 1.—SPATANGUS COR-ANGUINUM. (*Micraster, Agassiz.*)
View from above.
2.—View of the base.

Chalk. The Spatangi are more or less oval, elongated, and heart-shaped, wider before than behind, and with a *sulcus*, or furrow, at the front termination. The shell is thin and delicate, sprinkled with minute tubercles, and composed of large polygonal plates. The spines are very short and small. The mouth is situated more or less anteriorly, and is transverse, and surmounted by a strong projection of the odd inter-ambulacral area, which is named the lip. The vent is terminal, and placed above the margin. There are but four ambulacra, and



LIGN. 84. SPATANGUS COMPLANATUS. *Chalk-marl. Hamsey.*

Fig. 1.—Profile.

2.—View of the summit, showing the vent at the side.

3.—View of the base, displaying the situation of the mouth, and the union of the five ambulacra; their pores are not introduced in figs. 2 and 3.

a. The narrow porous divisions of the shell, termed AMBULACRA.

b. Interambulacral spaces.

c. AREÆ, or spaces covered by the wide plates.

d. The mouth.

e. The vent, or outlet.

these are incomplete, and in some species petaloid, and situated in deep dorsal furrows.

SPATANGUS COMPLANATUS, *Lign.* 84 (*Holaster* of M. Agassiz).—In this form of Spatangus (constituting the genus *Holaster Agass.*), the ambulacra are not depressed or furrowed, as in the preceding species, nor petaloid (*leaf-shaped*), as in those which M. Agassiz denominates true Spatangi; but they converge to a point on the summit, as is shown in fig. 2: the mouth is transverse, fig. 3, *d*; and at the anterior part of the inferior face there is a depression, which results from the convergence of the ambulacral areæ towards that point. The vent is in the posterior face. This species is stated to be confined, in France, to the *Neocomian* strata; I introduce it to illustrate the characters of several others, which the French geologists suppose to be peculiar to their Neocomian formation, but which occur in the British Lower Chalk and Marl.

NUCLEOLITES (*nut-like Echinite*).—These are generally of small size, depressed, and cordiform; the vent is placed in a deep groove, or furrow, on the posterior face, extending towards the summit of the disk (see *Wond.* p. 311.). The mouth is subcentral. The shell, like that of Ananchytes, is covered pretty uniformly with minute tubercles, or granules. Several species are abundant in the Chalk-marl, Green Sand, and Oolite. There is one species in the Tertiary strata, and one living.

CLYPEUS (*Buckler-Echinite*) EMARGINATUS. (*Org. Rem.* Vol. III. Pl. II. figs. 1, 2.).—This name is given to the large depressed species of fossil Echinidæ, from their fancied resemblance to the round buckler of the ancients. The *Clypei* principally occur in the Oolite of Oxfordshire, Gloucestershire, &c. The upper surface is convex, and divided into ten areæ by ten striated ambulacra, and is marked by a deep furrow, or groove.

Our limits will not admit of a more extended notice of the fossil Echinidæ; excellent figures of the genera are given in *Org. Rem.* Vol. III.; and many chalk species in *Geol. South Downs.*

GEOLOGICAL DISTRIBUTION AND LOCALITIES OF FOSSIL ECHINIDÆ.—No traces of this order have, I believe, been observed in the Silurian system, but Cidarites are found in the Carboniferous. In the Lias, Echinidæ begin to prevail with Stelleridæ, and become largely developed in the oolitic and cretaceous formations. In the marine tertiary they are as numerous as in the modern deposits. While scarcely twenty species of Stelleridæ have been discovered, upwards of a hundred of Echinidæ have been obtained from the British strata, and almost the whole of these belong to extinct or unknown forms.

Beautiful Cidarites, and their spines, may be collected at Calne, Chippenham, Faringdon, Bath, &c.

The Green Sand of Wiltshire abounds in small species of Cidaris and Nucleolites; and Chute Farm, near Heytesbury, is a celebrated locality for these remains.

The large sinuated *Clypeus* is found in great perfection at Malton, and also in the Oolite, near Cheltenham.

The Chalk Echinites are to be met with in most localities of that formation; but certain species prevail in each division. The smooth Spatangi abound in the Galt and Chalk-marl, and the Galerites vulgaris, Ananchytes ovatus, and Spatangus cor-anguinum, in the upper White Chalk.

ON COLLECTING AND DEVELOPING FOSSIL ECHINODERMA.—In our previous remarks on the radiated animals comprised in this survey, we have pointed out those characters which are the most important, and which it should be the especial object of the student to discover in a fossil state. Thus, in searching for fossil Crinoideans, the receptacle or body should be the principal object; and if only detached plates can be extracted from the rock, their natural position should be carefully noted, and the specimens glued to a card or board, in that order; and some of the ossicula of the column, and of the arms, or tentacula, be placed with them.

Mr. Miller dissected specimens of every genus, and has figured the separate plates or bones that enter into the composition of the pelvis, column, and arms. Traces of the arms, and their subdivisions, must be sought for, and if any be discovered, they should be removed with the blocks of stone to which they are attached, and the stone afterwards reduced in size by a mason's saw, and not by blows of a hammer, which would displace the delicate ossicula.

When imbedded in Lias shale, or other fragile material, a thick slab should be removed, for greater safety in conveyance; this, when reduced to a convenient size and thinness, should be placed in a tray with plaster of Paris, or glued to a piece of thin, well-seasoned mahogany, or oak. The specimens of the Pear Encrinite of Bradford (by Mr. Pearce), and of the Pentacrinites from Lyme Regis (by Miss Mary Anning), in the British Museum, were prepared in this manner.

The crinoideal remains in the Chalk belong but to few genera; they merely require the usual manipulation of cretaceous fossils; but the collector should remember that the ossicula and plates of the pelvis (as for instance in the Marsupite), are but slightly adherent to each other, and the chalk must not be wholly removed, or they will become detached. The receptacle of the Apiocrinite of the chalk is rarely found with more than a few joints of the column attached; and I believe no vestige of the arms has been observed: these parts are therefore desiderata, and should be sought for diligently; the radicles of this crinoidean are long, articulated, and branching, and, without due caution, may be mistaken for the arms, or for another species. The first remark will also apply to the Marsupite; any specimens with but a few ossicula of the arms are very precious. I may observe that there is yet much to learn as to the number of species and genera, and the peculiar characters of the Crinoideæ of the chalk, and that any addition to our knowledge on this subject will be valuable. The *Stelleridæ* are so simple in form and structure, that it is unnecessary to offer any suggestions for their development; the more perfect they can be obtained the better: of course they must not be removed from the stone. Among the detached calcareous echinodermal ossicula diffused through the chalk, the student will remember that the large coral-like tubercle of the Star-fish may often be presented to his notice. It may easily be mistaken for an encrinital body, or for a coral, but an accurate inspection will show that it is not composed of anchylosed plates, like the receptacle of an Apiocrinite, but has surfaces for attachment to the surrounding ossicula; while the extremities, which in a crinoideal column would present radiated surfaces, are rounded and entire.

In collecting the Echinidæ, much caution is required in dissecting specimens surrounded by spines. If imbedded in hard limestone, or in laminated clay, it is scarcely possible to succeed; but it often happens that the Cidarites of the Oolite are attached by the base to the solid limestone, and the body with the spines is imbedded in clay, or in a sandy, friable aggregate, not difficult of removal. The specimen in my cabinet, with upwards of fifty of these appendages attached to the shell, was obtained under such circumstances. The Chalk Echini will be found to possess spines more frequently than is commonly supposed, if care be taken to explore the surrounding stone before it be removed. I have often obtained Cidarites with the spines, when there were no manifest evidences of these appendages, by carefully scraping away the surrounding mass until the extremity of a spine appeared, and then tracing it to the body of the shell; another point was discovered by further removal, and that was developed in the same manner; till at length a Cidaris with several spines was disclosed. The chalk around the situation of the mouth should always be cautiously removed in the dentated species, in the hope of preserving the teeth, as in the specimens *Lign.* 77, fig. 1, and *Lign.* 79, fig. 1.

As the shells of Echinites, when hollow, are often lined with crystals (see *Lign.* 82, fig. 3.), it is worth while to break all indifferent specimens of the common species, in the hope of discovering such examples.

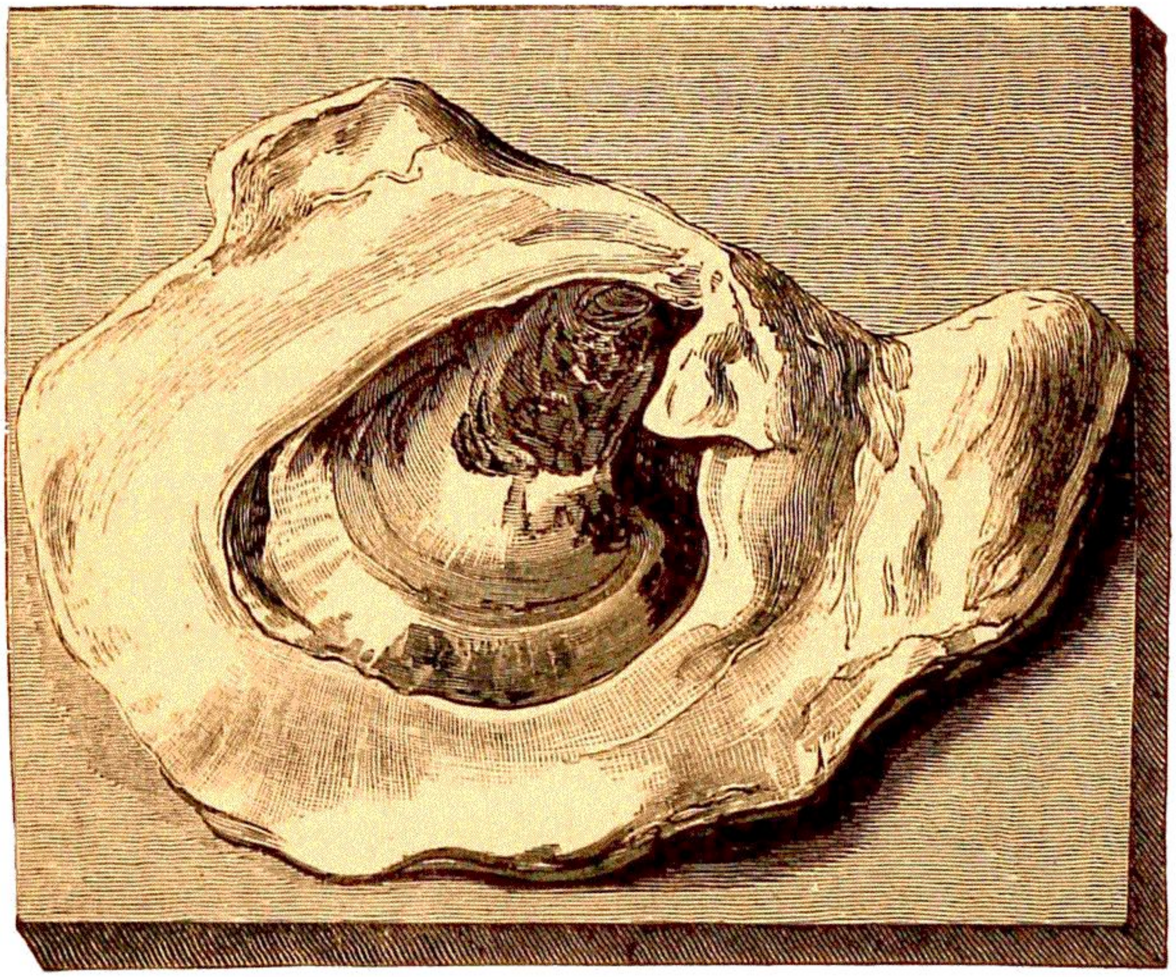
The chalk must not be *scraped*, from the crust or shell of the Echinites, or the minute papillæ will be injured or removed; it should be flaked off piecemeal with a blunt point.

In loose arenaceous strata, as in some of the Maestricht and Tertiary deposits, the Echinites may be extricated in as perfect a condition as if fresh from the sea; and it is probable, from the known habit of these animals of burrowing in mud and sand, that they still occupy their original situations, and were entombed alive by the sediment in which they are now imbedded.

The student may always procure from the dealers named at the end of this work, specimens of the common fossil species of Echinoderma, at moderate prices.

CHAPTER XII.

FOSSIL TESTACEOUS MOLLUSCA, OR SHELLS.



LIGN. 85. FOSSIL OYSTER, FROM THE CHALK.

Kemptown, Brighton.

ON FOSSIL MOLLUSCA.—Numerous as are the fossil remains of the various classes of animal organization which have already passed under review, with the exception of the Infusoria, they are far exceeded in number and variety, by the relics of the beings whose mineralized skeletons we now propose to investigate. Although every one is familiar with the external appearance of the shells cast up by the waves on the shores of our island, and of those which, from their varied colours and elegant forms, are preserved in the cottage of the peasant, and in the mansion of the rich, but few persons are conversant with the nature of the animals that secreted and inhabited these beautiful and enduring structures. The organization even of the oyster, mussel, whelk, &c., is known only to the naturalist. Appearing to the uninstructed eye as a shapeless gelatinous mass, there is nothing to arrest the attention, or excite the imagination. Yet the beings which secreted, and were protected by these durable cases, are objects of the highest interest, and offer a rich field of instructive investigation.

Except as shedding some light on the structure and ecomony of their inhabitants, shells, in the estimation of the naturalist, are the least interesting part of the organization of the Mollusca; but to the geologist, from their permanent nature, and the proofs they yield of the conditions under which the strata that contain them were deposited, they are important in the highest degree. It has even been found convenient to classify formations, in which fossil shells largely prevail, by the relative numerical proportion of the recent and extinct species found in the different groups of strata, and the terms, *Eocene*, *Miocene*, and *Pliocene*, (proposed by Mr. Lyell,) have reference to this character, as we have previously explained (see p. 31.).

The *Mollusca* (a name indicative of the soft nature of their external skin or integument,) constitute a very comprehensive subdivision of the animal kingdom. They are separable into two principal groups.

I. The ACEPHALA (so termed because they have no head) are without jaws, tongue, or distinct mouth. They are aquatic, and are subdivided into classes, according to the modification of their integument, or of their gills.

The TUNICATA (from the elastic *tunic, or mantle*, in which they are enclosed) have no shell, and therefore do not come within the scope of our inquiries: yet it is possible that the soft parts even of these perishable structures may have left some trace, or that markings of their trails on the slime or mud may be preserved; and I would recommend the student to search for such indications on the rippled surface of clays and sandstones.

The BRACHIOPODA (*arm-feet*) have two long spiral fleshy arms, or *brachia*, developed from the sides of the alimentary orifice, are enclosed in bivalve shells, and respire by means of their vascular skin, or mantle. They have not the power of locomotion, but are fixed by a peduncle to other bodies.

The LAMELLIBRANCHIA (*plated gills*) have also bivalve shells, but their respiration is effected by gills composed of vascular membrane disposed in plates, and attached to the mantle. The *beard* of the Oyster is the respiratory apparatus of that animal. These bivalve Mollusca are subdivided into those which close their shells by one adductor muscle, hence called *Monomyaria*, as the Oyster; and those which have two muscles, *Dimyaria*, as the *Cardium*, or Cockle. As the impressions left on the shells, by the attachment of these muscles are found as perfect in the fossil as in the recent state, they constitute important characters.

II. The ENCEPHALOUS MOLLUSCA.—These possess a head, with feelers, or soft tentacula, eyes, and a mouth with jaws; they are arranged in classes, according to the modification of their locomotive organs; for, with but few exceptions, they are free animals, and can crawl, climb, or swim. Their shells are, for the most part, composed of one piece, or valve, hence they are termed *Univalves*. In some genera the shell is a simple cavity, spirally disposed, as in the Snail; in others, it is conical, consisting of one or many pieces, as in the *Limpet* and *Chiton*. In the Cephalopoda it is divided into many cells, or chambers, as, for example, in the Nautilus. The

Encephalous Mollusca are subdivided into the following classes.

The PTEROPODA, (*wing-feet*).—In these the organs of progression are two wing-like muscular expansions, proceeding from the sides of the neck, by which they can swim and float in the open sea: all the species are of small size.

The GASTEROPODA (*feet under the body*).—These crawl by means of a muscular disk, or foot, which is attached to the under-part of the body; most of the species are marine, but some are terrestrial, and others inhabit fresh-water. They are very widely distributed; the garden snail is a familiar instance of a terrestrial Gasteropod.

The CEPHALOPODA (*feet around the head*) have powerful muscular arms, or tentacula, which surround the head, or upper part of the body; some genera have no shell, but possess an internal skeleton, as the cuttle-fish; in all the other mollusca the hard parts are external. Most of the testaceous Cephalopoda have a discoidal, univalve shell, divided by partitions.*

In many univalves the aperture or opening is entire, that is, without any notch or groove; in others it is perforated, or extended into a canal, or siphon, and this character has relation to the respiratory organs: thus the Gasteropods, in which the water is conducted to the interior by a muscular

* See Prof. Owen's Lectures on Comp. Anat. 1843.

tube, or siphon, have the margin of the aperture of the shell channelled; as in the Whelk, or *Buccinum*. Almost all the land and fresh-water species have entire openings, and are, for the most part, herbivorous; while the greater number of the marine univalves have the aperture indented or notched, and are carnivorous. Some of these mollusca, too, have a retractile proboscis, armed with minute teeth, by which they can rasp or bore into the shells of the species on which they prey. There are some exceptions to the above rules, but the prevalence of the characters specified afford pretty certain indications of the fluviatile or marine nature of the originals. The application of these data to geological investigations will be demonstrated hereafter.

In the generic distinctions of the simple univalves, the form of the mouth becomes, therefore, a very important character; while in the bivalves, the configuration of the hinge affords an equally convenient aid for their classification.

Some tribes of testaceous mollusca are exclusively marine; many are restricted to the brackish water of estuaries; others live only in fresh-water; and some on the land. Their geographical distribution is alike various: certain groups inhabit deep water only, and are provided with an apparatus by which they can rise to the surface from the depths of the ocean; while others are littoral, that is, live in the shallows along the sea-shores. Many exist in quiet, others in turbulent waters; some are gregarious, like the oyster; while others occur singly, or in groups. The vertical range, that is, the relative depths in which the mollusca live in the sea, is also strictly defined; certain genera being, in a great measure, restricted to moderate depths, others to a few fathoms, and many to the profound abysses of the ocean, which neither the dredge nor the plummet can reach. All these varieties of condition are more or less strongly impressed on the shells, which may be considered external skeletons; and the accomplished conchologist is enabled, by certain characters, to determine the nature of the animals which inhabited them, and the physical conditions in which they were placed.*

The number of living species of testaceous mollusca known to naturalists exceeds six thousand; and almost every day is adding new species, for scarcely a vessel arrives from distant seas without enriching the stores of the conchologist. The numerous genera into which they are divided by systematists, and the constant changes effected in arrangement and nomenclature by every writer on the subject, render it exceedingly difficult, if not impossible, to present the reader with any satisfactory epitome of modern conchology.†

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* For an extended notice of the geographical distribution of testacea, see Ly. Principles, Vol. III. p. 142, sixth edition.

† The student desirous of pursuing this department of Palæontology, should refer to works especially devoted to

I must content myself with a brief commentary on some of the genera and species that occur in the British strata; and shall dwell more particularly on those which prevail in the secondary formations, because they present the most important deviations from the existing types that are familiar to the general observer; and by reference to figures in other works, the student will, I trust, be enabled to identify the fossil shells of most frequent occurrence.

FOSSIL BIVALVE SHELLS; INCLUDING THE BRACHIOPODA AND LAMELLIBRANCHIA.

Although in the modern Tertiary strata, as the Crag, and in the arenaceous beds of the Eocene formations, shells are generally found in so perfect a state, that no caution or knowledge is requisite for their collection, yet a few preliminary remarks are necessary to point out certain conditions in which the remains of mollusca, or evidence of their exist-

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Conchology. The edition of Lamarch, edited by M. Deshayes, is the best on fossil shells; but it will first be requisite to acquire an accurate knowledge of the recent genera; and for this purpose the "CONCHOLOGICAL MANUAL," by G. B. Sowerby, jun. Esq. 1 vol. 8vo. 1842, with numerous coloured figures, will be found an excellent work of reference.

ence, occur in the mineral kingdom, and particularly in the older fossiliferous rocks. Shells are found in the strata in the three following states:—

1st. Shells in which the constituent substance has suffered no change but that of decay. Many of the specimens in the sands of the Crag in Norfolk and Suffolk, and in the Eocene beds at Grignon, near Paris, and the Pliocene of Palermo, in Sicily, are as perfect as if collected from the sea-shore, having suffered no loss but that of colour. In some instances, even the variegated markings remain; but in general they are bleached, or have a ferruginous stain.

2dly. The form preserved, but the constituent substance mineralized. This state is very common in shells that are imbedded in hard rock, whatever may be the age of the deposit. In calcareous strata the constituent substance is generally transmuted into calcareous spar, as in most of the shells of the chalk, oolite, mountain limestone, &c. In sands abounding in silex, the shell is changed into flint, as in the exquisite specimens from the Green Sand of Blackdown, Devonshire; in deposits permeated with sulphuret of iron, the shells are often metamorphosed into pyrites, as in the clays of the Lias, Galt, &c.

3dly. In the state of *Casts* and *impressions*. Although in loose sands the shells are either empty, or filled with detritus easily removable by washing, in clay, limestone, and sandstone, the cavities are generally occupied by consolidated materials, which had entered when in a soft or fluid state; and frequently the substance of the shell has disappeared, and the stony cast of the interior alone remains. In many instances, the spaces left by the dissolution of the shells are filled with spar, or the casts are closely invested by the surrounding stone, from long-continued superincumbent pressure; and in such cases the casts are often distorted and flattened. But the vacancy is occasionally empty, and on its walls is found an impress of the external surface of the shell, with all the lines and ornaments of the original as sharp as if cast in plaster of Paris.

The specimen, *Lign.* 86, fig. 2, from the tertiary strata at Bracklesham Bay, Sussex, is a polished slice of indurated argillaceous limestone, from a septarium (*nodule divided by fissures*), abounding in spiral univalve shells, called *Turritellæ.* Fig. 1, is a perfect shell of the same species, extracted from soft clay; and fig. 3, a cast in calcareous spar, obtained from the septarium. In the polished slab, fig. 2, sections of numerous shells are seen. The dark partitions, or septa, are veins of spar, which occupy interstices that have been formed in the clay-nodule by shrinking; and if the specimen be closely examined, the shells will be found split across and displaced by the fissures; thus presenting an interesting illustration of the *faults*, or dislocations, of the strata, so familiar to the geological observer. In the present instance, the lines on the

LIGN. 86. TURRITELLÆ, FROM BRACKLESHAM, SUSSEX. *Tert.*

(*Drawn by Mr. Joseph Dinkel.*)

Fig. 1.—TURRITELLA CONOIDEA; the perfect shell: *nat.*

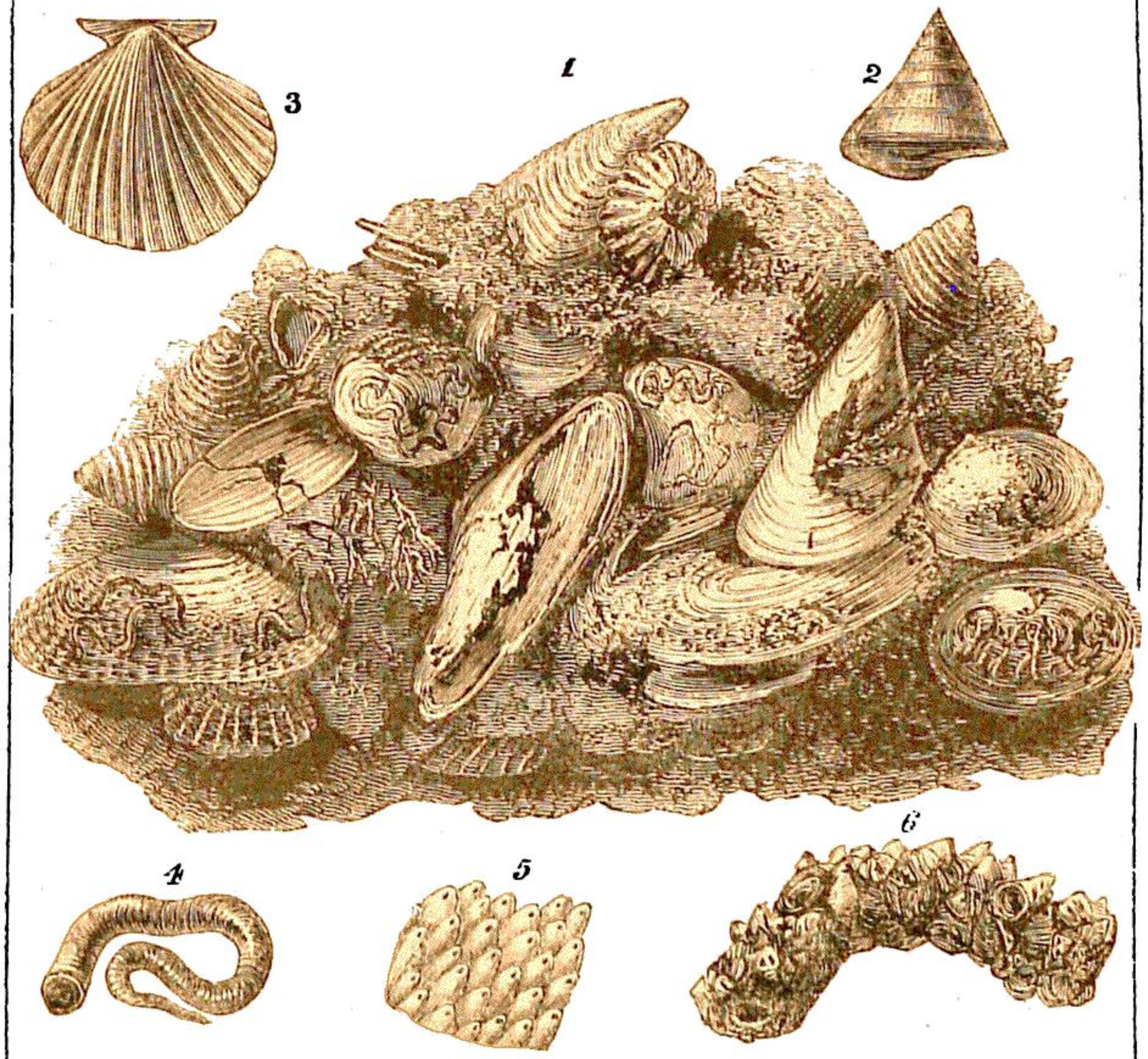
2.—SEPTARIUM, with TURRITELLÆ; a polished slab: $\frac{1}{3}$ *nat.*

3.—A cast of one of the shells, in calcareous spar: *nat.*

exterior of the shell do not materially differ from those on the interior, and, consequently, the cast, fig. 3, and the shell, fig. 1, resemble each other; but in many species there is a striking contrast between the outer and inner surfaces, the external aspect being strongly ornamented, while the internal is smooth; the cast, therefore, in such examples, so little resembles the shell, that an inexperienced collector may readily suppose it belongs to a different species. The bivalve called *Trigonia*, *Lign.* 91, figs. 1, 2, is an instance of this contrast.

The polished slab of the Septarium, *Lign.* 86, fig. 2, demonstrates another condition of fossil shells—that of a compact argillaceous limestone—and entire beds of marble are composed of an aggregation of this kind, formed of shells and other animal exuviæ, consolidated by mineral infiltrations. In the older secondary strata this state prevails; and the beautiful markings of many valuable marbles, are caused by sections of the enclosed shells. But this process is not restricted to the deposits of ancient date; at the present moment the same operation is silently but constantly going on in our seas, and an examination of the specimen, *Lign.* 87, will afford an exemplification of the manner in which these shelly limestones are produced.

We have here a solid mass of stone, composed of several recent species of shells, corals, &c. It is a fragment of a large block, dredged up from the British Channel, off Brighton. Similar masses have



LIGN. 87. SHELL-CONGLOMERATE; now forming in the British Channel. *Dredged off Brighton.*

(*Drawn by Mr. Joseph Dinkel.*)

Fig. 1.—An Aggregation of Shells and Corals; the interstices are filled up with sand, and the mass is consolidated by an infiltration of carbonate of lime.

2.—TROCHUS ZIZIPHINUS; extricated from the mass with the following.

3.—PECTEN LINEATUS.

4.—SERPULA.

5.—Portion of a FLUSTRA; magnified.

6.—SABELLA.

been obtained at different soundings along this part of the Sussex coast; and in some specimens numerous other species of recent shells, as oysters, mussels, whelks, &c. enter into the composition of the consolidated rock. The shelly and coralline limestones and sandstones, so abundant in the ancient strata of England, have been formed in a similar manner; and when the modern conglomerate of Brighton shall have been permeated with crystalline matter, and subjected to great pressure by superincumbent deposits, through countless centuries, and at length be elevated above the waters, it will constitute beds of shell-marble, in some mountain range, and become an interesting, perhaps the only memento, of the races of mollusca and polypiaria of the present seas, when all record and traces of Great Britain and its inhabitants shall be destroyed.

Off the Kentish coast, near the mouth of the Thames, a bank of consolidated shells, chiefly of one species, is in the progress of formation, from which blocks may be obtained of great firmness and solidity (*Lign.* 88.); these, when cut and polished (fig. 3.), display a variety of markings, produced by the sections of the shells. Extensive shoals of loose shells, composed almost wholly of the *Cardium edule*, exist in several localities, near the embouchure of the Thames; and these are continually shifting, with the changes of the wind and tide; it is only in a few places that consolidated

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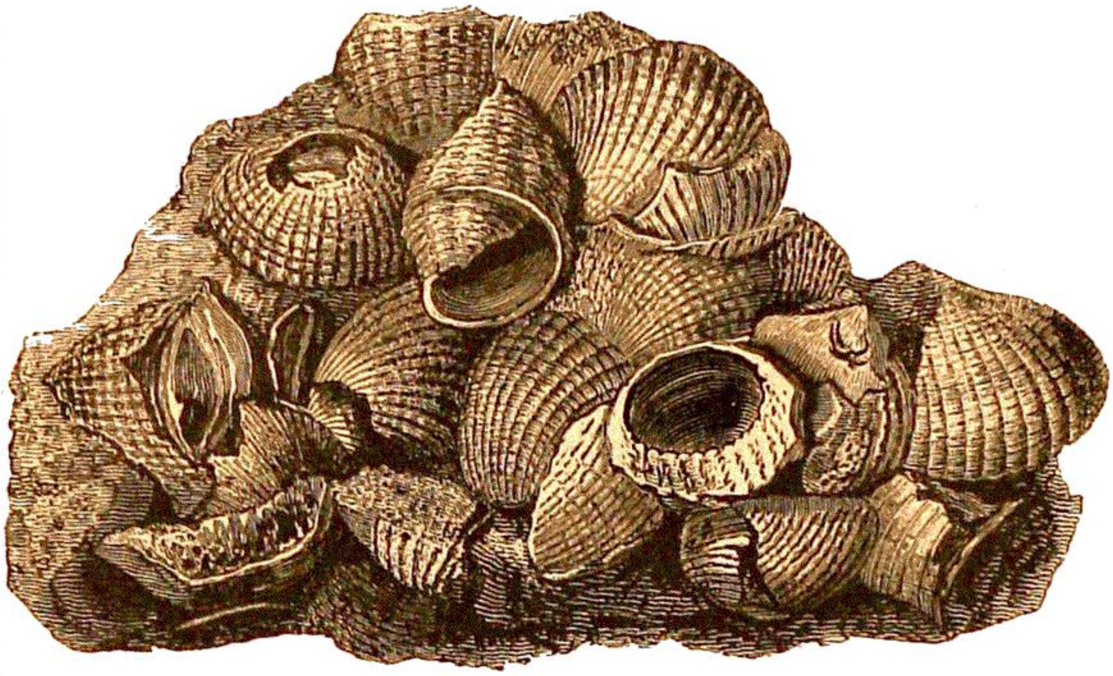

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LIGN. 88. SHELL-LIMESTONE; FROM THE MOUTH OF THE THAMES.

(*Drawn by Mr. Joseph Dinkel.*)

Fig. 1.—A mass of Cockle-shells and Whelks, consolidated into a coarse limestone.

2, 4.—One of the shells, CARDIUM EDULE, extracted from the block.

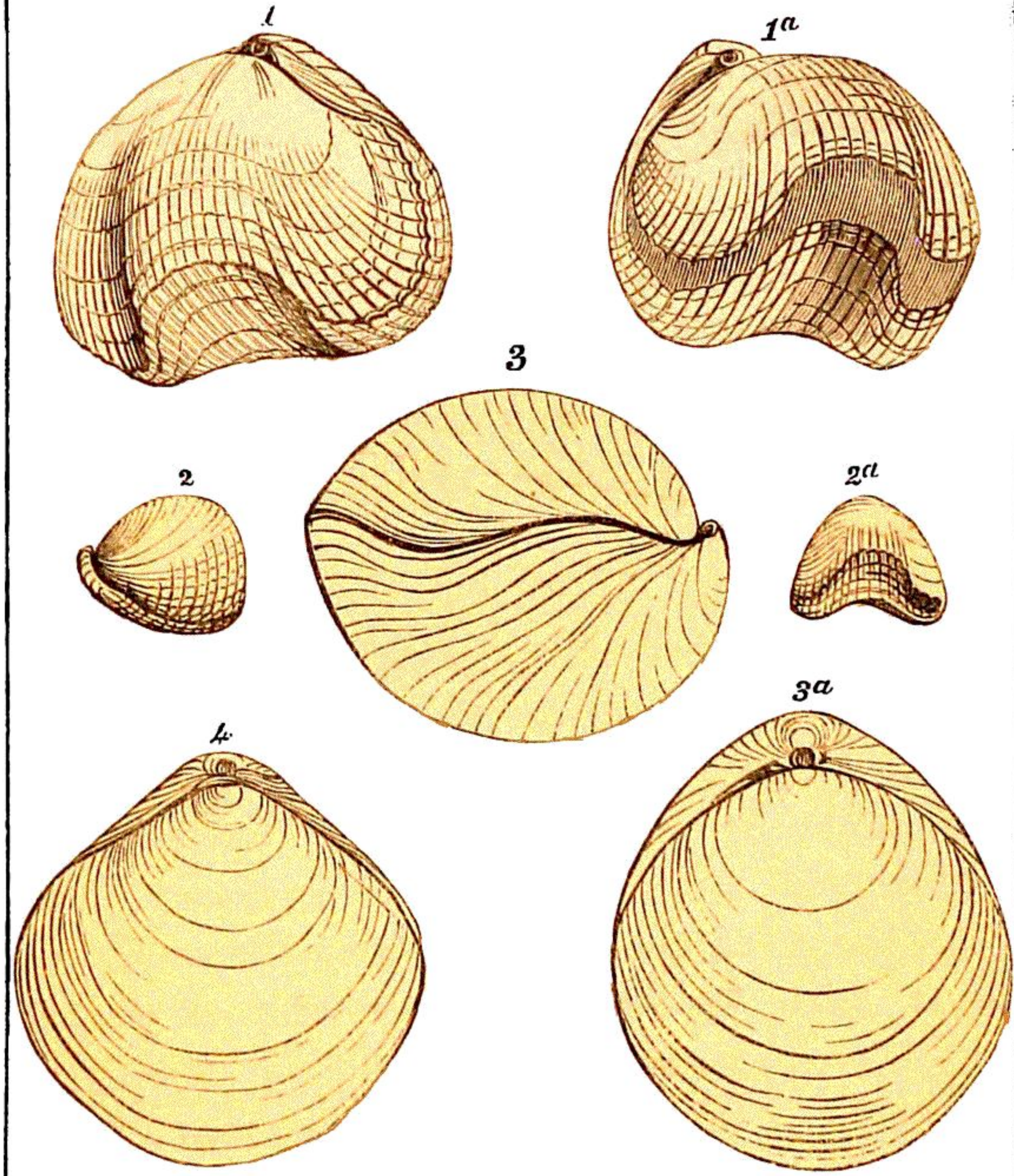
3.—A slice of the same, polished, the markings on the surface being derived from sections of the shells.

blocks occur, like that of which a fragment is figured in *Lign.* 88. These examples of shelly limestones and sandstones now forming, will familiarize the student with the nature and origin of those ancient deposits of a similar character, which contain extinct species and genera of mollusca.

FOSSIL SHELLS OF THE BRACHIOPODOUS MOLLUSCA.—These are bivalve shells, of which nearly five hundred species are found in the British strata. They occur in incredible numbers in the ancient rocks, to which several genera are restricted; while some continue through all the formations, and inhabit the present seas; but the existing genera are few.

TEREBRATULA (*bored, alluding to the perforated beak*). *Lign.* 89.—The common species of this genus must be familiar to all who have ever looked into a quarry of Chalk, or Shanklin sand, in the south-east of England. They have been humourously called the *Fossil Aristocracy*, from the incalculable antiquity of their lineage.

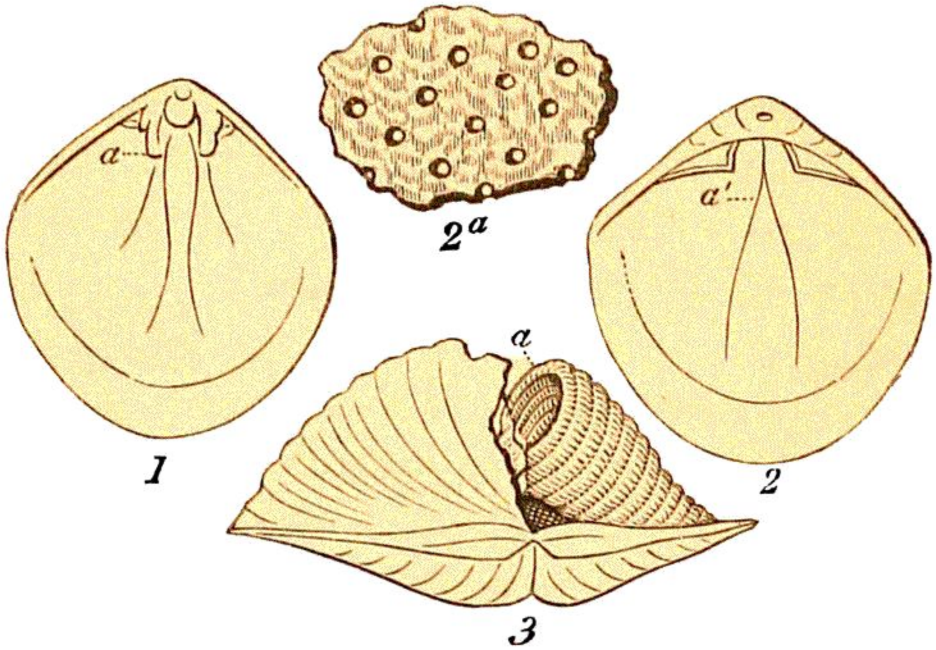
The species are very numerous; those figured in *Lign.* 89 are from the White Chalk, and are beautifully preserved; even vestiges of the colour occasionally remain. In a living state, the animal is fixed to foreign bodies by a byssus, or peduncle, which is protruded through the opening in the



LIGN. 89. TEREBRATULÆ, FROM THE CHALK. *Lewes.*

Fig. 1.—TEREBRATULA OCTOPLICATA.
1a.—The same species, partly open.
2.—TEREBRATULA SUBPLICATA.
2a.—Front view of the same.
3.—TEREBRATULA SEMIGLOBOSA; side view.
3a.—The same species, seen from above.
4.—TEREBRATULA SUBROTUNDA.

beak, or arched extremity, of the shells. The most interesting circumstance relating to these mollusca, is the respiratory apparatus, which consists of two long ciliated tubes, spirally coiled, united at their



LIGN. 90. TEREBRATULA AND SPIRIFER.

Fig. 1 and 2.—Upper and under valve of TEREBRATULA CARNEA. *Chalk; Lewes: a, a,* remains of the calcareous support of the *brachia*.

2a.—Portion of the shell of *Terebratula carnea*, magnified to exhibit the perforations.

3.—SPIRIFER TRIGONALIS, with part of the upper valve removed, to show one of the spiral processes. (*Min. Conch.*) *Mountain Limestone.*

base, and supported by slender calcareous processes, which are often preserved in the fossils. Thus, in specimens from the soft chalk, the calcareous earth may be removed from the interior of the shell, and the appendages exposed, as in the examples, *Lign.* 90, figs. 1, 2; and in the shells that are empty, these processes occasionally remain distinct, or are coated by a thin pellicle of calcareous spar, or pyrites.

In the smooth *Terebratulæ*, the laminations of the shell are full of minute perforations, which may be seen by a lens of moderate power; the appearance of this structure, when highly magnified, is shown fig. 2[a]., *Lign.* 90.* The plicated Terebratulæ (as *Lign.* 89, figs. 1, 2,) do not possess this organization.

SPIRIFER (*containing spiral processes*). *Lign.* 90. —In the Silurian, Devonian, and Carboniferous limestones, there is a profusion of several genera of *Brachiopoda*, whose peculiar forms render them easily recognisable. Among these, the Spirifers are the most interesting, on account of their spiral calcareous processes, which in the recent state supported the ciliated *brachia*, being often preserved. A specimen, in which part of the upper valve of the shell has been removed, and one of the spires exposed, is figured *Lign.* 90, fig. 3. (*Wond.* pp. 474—476.).† Three other related genera of

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* An interesting Memoir on the Microscopal Examination of Shells, has recently been communicated to the Royal Society by Dr. Carpenter.

† See an admirable Memoir on the Anatomy of the Brachiopoda, by Professor Owen. Zoological Trans. Vol. I. p. 145, *et seq.*

Brachiopoda are associated with the Spirifers; namely, *Productus*, (called in *Murch. Sil. Syst.*, *Leptena*,) figured *Wond.* p. 475, fig. 3: *Atrypa*, *Wond.* p. 475, fig. 8, distinguished from Spirifer by a short hinge-line, and being without, or with but a very small, triangular foramen; and *Orthis*, which differs from the preceding, in the long narrow hinge, and circular form of the shell, and striated surface; figured *Ly.* II. p. 162. I am induced to notice these shells, to explain the terms *Leptena*, *Atrypa*, and *Orthis*, which, although of but late introduction, are now generally employed.* All these genera are extinct; they prevail in the oldest fossiliferous rocks, and gradually disappear as we ascend to the newer formations; the last trace of their existence is in the Lias, in which one species has been found. But the *Terebratulæ* abound in the Lias, Oolite, Chalk, &c., occur in the tertiary formations, and several living species inhabit the seas around Australia and New Zealand.

CRANIA, *Ly.* I. figs. 165 and 13.—These are small brachiopodous shells, attached to other bodies; very frequently to the Echinites of the chalk. The free valve is commonly wanting, but I have found specimens dispersed in the rock. In many of the

* Numerous species of these genera are figured by Mr. Murchison in Sil. Syst., and by Professor Phillips in Geol. Yorks.

quarries in Kent and Sussex, the helmet Echinites bear groups of these shells.

PENTAMERUS. *Ly.* II. p. 164.—With the Spirifers, and other Brachiopoda of the Silurian System, some bivalves which, in their general figure, resemble certain species of Terebratulæ, frequently occur. These shells differ in their internal structure from all other genera, in having a septum, or plate, by which their cavity is divided into four chambers; and in one valve the septum itself contains a cell, thus making five chambers, whence the name *Pentamerus* (*five-celled*). The casts of these shells often have fissures, produced by the decomposition of the septa; and occasionally these cavities are occupied by calcareous spar. Four species are known, and all belong to the Silurian rocks.

LINGULA. *Ly.* II. p. 165, fig. 349.—The Brachiopoda referred to this genus have a long peduncle, and their spiral respiratory apparatus has no calcareous support; the recent species burrow in the sand, being usually inhabitants of shallow waters. The *Lingulæ* are readily distinguished from the Terebratulæ by their imperforate, equivalved shells. One species is found in the Aymestry limestone, and several have been collected from the Mountain limestone, Oolite, and Shanklin sand.

With reference to the species of Brachiopoda, particularly of the Terebratulæ, which inhabit the depths of the ocean, Professor Owen observes, that "both the respiration and nutrition of animals, which exist beneath a pressure of from sixty to ninety fathoms of sea-water, are subjects suggestive of interesting reflections, and lead us to contemplate with less surprise, the great strength and complexity of some of the minutest parts of the frame of these diminutive creatures. In the unbroken stillness which pervades those abysses, the existence of these animals must depend on their power of exciting a perpetual current around them, in order to dissipate the water laden with their effete particles, and to bring within the reach of their prehensile organs, the animalcules adapted for their sustenance."

FOSSIL SHELLS OF THE LAMELLIBRANCHIA.—These are bivalve shells, the animals of which differ from the preceding class, as we have already stated, in performing respiration by means of lamellated gills. The valves are united by a strong substance, termed the ligament, which, by its elasticity, admits of the shells being opened to a considerable extent; and they are closed by powerful, short, thick muscles, called adductors. The shells of some of the genera, as the Oyster and Scallop, have but one muscle (*monomyaria*); others, as the Cockle, or Cardium, and Venus, have two (*dimyaria*); and by these characters the class is arranged in two groups.

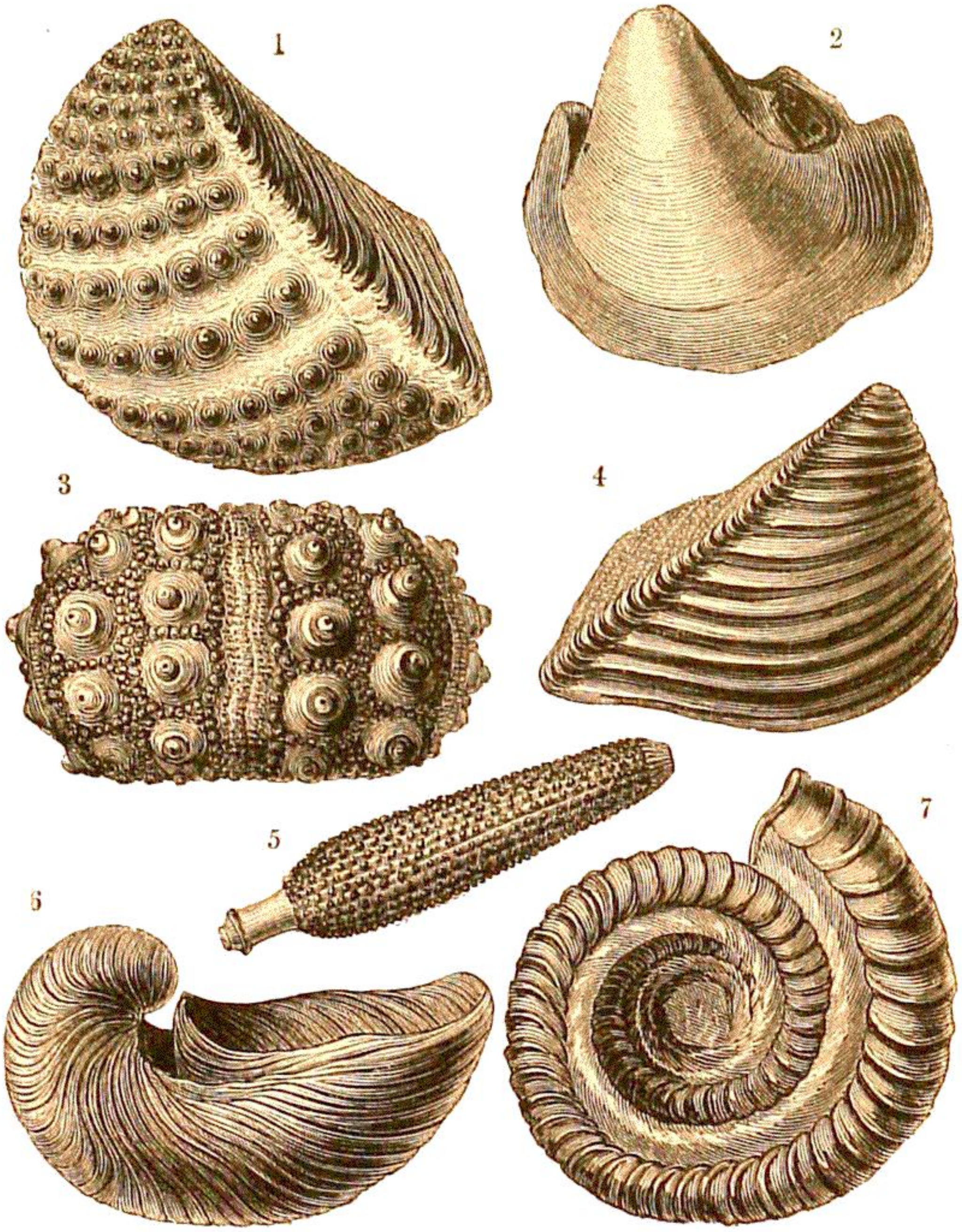
MONOMYARIA: *Bivalve Shells, with one muscular impression.*

OSTREA, *Lign.* 85.—The Oyster is well known to possess no power of locomotion; it is attached to rocks, pebbles, and other bodies, and forms extensive beds, consisting of numerous individuals, of all sizes. There are many fossil species; the British strata yield between forty and fifty. In some localities, Oysters are found in thick beds, of great extent, apparently on the spots they occupied when living. One of the most interesting localities I am acquainted with, is Sundridge Park, near Bromley, in Kent, where a hard conglomerate, entirely made up of oyster-shells, and the shingle that formed their native bed, is quarried. This stone is much employed for ornamental rock-work, and several walls in and near Bromley are constructed of it: these display the fossils, some with the valves closed, others open, others detached, and the whole grouped as if artificially imbedded to expose the characters of the shells. These oyster-beds belong to the tertiary strata of the London basin; they extend to Plumstead, and other places in the vicinity; and in some localities, the oysters are associated with other bivalves, called *Pectunculi.* In the tertiary clays near Woolwich and Bexley, fossil oyster-shells abound. In the neighbourhood of Reading, in Berkshire, an extensive layer of fossil oysters occupies the same geological position, namely, the lowermost sands and clays of the London basin. Wherever the strata around London are perforated to a sufficient depth, this oyster-bed is reached. Very recently an Artesian well was bored at Hanwell, in Middlesex, and at the depth of two hundred and eighty feet this stratum of sand with oyster-shells, was found. At Headley, near Reigate, in Surrey, there is a similar deposit. These oysters very closely resemble the edible species.

The white Chalk contains several species of Ostrea, but I believe no beds of these shells have been found; on the contrary, the shells are diffused promiscuously through the strata. I have collected a few groups of from thirty to forty shells, evidently the young or fry of the species (*O. semiplana*) figured *Lign.* 85. This specimen is an interesting example of the petrifactive process which the mollusca have occasionally undergone; the soft parts of the oyster are transmuted into flint, and the shell is changed into carbonate of lime, having a crystalline structure. Both valves were perfect when discovered, but I chiselled off the greater part of one shell to expose the silicified body of the animal.

A small oyster, called *Ostrea vesicularis,* is a characteristic shell of the chalk; one valve is convex, the other flat; it is abundant in the Chalk of Norfolk, and also in the Firestone of some localities: it is figured *Ly.* I. p. 389. Another small species, having the margin plicated (*O. plicata*), is also frequent in the Chalk. A large shell, with the margins deeply indented by angular folds, resembling the recent cockscomb oyster, is abundant in the Chalk Marl and Firestone; particularly near Dover, and around Selbourne in Hampshire; it is named *Ostrea carinata*, and figured *Ly.* I. p. 388, fig. 169. One other species may be noticed, the *Ostrea deltoidea*, which has been found in every locality of the Kimmeridge Clay in England and France. It is a very flat species, and of a triangular form; the specific name is derived from a supposed resemblance to the Greek letter Δ, *delta*. I believe that in England no shells of this genus have been observed in strata older than the Lias.

GRYPHÆA. *Lign.* 91, fig. 6.—The shells to which the term *Gryphæa*, or *Gryphites*, is applied, are related to the Oyster, but distinguished by the deep concave under valve, and its curved summit, or beak, and the almost flat, or opercular upper shell. The Gryphites are of a finer laminated structure than the oysters, and the ligament of the hinge is inserted in an elongated curved groove. There are about thirty British fossil species, none of which have been noticed below the Lias, in which formation one very remarkable species is so abundant as to be considered characteristic of the Liassic deposits. It is so faithfully represented, *Lign.* 91, fig. 6, that description is unnecessary. In the upper argillaceous beds of the Oolite, and Kimmeridge



LIGN 91. SHELLS, AND ECHINITE FROM THE COLITE AND LIAS.

(*Drawn by Mr. Joseph Dinkel.*)

Fig. 1.—TRIGONIA CLAVELLATA. *Oxford Clay: near Weymouth.*
2.—TRIGONIA COSTATA; a limestone cast. *Isle of Portland.*
3.—CIDARIS BLUMENBACHII. *Oolite. Calne, Wilts.*
4.—TRIGONIA COSTATA. *Oolite. Highworth, Wilts.*
5.—Spine of the Cidaris Blumenbachii.
6.—GRYPHÆA INCURVA. *Lias. Cheltenham.*
7.—AMMONITES WALCOTII. *Lias, near Bath.*

Clay, a very small gryphite, (*G. virgula*, *Ly.* II. p. 48,) is so abundant, that it constitutes entire layers. The low cliffs on the west of Boulogne harbour, like those near Weymouth, are composed of this clay, and myriads of the gryphites are scattered on the shore, with other shells of the same deposits; these shelly beds are called *marnes à gryphées*, by the French geologists. A very large gryphite, *Gryphæa sinuata*, (*Min. Conch.* tab. 336,) is found in the Shanklin sand of the Isle of Wight, and of Kent and Sussex. At low water, in the sand along the shore under Dunnose Cliff, near Shanklin-Chine, numerous specimens are always obtainable.*

Plagiostoma. *Lign.* 92.—A species of this genus is so frequent in the Chalk, that it ranks with certain Terebratulæ, as characteristic of that formation. One valve is covered with long slender spines, which, in the usual examples, are destroyed by the mode of extracting them. The specimen figured shows the appearance of a shell partly cleared; the remainder of the chalk might be removed by a pen-knife (taking care to leave the longest spines supported by brackets of chalk), and it would then resemble the beautiful fossils figured *Min. Conch.*

* The name *Exogyra* was applied to several species of Gryphæa by the late Mr. Sowerby, and other writers; but subsequent authors have included these shells in the present genus.

tab. 78, and in *Geol. S. E.* p. 125. Between the beaks there is a triangular aperture in the spinous valve, which some naturalists, with much probability, suppose was filled up in a recent state with cartilage, and that the original was a true *Spondylus*. In the present state of fossil conchology, and in an elementary work like the present, it appears to me

LIGN. 92. PLAGIOSTOMA SPINOSUM. *Chalk. Lewes.*

desirable to retain the well-known name, originally imposed by the celebrated Lhywd.

In the cretaceous strata of North America, Dr. Morton has discovered a Plagiostoma (*P. dumosum*) very nearly related to *P. spinosum*; but it differs in its general form, and has both valves beset with strong spines. There are several species of the genus without spines in the Chalk,* Oolite, and Lias.

A very large species (*P. giganteum*), sometimes ten inches in diameter, abounds in the Lias (*Ly.* II. p. 60.). It is somewhat depressed in form, with the surface slightly striated; each valve has a pointed beak, with two lateral expansions, or ears, as they are termed by conchologists.

Of the SPONDYLUS (*Clam-shell*), so well known in a recent state, but one species has been recognised in the British strata; but it is probable that some of the Plagiostoma, Ostreæ, &c. may belong to the Spondylidæ. I have the fragment of a large bivalve from the Kentish Rag (Mr. Bensted's quarry), which has the peculiar structure of the Water-clam (*Spondylus varius* of Mr. Broderip); namely, hollow interspaces formed by shelly layers or partitions, which were secreted by the posterior part of the mantle, or investing integument of the animal, as it gradually receded from that part of the shell. In the recent Water-clam the cells are full of fluid.†

PLICATULA, is another genus of this family, of which there are three British fossil species. A delicate shell, with slender depressed spines (*P. inflata. Foss. South D.* Tab. XXVI.), occurs in the Chalk

* See Foss. South Downs, Plate XXVI.

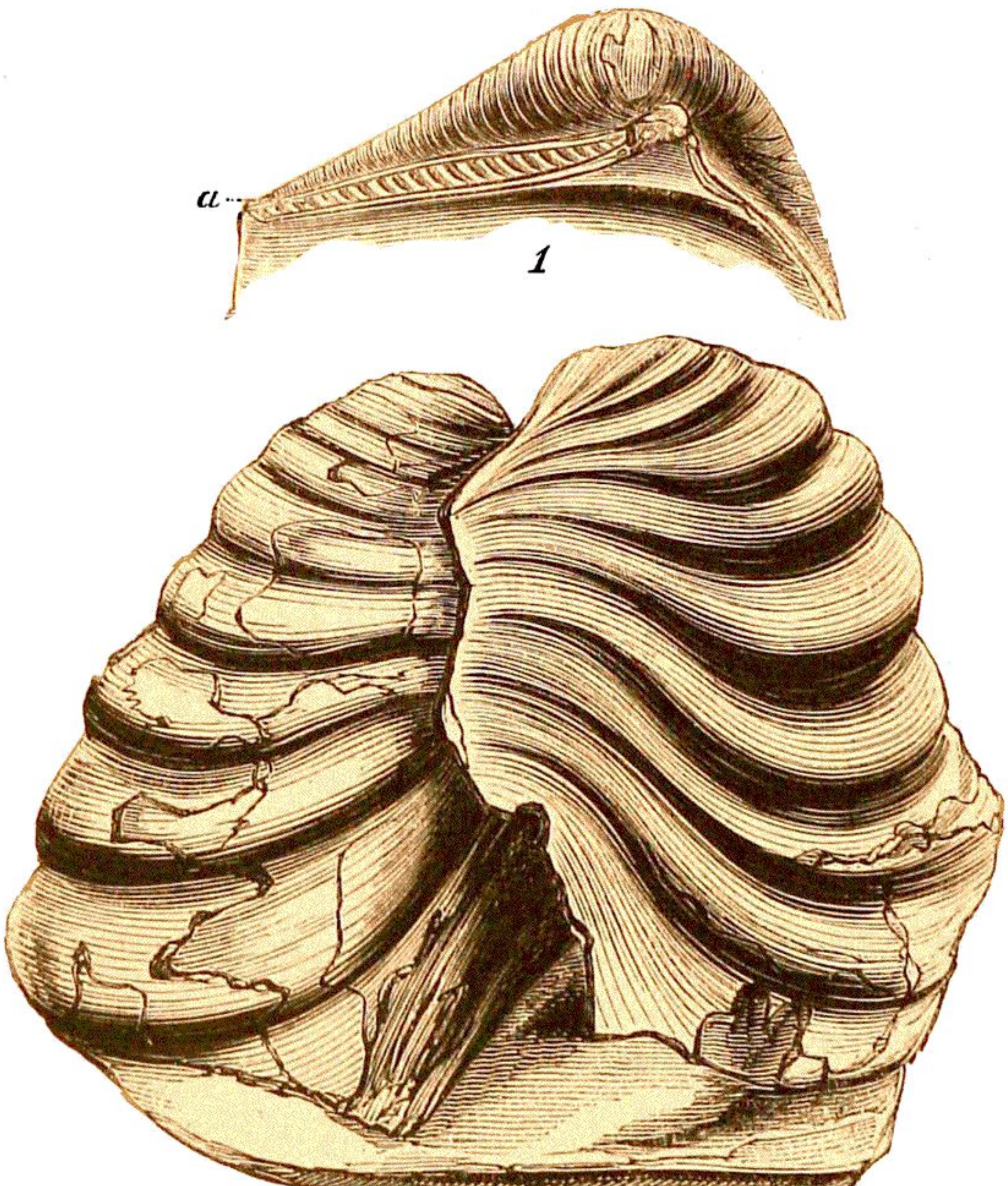
† See Penny Cyclop. Art. *Spondylidæ.*

Marl. The recent species are natives of the seas of warm climates.

PECTEN.—The common scallop-shell will serve as a type of this genus. The animals of these shells, unlike the oysters, have the power of locomotion, and when in the water, may be seen moving with rapidity, and flapping their shells to and fro with great activity. Numerous species are found fossil. In the Pliocene, and other marine tertiary deposits, Pectens abound; in the White Chalk there are several elegant forms (see *Foss. South D.* Plate XXV.); many kinds in the Oolite and Lias; and several in the Devonian strata.

A large Mediterranean species (*Pecten Jacobæus, Ly.* I. p. 296.) occurs in the Pliocene strata of Palermo, in every stage of growth, and as perfect as if recent. The Chalk and Shanklin Sand contain a small inequivalved Pecten, the lower valve of which is convex, and pentangular, the upper flat, and both strongly ribbed, or pectinated; it is named, *Pecten quinquecostatus* (*Foss. South D.* Pl. XXVI. *Ly.* I. p. 403.); and in the cretaceous strata of North America a variety of this species is found.

In the Chalk Marl a large and beautiful Pecten (*P. Beaveri. Min. Conch.* tab. 158.) is very common, and I have obtained from Hamsey and Southerham, examples in the most perfect state of preservation; it is a characteristic shell of the Chalk Marl of England (*Foss. South D.* Plate XXV. fig. 11.).



LIGN. 93. INOCERAMUS CUVIERI. *Chalk. Lewes.*

Fig. 1.—Beak and hinge of an INOCERAMUS.

a. The hinge line.

2.—Two valves of I. CUVIERI, displaced, and both showing the external surface.

INOCERAMUS (*Lign.* 93.).—This name, which refers to the fibrous structure of the shell, has been given to a fossil genus, of which there are about thirty species in the cretaceous and oolitic formations; and very recently four or five species have been discovered in the Silurian strata of Ireland.* These shells are chiefly characterized by their hinge (see *Lign.* 93, fig. 1 *a.*), and by the fibrous structure of their constituent substance, which closely resembles that of the recent *Pinna;* and under the microscope is found, like that shell, to consist of prismatic cells, filled with carbonate of lime.† The species vary in size from an inch to three or four feet in diameter. The shell, in consequence of the vertical arrangement of the fibres, readily breaks to pieces, and it is often extremely difficult to extricate a specimen with the hinge and beaks tolerably entire. That they were equally brittle when recent is evident from the numerous fragments diffused through the chalk and flint, and occasionally imbedded in pyrites.‡ The form of

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* The term Inoceramus is restricted by the French geologists to the beaked and laminated species of the Galt; and the chalk Inocerami are arranged under the name *Catillus.*

† Dr. Carpenter on the Microscopical Structure of Shells. To detect this structure, the shell should be immersed in diluted hydrochloric acid, and, when partially dissolved, the cells will be apparent.

‡ It was many years before I succeeded in obtaining a specimen with the hinge perfect; and M. Brongniart, unable

the hinge is shown in *Lign.* 93, fig. 1: in the lower specimen two valves of the same individual are seen displaced, one lying over the other. The usual chalk species are figured *Foss. South D.* Pl. XXVII. and in *Min. Conch.*

In the Galt, or Folkstone marl, two small species of this genus are to be found in every locality I have visited. They were first figured and described by Mr. Parkinson, under the name of *Inoceramus sulcatus*, and *I. concentricus* (*Wond.* p. 313, figs. 1. and 3.). In most examples the shell is in the state of a white, friable earth, and readily decomposes, leaving patches of iridescent nacre on the casts; but I have seen examples which prove that the originals were of a fibrous structure, like the Inocerami of the Chalk.

The shells of the Inocerami, like those of the oyster, and other living mollusca, were exposed to the attacks of some parasite, or perhaps of some Annelide, as the *Nereis*. The shells are often quite cellular from this cause, and the cavities are found either hollow, or filled with chalk; or, as in the example *Lign.* 94, *a*, with flint. In the latter case, upon the decomposition of the shell, the siliceous casts remain in relief on the surface of the flint, as in *Lign.* 94, *b*. Such specimens are common in the

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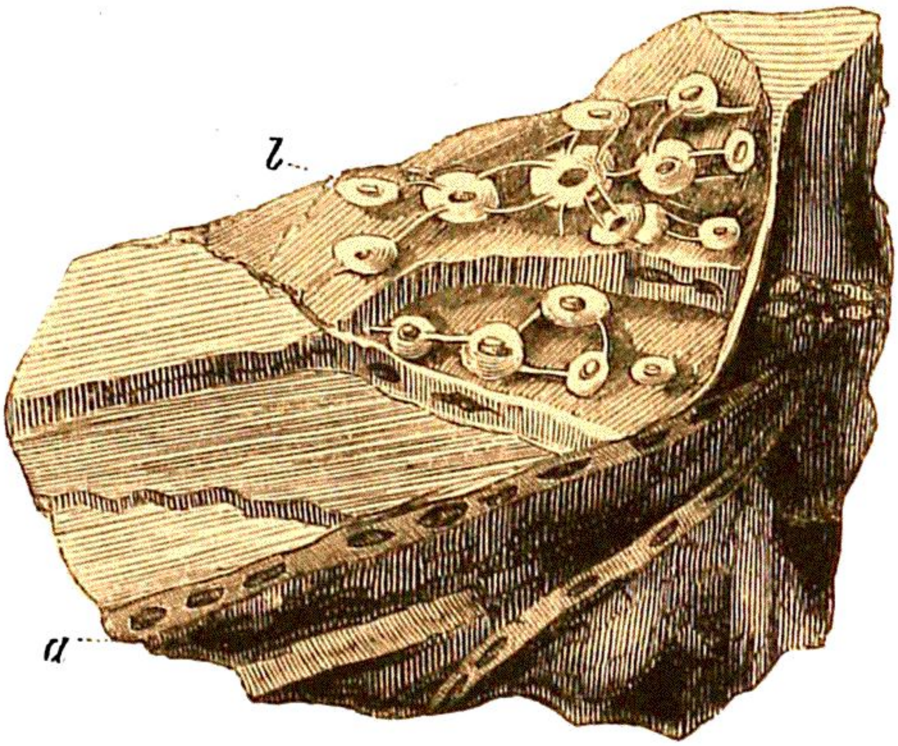
to obtain one from the chalk of France, gave the figure of this genus from my Foss. South D. Pl. XXVII. in the Géog. Min. Env. de Paris.

water-worn flints of the South Downs, and in the shingle on the sea-shore of chalk districts; and



LIGN. 94. FLINT, WITH FRAGMENTS OF INOCERAMUS.

Chalk. Lewes.

a. Marks the section of a fragment of shell, with numerous cavities, occasioned by the depredations of some boring animals.

b. Portion of shell partially decomposed, and exposing siliceous, globular bodies, connected by filaments, which are flint casts of hollows occasioned by the ravages of the borers.

their origin would be difficult to understand without this explanation.*

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* The Rev. W. Conybeare first ascertained the origin of these fossils, and figured and described them in an elegant Memoir, published in Geol. Trans. Vol. II. first series.

AVICULA. *Ly.* II. pp. 59, 93, 109.—Above fifty species of this genus of shells have been found in the British strata; their general character will be readily understood by reference to the pearl-oyster, (*Avicula Margaritifera,*) which is so largely imported for the manufacture of mother-of-pearl ornaments. A remarkable species is found in the Lias, called, from the great disproportion in the size of the shells, *Avicula inequivalvis, Ly.* II. p. 59. The recent species are inhabitants of warm climates.

Our limits will not admit of further notice of the *Monomyaria,* and we proceed to the second division of the plated-gilled mollusca.

DIMYARIA: *Bivalve Shells, with two muscular imprints.*

The conchifera, or bivalve shells, of this group, found fossil, are more than double in number those of the preceding; nearly eight hundred species are known in the rocks of Great Britain, of which by far the greater number is marine. But we must restrict our notice of this division to a few genera, that more space may be devoted to that important class, the Cephalopodous Mollusca.

The *Cardium, Venus,* and Mussel shells, are familiar examples of the *Dimyaria.* The conglomerates, now forming in the British Channel, from accumulations of the recent species of Cockle (*C. edule*) have been previously noticed; see *Lign.* 88, p. 377. In the strata of England there are upwards of thirty species: the *Crag* contains several, particularly a large and delicate shell, the *Cardium Parkinsoni* (*Min. Conch.* tab. 49.). Others are peculiar to the London clay, as the *Cardium semi-granulatum*, a beautiful shell, having the surface smooth, except on the posterior side, which is covered with strong ridges, beset with minute granules; it is found in many localities (*Min. Conch.* tab. 144.). Among the silicified shells of the Shanklin sand of Devonshire, an elegant Cardium (*C. Hillanum. Min. Conch.* tab. 14) occurs. But one species is known in the formations below the Lias: the *Cardium striatum*, (*Murch. Sil. Syst.* tab. 6, fig. 2,) found in the Aymestry limestone.

VENERICARDIA. *Ly.* I. p. 348, plate 4, fig. 10.—These shells are abundant in the tertiary strata; one large species, *V. planicosta*, (*Ly.* I. plate 4, fig. 10,) is found in immense quantities in the clay and sand at Bracklesham Bay, in Sussex, from the young to the adult state; some examples are very large, and perfect. In the sand at Grignon, near Paris, the same shell is abundant, possessing the usual white and delicate aspect of the fossils of that celebrated locality of the *Calcaire grossier*. Only one species has been noticed in the British secondary strata.

PECTUNCULUS. *Wond.* p. 231, fig. 8.—In the London clay at Bracklesham Bay, Highgate, Hordwell Cliff, and in the arenaceous limestone of Bognor rocks, an immense number of the bivalve shells, called *Pectunculi* (*little pectens*) occur. Some of the French marine tertiary strata also abound in the same, and other species of this genus. In the above-mentioned Sussex localities, these shells are so numerous, as to be the most frequent fossils that come under the notice of the collector. They are readily known from their associates by their rounded equivalve shells, and the single arched row of teeth along the hinge, resembling the common *Arca.** (See *Min. Conch.* tab. 27.). At Plumstead, near Woolwich, a smaller species is found; and also occasionally with the oysters at Bromley.

NUCULA.—Several species of a small elegant bivalve, related to the preceding, but distinguished by having two rows of teeth on the hinge, diverging from an interspace between the beaks, are found in the Crag and other tertiary deposits. (*Min. Conch.* tab. 180, 192.). Two species occur in the Galt (*Foss. South. D.* Pl. XIX. figs. 5, 6, 9,) at Ringmer, Folkstone, Bletchingley, &c., sometimes with the shell perfect, but generally in the state of casts composed of indurated clay, and having impressions

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* The species so abundant at Bognor, is *P. brevirostris* Min. Conch. tab. 472. I have seen a block of the limestone, in which, spread over an area of a foot square, there were upwards of fifty specimens lying in relief.

of the muscles and of the two rows of hinge-teeth. The shell of one species is marked with fine transverse grooves, or striæ, (*N. pectinata*); the other is of a flattened ovate form, and the surface smooth (*N. ovata*).

PINNA.—The common large *Pinna*, of the Mediterranean, is well known, and differs so entirely from other shells, as to be readily distinguished. There are about fifteen or sixteen British fossil species. The earliest appearance of this genus is in the carboniferous limestone of Derbyshire, (*Phil. York.* tab. 6.), in which there are two species. The Lias contains one species; the Ooolite eight; the Cretaceous formation four; and the London clay two. One of the tertiary species, *Pinna affinis* (*Min. Conch.* tab. 313.), occurs in considerable numbers in the Bognor rocks, associated with Pectunculi, varying in length from one to six or seven inches. A beautiful and delicate species is found in the *Calcaire grossier*, of Grignon. Shells of this genus are very rare in the White Chalk, most of the supposed *Pinnæ* being imperfect examples of *Inocerami;* but I have seen specimens from Norfolk (by the late Mr. Woodward), and one from Sussex, in the cabinet of the Marquess of Northampton.*

* Dr. Lee has recently discovered in the Kimmeridge Clay on his estate at Hartwell, Bucks, a species of Pinna not previously observed in England. Professor Forbes informs me

MYTILUS, OR MUSSEL.—There have been found about twenty species of this well-known genus of marine shells in the British strata. They are sparingly distributed through the several formations, from the Silurian to the newer Tertiary. One species (*Mytilus Lyelli, Wond.* p. 377.) occurs in the Wealden, associated with fresh-water shells.

Of the genus termed MODIOLA, which comprises those mussels that have a rounded anterior termination, nearly forty British species have been discovered; ranging through the fossiliferous strata, from the Silurian to the Crag. A beautiful species (*Modiola elegans. Min. Conch.* tab. 9.), with the shell generally retaining its pearly coat, is found in the London Clay, and in the limestone of Bognor.

An undescribed striated *Modiola* (which may be named *M. striata,* since the striæ are peculiar), occurs in the Kimmeridge Clay, at Hartwell.

Those species of Modiola, which pierce hollows in stones, and inhabit them, are arranged in a genus termed *Lithodomus.* The occurrence of these shells in the remaining erect pillars of the Temple of Jupiter Serapis (*Wond.* p. 95.), at Puzzuoli, has afforded important and unequivocal evidence of the physical mutations which that part of Italy has

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that it resembles *Pinna conica* (of Röemer), and is related to *P. lanceolata* of Sowerby, but appears to be distinct from both.

undergone. Two species of Lithodomi have been found, by Mr. Lonsdale, in the Oolite.

PHOLADOMYA. *Ly.* II. p. 50.—This genus of shells (established by that eminent conchologist, Mr. G. B. Sowerby, from a recent species), comprises about twenty British fossils, all of which, with but two exceptions, occur in the Lias and Oolite. They are equivalved shells, with the posterior end short, and rounded, and the anterior elongated and gaping. The surface is generally marked with ribs, or alternate elevations and depressions, diverging obliquely from the beaks to the margin. In the clay at Osmington and Radipole, near Weymouth, a large species (*P. æqualis. Min. Conch.* tab. 546.) is abundant. The Oolite of Brora, in Scotland, contains several species. The only species found in our Chalk, is the beautiful shell (*P. decussatum*), figured *Foss. South D.* Tab. XXV. fig. 3, and first discovered by me, in 1820, in a bed of Chalk Marl, which at that time was exposed at low-water, at the base of the cliff at Brighton, near the present entrance to the Chain-pier. The same species has since been found at Clayton, Hamsey, Southbourn, and other localities of the Marl.

PHOLAS. *Lign.* 113, figs. 5, 6.—The common boring bivalve called *Pholas*, must have attracted the attention of every stroller by the sea-shore, from the numerous perforations in blocks of chalk, and other limestones, occasioned by its operations. Some species burrow in wood, and often commit serious ravages in piles and other submarine works constructed of timber. In the earlier ages of our planet we find evidence of the existence of the same kind of living instruments for the disintegration of floating wood, and the reduction of masses of rock into detritus. But no traces of these shells have been found in strata below the Oolite. One species occurs in the Coral Rag, another in the Kimmeridge Clay; two in the Galt and Green Sand; and three or four in the tertiary deposits. In the Crag, blocks of stone are occasionally found with the shells of *Pholades* occupying the perforations they originally formed and inhabited. But all the specimens I have observed in the Galt, Green Sand, and Oolite, were *xylophagous* (*wood-eating*) species. In the Shanklin Sand, masses of fossil wood, literally honey-combed by the perforations of Pholades, are frequent; but the shells themselves are rare. Mr. Sowerby has figured a beautiful specimen of silicified wood, from Sandgate, with numerous shells of this genus (*Pholas priscus. Min. Conch.* tab. 581.). *Lign.* 113, fig. 5, represents a fragment of fossil wood, with three shells *in situ; a*, a shell seen longitudinally; and below, the rounded anterior extremities of two other shells are exposed.

Masses of wood perforated by Pholades, from which all traces of the shells have disappeared, have given rise to some curious fossil remains, which are often very enigmatical to the young collector. In the Kentish Rag, as for example, in Mr. Bensted's quarry, near Maidstone, large blocks of stone are found, covered with groups of subcylindrical mammillary projections, which are obtuse or rounded at the apex. In some examples the interstices between these bodies are free; in others they are occupied by a reddish brown, friable substance, presenting obscure indications of ligneous structure; and rarely, distinct woody fibres may be observed, the direction of which is transverse, or nearly at right angles, to the mammillated projections. These blocks are, in truth, the stony casts of cavities formed by Pholades, in masses of wood, both the vegetable structure, and the shells, having perished.

In the White Chalk specimens of this kind are occasionally found.

A remarkable fact, relating to some of the specimens from the Iguanodon quarry, remains to be mentioned. Upon breaking off the projections, to ascertain if any traces of the shells of the Pholades remained, we discovered in several, near the apex, an univalve shell, a species of *Nerita*. *Lign.* 113, fig. 6, represents a fragment of stone with two of the casts, which have been broken, and in each, at *a*, an univalve is imbedded. At *b*, the ligneous structure of the original wood is visible. The only hypothesis that will account for the appearance of these univalves in their present position, is that of supposing that the Nerites crawled into the cavities made in the mass of timber, after the shells of the Pholades had been removed; and that the wood became engulfed in a sand-bank, and the univalves enclosed in the cavities; the ligneous structure in a great measure perished, and the stony casts of the perforations of the borers, with the imprisoned univalves remained. The Nerites, as shown in the example figured, do not occupy any particular position in the tubes; one has the apex towards the end of the cavity, and the other lies in a transverse direction.*

TEREDO. *Ly.* I. p. 51.—It will be convenient to notice in this place another genus of boring shells, whose fossil remains are far more abundant, than those of the Pholas. The *Teredo navalis*, or Ship-worm, which is the most vermiform of all the mollusca, forms tortuous cylindrical hollows in wood; and in some climates commits the most extensive injuries to ships, the piles of harbours, bridges, and other submarine works formed of timber. A reference to the illustration by Mr. Lyell will render detailed description unnecessary. The *Teredo* is furnished at one extremity with testaceous valves, by which it bores its way into the

* In a fragment of a perforated column, from Puzzuoli, in my possession, by favour of Sir Woodbine Parish, there were numerous living univalves in the cavities made and previously inhabited by the lithodomi.

wood, while from the surface of its soft body a calcareous matter is secreted, which lines with a shelly covering the hollows or channels formed by the animal in its progress. The fossil species differ from the recent in the valves being united to the calcareous tube. Wood perforated by *Teredines*, and occupied by their shelly tubes, occurs in almost every locality of the London Clay. Those specimens in which the wood is petrified, and the cavities of the tubes are filled with calcareous spar of various colours, furnish beautiful sections, when cut and polished (*Org. Rem.* Vol. I. Pl. VIII. figs. 8, 9.). When the canal in the Regent's Park was being formed, large blocks of perforated calcareous wood were discovered, having the ligneous structure well preserved, and the tubes of the Teredines occupied by yellow, grey, and brown spar, forming specimens of great beauty and interest. Wood, with Teredines, or some analogous boring mollusks, occurs sparingly in the chalk of this country; but in the cretaceous strata at Maestricht, large masses are frequently found. Fossil wood may occasionally be observed with perforations that have been made by other kinds of boring shells; but the preceding remarks will suffice to convey an idea of the nature and origin of such appearances.*

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* Other genera of boring shells also occur fossil, as Fistulana, Gastrochæna (Min. Conch. tab. 526), Saxicava (Min. Conch. tab. 466).

TRIGONIA. *Lign.* 91, figs. 1, 2, 4. — These bivalves are related to the *Arcadeæ* and *Nuculæ*, but distinguished by the peculiar character of the hinge; the right valve has two large oblong teeth, which diverge from the umbo, and are strongly furrowed, and fit into two corresponding grooved cavities, in the opposite, or left valve. These shells are very thick and nacreous; they abound in certain strata of the Oolite and lower division of the chalk, but have not been observed in the Lias and older deposits of this country; there are nearly thirty British species. The only known living species of Trigonia (*Trigonia Margaritacea*), is an inhabitant of the seas of New Holland and New Zealand, where it is associated with Terebratulæ. Some of the argillaceous beds of the Oolite, as the Oxford and Kimmeridge clays, abound in Trigoniæ; Osmington and Radipole, near Weymouth, are celebrated localities for these fossil shells, which are found there in great perfection; and on the French coast, where similar strata appear, the Trigoniæ are equally abundant. Under the cliffs, near Boulogne harbour, the shore is strewn with them. Three common species are figured in *Lign.* 91. The casts of most of the species are smooth, as in fig. 2; and the collector should, therefore, search for impressions of the outer surface, when the shell is absent, as is generally the case in the Portland Oolite and Shanklin Sand, in which Trigoniæ are very numerous. Near

Highworth, in Wiltshire, very fine and large examples of *Trigonia costata*, fig. 4, occur, with the shell preserved. The impressions of the large, oblong, diverging teeth of the hinge, are usually so strongly marked in the casts, as to render it easy to identify the shells of this genus. The quarries of Portland Oolite at Swindon, Wilts, teem with casts of Trigoniæ, collocated with Ammonites. In the Isle of Portland they are also very numerous, some beds of stone being so friable, from the numerous cavities left by the removal of the substance of the shells, as to be unfit for paving, or other economical purposes. Very sharp casts may be obtained from this rock by merely breaking the stone to pieces. In the Whetstone of Blackdown, Devon, beautiful silicified Trigoniæ are occasionally found. Tisbury, in Wiltshire, yields very fine specimens, and in some examples, Mr. G. B. Sowerby has detected remains of the ligament.

FOSSIL FRESH-WATER BIVALVES.

The animals of the shells hitherto described are, with scarcely any exception, inhabitants of the sea; and the marine origin of the strata in which they occur, may consequently be inferred, with but little probability of error. I now propose noticing the fossil remains of those bivalves which inhabit rivers, lakes, streams, and pools of fresh water. The marine, or fresh-water, character of fossil shells, is inferred from their resemblance to the recent mollusca, whose habits are known; for the shells alone present no unequivocal marks, by which even the experienced conchologist can pronounce whether an extinct form belonged to a marine or to a fluviatile mollusk, although certain characters may admit of an approximative inference. Thus, for instance, as none of the known living fresh-water bivalves belong to the previous division, the *Monomyaria*, the presence in a stratum of numerous shells with but one muscular impression, would afford a fair presumption of the marine origin of such deposit. The remains with which the shells are associated, and the mineralogical characters of the strata in which they occur, would, of course, afford important corroborative evidence.*

The living fresh-water bivalves comprise but a few genera and species; and those which have been found fossil in the British strata belong to but four or five genera. Their distribution is restricted to strata of undoubted fluviatile origin, and to those local intercalations of fresh-water and land productions in marine deposits, which occur in some of the secondary, and in many of the tertiary formations.

UNIO. *Ly.* I. p. 62.—The river Mussels, or *Unionidæ*, have a solid, pearly shell, with two principal and two lateral teeth on the hinge; and their

* See Mr. Lyell on the distinction between fresh-water and marine deposits. Ly. I. p. 59.

umbones, or bosses, are generally smooth, or longitudinally undulated. Those which have no cardinal teeth are arranged under the genus, *Anodon:* but it is not necessary for our present purpose, to enter into minute conchological distinctions. In number, variety, and beauty, the species which inhabit the large rivers of North America present a striking contrast with the few and homely British freshwater mussels ; nor have we, in a fossil state, any shells of this family at all comparable with those living types. The earliest fossil *Uniones* appear in certain layers of clay, and argillaceous ironstone, belonging to the Carboniferous system of Derbyshire, Coalbrook Dale, &c. (*Min. Conch.* Vol. I. tab. 33.). In the former county, these strata are termed *mussel-band ;** and some beds constitute a compact shell-limestone, which admits of being manufactured into vases, &c., and takes a good polish; the sections of the Uniones in this marble, are white, on a dark ground. The Carboniferous strata of Scotland also yield one or two species of Unio.

The only other undoubted shells of this genus from the British strata, are, I believe, those first discovered by me in the strata of Tilgate Forest, (*Foss. South D.* p. 45, and *Foss. Tilg. For.* p. 57.), and subsequently found in numerous localities of

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* "A solid stratum of ironstone with mussel-shells extends from Tupton Moor to Staveley." Martin's Petrificata Derbiensia, pl. 27.

the Wealden.* I shall reserve my remarks upon the important aid these fossils afforded in the determination of the fluviatile origin of the Wealden, for our *Excursion to Tilgate Forest*.

CYCLAS. *Wond.* p. 350. *Ly.* I. p. 61.—Another genus of fresh-water bivalves is termed *Cyclas*, of which there are ten species in the Wealden formation: and, with the exception of four or five recent forms, which occur in the tertiary fresh-water strata, none others have been found in England.† The shells of the genus Cyclas are oval, transverse, equivalved bivalves, with the hinge-teeth very small: the substance of the shell is thin and fragile; the figures in *Wond.* and *Ly.* accurately represent the appearance of the fossil *Cyclades* of the Wealden, and tertiary strata. Entire layers of two or three species of these shells occur in the argillaceous deposits of the Wealden, generally in a friable state, but from among the masses of crushed shells, perfect specimens may be obtained, and sometimes with the remains of the epidermis and ligament. The hard stone, termed calciferous grit, in the neighbourhood of Hastings, Tilgate Forest, Horsham, and other places in the Weald of Sussex, abounds in casts of

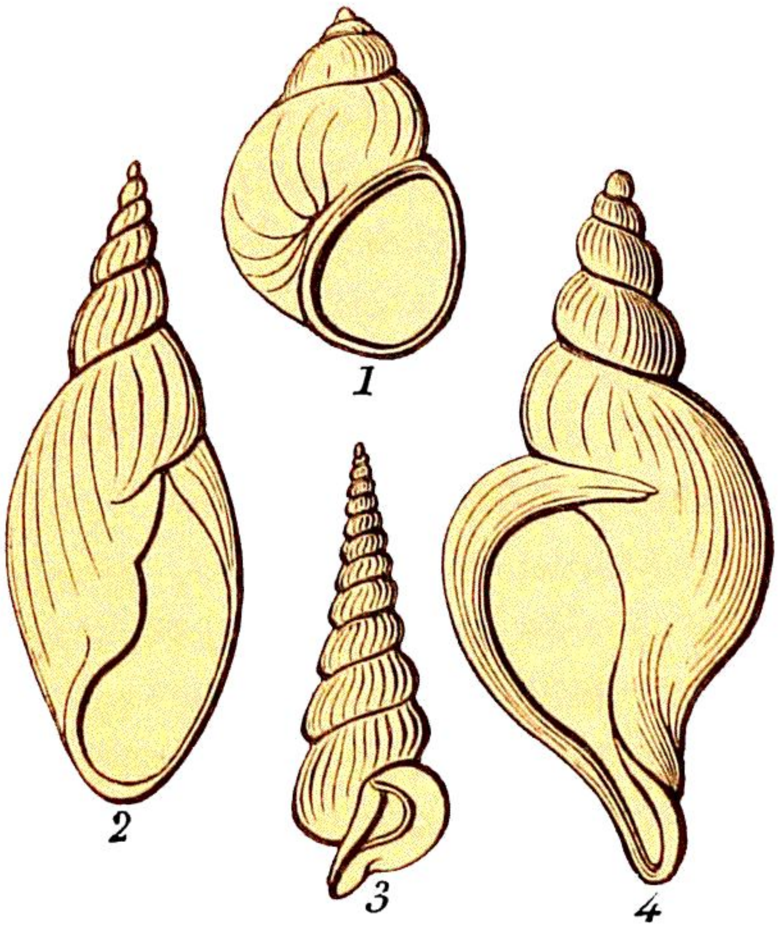
* They are figured in Geol. S. E. p. 250; and in Dr. Fitton's Memoir, Geol. Trans. Vol IV. pl. 21.

† *Cyrena*, is a genus so nearly related to Cyclas, that it is difficult to distinguish them, and it will be convenient to retain only the former name.

the same species, associated with the *Uniones*, previously described. In the cliffs on the southern shores of the Isle of Wight where the Wealden beds emerge, and also in the Isle of Purbeck, these shells are equally abundant. Together with the *Uniones*, they occasionally appear in the limestone, called Sussex Marble; and in the Isle of Purbeck there are beds of limestone wholly composed of bivalves belonging to these two genera, and presenting in polished slabs, markings formed by sections of the enclosed shells.

FOSSIL SHELLS OF GASTEROPODA.

The univalve shells, as we have previously explained, are the calcareous cases, or coverings, of a more highly organized class of molluscous animals, than the inhabitants of the bivalves (see page 366), for they possess a head, and mouth with jaws, eyes, and feelers; and while the *Acephala*, with but few exceptions, are incapable of locomotion, the *Encephala* are almost all of them furnished with organs of progression, and can creep, climb, and swim, or float on the surface of the water. Their shells are for the most part formed of one valve, hence the name of *univalve;* but in some species it is composed of several pieces. The most simple form of shell is that of the cone, of which the common *Patella*, or limpet, affords an example; and in the more complicated modifications, the cone is twisted, or convoluted spirally, either in the same plane as in the *Planorbis* of our rivers, or obliquely, as in by far the greater number of species. The direction of the spire is generally from left to right, the aperture being dextral to the observer when the shell is placed with its apex uppermost, as



Lign. 95. Fossil Shells of Gasteropoda.

Fig. 1.—Paludina fluviorum. *Wealden.*
2.—Limnæa longiscata. *Tertiary. Isle of Wight.*
3.—Cerithium lapidorum. *Tertiary. Grignon.*
4.—Fusus contrarius. *Crag. Essex.*

in *Lign.* 95, figs. 1, 2, 3; but in a few species the spire turns in the opposite manner, and the mouth or aperture is to the left, or sinistral, as in *Lign.* 95, fig. 4. In consequence of the form of the aperture of the shell, and the entire or notched condition of its margin, and the presence or absence of a canal or siphon, always having relation to the soft parts of the animal, these characters afford data by which the genera and species of the shells may be determined, and information obtained as to the structure and economy of the originals.

The Gasteropoda generally creep by means of a fleshy disk, or foot, which is situated under the belly. Some kinds are terrestrial, others inhabit trees, many live in rivers and streams, others in stagnant and brackish waters; but the greater number are denizens of the sea.

The Common Snail, River Snail, and Periwinkle, are instances of terrestrial, fluviatile, and marine forms. The organs of respiration are situated in the last whorl of the shell; and in some genera the border of the mantle, or integument surrounding the body, is prolonged into a siphon, by which the water is freely admitted, without the head or foot being protruded: in these mollusks the shell has a corresponding channel to receive the siphon, as in the Whelk, or Buccinum, and in the fossil shell *Lign.* 95, fig. 4. The aquatic Gasteropoda are generally provided with an operculum, or moveable valve, by which the aperture is closed and defended when the animal retreats within its shell. In some species the operculum is a mere horny pellicle; in others it is a solid calcareous plate of considerable relative thickness. These mollusca, as is but too well known of the terrestrial species, consume large quantities of food. Some are herbivorous, and others carnivorous; many prey on living, and others on decaying animal and vegetable substances. As in a fossil state the shells alone remain to afford any clue as to the structure and economy of the originals, characters have been sought for, by which the fluviatile or marine nature, and the carnivorous or herbivorous habits of the living mollusca may be determined. As a general rule, it will be found, that the shells of terrestrial and fresh-water Gasteropoda have the aperture entire, as in the Garden Snail, and in the fossil *Lign.* 95, fig. 1; and that a large proportion of the marine species have the opening notched or channelled, as in the Whelk, and *Lign.* 95, figs. 3, 4; and most of the species with entire apertures are herbivorous. But these inferences must be regarded in a very general sense, and it will require corroborative evidence to establish the marine or fresh-water nature of those fossil shells which do not bear a close analogy to known living species.*

The various conditions in which the remains of univalve shells occur in the mineral kingdom have already been so fully explained, that but a few additional remarks on that subject are required (see p. 371.).

The *Gasteropoda* are found to progressively

* See Ly. I. p. 63 and p. 65.

diminish with the antiquity of the deposits, and it was once supposed that this type of molluscous organization was not contemporaneous with the ancient Cephalopoda. My discovery of several genera associated with Ammonites in the chalk (see *Foss. South D.* Pl. XVIII. XIX.), first tended to invalidate this hypothesis; and the subsequent researches of Dr. Fitton, Professor Phillips, and other geologists, have shown that the presence or absence of Gasteropoda in a stratum, is to be ascribed to the circumstance of the deposit having been formed in shallow, or in deep water. Thus when simple univalves largely predominate, under circumstances that indicate they were imbedded in their native habitats, it may be safely concluded that the rock is of littoral formation; or, in other words, was deposited in shallow water, near the sea-shore; and, on the contrary, when Nautili, Ammonites, and the shells of other mollusca known to live in deep waters, abound in a formation, it may be presumed that the strata were formed in the tranquil depths of the ocean. The number of described species from the British strata is nearly eight hundred; and these are distributed throughout the sedimentary formations, from the Silurian to the newest Tertiary; the latter containing by far the greater proportion.

FRESH-WATER UNIVALVES.—The fossil shells of Gasteropoda that are undoubtedly fluviatile, comprise but few genera and species, and are confined to those deposits, which, from the corroborative proofs afforded by other organic remains, are unquestionably of fresh-water origin. Such are the intercalated beds of clay and limestone in the London and Paris basins; the Wealden formation; and certain strata in the Carboniferous system. The most numerous specimens are principally referable to the common fluviatile genera, *Paludina, Limnæa, Planorbis,* and *Melanopsis* (see *Ly.* I. p. 63.).

PALUDINA. *Lign.* 95, fig. 1. (*Wond.* p. 378. *Ly.* p. 63.)—This common river shell is of a conoidal form, and the whorls of the spire, and the aperture, are rounded. Eleven British species are known. In the tertiary fresh-water beds of Headon Hill, at Alum Bay, Paludinæ with the shells perfect, and of a dull white colour, are abundant; and also in the limestone at Shalcombe, in the Isle of Wight, in the state of casts. In both these localities the Paludinæ are associated with other fresh-water shells. But the grand deposit of shells of this genus is the Wealden formation; throughout which there are extensive beds of marble, coarse limestone, and clays, almost wholly composed of Paludinæ, and minute fresh-water Crustaceans, of the genus *Cypris,* which will be described in a subsequent chapter. The compact paludina-limestone of Sussex, called Petworth or Sussex marble, is principally made up of one species, the *P. fluviorum, Lign.* 95, fig. 1, and is an aggregation of Paludinæ, held together by crystallized carbonate of lime; the cavities of the shells, and their interstices, being often filled with white calcareous spar. A polished slab, displaying sections of the enclosed shells, is figured, *Wond.* p. 379. Upon examining slices of this marble with the microscope, the cavities of the shells are found to contain myriads of the cases of Cyprides.* The Wealden limestone of the Isle of Purbeck, known as Purbeck marble, is, in like manner, composed of Paludinæ, but of a much smaller species. Both these marbles were in great repute with the architects of the middle ages, and there are but few of our cathedrals and ancient churches which do not still contain examples, either in their columns, monuments, or pavements, of one or both varieties. The polished marble columns of Chichester Cathedral, and those of the Temple Church, in London, are of Purbeck marble; in other words, they are composed of the petrified shells of snails, that lived and died in a river, flowing through a country inhabited by the Iguanodon and other colossal reptiles, all of which have long since become extinct. With the exception of the *mussel-band* limestone of the Carboniferous system, previously described, these are the only British fresh-water marbles.† There are four species of

* For a particular account of this marble, see Geol. S. E. pp. 182—187.

† The collector may obtain specimens, and polished slabs, of these limestones, of Mr. Martin, mason, Lewes.

Paludina in the Wealden, and four in the Tertiary strata of Hants.

LIMNÆA. *Lign.* 95, fig. 2.—Several species of these fresh-water mollusks inhabit our lakes and ponds, and may be known by their pointed spire, elongated oval body, and delicate thin shell; on the inner lip of the aperture there is an oblique fold. Fossil shells of this genus are found with Paludinæ in the fresh-water tertiary deposits. Headon Hill, and other localities in the Isle of Wight, abound in these shells; and in the limestone of Shalcombe beautiful casts are very numerous. The Paris basin yields several species; in the sands and clays the shells are well preserved; in the limestones the casts only remain. There are six species in the Isle of Wight Tertiary; I have not observed any decided examples in the Wealden. Shells of another genus of fresh-water spiral univalves, termed *Bulimus* (*Ly.* I. p. 65.), are found associated with the above. A large species (*B. ellipticus. Min. Conch.* tab. 337.), occurs in the limestone at Binstead, near Ryde, and at Shalcombe; I have collected specimens two inches long from the former locality; they are in the state of casts, with a friable white coating of the shell.

PLANORBIS. *Ly.* I. p. 63. *Wond.* p. 232.—The shells of this genus are also numerous in our rivers and lakes, and may be distinguished by their discoidal form, the shell being coiled up in a nearly vertical plane. There are about twenty living species; and sixteen are enumerated as fossil in the British tertiary; five occur in the Isle of Wight basin, in the localities of the fresh-water genera already mentioned; Headon Hill, in particular, yields shells of this genus in great abundance and perfection.

MELANOPSIS. *Wond.* p. 350. *Ly.* I. p. 63.—These are spiral univalves, the appearance of which will be better understood by the figures, than by any description. I allude to this genus because a small species is very numerous, with the other fresh-water shells, at Headon Hill; and two or more species are found in the argillaceous strata of the Wealden (see *Geol. S. E.* p. 249.).

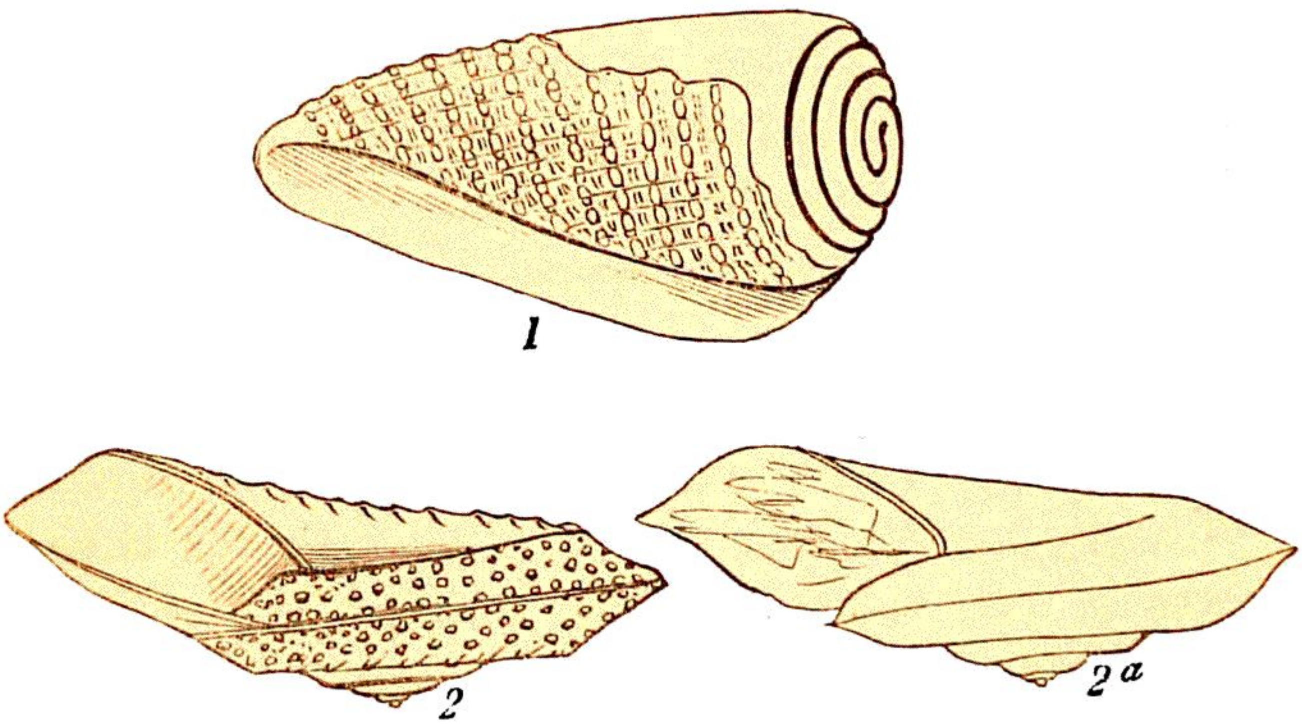
MARINE UNIVALVES.—Of the fossil marine Gasteropoda there are no less than eighty genera in the strata of the British Islands, and the species amount to several hundreds. To distinguish the species and genera, reference must, of course, be made to works expressly devoted to fossil conchology, as Sowerby's *Mineral Conchology*, and *Genera of Fossil Shells*; or to the works of French authors, particularly those of Lamarck, edited by M. Deshayes, and of M. Blainville. The *Penny Cyclopædia* contains admirable notices of fossil shells, under the respective heads of the classes, orders, and genera of the recent Mollusca.

BUCCINUM, of which the common Whelk is an example.—FUSUS, *Lign.* 95, fig. 4. *Wond.* p. 231. —PLEUROTOMA, *Ly.* I. p. 66. *Wond.* p. 231.— CERITHIUM, *Lign.* 95, fig. 3. *Wond.* p. 231.— ANCILLA, *Wond.* p. 231. *Ly.* p. 66.—CASSIDARIA, *Ly.* I. pl. 4, fig. 2.—MUREX, *Ly.* p. 321.—ROSTELLARIA, *Ly.* I. 341.—To the eight genera here enumerated a very large number of the marine simple univalve shells belong; and they are principally found in Tertiary strata. The animals of these shells are characterized by their respiratory organs, which are formed of one or two pectiniform gills, with a tube or siphon more or less elongated, for the free admission of sea-water to the branchial apparatus. This organization is indicated in the shell, either by a notch, or by a prolonged tubular canal. All the species are, with scarcely any exceptions, inhabitants of the sea, and carnivorous.

I have selected for illustration of the genus *Fusus*, a celebrated shell of the Crag, known among collectors as the "*Essex reversed Whelk*," *Lign.* 95, fig. 4; the spire is twisted in the opposite direction to the usual mode, and the mouth is consequently to the left of the observer; the same species occurs with the spire in the common direction. The shells of the genus *Pleurotoma* are distinguished by an incision, or notch, in the side of the right or outer lip; and those of *Cerithium*, by the form of the mouth, see *Lign.* 95, fig. 3. The latter is a very numerous genus, and more than two hundred fossil species are enumerated; it contains many elegant forms. The Tertiary strata at Grignon are particularly rich in these fossils; the shells are of a pearly whiteness, and as perfect as when recent. Some Cerithia are of considerable size; the *C. giganteum* is from ten to fourteen inches in length. The genus POTAMIDES comprehends shells closely resembling the Cerithia in form, but which are inhabitants of fresh-water. This is an instance of the difficulty which sometimes exists of arriving at certain conclusions as to the habits of the mollusks, from their testaceous coverings alone. The Tertiary clays at Castle Hill, near Newhaven, and those in the vicinity of Woolwich, abound in shells, which our best conchologists refer to *Potamides* (*Foss. South D.* Tab. XVII. figs. 3, 4.). At Castle Hill they are accompanied by fresh-water bivalves, and leaves of dicotyledonous plants.

Of the genus *Rostellaria*, there is a remarkable species in the London Clay, called *R. macroptera*, from the large wing-like expansion of its outer lip, in adult specimens; see *Ly.* I. p. 341. An elegant Rostellaria is found in the Galt, at Folkstone (*Foss. South D.* Tab. XIX. figs. 12, 14.), and other localities; and also in the Chalk Marl.

Casts of a large ventricose, globular univalve, called DOLIUM, of which there are seven recent species, one an inhabitant of the Mediterranean, have been found in the Chalk Marl, at Clayton, near Hurstperpoint, in Sussex. This species is distinguished from the recent by its transverse tuberculated bands; it is one of the rarest productions of the Chalk formation (*Min. Conch.* tab. 326.).* Turbinated shells related to the *Trochus*,



LIGN. 96. UNIVALVES, FROM THE CHALK OF TOURAINE.

(*M. D'Orbigny.*)

Fig. 1.—CONUS TUBERCULATUS, with part of the shell.
2.—SOLARIUM ORNATUM, with the shell.
2a.—Specimen of the same species, deprived of the shell.

and belonging to several genera, occur in the Cretaceous deposits. Two species of shells, called *Cirrus* (*resemblance to a curl*), are common in the

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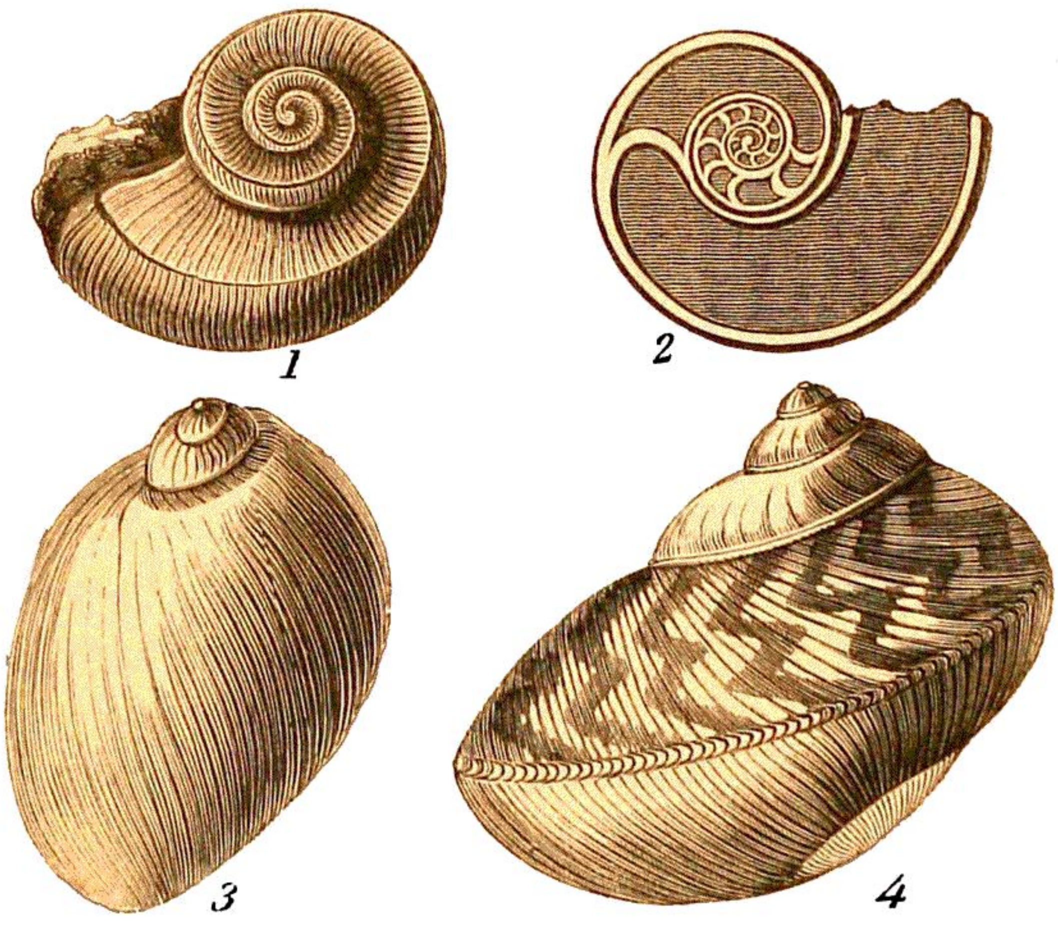
* The only specimens I have seen are in the possession of R. Weekes, Esq. of Hurst, and Henry Catt, Esq. of Brighton; both these gentlemen have choice collections of Chalk fossils.

White Chalk of England (see *Foss. South D.* Tab. XVIII.). Like most of the univalves in this formation, the shells have perished. In the Chalk of Touraine, species of the genera *Conus* (*Lign.* 96, fig. 1.), and *Solarium* (*Lign.* 96, fig. 2.), are found with the shells preserved. The specimens figured, *Lign.* 96, are selected to familiarize the student with the difference so commonly observable, between the surface of the casts, and the shells: in both these fossils the shells are marked with lines and tubercles, while the casts are destitute of any traces of such structure.

In the most ancient fossiliferous formations, the Silurian, Devonian, and Carboniferous, the shells of many species and genera of Gasteropoda have been discovered. Professor Phillips enumerates more than ninety species in the mountain limestone of Yorkshire (*Phil. York*), belonging to the genera *Cirrus*, *Turbo*, *Patella*, *Pleurotomaria*, *Melania*, *Buccinum*, *Rostellaria*, *Natica*, and *Euomphalus*. Mr. Murchison describes, from the Silurian rocks, thirty-four species (*Murch. Sil. Syst.* p. 706.).

The *Natica*, represented *Lign.* 97, fig. 3, sometimes attains thrice the size of the figure, and has been found in many localities in England and Ireland. A very interesting discovery connected with the shells of this genus, has been made by Mr. Lyell in the Devonian strata of Forfarshire. The lower beds of the formation in that district are very generally characterized by the remains of what appear to be fuci; and these vegetable fossils are frequently associated with groups of small, flattened, carbonaceous bodies, placed in slight depressions of the sands, or shales. These closely resemble in form



LIGN. 97. UNIVALVES, FROM THE MOUNTAIN AND WENLOCK LIMESTONES.

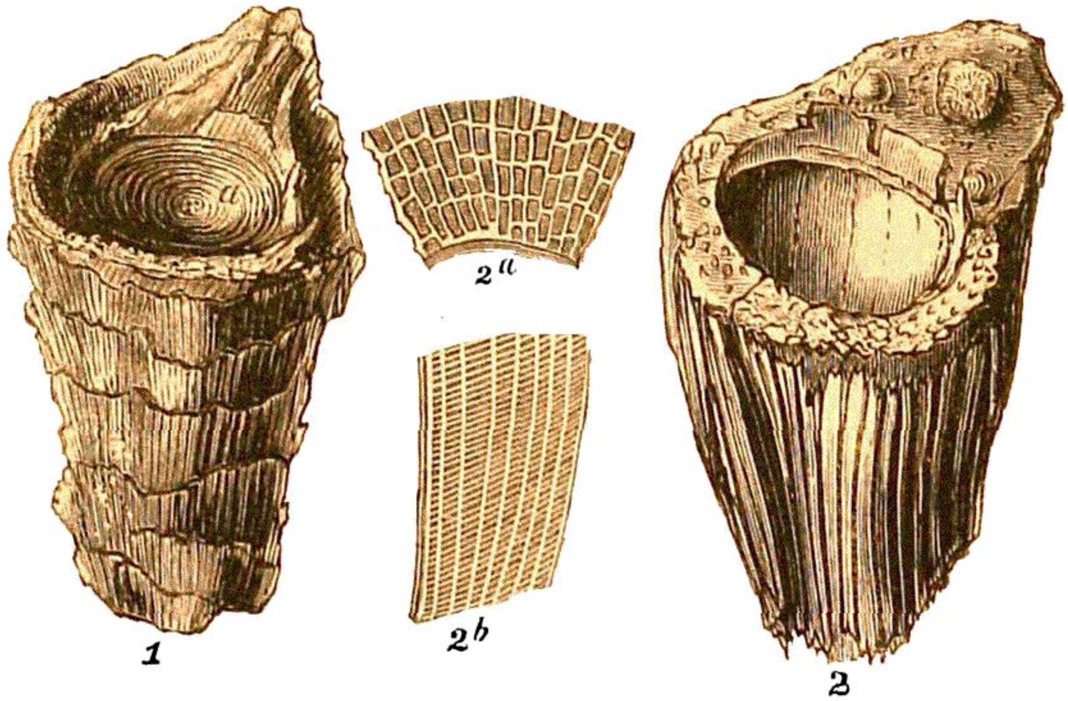
Fig. 1.—EUOMPHALUS PENTANGULATUS; upper surface.
2.—Polished section of the same species.
3.—NATICA PLICISTRIA. *Yorkshire. Mt. L.*
4.—PLEUROTOMARIA FLAMMIGERA. (*Phil. York.*) *Mt. L.*

the spawn of the recent *Natica*, in which the eggs are arranged in a thin layer of sand, and seem to have acquired a polygonal form by pressing against each other. The carbonaceous matter is probably the contents of the eggs in the state of carbon (see *Ly.* II. p. 151.). I have found recent masses of the spawn of frogs, imbedded under circumstances which deprived the ova of vitality, converted into a carbonaceous substance, very analogous to that observed by Mr. Lyell.

Some species of *Pleurotomaria*, an extinct genus, distinguished from *Trochus* by a fissure on the right lip, the position of which is indicated by the band along the back of the whorl (*Lign.* 97, fig. 4.), are found in the Mountain Limestone; vestiges of the markings of the shell are sometimes preserved, as in the example delineated. The same genus is common in the Oolite (*Ly.* II. p. 50.). Dr. Lee has discovered a splendid species, with the shell entire, in Kimmeridge Clay, at Hartwell.

EUOMPHALUS. *Lign.* 97, figs. 1, 2.—The shells of this extinct genus (so named by Mr. Sowerby, from the deeply umbilicated or excavated character of the disk) are discoidal, spiral univalves, having the inner whorls of their shell divided by imperforate septa, or partitions. The internal structure of these shells requires attention, and will serve to prepare the student for the investigation of those more complicated forms of the testaceous apparatus of the Cephalopoda, which form the subject of the next chapter. There are several recent spiral univalves, the animals of which retreat with growth from the apex of the spire; and the vacated portion becomes partitioned off by a septum, or plate of shell. In some genera a series of concave septa are thus formed; but in others the deserted cavity is filled by a compact accretion of calcareous matter (as in *Magilus*), and a solid elongated shell is produced. The *Euomphalus*, of which there are many species in the Silurian, Devonian, and Carboniferous strata, belongs to the former group. As the animal increased in size, it deserted the smaller and inner portion of the spire, the interspace remained hollow, and a nacreous plate, or partition, was secreted by the posterior part of the mantle; and as this process took place at different stages of growth, several cells were successively formed. This chambered structure is shown in the specimen *Lign.* 97, fig. 2, in which the internal cells are filled with spar; but the outer cavity is occupied by limestone like that in which the shell was imbedded; a proof that no communication existed between the last chamber inhabited by the animal, and the space from which it had withdrawn. The calcareous spar, as in the specimens of vegetable remains previously described (p. 83.), has percolated the substance of the fossil, and crystallized in the innermost cells. We shall again have occasion to refer to this interesting fact, when investigating the chambered cells of the Cephalopoda. It may be necessary to remark, that the cells of the Euomphalus did not serve the special purpose of the air-chambers of the Nautilus and Ammonite.

HIPPURITES. *Ly.* I. p. 409.—This genus belongs to a group of fossil shells, whose characters are somewhat problematical, some conchologists referring them to the bivalves, and others to the



NOTE: Spherulites are igneous in origin

LIGN. 98. SPHERULITES FROM THE CHALK OF FRANCE AND ENGLAND.

Fig. 1.—SPHERULITE, with its *operculum*, *a*.
2.—SPHERULITES MORTONI (G. A. M.), *from Lewes*: ½ *nat.*
2 *a*.—Cellular structure of fig. 2, in a transverse section: ×
2 *b*.—Structure, as seen in a vertical section: ×

univalves. Although *Hippurites* have not been discovered in the British strata, I am induced to notice them in this place, in consequence of their great abundance in the Cretaceous deposits of the South of France, and in the Oolite of the Pyrenees; and also to illustrate the nature of a nearly related genus, *Spherulites*, of which one or more species occurs in the Sussex Chalk.

The Hippurite (see *Ly.* I. p. 409.) is of an elongated conical form, and fixed by its base; it has internally a deep lateral channel, formed by two obtuse longitudinal ridges. The base is sometimes partitioned off by transverse septa, forming cells or cavities, as in the Euomphalus. The aperture, or opening, is closed by an operculum, or upper valve. The substance of the shell is cellular, and very thick, and when fractured much resembles that of the lamelliferous corals: the laminæ are sometimes separated into cells, or cavities, like the Spondyli. These shells often attain considerable magnitude, and in certain districts of the Pyrenees, where they abound, are called "*petrified horns*" by the inhabitants. It is remarkable, that, while in the Chalk of the South of France, Spain, Portugal, and Greece, shells of this genus so prevail, as to be considered the characteristic fossils of the formation, in the North of France they are very rare, and in England have not hitherto been discovered.*

SPHERULITES. *Lign.* 98.—No vestiges of a shell of this genus had been noticed in the English strata, until my discovery of some fragments in the Lewes

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* As marking the rapid progress of Palæontology in this country, it may be noticed, that the *only petrifaction*, figured in the first edition of the Encyclopædia Britannica, is one of these supposed petrified horns, described by the Abbé Fortis!

Chalk in 1820; from the lamellated structure of these fossils, I mistook them for corals, until specimens were obtained sufficiently perfect to show the form of the originals; these were described in the *Geol. S. E.* (p. 130), under the name of Hippurites. But these fossils are more nearly related to the *Spherulites*, which differ from the shells of the former genus in having no internal longitudinal ridges, and in the external surface being roughened by irregularly raised plates, as in *Lign.* 98, fig. 1, which is a specimen from the Pyrenees, collected by M. Alex. Brongniart; the operculum is seen at *a*.

The species found in the Sussex Chalk, *Lign.* 98, fig. 2, is characterized by the longitudinal striæ on the outer surface. In some examples there is an external longitudinal furrow, and a corresponding internal ridge.*

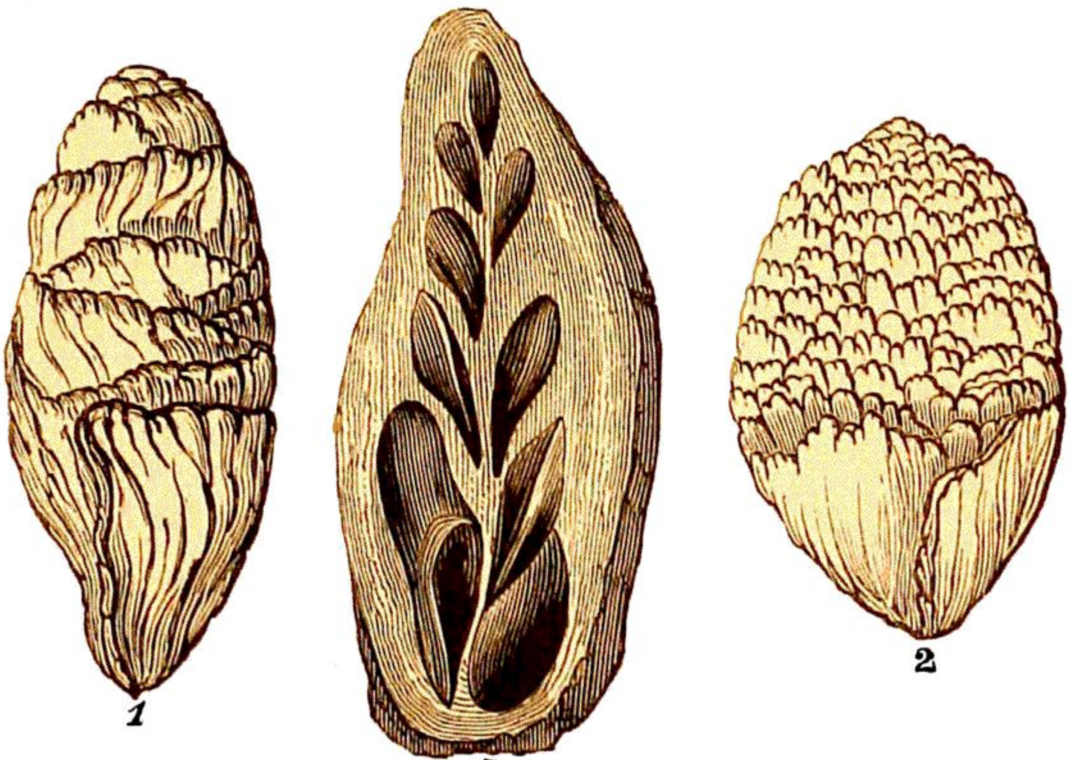
The Spherulites sometimes occur in groups; I had a large water-worn mass, consisting of five or six individuals, anchylosed together. Mr. Dixon has a very beautiful specimen of two united (figured by Mr. Lyell, p. 408), from the chalk near Worthing. This gentleman informs me, that he has obtained an operculum of this species from the same locality. The structure of the Spherulite is very accurately delineated in *Lign.* 98, figs. 2 [a], 2 [b].

* The specific name is in honour of Dr. George Morton, of Philadelphia, author of the "Synopsis of the Cretaceous Group of the United States."

The cavities of these shells are occasionally filled with flint, but in general with chalk, which may be entirely cleared away, as in fig. 2. The Hippurites of the limestone of the Pyrenees are frequently occupied by calcareous spar, and the substance of the shells is occasionally transmuted into the same mineral.

MOLLUSKITE; OR THE CARBONIZED REMAINS OF THE SOFT PARTS OF MOLLUSCA.—Before proceeding to the consideration of that numerous and important division of the mollusca, the *Cephalopoda*, I will offer a few remarks on a carbonaceous substance resulting from the gelatinous matter of which the soft bodies of these animals are composed, and for which I propose the name of *Molluskite*, to indicate its nature and origin.

This substance is of a dark brown or black colour, and occurs either in shapeless masses, which are irregularly distributed among the shells, and other organic remains, in sandstone, limestone, &c.; or as casts of shells, or occupying their cavities, as in the specimen *Lign.* 99, fig. 3; which is a vertical section of a spiral univalve (*Rostellaria*), filled with the soft parts of the animal, converted into Molluskite. Upon analysis this substance is found to contain a large proportion of animal carbon.* The rocks of firestone at Southbourne, on the Sussex coast, are mottled with brown molluskite, and hard amor-



LIGN. 99. COPROLITES AND MOLLUSKITE. *Cret. and Sh. s*

Fig. 1.—COPROLITE of a fish (*Macropoma*). *Chalk, Lewes.*
2.—COPROLITE of a fish (*Squalus*). *Chalk marl, Hamsey.*
3.—MOLLUSKITE of a *Rostellaria* (*Mr. Bensted*). *Kentish Rag, Maidstone.*

phous concretions, consisting of carbon and phosphate of lime, mixed with sand and other extraneous

* The Molluskite has, at my request, been analyzed by Mr. Rigg, who obliged me with the following remarks:—"After removing the lime by means of hydrochloric acid from ten grains of this substance, there remained 1.2. grain

matter. Casts of shells, of the genera *Venus*, *Arca*, &c. entirely composed of the same kind of materials, are also abundant in those rocks. The lowermost bed of Galt, at its line of junction with the Green Sand beneath, at Folkstone, and in many other localities, is largely composed of similar matter, resembling in appearance the fossils called *Coprolites*, hereafter described. The outer chamber of the Ammonites, and other shells, so abundant in the Galt, are often filled with this substance. But the most interesting deposit of Molluskite is in the Kentish Rag, of Mr. Bensted's quarry, near Maidstone. This phenomenon had not escaped the notice of that intelligent and accurate observer, who liberally placed at my disposal numerous shells, particularly of *Trigoniæ* and *Terebratulæ*, which were filled with Molluskite; and large slabs of the sandstone, full of concretionary and amorphous masses of the same. The latter Mr. Bensted suggested were derived from the fossilized bodies of the dead Mollusks, which had become disengaged from their shells, and aggregated together, and had floated in

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of dark powder, which gave, by analysis with oxide of copper, .16 of a cubic inch of carbonic acid, and a small portion of nitrogen. On subjecting to the same kind of analysis two grains of the darker body, without previously acting upon it by any acid, .054 of a cubic inch of carbonic acid was obtained; so that from these results there is no doubt but the darker portion of the Molluskite contains about .35 per cent. of its weight of carbon in an organized state."

the sea, until enveloped in the sand and mud, which is now consolidated into the arenaceous stone termed Kentish Rag. Mr. Bensted, in illustration of this opinion, referred me to the following curious fact, related in the *American Journal of Science*:—

In the year 1836, a fatal epidemic prevailed among the shell-fish of the Muskingum River, in the state of Ohio. It commenced in April, and continued until June, destroying millions of the mollusca that inhabited the beds of the tributary streams, and the river. As the animals died, the valves of the shells opened, and decomposition commencing, the muscular adhesions gave way, and the fleshy portions rose to the surface of the water, leaving the shells in the bed of the river. As masses of the dead bodies floated down the current, the headlands of islands, piles of drifted wood, and the shores of the river, in many places, were covered with them; and the air in the vicinity was tainted with the putrid effluvia exhaling from these accumulations of decomposing animal matter. The cause of the epidemic was unknown. "Now nearly the whole of the shells in these beds of Kentish Rag," Mr. Bensted remarks, "have their shells open, as if they were dead before their envelopment in the deposit. And from the large quantity of water-worn fragments of wood perforated by Pholades imbedded with them, it seems probable that this stratum had originally been a sand-bank covered with drifted wood and shells, and presenting a very analogous condition to the phenomenon above described."

The gelatinous bodies of the *Trigoniæ*, *Ostreæ*, *Rostellariæ*, *Terebratulæ*, &c., detached from their shells, may have been intermingled with the drifted wood in a sand-bank; while, in some instances, the animal matter would remain in the shells, be converted into Molluskite, and retain the form of the original.

A microscopical examination of the Maidstone Molluskite detects, with a low power, innumerable portions of the nacreous laminæ of shells, intermingled with the carbonaceous matter; together with many siliceous spicula of sponges, minute spines of Echinoderms, and fragments of Polyparia; these extraneous bodies probably became entangled among the floating animal matter. A large proportion of the shelly laminæ, examined with a high power, displays the peculiar structure of the *Terebratulæ* (see *Lign.* 90, fig. 2 [a].), of which several species are abundant in the Kentish Rag.

The dark masses and veins so common in the Sussex and Purbeck marbles, are produced by Molluskite. When at the period of their envelopment the shells were empty, they are now filled either with grey marl, and limestone, or with white calcareous spar; but when the bodies of the Mollusks were enclosed, the soft mass was changed into carbonaceous matter; and in polished sections of the marble, the *Molluskite* appears either in black or dark brown spots, or accurately filling up the cavities of the shells. The dark blotches and veins observable in the fine pillars of Purbeck marble, in the Temple Church, London, are produced by *molluskite;* and the most beautiful slabs of Sussex marble owe their appearance to the contrast produced by the black *molluskite* with the white calcareous spar.*

Carbon, resulting from animal remains, is of frequent occurrence in many strata; and the fetid emanations from certain limestones, upon being broken or rubbed, are attributable to the evolution of sulphuretted hydrogen, from the animal matter which they contain.

GEOLOGICAL DISTRIBUTION OF THE BIVALVE AND UNIVALVE MOLLUSCA.—If the more rare and splendid organic remains may be regarded as the "*Medals of Creation*," the fossil testaceous mollusca, from their durability, numbers, and variety, may be considered as the *current coin* of Geology.

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* See a "Memoir on the Carbonized Remains of *Mollusca*," by the author. Read before the Geological Society of London, December, 1842.

Occurring in the most ancient fossiliferous strata in small numbers, and of peculiar types; becoming more abundant and varied in the secondary formations; and increasing prodigiously, both numerically and specifically, in the tertiary, these relics are of inestimable value in the identification of a stratum in distant regions, and in the determination of the relative age of a series of deposits. To the solution of the former problem the sagacity of the late Dr. William Smith first suggested their applicability;* while the idea so happily conceived, and so philosophically carried out, by Mr. Lyell, of arranging that heretofore chaotic mass of deposits termed the Tertiary, into groups, by the relative number of recent and extinct species of shells, demonstrated the important aid to be derived from this class of organic remains, in the determination of some of the most difficult questions in geological science.

Many useful tables have been constructed by Professor Phillips,† Mr. Lyell, M. Deshayes, and other eminent observers, to illustrate the geological distribution in the several formations, of the genera and species of fossil shells hitherto described. In the works which we have especially recommended

* An interesting memoir of Dr. Smith has just appeared, from the pen of his distinguished nephew, Professor Phillips.

† A Treatise on Geology; and Art. *Geology*, Encycloped. Metropolitana.

to the student for reference, figures are given of a few characteristic shells of each formation, as follow; commencing with the most ancient deposits.

SILURIAN SYSTEM. *Ly.* II.

Orthis orbicularis; fig. 344.
—— grandis; fig. 361.
Terebratula navicula; fig. 345.
—— Wilsoni; fig. 347.
Pentamerus Knightsii; fig. 346.
—— lævis; fig. 171.
Atrypa affinis; fig. 348. *Wond.* p. 475.
Lingula Lewisii; fig. 349.
Producta depressa; fig. 356. *Wond.* p. 475.

DEVONIAN SYSTEM. *Ly.* II.

Calceola sandalina; fig. 339.
Terebratula porrecta; fig. 340.
Megalodon cucullatus; fig. 341.

"The SILURIAN SYSTEM," by R. I. Murchison, Esq., Pres. Geog. Soc. &c., a splendid work on the rocks and fossils of the above formations, contains numerous figures of the shells peculiar to each group of strata; and many other species are delineated in the Memoir on the Devonian deposits of Devonshire and Cornwall, by Professor Sedgwick and Mr. Murchison, *Geol. Trans. New Series*, Vol. V. plates 52—57. A Memoir on the Palæozoic Rocks of Germany and Belgium, by the same distinguished geologists, is also accompanied by many figures of fossil shells belonging to the same geological epochs. *Geol. Trans.* Vol. VI.

CARBONIFEROUS SYSTEM. *Ly.* II. *Wond.* p. 475.

Producta punctata; *Wond.* fig. 1.
——— depressa; . . . fig. 3.
Pleurotomaria flammigera; *Lign.* 97, fig. 4.
Euomphalus pentangulatus; *Lign.* 97, fig. 1.
Natica plicistria; *Lign.* 91, fig. 3.
Spirifera trigonalis; *Wond.* Tab. 97, fig. 9.
——— triangularis; . . . . . . fig. 10.
——— octoplicata; . . . . . . fig. 11.
——— glabra; *Ly.* II. p. 122.
Microconchus carbonarius; *Ly.* II. fig. 298.
Avicula papyracea; . . . fig. 301.

The shells of the Mountain Limestone of Yorkshire are admirably figured in Professor Phillips's Geology of Yorkshire; and many of those of Devon, &c. in the "PALÆOZOIC FOSSILS," by the same author.*

NEW RED, SALIFEROUS, OR TRIAS SYSTEM. *Ly.* II.

Posidonia minuta; p. 93, fig. 289.
Avicula socialis; . . . fig. 290.
Producta calva; p. 97, fig. 291.
Spirifer undulatus; . . . fig. 292.

LIAS. *Ly.* II. p. 59.

Trochus Anglicus; *Ly.* I. p. 83.
Avicula inæquivalvis; *Ly.* II. fig. 263.
Plagiostoma giganteum; p. 264.
Gryphæa incurva; *Lign.* 91.

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* To prevent confusion, it may be necessary to state that Professor Phillips, in the work referred to, terms the Silurian strata the "*lower palæozoic;*" and the mountain limestone, the "*upper palæozoic.*"

OOLITE. *Ly.* II. p. 48.

Gryphæa virgula; *Ly.* II. fig. 243.
Ostrea deltoidea (Kimmeridge Clay); fig. 244.
Trigonia gibbosa; fig. 245.
——— clavellata; *Lign.* 91.
——— costata; *Lign.* 91.
Nerinæa Goodhallii; *Ly.* II. fig. 247.
Diceras arietina; . . . fig. 248.
Pleurotomaria; . . . fig. 250.
Terebratula spinosa; . . . fig. 251.
——— digona; . . . fig. 256.
Orbicula reflexa; . . . fig. 254.
Ostrea Marshii; . . . fig. 257.
Phasianella Heddingtonensis; *Ly.* I. p. 83.

Many of the characteristic shells of the Oolite and Kimmeridge Clay, are figured in Plates XXII. and XXIII. of Dr. Fitton's Memoir on the Strata below the Chalk; *Geol. Trans.* Vol. IV.

WEALDEN. *Wond.* Vol. I. *Geol. S. E.* and *Foss. Tilg. For.*

Melanopsis attenuata; *Wond.* p. 350, Tab. 66, *a.*
Cyclas media; . . . Tab. 66, *b.*
——— membranacea; . . . Tab. 66, *c.*
Paludina Sussexiensis; p. 377, fig. 1, and Tab. 78.
Neritina Fittoni; . . . fig. 3 . . .
Psammobia tellinoides; . . . fig. 5 . . .
Unio Gualteri; . . . fig. 6 . . .
Mytilus Lyellii; . . . fig. 8 . . .
Unio antiquus; *Geol. S. E.* p. 250, fig. 1.
—— compressus; . . . . . . fig. 2.
—— aduncus; . . . . . . fig. 3.
—— porrectus; . . . . . . fig. 4.

The shells of the Wealden are also figured by Dr. Fitton, *Geol. Trans.* Vol. IV. Pl. XXI.

Chalk Formation.

I.—Shanklin, or Lower Green Sand.

Dr. Fitton's Memoir, previously quoted, contains numerous figures of the characteristic shells of this division of the Chalk, particularly of the species which abound in the celebrated *Whetstone* of Devonshire. *Geol. Trans.* Vol. IV. Pl. XIII—XVIII.

II.—Galt and Chalk Marl. *Wond.* p. 313. *Ly.* I. pp. 388, 403.

Inoceramus concentricus; *Wond.* p. 313, fig. 1.
———— sulcatus; ... fig. 3.
Terebratula lyra; *Ly.* I. fig. 185.
Pecten quinque-costatus... fig. 186.
Ostrea carinata; ... fig. 169.

In Plates XI. and XII. of Dr. Fitton's Memoir, there are figures of more than twenty characteristic shells of this division of the Chalk.

III.—White Chalk. *Ly.* I. p. 388, 408, 409, *Foss. South D. Geol. S. E.*

Some cretaceous species are delineated in *Lign.* 89, 90, 92, 93, 98. Mr. Lyell figures a few additional species; but I must refer the student to the *Foss. South D.* and *Geol. S. E.* as accessible works containing numerous figures of the fossil shells of the Chalk. Accurate descriptions and representations of all the British chalk shells are much required. The shells of the Cretaceous strata of the United States are figured and described in an elegant work by Dr. Morton, of Philadelphia.*

* A Synopsis of the Organic Remains of the Cretaceous Group of the United States of North America, with 19 plates, by Samuel George Morton, M.D. 1 vol. 8vo. Philadelphia. 1834.

TERTIARY FORMATIONS.

I.—EOCENE. *Ly.* I. p. 341, and pl. 4. *Wond.* p. 231.

II.—MIOCENE. *Ly.* I. pl. 3.

III.—PLIOCENE. *Ly.* I. pl. 1.

The specimens figured by Mr. Lyell have been so carefully selected, and are so well engraven, as to present a *coup-d'œil* of the most characteristic shells of the three grand divisions of the Tertiary Deposits.

I have reserved for especial mention in this place, the work, which of all others, will afford the student of British fossil Conchology the most important aid in the identification of specimens, namely, the "*Mineral Conchology of Great Britain*," by the late eminent naturalist, JAMES SOWERBY, Esq., and continued by his Son; in six volumes, 8vo., with several hundred coloured plates. Unfortunately, the necessary high price of this invaluable work, places it beyond the reach of many; but it is to be found in most public libraries.

ON THE COLLECTION AND ARRANGEMENT OF FOSSIL SHELLS.—The instructions already given for the collection of corals, echinoderms, &c., will have familiarized the student with the methods generally adopted, and render it unnecessary to enter into much detail. The shells in arenaceous deposits particularly in those of the Tertiary formations, are commonly so perfect, as merely to require careful removal: those in the clays are more fragile, and must be extracted with great caution; and when very delicate, should be left attached to the clay or shale; as in the examples, *Wond.* p. 350. The specimens extracted entire, may be kept either in paper trays, lined with wadding, or fixed to pieces of card, or thin board covered with paper, by thick gum-water; attaching three or four specimens, in different positions, so as to expose the essential characters, as the aperture, spire, and back of the univalves; and the hinge, muscular imprints, &c. of the bivalves. Where only casts remain, search should be made for an impression of the outer surface of the shell, and a cast taken of it in wax or plaster of Paris. In indurated clays, sometimes both shells and casts may be obtained; and a specimen of each should be preserved. Mastic varnish delicately applied to fragile shells tends to preserve them, and improves their appearance. It is desirable to collect the same species in various states of growth; the form of the young shell (as in *Rostellaria macroptera. Ly.* I. p. 341.) often differing essentially from that of the adult. It will be found convenient to have trays or boards of different colours; and to select one tint for the shells collected from a particular formation, or deposit; for example, the newer Tertiary may be placed on yellow paper; the older, or Eocene fossils, on light-blue. It is also desirable to separate the marine from the fresh-water species.

Shells imbedded in chalk, limestone, &c., often require much labour to display their more delicate and important characters. For clearing chalk specimens, a stout penknife, and a few gravers or gouges of various sizes, will be necessary; and by a little practice, the collector may readily expose the spines of the Plagiostoma (*Lign.* 92.), and the beaks and hinge of Inocerami (*Lign.* 93.), &c. The shells in compact stone, as those of the mountain limestone, must generally be cleared with the hammer and chisel. Common species may be broken out, and, from several examples, probably one or two will be found perfect; but choice and rare specimens should not be thus risked; they will amply repay the trouble of the less expeditious method, of chiselling away the surrounding stone.

To determine the names of the specimens that he has collected should be the next care of the student. No method will so readily initiate the young collector in fossil conchology, as the careful examination of a small series of the common species, with their names attached.* By the geological map,† the nature of the deposit in which the

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* Such a series may be obtained at very little cost, of dealers in objects of natural history; as, Messrs. Stutchbury, Tennant, Sowerby, &c. See Appendix.

† A Geological Map of England and Wales, coloured by Mr. Woodward, under the direction of R. I. Murchison, Esq.

locality of the specimens is situated, may be ascertained; and the remarks previously advanced on the prevailing shells of each formation, will afford a general idea of the genera to which they belong; and by referring to the figures quoted, the specific names may be determined.

I subjoin a list of some localities of fossil shells, to direct research in places which are likely to be productive.

BRITISH LOCALITIES OF FOSSIL SHELLS.

Aldborough, Suffolk. The usual shells of the *Crag*.

Alum Bay, Isle of Wight. Shells of the London Clay, and numerous fresh-water species.

Ancliff. Great variety of minute Oolitic shells.

Arundel, Sussex. Chalk-pits in the neighbourhood; *very productive*.

Atherfield, Isle of Wight. Shells of the lower beds of the Shanklin Sand.

Aylesbury, Bucks. Shells of the Kimmeridge Clay.

Aymestry. Shells of the genus *Pentamerus*, and other Silurian types.

Barnstaple, North Devon. Numerous Silurian shells. *Posidonia*, *Orthocerata*.

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has just been published by the Society for the Diffusion of Useful Knowledge, at the low price of 5*s*. Although on a very small scale, and therefore not to be compared for utility and convenience with that by Professor Phillips (recommended p. 11.), it will be found eminently serviceable.

Barton Cliff, Hants. London Clay shells in profusion.

Binstead, near Ryde, Isle of Wight. In the stone quarries, fresh-water shells, as *Bulimus*, *Helix*, *Phasianella*, *Paludina*, and *Planorbis*.

Blackdown, near Collumpton, Devon. Numerous silicified shells, of great beauty. *Trigonia*, *Venus*, *Corbula*, *Rostellaria*, &c. &c.

Bognor Rocks, Sussex. Vermetus, Pectunculus, Pinna, Murex, &c.

Bolland. Numerous shells of the Mountain Limestone.

Bradford. Numerous Oolitic shells. *Avicula.*

Bramerton Hill, near Norwich. Shells of the Norfolk Crag.

Breden, near Derby. *Producta*, *Spirifera*, &c. in Magnesian Limestone.

Brighton. Plagiostoma, Terebratula, Ostrea, Pecten, Inoceramus, &c. Many species in the chalk.

Bromley, Kent. Oyster conglomerate. *Pectunculi*, *Pectens*, &c.

Brora, Scotland. *Pholadomya*, *Sanguinolaria*, and other shells of the Oolite.

Calbourn, Isle of Wight. Fresh-water Univalves.

Cambridge. In the Galt and Chalk-marl, the usual shells.

Castle Hill, near Newhaven, Sussex. In the Tertiary strata, on the summit of the hill. Numerous Potamides, Cyclades, and other fresh-water shells. Ostreæ, with pebbles.

Cheltenham. Fine shells of the Oolite and Lias.

Christchurch, Hants. Abounds in the London Clay shells.

Chute, near Longleat, Wilts. Immense quantities of Green Sand shells.

Clayton, near Hurst, Sussex. In Chalk-marl, many rare shells; as, *Dolium nodosum* (*Min. Conch.* tab. 326.).

Clifton. *Spirifera*, *Producta*, &c.

Coalbrook Dale. Euomphalus, and other Silurian and Carboniferous species.

Cork. In the vicinity. *Cardium Hibernicum* (*Min. Conch.* tab. 82.), &c.

Crich Hill, Derbyshire. The usual shells of the *Mountain Limestone.*

Cuckfield, Sussex. In the Sandstone and Grit, fresh-water shells of the Wealden.

Dowlands, near Lyme Regis. Many fine shells. *Pachymya gigas* (*Min. Conch.* tab. 504.).

Dudley. Profusion of shells of the Silurian strata.

Dundry, near Bristol. Beautiful shells in the Inferior Oolite. *Trochus*, *Cardita*, &c.

Earlstoke, Wilts. Many shells of the Green Sand.

Faringdon, Berks. The usual shells of the Oolite in the Coral Rag, &c.; and of the Green Sand, in the Gravel-pits.

Folkstone, Kent. *Inoceramus*, *Arca*, *Rostellaria*, *Dentalium*, &c., in the Galt. In the Green Sand, a large Gryphæa, Ostrea, &c.

Gravesend. Beautiful shells of the White Chalk.

Hampstead Cliff, Isle of Wight. Freshwater Tertiary shells.

Hampton Quarry, near Bath. Abounds in Oolitic shells.

Hartwell, Bucks. On the estate of Dr. Lee, beautiful shells of the Kimmeridge Clay.

Harwich Cliff, Essex. The Crag shells. *Voluta Lamberti* (*Min. Conch.* tab. 129.).

Hastings, Sussex. Fresh-water shells of the Wealden.

Headon Hill, Isle of Wight. Fresh-water Tertiary shells in profusion.

Heddington. Oysters in Kimmeridge Clay (*Ostrea deltoidea*). *Perna*, *Gervillia*, *Trigonia*, &c.

Highworth, Wilts. Very fine Trigoniæ, and other Oolitic shells, in the stone-quarries.

Hollington, near Hastings. Fresh-water bivalves in limestone.

Holywell, near Ipswich. Shells of the Crag, abundantly.

Hordwell Cliff, Hants. The usual tertiary shells of the *Eocene* deposits, in immense quantity, variety, and perfection.

Horningsham, near Frome, Wilts. *Terebratula*, *Pecten*, &c. in great numbers.

Horsham, Sussex. Fresh-water shells of the Wealden, in the stone-quarries.

Hythe, Kent. *Trigonia*, *Gryphæa*, *Pecten*, &c.

Ipswich. The usual Crag shells.

Langton Green, near Tunbridge Wells. In the sandstone quarries, immense numbers of *Uniones*, and *Cyclades*, &c.

Leckhampton Hill, near Cheltenham. Numerous shells of the Lias.

Lewes. Inoceramus, many species. Pecten and usual shells of the White Chalk and Chalk Marl.

Ludlow. Pentamerus, Spirifera, &c. and many other Silurian shells.

Lyme Regis. Plagiostoma giganteum, Terebratula, and other shells of the Lias.

Malton. Beautiful shells of the Oolite.

Matlock, Derbyshire. The mountain limestone in the vicinity abounds in the characteristic shells, Leptæna, Spirifer, Atrypa, &c.

Middleton Moor, Derbyshire. Shells of the Mountain Limestone.

Muddiford. London Clay shells, in abundance.

Osmington, near Weymouth. Trigonia, Gervillia, Perna, Pholadomya, &c. and many other genera.

Portland, Isle of. In the stone-quarries immense numbers of the genera *Trigonia*, *Venus*, *Ostrea*, *Pecten*, &c.

Radipole, near Weymouth. *Trigonia*, *Pholadomya*, &c. in Oxford Clay.

Sandgate, near Margate. In the Green Sand, the usual shells.

Scarborough. In the cliffs along the shore, a profusion of Oolitic and Liassic shells.

Selbourn, Hants. In the firestone, *Ostrea carinata* and other characteristic shells.

Shalcombe, Isle of Wight. In fresh-water limestone, shells of various genera, as *Bulimus*, Helix, *Planorbis*, &c.

Shanklin Chine. In the cliffs along the shore, Terebratulæ, Gryphites, Gervilliæ, and other Green Sand shells.

Sheppey, Isle of. London Clay shells, in abundance.

Stonesfield, Oxfordshire. Trigoniæ and other shells of the lower Oolite.

Stubbington Cliff, near Portsmouth. London Clay shells.

Swanage. In the quarries of Purbeck limestone in the vicinity, the prevailing fresh-water shells of the Wealden.

Swindon, Wilts. The Portland limestone abounds in the usual shells of that deposit. *Trigoniæ*, *Gervilliæ*, &c.

Taunton, Somersetshire. *Lima*, *Pecten*, and other Oolitic shells.

Tisbury, Wilts. Beautiful Trigoniæ, and other shells of the Portland Oolite.

Vincent's, St., near Clifton. The rocks abound in the usual shells of the mountain limestone.

Walton, Essex. Shells of the Crag, in great variety.

Weymouth. The Oxford Clay and other strata in the vicinity, contain great variety of fossil shells.

Worthing. The chalk quarries in the neighbourhood are remarkably prolific in the usual species; and yield Spherulites.

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R. CLAY, PRINTER, BREAD STREET HILL.