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TRANSACTIONS

OF THE

CONNECTICUT ACADEMY

OF

ARTS AND SCIENCES.

VOLUME XI,

(CENTENNIAL VOLUME.)



NEW HAVEN :

PUBLISHED BY THE ACADEMY.

1901-1903.

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY.

TRANSACTIONS
OF THE
CONNECTICUT ACADEMY
OF
ARTS AND SCIENCES.

VOLUME XI,
(CENTENNIAL VOLUME)
PART I.



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THE ACADEMY REGRETS TO ANNOUNCE THE DEATH OF
PROFESSOR JOSIAH WILLARD GIBBS.

Professor Gibbs was born in New Haven, Conn., February 11, 1839, and died April 28, 1903.

At the regular meeting of the Academy held May 13, the following minute on the death of Professor Gibbs was unanimously adopted :

The Academy has learned with the deepest regret and sorrow of the death of its most distinguished member, Professor Josiah Willard Gibbs, and desires to place on record its deep sense of the loss sustained by the whole scientific world, and in an especial degree by the members of this body.

The first published investigations of Professor Gibbs appeared in the Transactions of this Academy in 1873, under the titles of "Graphical Methods in the Thermodynamics of Fluids," and "A Method of Geometrical Representation of the Thermodynamic Properties of Substances by means of Surfaces," and these were followed, in 1875 and 1878, by his celebrated papers on "The Equilibrium of Heterogeneous Substances." The great importance of this work is shown by the fact that the author anticipated, by purely theoretical considerations, a large number of the discoveries in Physical Chemistry which have since been made, and that he introduced, into this field, the most powerful method of theoretical investigation now known :—a method, moreover, which, being independent of special hypotheses, seems destined to hold a permanent place among those great scientific methods which the lapse of time does not render obsolete. The Academy in emphasizing, in this memorial, the researches of Professor Gibbs published in its Transactions, is not unmindful of his distinguished achievements in other scientific lines, but it leaves to others the special mention of such work, proud of the fact that it recognized so early the value of his researches in Thermodynamics, and was instrumental in giving that work to the scientific world.

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THE CONNECTICUT ACADEMY OF ARTS
AND SCIENCES.

CENTENNIAL ANNIVERSARY, OCTOBER 11TH, 1899.

NORTH SHEFFIELD HALL.

AFTERNOON SESSION, 3 P. M.

1. Reading of Communications from Corresponding Societies, by ALEXANDER W. EVANS, Ph.D., Secretary of the Academy.
2. Address of Welcome, by His Honor LYMAN A. MILLS, Lieutenant Governor of Connecticut.
3. Address; The Debt of this Century to Learned Societies, by Professor WILLIAM H. BREWER, Ph.D., President of the Academy.
4. Address; Scientific Thought in the Nineteenth Century, by Professor WILLIAM NORTH RICE, LL.D., of Wesleyan University.

[At the close of the addresses an opportunity will be offered for oral communications from delegates of Corresponding Societies.]

EVENING SESSION, 8 P. M.

5. Address; The History of the Academy during its First Century, by Hon. SIMEON E. BALDWIN, LL.D.

Reception by the Academy of delegates from Corresponding Societies and invited guests, in Winchester Hall, from 9 to 11 P. M.

With the above program the Connecticut Academy of Arts and Sciences, the third in age of the learned societies of America, celebrated on the 11th of October, eighteen hundred and ninety-nine, its one-hundredth anniversary. By a happy coincidence the Centennial of the Academy came into near conjunction with the Bicentennial of Yale University, the foster-parent of the

Academy, but at the same time was far enough removed to escape occultation.

In the absence of his Excellency the Governor of Connecticut, who had official engagements elsewhere, the Lieutenant Governor, Hon. Lyman A. Mills, welcomed the Academy and its guests in the name of the State.

The addresses of the occasion, by the President of the Academy and two of its honored members, are printed in the pages that follow. Both to Judge Baldwin, of the Supreme Court of Connecticut, who drew so faithful a picture of the Academy's past, setting it in just relation to its environment and making even its more humble details attractive, and to Professor Rice, of Wesleyan University, who so admirably outlined the course of scientific thought in the nineteenth century, the Academy is under great obligation for the service rendered.

The cordial greetings received from the correspondents of the Academy at home and abroad, conveying congratulations on the work achieved in the past and good wishes for the future, added much to the interest of the occasion. Their number and wide distribution, as shown in the subjoined list, bear witness to the sympathy which in this age unites the workers in science of all lands.

Johns Hopkins University,	Baltimore.
Boston Society of Natural History,	Boston.
Harvard University,	Cambridge.
Field Columbian Museum,	Chicago.
Connecticut Historical Society,	Hartford.
Trinity College,	Hartford.
State Historical Society of Wisconsin,	Madison.
Wesleyan University,	Middletown.
New London County Historical Society,	New London.
Linnean Society of New York,	New York.
New York Academy of Sciences,	New York.
American Philosophical Society,	Philadelphia.
Franklin Institute,	Philadelphia.
Pennsylvania Historical Society,	Philadelphia.
Missouri Botanical Garden,	St. Louis.
Academy of Science,	St. Louis.
Essex Institute,	Salem.
Georgia Historical Society,	Savannah.
Smithsonian Institution,	Washington.
United States Naval Observatory,	Washington.

Koninklijke Akademie van Wetenschappen,	Amsterdam.
Naturforschende Gesellschaft,	Basel.
Bataviaasch Genootschap van Kunsten en Wetenschappen,	Batavia.
Koninklijke Naturkundige Vereeniging in Nederlandsch-Indië,	Batavia.
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Kongliga Vetenskaps och Vitterhets Samhälle,	Gothenburg.
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Royal Historical Society,	London.
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Literary and Philosophical Society,	Manchester.
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Geological Survey of Canada,	Ottawa.

Société Mathématique de France,	Paris.
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Società Italiana delle Scienze detta del XI.,	Rome.
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Comité Géologique,	St. Petersburg.
Observatoire Physique Central Nicolas,	St. Petersburg.
Russisch Kaiserliche Mineralogische Gesellschaft,	St. Petersburg.
Sociedad Científica de Chile,	Santiago.
Royal Society of New South Wales,	Sidney.
Museum,	Trömsö.
Reale Museo di Zoologia e di Anatomia Comparata,	Turin.
Konglige Universitet,	Upsala.

From these greetings we venture to select for reproduction here, on the ground of our inheritance of a common language and of other common heritages, the following :

THE ROYAL SOCIETY OF LONDON

FOR IMPROVING NATURAL KNOWLEDGE

Sends to the Connecticut Academy of Arts and Sciences on the happy occasion of its celebrating the Centenary of its foundation brotherly greetings and hearty congratulations.

From the earliest days the Royal Society has felt that its efforts should not be confined to the city whose name forms part of its title, and has always sympathized with, and, from time to time, has assisted undertakings for improving Natural Knowledge carried out in various parts of the world. It remembers with pride how since its early years it has been able to count as members of itself many distinguished men of science dwelling on the other side of the Atlantic, some of whom Connecticut can claim as its own.

And to the earnest wish that the Connecticut Academy of Arts and Sciences may enjoy continued prosperity in time to come it adds the no less sincere and earnest wish that the brotherly ties between those who on the two sides of the ocean are devoting themselves to improving Natural Knowledge may grow still stronger as the years pass on.

LISTER,

Pres. R. S.

THE LONDON MATHEMATICAL SOCIETY

Present fraternal greetings to the Connecticut Academy of Sciences on the occasion of the hundredth anniversary of their foundation.

They look back with satisfaction on the exchange of publications which has subsisted between the two bodies ever since their own foundation in the year 1865.

They recognize with much pleasure the importance of the researches in Mathematical and Physical Science given to the world by the Connecticut Academy in a language which does not convey to them any suggestion of a foreign origin. In no country has the value of these researches been earlier or more fully recognized than in Great Britain.

They desire and expect a long career of increasing usefulness and honor for the Connecticut Academy of Sciences, which even now takes rank among the most ancient of the existing learned societies of the world.

Signed in behalf of the London Mathematical Society.

KELVIN, *President.*

JOSEPH LARMOR, *Treasurer.*

ROBERT TUCKER, } *Secretaries.*

A. E. H. LOVE, }

London, July 31, 1899.

THE COUNCIL OF THE MANCHESTER LITERARY
AND PHILOSOPHICAL SOCIETY

Send most cordial greetings on the occasion of the Centenary of the Connecticut Academy of Arts and Sciences.

They recall the great services which the Academy has rendered, not only in the encouragement of scientific research within its own borders, but also by the singular merit of its publications, many of which they feel will rank as permanent landmarks in the history of Science.

The Council feel that they can express no better wish than that the Academy may continue to flourish in a manner worthy of its past traditions.

26th September, 1899.

HORACE LAMB, *President.*

R. G. GWYTHYR, } *Honorary*

FRANCIS JONES, } *Secretaries.*

ROYAL OBSERVATORY, EDINBURGH.

27th September, 1899.

*To the Secretary Connecticut Academy of Arts and Sciences,
New Haven, Connecticut, U. S. A.*

DEAR SIR—The Staff of this Observatory desire to join with me in most heartily congratulating the Connecticut Academy of Arts and Sciences on the celebration of the hundredth anniversary of its foundation.

On this auspicious occasion we particularly call to mind the distinguished services to the Sciences of Meteorology and Astronomy done by your illustrious members Loomis and H. A. Newton, whose names will ever be associated with the scientific progress of the closing century.

Wishing the most complete success to your commemoration and regretting that it is not practicable for any of us to share personally therein, I am, Dear Sir,

Very faithfully yours,

RALPH COPELAND.

In addition to the greetings sent, several of the societies had also appointed delegates to represent them at the Celebration, delegates of foreign societies being naturally chosen from their American membership. Some who had accepted appointment found themselves at the last moment unable to come. Actually present were these: from the Boston Society of Natural History, Professor Edward S. Morse; from Harvard University, Professor Charles R. Lanman; from the Connecticut Historical Society, Hon. Simeon E. Baldwin; from Wesleyan University, Professor William North Rice; from the Geological Society of London, Professors George J. Brush and Edward S. Dana; from the Literary and Philosophical Society of Manchester, Professor J. Willard Gibbs; from the North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne, Mr. Richard P. Rothwell, of New York.

With a reception tendered by the Academy to the delegates and invited guests, the celebration, and with it the record of the first century, was closed.

THE FIRST CENTURY OF THE CONNECTICUT ACADEMY OF ARTS AND SCIENCES.

An Historical Address delivered before the Academy at its Centennial
Anniversary, on October 11th, 1899.

BY SIMEON E. BALDWIN, LL.D.

American science, and perhaps we may say American letters, first began to take shape in the latter half of the eighteenth century. Franklin was easily the first in each. One is almost tempted to declare that he was the first American who wrote good English: it is certainly safe to say that he was the first whose style of composition had a distinct and lasting charm. This gave wings to his scientific discoveries and conclusions, and made him a citizen of the world.

It was natural that he should take the lead in introducing upon our continent the learned academy.

The American Philosophical Society sprang from his creative touch, and had its first beginnings at Philadelphia in 1744. Boston followed in 1780 with the American Academy of Arts and Sciences, and the list for the century was closed at New Haven with the Connecticut Academy of Arts and Sciences in 1799.*

It is seldom that anything enduring is originally constituted in the form and manner which subsequently mark its character.

In laying the foundations of the oldest of the societies which I have named, which was in 1743, it was Franklin's aim to bring into association all who had any reputation for scientific attainments in the different colonies. While an organization was effected in 1744, no one came in, outside of Pennsylvania, New York and New Jersey, and after a languishing existence of a quarter of a century it was merged with a local society of Phila-

* An association called "The Society for Promoting Useful Knowledge" existed in the city of New York in 1792, which met monthly; but it was not incorporated. Morse's *American Geography*, ed. of 1792, 265.

delphia under a charter from the State of Pennsylvania, incorporating it as the American Philosophical Society for the Promotion of Useful Knowledge. Of this Franklin was the first President, and it has ever since maintained an honorable position in the republic of letters.

In like manner the Academy, whose centennial we meet to-night to celebrate, was founded on the ruins of an earlier organization, the Connecticut Society of Arts and Sciences. In 1779, Benjamin Guild, a Harvard tutor, who was then planning the foundation of the American Academy at Boston, on his way back from Philadelphia, where he had probably made himself acquainted with the constitution and methods of the American Philosophical Society, stopped over at New Haven to see one of its early members, President Stiles. The establishment of academies both at Boston and New Haven was talked over at length, and each soon made earnest efforts in that direction. A few months later, Mr. Guild was able to send Dr. Stiles a copy of the charter granted by Massachusetts for the American Academy of Arts and Sciences. In Connecticut, however, a less friendly spirit was shown. The relations between the State and Yale College were somewhat strained. That institution had become a body of great and growing importance. It was self-governing. The fellows or trustees were all Congregational clergymen, and perpetuated themselves by filling vacancies, as they might arise. No power of visitation had been reserved in terms to the State, when the charter was granted, and none was admitted to exist by the College authorities. It was obvious that any academy of arts and sciences which might be incorporated would naturally gravitate towards the College, and come ultimately under the leadership of the same set of men.

There were those also, even among the Congregational clergy, by whom the College was viewed with some distrust. President Clap had been a Calvinist of the old school, but President Stiles was what in those days was denominated a Latitudinarian. He was of opinion that the true theory of Christian redemption was that—to use his own words in a letter to Dr. Franklin—a “happy immortality” had thus been “purchased for the virtuous and truly good of every religious denomination in Christendom, and for those of every age, nation and mythology, who reverence the

Deity, are filled with integrity, righteousness, and benevolence.”* Such sentiments did not generally prevail in the Congregational pulpits of the State, and those who did not share them were able to point to the declining state of the College church as evidence of their evil tendency.

Under these circumstances a charter for “the Connecticut Academy of Arts and Sciences,” drafted by President Stiles, was sent by him to the Rev. Dr. Nathan Strong of Hartford for presentation to the General Assembly at its May session, to be held in that city in 1781. The Academy was to consist of a President and Fellows, the first meeting to be called by Dr. Stiles and held at “the chapel of the College of Connecticut Hall in New Haven.” A blank was left in the draft for the names of the incorporators, which it was probably supposed could best be filled by Dr. Strong on consultation with the friends of the measure in the Assembly. Apparently it found friends in the upper house, for it was there passed, and with such inconsiderate haste that the blank was left unfilled, thus making the bill totally inoperative. In the lower house it received more careful attention. An amendment was proposed to make the Academy “at all times subject to the visitation and inspection of the General Assembly” and the matter continued to the next session at New Haven.† In this disposition of it the upper house finally concurred, and after one or two similar continuances at subsequent sessions, Dr. Stiles evidently thought it best to make a fresh start on a different basis, for we find him, in 1783, in consultation with his cousin, Rev. John Devotion of Saybrook, over a new charter, for the “Connecticut Academy of Sciences,” making the Governor of the State the first President, and the Secretary of the State the “chief Secretary.” The Academy was to have power to establish a botanical garden and to purchase or erect a suitable building, containing a hall for its meetings, a library, and rooms adapted to the purposes of a museum. The first meeting was to be held at Middletown.‡

* Franklin's Memoirs, Phila. ed. of 1834, i, 622.

† Conn. State Mss. Archives, Colleges and Schools, 1763-1789, No. 134. The Yale Book, I, 331.

‡ Mss. Diary of President Stiles, Vol. 11, p. 282. This draft of a charter is also preserved in the Stiles Mss., in the Yale library.

A sedulous desire to avoid any marked connection with the College is shown in this scheme of organization. The arts were even excluded from the corporate name. It fared, however, no better than its predecessor; one cause perhaps, being that it provided that the proposed building should be free of taxation. The public mind, also, was full of other things. The era of the revolution had closed, but that of reconstruction, with all its possibilities, was now opening.

Three years later, in despair of obtaining the legislation desired, a voluntary association* was formed at Hartford during the session of the General Assembly there, by the name of the Connecticut Society of Arts and Sciences. Dr. Stiles and Dr. Strong were among its active promoters, the number of whom was limited to sixty, and soon rose to over forty, the Lieutenant-Governor of the State being the first President. It was to have two semi-annual sessions, alternately at Hartford and New Haven, during the session of the legislature at each place.

No prophet was needed to predict the practical failure of this scheme. It was an appendage to the General Assembly, but without its countenance. It had no fixed center nor place of abode.

A learned academy must be the outgrowth, or at least must have the cordial support, either of a university or of a capital. It must draw its life from an exchange of the fruits of scholarship, or an exchange of news of scientific discovery. Nor can it be migratory. It must have a $\pi\omicron\upsilon\ \sigma\tau\omega$, if it would exert a continuous and lasting influence.

But one paper was ever published by the Connecticut Society of Arts and Sciences—a dissertation on the Language of the Muhhekaneew Indians, by Rev. Dr. Jonathan Edwards, the younger. It is one of acknowledged merit, and was communicated to the Society in October, 1787.

The times were then growing more and more unfavorable to the cultivation of any science but that of politics.

The one great subject of thought was the formation of a better government for the United States. The Convention which

* Stiles' Diary, Vol. 10, p. 150. A search through the Journal of the May Session, 1786, confirms the accuracy of Dr. Stiles' entry as to its not being incorporated.

framed the Constitution of 1789 had just closed its sessions. Whether to ratify or reject the work, whether to side with Hamilton or Patrick Henry, were questions which quite superseded any that could be raised by Dr. Edwards as to the analogy between the Hebrew and the tongue of the Muhhekaneews. Party spirit soon awoke, and whatever time Connecticut could give to academic subjects was devoted to readjusting the relations between the State and Yale College by bringing the Governor, Lieutenant-Governor, and six of the Assistants into her board of management.

This was accomplished in 1792, and seven years later, on March 4th, 1799, a new organization was quietly effected at New Haven, under the name originally selected by Dr. Stiles. It was at first a voluntary association, but a few months later, at the October session of the General Assembly, in 1799, a charter of incorporation was easily obtained. It included many of the members of the Connecticut Society of Arts and Sciences, but there was no formal merger of the moribund institution with that thus brought into existence.

The first meeting of the Academy under its charter was held at the State House in this city on October 22d, 1799.

There was an organization on a solid foundation. The President was the President of Yale College. The Vice-President was the Governor of the State, and the head of the "Counselors" was the Lieutenant-Governor; both also being *ex officio* Fellows of the College. The charter did not specify the objects of the Academy, otherwise than by its name, and in the preamble, which declared that "literary Societies have been found to promote, diffuse and preserve the knowledge of those Arts and Sciences, which are the support of Agriculture, Manufactures, and Commerce, and to advance the dignity, virtue and happiness of a people." These same words were repeated in the charter of the American Geological Society, when that was incorporated by Connecticut, twenty years later.*

Any organization of which President Dwight was the head had from that fact alone an assurance of success. His strong, dominating character, active mind, and untiring energy, set the Academy at once upon a course of useful activity.

* Private Laws of Connecticut, Vol. 1, p. 1098.

New Haven was but a small capital. Yale was but a small college. But there were then few larger cities, and only one larger college on the American continent.

The membership of the Academy was co-extensive with the State, and embraced men of all parties and all shades of opinion. Among those named in the charter were Chief Justice Swift of Windham, whose treatises on legal topics were among the earliest as they are among the best of American works of that character; Josiah Meigs, an ardent Jeffersonian, then holding the chair of Mathematics and Natural Philosophy at Yale, but soon to find a more congenial political atmosphere in Georgia, where he went in 1801 to become President of its State University; Noah Webster; Abraham Bishop, whose attacks on President Dwight in political addresses soon put an impassable gulf between them; Chief Justice Hosmer of Middletown; Judge Pierpont Edwards; Chief Justice Ellsworth of Windsor; and Dr. Bela Hubbard, rector of Trinity Church, and the leader of the Episcopalian clergy of the diocese.

President Dwight was particularly interested in political science. He was also a close student of history, and saw the importance for the United States of reducing to proper form for future use all the historical and statistical material that, so familiar as to be uninteresting to one generation, is of priceless value to the next.

Under his lead, in December, 1799, action was taken towards memorializing Congress to enlarge the objects of the national census of 1800, and to secure greater particularity in the returns. Coöperation in this effort was invited from the American Philosophical Society and the American Academy of Arts and Sciences.

The Academy also, a week later, agreed on a circular letter to be issued in its name, asking for statistical information as to the State of Connecticut and the several towns within its jurisdiction. The result of this request, which was followed up by newspaper addresses, and much private correspondence, was that such statistics were obtained from more than thirty towns;* by far the most valuable being those for New Haven prepared by President Dwight. This piece of his work was published by the Academy in 1811, in a pamphlet of 84 pages, as the first part of the first

* The Yale Book, I, 333.

volume of a series to be entitled "A Statistical Account of the Towns and Parishes in the State of Connecticut." It was followed, in 1815, by a similar account of the towns in Litchfield county, by James Morris, and in 1819, by one of those in Middlesex county, by Rev. Dr. David Dudley Field of Haddam, father of an illustrious family. To this work Dr. Field added in 1827 a sketch of the history of Guilford and Madison.* It is to be regretted that the projected series was carried no farther.

During its first twenty years of existence, the Academy held its annual meetings at the State House in New Haven, and its others at the residences of its members in succession. An oration by some person of distinction was a feature of the annual meeting, and at those held at private houses some paper of a less formal character was generally presented, or topics of general interest discussed. If one of the members was writing a book, some of the chapters would be likely to pass in this way, while in manuscript, before the Academy, and the views presented receive its friendly criticism. President Dwight's defence of the common language of New England, and of the pronunciation of English by her people, contained in a letter to an imaginary Englishman, published after his death in the fourth volume of his "Travels in New England and New York," was presented in this way as a communication to the Academy in 1813.

In 1818, a report was adopted from a committee of which Professor Silliman was the chairman, urging the importance of a proper geological survey and map of the State. This was the beginning of an effort to press the subject upon the attention of the legislature, which resulted, in 1835, in the appointment by the State of two members of the Academy, Dr. Charles Upham Shepard and Dr. James G. Percival, to undertake the work. Dr. Shepard's report, which was mainly confined to mineralogy, was published in 1837, in a thick pamphlet of 188 pages, and Dr. Percival's, with the geological map, followed five years later in a volume of much larger dimensions.

The published transactions of the Academy, aside from the Statistical Account of the State, which was designed to stand by itself as a separate work, began with Part 1 of Volume 1, printed

* This was the foundation of Smith's History of Guilford, published in 1874.

in 1810. The second part followed in 1811, the third in 1813, and the fourth and last in 1816. The range of subjects discussed was broad. Two papers read by Noah Webster in 1799 and 1806 had the place of honor, and treated of the supposed moderation in the temperature of winter in modern times. It was his opinion that the spread of population over the earth, and the attendant alterations in the face of the ground occasioned by clearing and cultivation, had resulted in a less equal and uniform distribution of heat and cold among the several seasons, but that the cold of winter was in the aggregate as great as ever, though less steady. Judge Daggett narrated the history of a law suit brought for destroying a dam across the Housatonic river, in which the defence was that ponding the water had been a cause of fever and ague. A lengthy paper by Dr. Benjamin W. Dwight, of Catskill, New York, a son of the President, on Chronic Debility of the Stomach, excited wide attention, and was republished in England. One of its positions might well commend it to English readers. "Wine, and wine only," he wrote, "is recommended in holy writ for dyspeptic complaints. 'A little wine for thy stomach's sake, and thine often infirmities' was the direction of the Apostle Paul to Timothy. The words 'thy stomach's sake, and thine often infirmities' prove the disease to have been Chronic Debility of that viscus, with a numerous train of morbid sympathies; and no prescription of Hippocrates could have been better."

Another son of the President, Sereno E. Dwight, then a member of the New Haven Bar, contributed a dissertation on the Origin of Springs. The volume closed with a mathematical demonstration of Stewart's Properties of the Circle, by Professor Strong of Hamilton College. It contained also a number of papers on subjects of natural philosophy, and two from the pen of President Dwight, the more important one being Observations on Language, the theme of which was that the intelligence of any nation may be exactly estimated from its vocabulary.

The year after the completion of Volume 1 of the Memoirs of the Academy (which was the style of the title adopted) President Dwight's death sent the Presidency of the College, and with it naturally that of the Academy, into the hands of Dr. Day.

His horizon was not so broad as that of his predecessor in these offices, nor his executive powers of equal energy.

Another circumstance also now occurred to weaken the position of the Academy as an active force in the cultivation of the Arts and Sciences. In 1818, Professor Silliman undertook the arduous task of editing and publishing a scientific periodical of a general character, and in July of that year, the first number of the "American Journal of Science and Arts" appeared from the New Haven press. He had made important contributions to the first volume of the Academy's Memoirs, and had always been one of its leading spirits. Such, indeed, he continued to be for many years, but his main interest henceforth as to scientific publications was naturally centered in the Journal, for whose regular issue he had become responsible, and which was soon called, in common parlance, by his name. To support his undertaking, a vote had been passed in February, "that the Committee of Publication may allow such of the Academy's papers as they think proper, to be published in Mr. Silliman's Scientific Journal."

Free use was made of this authority, and a large part of the contents of the Journal was for many years drawn from this source. In some cases this fact was noted in publication; but in most it was not. Among the more important communications to the Academy which were thus transferred to the Journal of Science may be mentioned a series of articles, some by Edward C. Herrick, and others by Professors Olmstead and Loomis, stating the observations and conclusions which did so much to call general attention to the periodicity of meteoric showers and to confirm what is now the universally accepted theory of their cause.

In 1826, when the Journal was in great need of financial support, the Academy further voted to pay for a year the cost of printing such of its papers as might be published in it. In Baldwin's *Annals of Yale College*,* published in 1831, it is described as a publication "honorable to the science of our common country," and having "an additional value as being adopted as the acknowledged organ of the Connecticut Academy of Arts and Sciences."

The *Christian Spectator*, also, another New Haven magazine, which was founded in 1819, drew heavily from the productive

* P. 207.

force of the Academy. That, and its successors, the *New Englander*, and the *Yale Review*, were always mainly conducted by our members. The *Spectator* and the *New Englander* both cultivated political as well as theological science, and spoke on most of the subjects which from time to time commanded public attention. The *Review* has confined itself mainly to matters of politics and economics.

The last of the regular series of annual orations was delivered by Professor A. M. Fisher, in 1818. In 1819, the annual meeting, instead of taking place at the State House, was held at the residence of President Day, and in 1820, the day of it falling in the College vacation, when the Secretary was absent from town, none was called.

The Academy was now fast becoming a mere local literary society, and, if the truth must be told, but a languishing one at that. Its meetings were often without a quorum, and it seemed to have lost its life and spring. As a feeder to the *American Journal of Science*, it served a useful purpose; as a center of social intercourse it served another: but neither was the appropriate function of an academy of arts and sciences. That must not only do something: it must publish its doings, or die.

In 1833, an earnest effort was made to place it upon a better foundation, by dividing up the field which it sought to cover into distinct departments, and confiding each to a standing committee for regular inquiry and report. Early in 1834 such committees were appointed, and their arrangement was as follows:

On Mathematics and Natural Philosophy: Professor Olmstead, chairman.

On Chemistry and the kindred sciences, including Mineralogy and Geology: Professor Silliman, chairman.

On Botany and Zoology: Mr. C. M. Shepard, chairman.

On Medical Science: Professor Charles Hubbard, chairman.

On Intellectual Science: President Day, chairman.

On Law and Political Science: Judge Daggett, chairman.

On Theological Science (including Sacred Literature, Ecclesiastical History, Natural and Revealed Religion, Homiletics, Liturgies, Canon Law): Rev. Dr. James Murdock, chairman.

On Historical Science (including History, Geography, Chronology, Antiquities and Statistics): Dr. Noah Webster, chairman.

On Philology and Criticism : Professor Kingsley, chairman.

On *Belles-Lettres* : Professor Goodrich, chairman.

On the Fine Arts : H. Augur (the sculptor), chairman.

On Education : Professor Woolsey, chairman.

On these committees appeared the names of a number of non-resident members, including Professors Lathrop of Hamilton College, New York, Fowler of Middlebury College, Vermont, and Mitchell of Chapel Hill College, North Carolina, Rev. J. P. Cowles of Princeton, Massachusetts, and Professor Ethan A. Andrews of Boston.

The scheme was too ambitious, and little was accomplished by it.

A specialization of research of another character was commencing at Yale, which was perhaps more in accordance with the spirit of modern scholarship, but was destined to exert an unfavorable influence on the fortunes of the Academy. I refer to the formation of particular societies for the promotion of particular sciences. One of the earliest was the Yale Natural History Society, which achieved considerable results, particularly through the investigations of James Harvey Linsley of Stratford, whose catalogue of the Mammalia of Connecticut, and of the Shells of Connecticut, prepared for its service, were afterwards published in the *American Journal of Science and Arts*. Other organizations of a similar kind followed later, and one by one, especially of late years, the Classical Club, the Political Science Club, the Mathematical Club, and others at Yale have seized upon almost every field originally appropriated by the Academy, pursuing their studies with the ardor of youth, and the enthusiasm that is best kindled by daily intercourse between men engaged in the same pursuits, and acting under the lead of a trained scholar, eager to share with them the latest word of the best man on the subject in hand.

In 1836 President Day declined a re-election to the Presidency of the Academy, and that position passed into the hands of Professor Silliman.

In every association, whatever its form or purpose, the presiding officer holds a great power in the matter of shaping its general policy. It is the greater because it is largely undefined and, so to speak, unexpressed. He inspires resolutions which others offer ;

leads the way to the consideration of this subject rather than that; appoints on committees those who reflect his own views. He is held by the public responsible for the success of the organization, and he must have an influence commensurate with his responsibility.

President Day's retirement loosened the connection between the Academy and the College, and none of his successors in the presidency of Yale have had any prominent official connection with the Academy. President Woolsey's studies ran in the direction of the classics and of political science and jurisprudence. From these the Academy had largely turned away since the institution of the *American Journal of Science and Arts*, and during his term of office as President of the University, the rise and growth of the Scientific School had brought it into a more vital connection with that than it had ever had with the college proper, or, as it now began to be called, the academic department.

Another change came over the Academy at the time when the last of its original founders were passing away. In the true and original sense it had from its early years been a convivial body. Nothing, after all, promotes freedom of intellectual intercourse, and the exchange of thought, so much as gathering to share a social meal. Such assemblies the Romans called *convivia* because, as Cicero says in one of his letters,† it is on occasions of this kind that life is most truly enjoyed.

From its early days it had been one of the unwritten laws and institutions of the Academy, that the member at whose house the monthly or bi-monthly meetings were held should provide some simple entertainment to succeed the regular business of the evening. At first the refectation was confined to the fruit in season, or nuts and raisins. Later it assumed more the form of a supper, and while some of the members insisted that it did as much as anything else to hold the Academy together, there were others, among whom President (then Professor) Woolsey was prominent, who declared that it was a diversion from their proper work and ought to be abandoned.

In November, 1842, a committee was appointed to report on the expediency of such a change of practice, consisting of Rev. Dr. Murdock, and Professors Larned and Olmstead. A month

* To Lucius Papinius Paetus, Book XIII, Ep. IX.

later they reported that while the customary entertainment might be "an elegant and agreeable relaxation after the severer exercises of the meeting" and afforded a pleasant opportunity for social intercourse, yet, to quote their words, "that the indulgence of the sensual appetites never made a philosopher; that animal pleasures and indulgences are unbecoming and unsuitable in the conventions of scientific men for scientific purposes; that such festivities, late in the evening, are generally injurious to health; that the expense and trouble of preparing them are very considerable and unequally fall on only a part of the attending members; that these festivities are becoming more and more luxurious and expensive, and cannot easily be kept within moderate bounds; and lastly that they are a bad example to be exhibited in the vicinity of the college: they afford to dissipated students a plausible excuse for their midnight revels, and tend to paralyze the efforts of the college officers to restrain their pupils from debasing and expensive carousals."

The report was accepted, and so in Christmas week of 1842 the modest suppers of the Academy came to an end. Tradition says that President Woolsey never attended another meeting.

There is, in truth, a certain and altogether natural and right attraction to almost every man, now, as fully as in the days of Cicero, in the pleasures of the table, enjoyed in moderation and in congenial company. The Academy had thrown away what had been a real magnet, and its meetings as years went on became more formal, and not infrequently were without a quorum.

One may sometimes read between the leaves of history more than the page contains. I am inclined to think that President Woolsey's attack and Professor Larned's report came in part—though no doubt half unconsciously to themselves—from the fact that their wants in the direction of such social entertainments had been better met by an institution, now become a venerable one, founded in 1838 by eight gentlemen of the city, all, I believe, members of the Academy, and still known, by right of primogeniture, only by the name of "The Club."

This was a company of personal friends, by 1842 somewhat enlarged in numbers, who took tea, in the old New England fashion (what the housewives call a "high tea") at each other's houses in succession two or three times a month, and afterwards

listened to a paper or a talk on a given subject which was afterwards discussed by all in turn.

Of this President Woolsey, Professor Larned, Dr. Bacon, Professor Gibbs, Professor Twining, Henry White, Rev. Henry G. Ludlow and Dr. Henry A. Tomlinson were the original members, and in a smaller circle and with the freedom which greater intimacy gives, after what took the place of an ordinary meal could enjoy the pleasures of literary conversation.

The weakening of the Academy which followed the abandonment of the supper was soon manifested in another way.

A library of some value had been accumulated, partly by gift or exchange and partly by purchase, during its first half century. In 1847 the whole of it was sold to Yale College.

The Connecticut Historical Society of Hartford had been incorporated in 1825. Here was another organization formed to accomplish what had been originally one of the cherished objects of the Academy, and towards which its early members had made such important contribution. In 1847, at the same time when the library was disposed of, it was voted to deposit with this Society, as a loan, all the statistical accounts of Connecticut towns which remained in manuscript in its archives. These covered with more or less completeness, twenty-five towns.*

Subsequently, in 1859, when the Historical Society was about to publish a volume of its transactions, the Academy contributed a sixth of the entire cost.

The change of policy manifested by the steps taken in 1847 which I have mentioned was followed in 1848 by a vote to suspend the collection of the annual dues.

The Academy had thus in some measure settled its estate; but it was by no means dead. The meetings were still often of decided interest, and served at least to diffuse intelligence of what

* The list of the statistics thus turned over to the Connecticut Historical Society includes those for the following towns: Bethlehem, Bolton, Canterbury, Cheshire, Cornwall, Coventry, East Windsor, Farmington (Wintonbury parish), Franklin, Haddam, Goshen, Lebanon, Lisbon, Pomfret, Preston (North Society), Ridgefield, Stratford, Tolland, Union, Wallingford, Washington, Watertown, Willington, Windham, Winchester. Certain statistics as to New London remain in the archives of the Academy.

was going on in the scientific world.* In 1856 a movement was made toward resuming greater activity, by the introduction of a resolution "that literature as well as science and every subject tending to the advancement of knowledge or the promotion of human happiness comes within the scope and original plan of this Association," and further that papers suitable for publication should thereafter be published as from the Transactions of the Academy, either in the American Journal of Science or in the volume form, and that collection of the annual dues should be resumed.

A discussion, however, resulted in laying these propositions on the table. They were evidently somewhat antagonistic to the policy which had been adopted by the American Journal of Science, which naturally preferred to ignore the original sources from which so many of its articles were derived. In 1861, however, a vote was passed to request the editors of the Journal to give credit to the Academy for all papers which had formed a part of its transactions

A year later the Academy obtained what it had long needed, and the more imperatively, since the discontinuance of its evening suppers, a regular and fixed place of meeting. This was due to the kindness of Mr. Sheffield, one of its members, who is gratefully remembered as the founder of the Sheffield Scientific School.

Its last gathering at the house of a member was on November 19, 1862, at that of Tutor Lebeus C. Chapin, on the corner of Church and Wall streets, and it has met ever since at Sheffield Hall. In modelling that building, a few years later, Mr. Sheffield constructed the handsome library room in the third story with special reference to the wants of the Academy, and in conformity with his wishes, the Governing Board of the School in 1866 offered it as a place where our meetings could be permanently held. The offer was received with due thanks, but the Academy did not commit itself to an acceptance in terms. Had it done so, it would have been less wise and far-seeing than those who laid its first foundations. The charter prepared by President Stiles and Mr. Devotion, in 1783, contemplated a building which the Acad-

* Those of its members most interested in philological studies had, under the lead of Dr. Murdock, procured a charter from the State in 1844 for their incorporation as the "Philological Society." Special Laws of Conn. IV, 1199.

emy should own, itself, and make a place, not only for its meetings, but for collections which might be of public value. Such a building may yet be its final home. Let us hope that when our successors celebrate its next centennial, it may be in an unborrowed hall, that shall perpetuate the name of some friend of learning and stand as his stately gift to science and the arts, as cultivated by the people of Connecticut.

In December, 1863, at the instance of Professor Gilman, now President of John Hopkins University, the Academy voted to recommence the publication of its transactions, but to aim especially at printing such papers as "on account of their length, their technical or special character, or their local interest, would be inappropriate to the *American Journal of Science*;" particularly disclaiming any desire to interfere with "the field which the *Journal* occupies with so much credit to the country and the College."

Collection of the annual dues of the Academy had been resumed, and with the aid of some special subscriptions to the publication fund, the first part of the first volume of the current series of our *Transactions* was carried through the press in 1865. In 1867 a further contribution of nearly \$400 was received from the treasury of the "Yale Natural History Society," which had become practically defunct, to be devoted to the publication of papers on the branches of science which that Society had been formed to promote. In 1871 the second part of the volume appeared, and since then parts of volumes have been issued every few years, the tenth volume being now half through the press.

The general character of their contents is such as was indicated by the vote of the Academy in 1863. There is little in them of a popular character; but it may fairly be said that there has been much to interest and to inform the scientific reader. An occasional contribution will be found by students of philology, and one pertains to the general history of letters and the drama, but the subjects considered have generally been such as relate to Natural History, Physiology or Mathematics, and the papers mainly of the kind that are originally submitted by title, and are known only to the committee on publication before they appear in print.

While this is true of them, in the shape in which they appear in our *Transactions*, it is, however, no less true that in many instances the subject considered has been less formally presented

by the author at the meetings of the Academy, and the main results or conclusions thus communicated and discussed.

Our first published volume bore, as has been said, the name of *Memoirs of the Academy*. In planning for the second volume, half a century later, it was thought best to entitle it as the *Transactions of the Academy*. The question then arose whether it should be numbered as volume two, or volume one, and in view of this change of name, as well as of the great lapse of time since the earlier publication, it was concluded to make it the commencement of an independent series.

The exchange list of the Academy in 1810 was limited for the United States to the Massachusetts Historical Society; the American Academy of Arts and Sciences; the New York Agricultural Society; the New York Historical Society, and the American Philosophical Society.

Six copies of Part 1 of Volume I were also put in the hands of Dr. Noah Webster, to be transmitted by him to such foreign societies or libraries as he might think proper to select. At present our *Transactions* are exchanged for those of nearly a hundred learned societies in this country, and of more than twice as many in foreign countries.*

A valuable library has thus been accumulated, which is deposited for convenience, and under an arrangement which contemplates its remaining there permanently, in the library of Yale University, the head of which is also the librarian of the Academy.

The Academy now assembles monthly in the Faculty room on the first floor of Sheffield Hall, its last meeting being its seven hundred and eighty-sixth.

Its ordinary course of business does not differ materially from that which I have described as pursued half a century ago. Some topic previously announced is presented, either by a written paper, or an oral explanation, and opportunity is then given for a general discussion.

In this way, independently of what has been accomplished by its publications, the Academy has been of substantial service for a hundred years to the College and to the city, particularly, but often to the State and to the country, as well.

* About 225.

To some of the results of its labors I have already sufficiently adverted. I must add that too high a value can hardly be set on the Statistical Account of New Haven by President Dwight, as a study of an American town in the formative period of American government. It was republished, a few years ago, by the city authorities in its year book. A census of New Haven was also taken by a committee of the Academy early in the century, the results of which are on file in our archives, and well merit future publication. The collection of statistics from all the towns in the State would probably have been achieved, had President Dwight lived ten years longer, and what was accomplished will be of the greatest importance whenever a history of Connecticut is written that deals, from the standpoint of the sociologist, with the character of her people and her institutions.

In 1836, when the two hundredth anniversary of the founding of New Haven was approaching, the Academy voted to appoint one of its members to prepare a historical address for the occasion, and took an active part in providing for its proper celebration. The address by Professor Kingsley, which was its main feature, was a careful and masterly production, and the Academy also procured, partly at its own expense, the striking of a set of medals to commemorate the day.

In 1873, the necessity of a better map of the State than any yet produced was made the subject of discussion at several of our meetings. The result was a memorial from the Academy to the General Assembly for a new topographic survey, and a public agitation of the question, out of which came the very excellent topographical atlas of Connecticut, published in 1893 by the collaboration of the United States Geological Survey and a Commission appointed by the State, of which the chairman was the present President of the Academy.

Provision was made by the Academy in 1799 for keeping at its expense a meteorological register, and the results contained in its archives, when combined with some records of an earlier and others of a later date, made by other observers at New Haven, constitute a history of the weather which is nearly complete from 1779 to the present hour.*

* See the Yale Book, I, 335.

The stimulating effect of the discussions at the ordinary meetings of the Academy on the life of the community one is liable to underestimate. Here, one after another, each of the great discoveries of modern science, of the great advances in modern thought, has been presented by those competent to explain its character and bearings, and made familiar to a company of intelligent men, who in turn were sure to diffuse the information so received through a wider circle.

Thus, the stethoscope was exhibited and its utility demonstrated before the Academy by Dr. Charles Hooker in 1829, when it was still unknown to many of his profession, and distrusted by many more.

So of the discoveries and conclusions of Professor Marsh in the domain of palaeontology, several were informally communicated to the Academy before they had become the property of the world. In the field of philology, the origin and growth of language, early discussed, as we have seen, by President Dwight, was taken up, forty years ago, with a profounder scholarship, by Professor Whitney, and the positions stated here which he afterwards advanced in his printed works. It would be easy to refer to others, many of whom are still of us, who have in such ways contributed to make the ordinary meetings of the Academy a source of influence and power.

Its functions, however, have become, as the years go on, divided by sharper and sharper lines. Its unpublished transactions bear little relation to its published transactions. It may not unfairly be said that it prints nothing that has been read before it, and nothing that could be read before it. Our transactions include, as has been stated, much, the germ or antecedents of which have been the subject of an informal talk or brief paper at one of our meetings. But much of the matter is so elaborated and expressed in terms so technical as hardly to be intelligible to any one without the aid of plates and figures, and not to be intelligible to most of the author's associates in the Academy, at all. He is speaking to a different audience. The mathematician sends his message to scholars in his line,—to two or three in this foreign university, and two or three in that. The naturalist, in like manner, may interest one man in Vienna, another in Paris, another in Oxford. Neither of these writers, perhaps, could understand, or would care

to understand, the paper of the other. Each has made a contribution to the stock of human knowledge, and the Academy, without committing itself to the conclusions of any of its members, is glad to serve as a vehicle of transmission, by which such as it may deem of sufficient importance may be communicated to the scholars of the world.

The estimation in which the publications of the Academy are held by those to whom they are thus especially addressed may be shown from a single though certainly a conspicuous instance.

The three papers contributed by Professor J. Willard Gibbs to the second and third volumes of our Transactions, on Thermodynamics, and fresh modes of expression which Chemistry can borrow from Mathematics, have been universally recognized as containing practical suggestions of the first importance, as well as statements of certain laws never before distinctly formulated, as to the properties and inter-relations of heterogeneous substances. One of those (the law of phases) is now commonly known by chemists as Gibbs' law. These articles were translated into German by Professor Ostwald of the University of Leipsic, in 1892, and a French version of one of them, (that in regard to the equilibrium of heterogeneous substances), by Professor Chatelier of the College of France, has appeared this year at Paris. In the preface to this book, Professor Chatelier declares that the symbolic representations of chemical substances or compositions proposed by Professor Gibbs in the second volume of our Transactions have already proved of inestimable service to science by opening a way to the study of subjects so complex that it would have been absolutely impossible to reach any intelligible result without the aid thus afforded of what spoke to the senses and the imagination. A new branch of chemistry, he says, has thus been created "*dont l'importance, tous les jours croissante, devient aujourd'hui comparable à celle de la chimie pondérale créée par Lavoisier.*"*

I need not comment on the comparison thus suggested between the recent advance in chemical science flowing from the use of Professor Gibbs' methods of investigation, and the great stride taken in human knowledge when the "phlogiston" theory of Stahl was replaced by the proposition of Lavoisier that nothing is lost

* *Équilibre des Systèmes Chimiques*, Paris, 1899, vi.

in combustion, the weight of the products being equal to the weight of the constituents.

As we look back on the century which closes to-day, we cannot but see that the Connecticut Academy of 1799 was Yale College in another form.

In one sense it was a higher form, for it was a reaching forward to a broader field of acquirements and achievements than any college could lay open. It was a movement towards bringing to New Haven the life of a University,—the first movement; for the College had done nothing beside College work, save in the single line of theology.

Most of the original members of the Academy were graduates of Yale, and, if we except Dr. Webster, the leaders among them were actively connected with its faculty or board of government.

From such a body, formed in the eighteenth century, nothing was to be expected in the line of technical or abstract research.

For that the mind even of their great chief, President Dwight, was unfitted. He had large executive ability, and remarkable powers of close observation and forcible statement. But he was no scholar, as we now count scholarship.

The same thing may be said of his colleague Silliman. He had the art of teaching others what he knew himself. He was active in gathering facts upon which later science might build theories. But he was one of those from whose followers some soon must come to outstrip him.

It was not indeed until the second half of this first century of our existence that a generation of professed scholars existed in the United States. The material of our college faculties before that time was taken from the church, the bar, or the medical profession.* There were no doctors of philosophy. Dr. Shepard and Dr. Percival, who made, as has been said, the geological survey of Connecticut, were doctors of medicine. We are apt to forget how short was the entire list of college presidents and professors in the United States at the close of the eighteenth century. Instead of the thousands whom we can count to-day, they hardly

* Much of the teaching was done, as it still is in our professional schools, by men whose life was mainly devoted to other pursuits, to which their connection with the college was merely an incident. See *Life of Francis Wayland*, I, 210.

numbered fifty in all. It was the day of small things in American letters.

Our first volume of memoirs was such a collection as might now be made (but would not now be made) by the collaboration of a dozen intelligent men of liberal education, none of whom had made any department of human knowledge a special study, except so far as it might afford him a means of professional livelihood. I say would not now be made, for the world is quick to recognize the worth of specialization in scholarship, and to demand that what a learned academy shall publish be such as only learning and original research can produce.

The history of the Academy up to 1840 was sketched by Edward C. Herrick in the *American Quarterly Register* for August of that year. A later article in the *Yale Book*,* by Professor Loomis, brought it down to 1877. Its first century is now auspiciously closed, and its story is before you.

It is a record perhaps of no great achievements. It may have published no dazzling discoveries. Its influences have been often indirect, and their source perhaps unknown. But in one way or another, changing its course from time to time to meet the new conditions it had to face, as best it could, it has kept steadily to its work, with no break of activity, and hopes that it has done no dishonor to its position as the third in age of the literary societies of the United States.

It has failed in the original aim, indicated by its name, of serving to promote and develop the cultivation of the arts and sciences in the State of Connecticut in particular. Instead of becoming a real State organization, it has assumed the character of a local one. An association formed between men who live at a distance from each other may be able to gather many of them together at an annual meeting, or on some special occasion when topics of interest are to be discussed by those whose opinions are worth hearing. Such is the case with our State Medical and Bar Associations, and those of the clergy of the various denominations. But if meetings are to be held monthly, and always at the same place, they will soon inevitably become meetings of those who reside there, and the proceedings will take a local color.

* I. 329.

To this may be attributed in part the failure to complete the Statistical Account of the towns of Connecticut. Comparatively few, outside of New Haven, would interest themselves actively in a work directed and controlled by a handful of New Haven men.

On the other hand, the Academy has been a source for the diffusion of knowledge throughout all our States, and, we may say, throughout all the world. It has been, more than anything else, the perpetual springhead of the American Journal of Science, and its Memoirs and Transactions have preserved statistics, recorded observations and developed theories, that have been of service wherever science is cultivated and arts pursued.

It has not fulfilled all of its founders' hopes. But it may have done better. If it has narrowed its field in one direction, it has widened it in another.

It does not end the century as it began it. If it did, it would be unworthy of its name. It has changed with the times. New modes of action, new premises of reasoning, new rules of science, have become the property of the world. To these the Academy has sought to conform, and as it stands before the door of the Twentieth Century, and awaits its opening, it may claim to enter as one of the rightful heirs of possessions and possibilities to which it has itself made no unimportant contributions.

Child of the eighteenth century, trained at the school of the nineteenth, the Academy now steps forward to a third age, still in the spirit that belongs to perpetual youth. That can be claimed by the corporation formed for the promotion of knowledge, alone of all human things. Perpetuity comes to it as the gift of the State: youth as its birthright; for human knowledge is yet in its infancy, and what we have already accumulated will be seen by each future generation in a different light, bringing to them a new meaning, and asking from them new conclusions.

The business corporation, the ecclesiastical corporation, the corporation to support this or that particular school of professional practice, may find, as centuries go by, not only its methods but its objects antiquated and outworn. It is the corporation formed to promote all knowledge, to seek truth wherever it may be found, to expose error wherever it may be detected, that endures.

SCIENTIFIC THOUGHT IN THE NINETEENTH CENTURY.

It is an interesting fact that the life of our Association is almost coextensive with that nineteenth century of Christian civilization which is now drawing to a close. In intellectual, as in physical phenomena, we are tempted to overestimate the magnitude of near objects and to underestimate that of distant ones ; but science and art tend to advance with accelerated velocity, and we are undoubtedly right in ranking the achievements of our age in science and its applications as far greater than those of any previous century.

When our predecessors assembled a hundred years ago to organize this Academy, they could avail themselves of no other means of transportation than those which were in use before the time of Homer. If they were required to traverse distances over land too great for convenient walking, they were carried or drawn by horses. If they had occasion to cross bodies of water, they used oars or sails. We have been brought to our destination to-day by the forces of steam and electricity.

The harnessing of these mighty forces for man's use has transformed not only the modes of transportation, but also the processes of production of all kinds of commodities. It has wrought a revolution in the whole industrial system. The day of the small workshop is gone. The day of the great factory is come. Every phase of human life is affected by those arts which have arisen from the applications of science. Comforts and luxuries which a hundred years ago were beyond the reach of the most wealthy, are now available for the use of even the poor. Aniline dyes give to fabrics used for clothing or decoration colors beside which those of the rainbow are pale neutral tints. Sanitary science arrests the massacre of the innocents, and increases the average duration of human life. Anæsthetics and antiseptics take away from surgery its pain and its peril.

But, though our Association is an Academy of Arts and Sciences, it has, at least in its later life, devoted itself chiefly to the cultivation of pure science, leaving to other organizations the

development of the applications of science. Fitly, then, our thoughts to-day dwell, not upon the vast progress of the useful arts, but upon the progress of pure science. Not the economic and the industrial, but the intellectual history of our century claims our attention.

I do not propose, in the few moments allotted to me this afternoon, to give an inventory of the important scientific discoveries of the nineteenth century. The time would not suffice therefor, even were my knowledge of the various sciences sufficiently encyclopædic to justify me in the attempt. I wish rather to call your attention to a single broad, general aspect of the intellectual history of our age. I wish to remind you in how large a degree those general ideas which make the distinction between the unscientific and the scientific view of nature have been the work of the nineteenth century.

The first of these ideas is the extension of the universe in space. The unscientific mind looks upon the celestial bodies as mere appendages to the earth, relatively of small size, and at no very great distance. The scientific mind beholds the stellar universe stretching away, beyond measured distances whose numerical expression transcends all power of imagination, into immeasurable immensities.

The second of these ideas is the extension of the universe in time. To the unscientific mind, the universe has no history. Since it began to exist, it has existed substantially in its present condition. Among Christian peoples, until the belief was corrected by science, the Hebrew tradition of a creative week six thousand years ago was generally accepted as historic fact. If, on the other hand, unscientific minds, not possessed of any supposed revelation in regard to the date of the world's origin, thought of the universe as eternal, that eternity was still conceived as an eternity of unhistoric monotony. The scientific mind sees in the present condition of the universe the monuments of a long history of progress.

The third of these ideas is the unity of the universe. To the unscientific mind the universe is a chaos. To the scientific mind it becomes a cosmos. To the unscientific mind, the processes of nature seem to be the result of forces mutually independent and often discordant. Polytheism in religion is the natural counter-

part of the unscientific view of the universe. To the scientific mind, the boundless complexity of the universe is dominated by a supreme unity. One system of law, intelligible, formulable, pervades the universe, through all its measureless extension in space and time. The student of science may be theist or pantheist, atheist or agnostic; polytheist he can never be.

What, then, let us ask ourselves, has been the contribution of our century to the development of these three ideas, which characterize the scientific view of nature:—the spatial extension of the universe, the historic extension of the universe, and the unity of the universe.

The development of the idea of the extension of the universe in space belongs mainly to earlier times than ours. The Greek geometers acquired approximately correct notions of the size of the earth and the distance of the moon. The Copernican astronomy in the sixteenth century shifted the center of the solar system from the earth to the sun, and placed in truer perspective our view of the celestial spheres. But, though astronomy, the oldest of the sisterhood of the sciences, attained a somewhat mature development centuries ago, it has in our own century thrown new light upon the subject of the vastness of the universe. The discovery of Neptune has greatly increased the area of the solar system; the measurement of the parallax of a few of the brightest and presumably the nearest of the stars has rendered far more definite our knowledge of the magnitude of the stellar universe; and telescopes of higher magnifying power than had been used before have resolved many clusters of small and distant stars.

If the development of the idea of the spatial extension of the universe belongs mainly to an earlier period, the idea of its historic extension belongs mainly to our century. It is true, indeed, that Pythagoras and others of the ancient philosophers did not fail to recognize indications of change in the surface of the earth. And, in the beginning of the Renaissance, we find Leonardo da Vinci and others insisting that the fossils discovered in excavations in the stratified rocks were proof of the former existence of a sea teeming with marine life, where cultivated lands and populous cities had taken its place. Hutton's "Theory of the Earth," which in an important sense marks the beginning of modern geological theorizing, appeared in the Edinburgh *Philosophical*

Transactions in 1788, but was not published as a separate work till seven years later. Not till 1815 was published William Smith's Geological Map of England, the first example of systematic stratigraphic work extended over any large area of country. To the beginning of our century belong also the classical and epoch-making researches of Cuvier upon the fossil fauna of the Paris basin. By far the larger part, therefore, of the development of geologic science, with its far-reaching revelations of continental emergence and submergence, mountain growth and decay, and evolution and extinction of successive faunas and floras, belongs to the nineteenth century. Far on into our century extended the conflict with theological conservatism, in which the elder Silliman, James L. Kingsley, and others of the early members of our Academy bore an honorable part, and which ended in the recognition, by the general public as well as by the select circle of scientific students, of an antiquity of the earth far transcending the limits allowed by venerable tradition.

To our century also belongs chiefly the development in astronomy of the idea of the history of the solar system. It is, indeed, true that, in the conception of the nebular hypothesis, Laplace, whose "Théorie de la Monde" was published in 1796, was preceded by Kant and Swedenborg; but the credit of a discovery belongs not so much to the first conception of an idea as to its development into a thoroughly scientific theory. Our century, moreover, has added to those evidences of the nebular theory which Laplace derived from the analogies of movement in the solar system, the evidence furnished by the spectroscope, which finds in the nebulae matter in some such condition as that from which the solar system is supposed to have been evolved.

But by far the most important contribution of this century to the intellectual life of man is the share which it has had in developing the idea of the unity of nature. The greatest step prior to this century in the development of that idea (and probably the most important single discovery in the whole history of science) was Newton's discovery of universal gravitation two hundred years ago; but the investigations of our century have revealed, with a fullness not dreamed of before, a threefold unity in nature—a unity of substance, a unity of force, and a unity of process.

Spectrum analysis has taught us somewhat of the chemical constitution, not only of the sun, but also of the distant stars and

nebulae; and has thus revealed a substantial identity of chemical constitution throughout the universe. Profoundly interesting, from this point of view, is the recent discovery, in uraninite and some other minerals, of the element helium, previously known only by its line in the spectrum of the sun. Profoundly interesting will be, if confirmed by further researches, the still more recent alleged discovery of terrestrial coronium.

The doctrine of the conservation of energy formulates a unity of force in all physical processes. In this case, as in others, prophetic glimpses of the truth came to gifted minds in earlier times. Lord Bacon declared heat to be a species of motion. And Huyghens, in the seventeenth century, distinctly formulated the theory of light as an undulation, though the mighty influence of Newton maintained the emission theory in general acceptance for a century and a half.

When Lavoisier exploded the phlogiston theory, and laid the foundation of modern chemical philosophy, it was seen that, in every chemical change, there is a complete equation of matter. But there was in the phlogiston theory a distorted representation of a truth which the chemical theory of Lavoisier and his successors ignored. They could give no account of the light and heat and electricity so generally associated with chemical transformations. These "imponderable agents," as they were called, believed to be material, yet so tenuous as to be destitute of weight, haunted like ghosts the workshop of the artisan and the laboratory of the scientist, wonderfully important in their effects, but utterly unintelligible in their nature. It was almost exactly at the beginning of our century that the researches of Rumford discovered the first words of the spell by which these ghosts were destined to be laid. When Rumford declared, in his interpretation of his experiments, "Anything which any insulated body or system of bodies can continue to furnish without limitation, cannot possibly be a material substance," the fate of the supposed imponderable body, caloric, was sealed; but it was not till near the middle of our century that Joule completed the work of Rumford by the determination of the mechanical equivalent of heat. About the same time, Foucault's measurement of the velocity of light in air and in water afforded conclusive proof of the undulatory theory of light. In these great discoveries was laid the

strong foundation for the magnificent generalization of the conservation of energy—a generalization which the sagacious intuition of Mayer and Carpenter and Le Conte at once extended beyond the realm of inorganic nature to the more subtle processes of vegetable and animal life. In this connection, I may be permitted to refer to the work of some of my colleagues, with the Atwater-Rosa calorimeter, which has given more complete experimental proof than had previously been given of the conservation of energy in the human body.

But by far the greatest of the intellectual achievements of our age has been the development of the idea of the unity of process pervading the whole history of nature. The word which sums up in itself the expression of the most characteristic and fruitful intellectual life of our age is the word evolution. The latter half of our century has been so dominated by that idea in all its thinking, that it may well be named the Age of Evolution. We may give as the date of the beginning of the new epoch the year 1858; and the Wittenberg theses of the intellectual reformation of our time were the twin papers of Darwin and Wallace, wherein was promulgated the theory of natural selection.

And yet, of course, the idea of evolution was not new, when these papers were presented to the Linnæan Society. Consciously or unconsciously, the aim of science at all times must have been to bring events that seemed isolated into a continuous development. To exclude the idea of evolution from any class of phenomena is to exclude that class of phenomena from the realm of science. In the former half of our century, evolutionary conceptions of the history of inorganic nature had become pretty well established. The nebular hypothesis was obviously a theory of planetary evolution. The Lyellian geology, which took the place of the catastrophism of the last century, was the conception of evolution applied to the physical history of the earth.

Nor had there been wanting anticipations of evolution within the realm of biology. The author of that sublime Hebrew psalm of creation, preserved to us as the first chapter of Genesis, was in his way a good deal of an evolutionist. "Let the earth bring forth,"—"let the waters bring forth,"—are words that point to a process of growth rather than to a process of manufacture in the origination of living beings. In crude and vague forms, the idea

of evolution was held by some of the Greek philosophers. Just at the beginning of our century Lamarek developed the idea of evolution into something like a scientific theory.

Yet it is no less true that the epoch of evolution in human thought began with Darwin. Manifold suggestions there were of genetic relationships between different organisms, whether organic forms were studied by the systematist or the embryologist, the geographer or the paleontologist; but each and all found the path to any credible theory of organic evolution blocked by the stubborn fact that variations in species appeared everywhere to be limited in degree, and to oscillate about a central average type, instead of becoming cumulative from generation to generation. In the Darwinian principle of natural selection, for the first time, was suggested a force, whose existence in nature could not be doubted, and whose tendency, conservative in stable environment, progressive in changing environment, would account at once for the permanence of species through long ages, and for epochs of relatively rapid change. However Darwin's work may be discredited by the exaggerations of Weismannism, however it may be minimized by Neo-Lamarekians, it is the theory of natural selection which has so nearly removed the barrier in the path of evolution, impassable before, as to lead, first the scientific world, and later the world of thought in general, to a substantially unanimous belief in the derivative origin of species. Certain it is that no discovery since Newton's discovery of universal gravitation has produced so profound an effect upon the intellectual life of mankind. The tombs of Newton and Darwin lie close together in England's Valhalla, and together their names must stand as the two great epoch-making names in the history of science.

Darwin's discovery relates primarily to the origin of species by descent with modification from preëxisting species. It throws no direct light upon the question of the origin of life. But analogy is a guide that we may reasonably follow in our thinking, provided only we bear in mind that she is a treacherous guide and sometimes leads astray. Conclusions that rest only on analogy must be held tentatively and not dogmatically. Yet it would be an unreasonable excess of caution that would refuse to recognize the direction in which analogy points. When we trace a continuous evolution from the nebula to the dawn of life, and again a con-

tinuous evolution from the dawn of life to the varied flora and fauna of to-day, crowned with glory by the appearance of man himself, we can hardly fail to accept the suggestion that the transition from the lifeless to the living was itself a process of evolution. Though the supposed instances of spontaneous generation all resolve themselves into errors of experimentation, though the power of chemical synthesis, in spite of the vast progress it has made, stops far short of the complexity of protoplasm, though we must confess ourselves unable to imagine any hypothesis for the origin of that complex apparatus which the microscope is revealing to us in the infinitesimal laboratory of the cell, are we not compelled to believe that the law of continuity has not been broken, and that at least a reasonable hypothesis as to the method of natural transition from the lifeless to the living may yet be within reach of human discovery?

Still further. Are we content to believe that evolution began with the nebula? Are we satisfied to assume our chemical atoms as an ultimate and inexplicable fact? Herschel and Maxwell, indeed, have reasoned, from the supposed absolute likeness of atoms of any particular element, that they bear "the stamp of a manufactured article," and must therefore be supposed to have been specially created at some definite epoch of beginning. But, when we are speaking of things of which we know so little as we know of atoms, there is logically a boundless difference between saying that we know no difference between the atoms of hydrogen and saying that we know there is no difference. Is it not legitimate for us to recognize here again the direction in which analogy points, and to ask whether those fundamental units of physical nature, the atoms themselves, may not be products of evolution? Thus analogy suggests to us the question, whether there is any beginning of the series of evolutionary changes which we see stretching backward into the remote past; whether the nebulae from which systems have been evolved were not themselves evolved; whether existing forms of matter were not evolved from other forms that we know not; whether creative Power and creative Intelligence have not been eternally immanent in an eternal universe. I cannot help thinking that theology may fitly welcome such a suggestion, as relieving it from the incongruous notion of a benevolent Deity spending an eternity in soli-

tude and idleness. The contemplation of his own attributes might seem a fitting employment for a Hindoo Brahm. It hardly fits the character of the Heavenly Father, of whom we are told that he "worketh hitherto."

In the last suggestion I have ventured outside the realm of science. But most men are not so constituted that they can carry their scientific and their philosophical and religious beliefs in compartments separated by thought-proof bulkheads. Scientific and philosophic and religious thought, in the individual and in the race, must act and react upon each other. It was, therefore, inevitable, that our century of scientific progress should disturb the religious beliefs of men. When conceptions of the cosmos, with which religious beliefs had been associated, were rudely shattered, it was inevitable that those religious beliefs themselves should seem to be imperilled. And so, in the early years of the century, it was said, "If the world is more than six thousand years old, the Bible is a fraud, and the Christian religion a dream." And later, it was said, "If physical and vital forces are correlated with each other, there is no soul, no distinction of right and wrong, and no immortality." And again it was said, "If species originate by evolution, and not by special creation, there is no God." So it had been said centuries before, "If the earth revolves around the sun, Christian faith must be abandoned as a superstition." But in the nineteenth century, as in the sixteenth, the scientific conclusions won their way to universal acceptance, and Christian faith survived. It showed a plasticity which enabled it to adapt itself to the changing environment. The magically inerrant Bible may be abandoned, and leave intact the faith of the church in a divine revelation. The correlation of forces acting in the human cerebrum with those of inorganic nature may be freely admitted; and yet we may hold that there are in the universe other forms of causation than physical energy, and that the inexpugnable belief of moral responsibility is more valid than the strongest induction. The "carpenter God" of the older natural theology may vanish from a universe which we have come to regard as a growth and not a building; but there remains the immanent Intelligence

"Whose dwelling is the light of setting suns,
And the round ocean, and the living air,
And the blue sky, and in the mind of man;"—

the God in whom "we live and move and have our being."

The church has learned wisdom. The persecution of Galileo is not likely to be repeated, nor even the milder forms of persecution which assailed the geologists at the beginning, and the evolutionists in the middle, of our century. And science, too, has learned something. In all its wealth of discovery, it recognizes more clearly than ever before the fathomless abysses of the unknown and unknowable. It stands with unsandaled feet in the presence of mysteries that transcend human thought. Religion never so tolerant. Science never so reverent. Nearer than ever before seems the time when all souls that are loyal to truth and goodness shall find fellowship in freedom of faith and in service of love.

WILLIAM NORTH RICE.

THE DEBT OF THIS CENTURY TO LEARNED SOCIETIES.

Address by Professor WILLIAM H. BREWER, President of the Academy.

In meeting together to rejoice over the completion of a hundred years' work, it is fitting that we should consider what the character of that work has been and what its relations are to the century's progress.

In the few minutes allotted me, any detailed history of the origin of learned societies will be impossible. I wish, therefore, to speak more particularly of the role they have played during the one hundred years of this Academy's existence, and I think it will be found that, in this period, they have been, directly or indirectly, a most potent factor of progress in material advancement and in intellectual culture. Their influence has probably been even greater than that of the universities, in that they have dealt with adult men rather than with youth; for it is from men in mature life that the impulse comes which demands and promotes progress.

When the Connecticut Academy was founded, the terms "learned," "learned societies," and "intellectual culture," were broad and comprehensive in theory, but in active use they were curiously restricted. There were then but three "learned" professions,—law, medicine, and theology. The universities recognized a fourth comprehensive department,—philosophy. But since that date, and chiefly during the last thirty or forty years, the world has acknowledged many other professions as learned. In my own college days, I can not remember of ever hearing the term "professional" engineer, or "professional" chemist, except as applied to the teachers of engineering or of chemistry in technical schools, colleges, or universities. I had never then heard the term "professional engineer" applied to a person whose vocation was that of planning or of carrying out engineering works, nor to the chemist employed in the manufacture of commercial products.

All this now is changed, and the public understanding as to what "learning" signifies is very different. The civil engineer, designing and building great structures; the mechanical engineer, employing abstruse mathematics in economizing the energies used in steam engines, electric motors, or water wheels; the chemist, conducting great metallurgical works or manufacturing commercial products: each is recognized as belonging to a learned profession as truly as is the village lawyer, the parish clergyman, or the country doctor. So, too, the societies of engineers, chemical and other similar associations, are recognized as learned societies as truly as those which are more especially devoted to history, literature, pure science, medicine, or philosophy.

But no line of separation can be drawn between those societies honored with the term "learned," organized for the promotion of intellectual culture, and those designed purely for material or economic objects. Nor does the precise name indicate the intellectual status. Under various designations,—academies, societies, associations, and clubs, they range through every grade.

Very few of the existing academies and learned societies of the world were founded before 1750. But between the middle and the end of the eighteenth century, the great social and industrial revolutions first allowed and then promoted the establishment of many such organizations. Some of these, although relating more particularly to the industries, may in a sense be classed as learned, since the promotion of science for its practical use in the arts of life can not be separated from its promotion for purely scientific investigation or mental culture.

In this country but two "learned societies" had been founded prior to the establishment of the Connecticut Academy, and when the last century closed these were too young to have had much influence. Before our Revolutionary War, the American Philosophical Society of Philadelphia was the only strictly learned society as then understood, but there were also a few local medical associations.

Zoology and botany may be said to have been established by Linnæus about 1750 or a little later. Geology and chemistry had their true beginning during the last quarter of the same century. There were, of course, a science and a literature of botany long before, as there was likewise a so-called science of

chemistry and geology, but these were not founded on natural laws in the sense in which these sciences are now understood.

The practical application of the natural sciences to the arts and industries began with the development of the sciences themselves, and the two went on together, so closely associated that they were never independent of each other. They were parallel and correlated. This was more especially felt as chemistry and geology progressed. Their applications were so important and varied, and the possible effects so far-reaching, that learned men began to take means to disseminate the knowledge gained and to make it available. While investigators in pure science thus labored directly to increase the sum of human knowledge, and indirectly to increase man's intellectual pleasure by contemplation of the phenomena of nature, the practical applications of science furnished the proper stimulus.

Hence, the dawning of the light of modern science inaugurated a new era in the arts and industries. Agriculture and manufactures form the foundation of civilization. Cultured nations subsist on the products of the soil; and without manufactures, particularly of the metals, there can be no considerable wealth. As arts, these industries had been developing from pre-historic times, but as mere arts unaided by science, they furnished little hope for advance in higher development. As populations became denser, and the soil was longer tilled, new problems arose which art alone could not solve. There was and could be no science of metallurgy or of agriculture until there was a science of chemistry; and other industrial arts had scarcely advanced for thousands of years.

As soon as chemistry and geology began to assume the dignity of exact sciences, their aid was, therefore, immediately invoked in various arts and industries. But it was agriculture that made the strongest demands for assistance. Consequently, before the close of the last century, agricultural societies were established in nearly every country of Europe, and in America as well. "*The Philadelphia Society for the Promotion of Agriculture*" was instituted in February, 1785, less than two years after the achievement of our national independence. A similar society was formed in Charleston, South Carolina, in August of the same year; another in New York, in February, 1791, one in

Massachusetts, in March, 1792; and in Connecticut, in August, 1794. The New York society was organized "for the promotion of Agriculture, Arts and Manufactures;" the others specified agriculture only. "*The Connecticut Society for the Promotion of Agriculture*" was founded three and a half years before this Academy, and for many years some of its leading members were the same men who were prominent in the Academy.

The material interest involved was so vast, that a few states attempted to carry on agricultural schools. Finally, in 1862, the United States Congress appropriated land for the establishment of schools of science in every state in the Union; and the organization of Agricultural Experiment Stations soon followed. That all this might have been accomplished in time, without the stimulus of "societies," is possible. It is probable, however, that, but for them, there would have been no such rapid spread of instruction in science and its applications.

We must bear in mind that in 1799 there was very little, if indeed any, natural science taught in the colleges and universities of this country. One or two professors of chemistry were appointed in the very last years of the last century, and a few more in the first decade of this. Instruction in geology came in somewhat later, but for forty years or more after the foundation of this Academy, in only half a dozen of the numerous colleges of the country was anything more than the merest rudiments of chemistry and geology taught, and nothing whatever of natural history except a little botany, which was also taught in some of the medical schools.

During this period, a somewhat better condition of things existed in the universities of Europe. There was a continuous appeal from the various industries to the colleges and higher institutions of learning for more instruction in the natural sciences. But from no other source was this appeal more persistent and at the same time more effective than from the many societies which had been formed in all these countries for the promotion and encouragement of science.

Polytechnic schools were started after a fashion about the beginning of this century, but it was not until later that they came into existence as schools of science, to be pursued for its application to the liberal arts. In a number of cases, these

schools were actually established by local societies, by extending their work from that of interesting adults to the teaching of youth also. To-day, polytechnic institutions are for "higher education," and scientific investigation goes on in them as truly and as zealously as in the universities.

Among the sciences, chemistry and geology have been much alike in their influence in turning the current of popular attention toward science. They are cultivated for their practical applications more than the other natural sciences, and this has brought them into closer touch with the masses of intelligent men in the industries.

So long as chemistry was pursued as a mere art, it was associated with astrology and magic. While its devotees sought the Philosopher's Stone or the Elixir of Life, the outside public looked on with awe and superstition. When the art of alchemy developed into the science of chemistry, there was a sudden burst of light. The mysterious chemical transformations, which before had awakened in the outside world only an awe resulting in superstition, now inspired a new interest, and awe was transmuted into scientific curiosity, a desire to learn what the laws were which controlled the wonderful phenomena.

Geology is so extensively an applied science that it receives more government aid than any other science. Geological surveys are established in every civilized country, because of industrial necessities. The first geological surveys, systematically made, of which I have any knowledge, were instigated and carried on under the direction of the early societies; and later, when states took up the work, it was often the case that this action was first stimulated by the local societies. This Academy initiated an early geological survey of Connecticut. The facts which these surveys brought out called into existence special geological societies. The field geologists had to meet in order to unify and systematize their publications, as well as for mutual instruction and encouragement. The meetings of the American Geologists led to the organization of the wider and more general *American Association for the Advancement of Science*. This in turn has reacted on the general public, and diffused the knowledge gained by special investigators. The great truths thus spread have given intellectual pleasure to thousands who do not study geology for its practical applications.

The oldest geographical society dates back to 1740, and there were but few, if any, more at the close of that century. In this century they have multiplied enormously. Some of them are general, but the great majority are either local or special in their objects. They have done much to extend and disseminate geographical knowledge, but vastly more in stimulating and cultivating a taste for the enjoyment of natural scenery. They followed rather than led the development of the societies for the promotion of geology and natural history, but have had much to do with fostering a love for these sciences in later times. Their most obvious effect on intellectual culture is the part they have played in cultivating a taste for nature, and in changing public sentiment in respect to the appreciation of natural scenery. The contemplation of the beauties of mountains or the sublimity of nature in her grander aspects formed an inconspicuous part of the intellectual pleasures of mankind until lately. Neither in the literature of sacred or profane writers of antiquity, nor in the literature of the middle ages, is there evidence of any such sentiment as pervades the poetry and literature of the century now closing. No one climbed mountains for the sake of enjoying the grandeur of the view, nor visited them to enjoy their beauties. Mountains were held in awe and fear; they were the abode of dragons and demons; they must sometimes be crossed because of necessity, but were never visited for the sake of pleasurable contemplation until scientists led the way. Before the last quarter of the last century, there are two or three records of persons visiting the Alps to see the wonderful glaciers; but to the world at large the Alps were dreary, desolate, awful. There are many allusions in literature to this fact.

As soon as the various branches of natural history began to develop as sciences, mountainous countries became most interesting fields for investigation, and began to be visited by scientific men, particularly those interested in geology, botany, and zoology. In 1760, that eminent scientist and lover of nature, de Saussure of Geneva, visited the valley of Chamounix, and the next year he advertised throughout the region that he would liberally reward any one who could discover a practical way to reach the top of the "Great White Mountain." Further, should the attempts be unsuccessful he would pay for the time lost in seeking a way.

Men crossed the mountains for business, and there were hardy guides well acquainted with the country, but they visited passes, not peaks. And not till more than a quarter of a century later did the guide Balmat succeed in finding a path to the top. The very next year (1787), de Saussure made his famous ascent, the first in history when any high mountain was climbed for scientific observation. There was a second ascent the following year, but no other till 1802. During the twenty-five years after de Saussure, there were less than half a dozen ascents; but no attempts whatever, that I am aware of, were made to climb any other high peaks. About 1840 were begun by Agassiz and Forbes those researches on glaciers, classic in the annals of science.

When these pioneers had successfully frightened away the demons and devils that had so long guarded the mountain mysteries and veiled their beauties, the general public, learned and unlearned people alike, began to find pleasure in the contemplation of the wild and the grand, and this sentiment now finds abundant expression in poetry, song, literature, and art. The exploration of mountains for scientific investigation has resulted in enormous gain to mankind in intellectual and æsthetic pleasure. There is to-day scarcely a mountain range in any country of our civilization but has a society or club of devotees organized for its study. As learned societies, they have greatly promoted our geographical knowledge; incidentally they have contributed in large measure to the amount of pleasure to be derived from travel and from the better appreciation of the beauties of nature.

Switzerland, which had been shunned for two thousand years because of its dreary mountains, has now, because of those same mountains, become the playground of Europe, and mountain climbing, about which so many tales of terror were formerly told, has now become a pastime and a sport. Railways carry the strong and the weak alike to peaks high in the clouds.

The publications of learned societies, under various names and in various ways, furnish by far the most comprehensive literature of science, philosophy, history, and art, that we have. For a time, this was almost the only way of publishing to the world new discoveries. To-day it is as pervasive as it is extensive, and as yet no substitute has been found for this means of publishing and dis-

seminating the details by which results have been obtained, even if the bare results might be made available through the periodical press or other channels. These publications are an important part of every public library, but by reason of their enormous extent no library can be complete in them. It is only when we attempt to investigate their number in any branch of science that we can appreciate the great influence such associations must have had in diffusing learning and information among the mass of the people and in making it available for their industries, their comfort and their intellectual pleasure.

Many of the learned societies maintain libraries and museums, and in some cases these libraries furnish almost the only considerable scientific literature accessible to the community, while the museum gives them further knowledge of other regions of the earth than their own.

Finally, learned societies practice and cultivate the brotherhood of mankind as do no other organizations. Science knows no nation nor country; it is bounded neither by oceans nor continents; its home can not be located by latitude or longitude; it knows no race nor people; it swears special allegiance to no form of government; it is bound by no creed; it claims no one language. A new fact observed, a new law demonstrated, immediately becomes public property. No matter in what continent or country it originates, or to what nation or creed or race the discoverer belongs, or in what language the new truth is first announced; the learned societies discuss it, and pass upon it, they aid in disseminating it, their publications give it a measure of authority, and through the various channels for the diffusion of knowledge it is sure in time to become the common property of mankind.

The function of these organizations will of course be modified in the new century upon which we are approaching, but it is safe to say that they will contribute as greatly to its progress as they have to that of the century now closing. Societies of one kind and another are to-day so numerous, they embrace such a wide range of objects, and there is gathered into them so large a proportion of the active men of all the countries of our modern civilization, that they have come to be the leading and perhaps the most important factor in shaping and directing human activities, both material and intellectual.

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I.—OBSERVATIONS ON THE DIGESTION OF PROTEIDS WITH PAPAÏN.
BY LAFAYETTE B. MENDEL AND FRANK P. UNDERHILL.

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IN his recent book on "The Soluble Ferments and Fermentation," J. R. Green writes: "It is uncertain whether pepsin is represented in the vegetable kingdom. All the proteolytic enzymes which have been fully investigated have been found capable of carrying the hydrolysis beyond the stage of peptone. The work of the earlier observers did not include a careful examination of the products of the decomposition, and hence for the present it remains uncertain whether or no some of the ferments belong to the peptic category."¹ In another connection the same author says: "On a review of all these vegetable proteolytic enzymes it will be seen that our knowledge is not at present sufficiently definite for us to say whether we have to do with one or many. Some of them may be peptic only, though it seems probable that they are all tryptic. Those which have been at all exhaustively examined undoubtedly carry the proteolysis to the stage of crystalline amides. We do not yet know, again, whether there is one enzyme only, varying somewhat in its features according to the conditions of its secretion, or whether the different plants discussed yield different varieties of trypsin. Bromelin and papaïn certainly show very little difference in their behaviour, and one is tempted to pronounce them identical. For the present, however, it is perhaps advisable to leave this question undecided."²

The proteolytic enzyme obtained from the fruit and juices of the melon-tree *Carica papaya* and ordinarily termed papaïn (papayotin),³ has usually been regarded as closely related in its action to the trypsin of the pancreas.⁴ There are, however, very few reliable observations on record which permit one to draw a definite conclusion regarding the class to which the enzyme may properly be assigned. The

¹ J. R. Green: The Soluble Ferments and Fermentation, 1899, p. 195.

² Green: loc. cit., p. 219.

³ Moncorvo employed the term "Caricin." (Jahresbericht für Tierchemie, 1880, x, p. 294.) Other names, such as "Caroid," "Papoid," are applied to commercial preparations of the enzyme.

⁴ Neumeister: Lehrbuch der physiologischen Chemie, 1897, pp. 141, 237. Moore: Schaefer's Text-book of Physiology, 1898, i, p. 403. Oppenheimer: Die Fermente und ihre Wirkungen, 1900, p. 135. (The references to the literature on papaïn and its action are here given.)

earlier investigators were content to note that the extracts of various parts of the plant, and preparations made from them, are able to dissolve proteids like fibrin in the presence of antiseptics, e. g. thymol and hydrocyanic acid. It had long been known that parts of the *Carica papaya* possess a vigorous action in softening meat and were used by the natives of tropical countries, when Wurtz¹ began his more careful studies of the proteolytic enzyme present in the plant. He gave to it the name papaïn, and ascertained that it dissolved fibrin, raw meat, coagulated egg-white and gluten; milk was clotted by it and the precipitated casein subsequently dissolved. He further found that a slightly purified enzyme mixture dissolved fibrin in acid, neutral and alkaline media. Regarding the products formed, Wurtz merely states in one case that 0.1 gram of his papaïn dissolved one hundred grams of moist fibrin in a neutral medium in the presence of HCN in thirty-six hours; from the products formed a small quantity of a crystalline substance having the appearance of leucin was isolated.² No mention is made of tyrosin. Because of the readiness with which it acts in neutral fluids, Wurtz concluded that papaïn is closely related to trypsin.

Somewhat later Martin³ undertook a study of papaïn. He used a commercial preparation in most of his experiments, while in a few cases the dry juice of the unripe fruit was employed. The results of the digestive action of the commercial papaïn on fibrin and egg-albumin solution were reported. Prussic acid was used to prevent putrefactive changes. A quantitative study of this enzyme preparation indicated that it was active in the highest degree in neutral and alkaline solutions (one-fourth per cent. Na_2CO_3); in solutions of higher alkalinity (one-half or one per cent. Na_2CO_3), the action, though well marked, was not so great. Acid prevented the action of the papaïn, though in weakly acid solutions (0.05 per cent. HCl) some degree of digestion may have taken place. Martin also investigated the products formed during the papaïn-digestion of fibrin in neutral and alkaline media. He observed the early formation of a "globulin-like" substance intermediate between the native proteid and the derived alkali-proteid usually formed in proteolysis. We shall have occasion to refer to this body later. It is not precipitated like alkali-proteid when the digestive fluids are neutralized, but separates out

¹ Wurtz and Bouchut: Comptes rendus de l'Academie des Sciences, 1879, lxxxix, p. 425. Wurtz: *ibid.*, 1880, xc, p. 1379; 1880, xci, p. 787.

² Wurtz: Comptes rendus de l'Academie des Sciences, 1880, xc, p. 1379.

³ Martin: Journal of Physiology, 1884, v, p. 213; 1885, vi, p. 336.

abundantly when these neutral fluids are heated. Its occurrence is too characteristic and the quantities formed are too large to be ascribed to traces of unprecipitated alkali-proteid. Peptones (in the older sense) were obtained by concentrating the filtrates from the globulin-like body and precipitating with a large excess of alcohol a substance which gave the biuret reaction and was readily diffusible. From the alcoholic solution, crystals of leucin were obtained. Martin experienced more difficulty, however, in showing the presence of tyrosin. No crystals could be obtained; but when the alcoholic peptone-filtrate was dried, an extract could be prepared from it with absolute alcohol. This solution gave Millon's reaction and led Martin to conclude the presence of tyrosin. In his own words "we have, then, in papaïn a proteolytic ferment acting almost exactly like trypsin: similar in the proneness of decomposition in solution, in its erosion of coagulated proteid: in the formation of an 'intermediate' body from the proteid; and the formation of a perfect peptone, and of leucin and tyrosin."¹ Later Martin obtained impure crystals of tyrosin and leucin from the dried papaw juice, and also apparently identified them in small quantity among the products of the self-digestion of this material. The crude way in which the material at his disposal was prepared by no means excludes the possibility of previous decomposition through the agency of bacteria and the formation of bacterial enzymes.² This might, at least, reasonably be assumed of a "yellow brown powder of sickly smell" obtained by drying, chiefly in the East Indies, the juice of the unripe fruit in the open air and under glass. Furthermore the quantity of leucin and tyrosin—if such they were—obtained in the digestions with large quantities of proteid, was extremely small when compared with the typical results of tryptic proteolysis; and Martin himself has been far more cautious in drawing any final conclusion than have those who have subsequently quoted his investigations. For he says: "It is evident moreover that too general a deduction cannot at present be drawn as to the nature of the proteolytic change, as to whether the agent acts like animal pepsin or like trypsin."³ In studying the literature of papaïn-proteolysis we have been surprised to find upon what scanty and meagre data some of the current statements on the subject are based; and we have dwelt particularly upon these widely quoted observations of Martin to illustrate this point.

¹ Martin: *loc. cit.*, 1884, v, p. 230.

² Some commercial preparations have been reported to contain spores and dead forms of bacilli. (Dowdeswell: *Practitioner*, 1883, xxx, May.)

³ Martin: *Journal of Physiology*, 1885, vi, p. 360.

In 1892, Chittenden¹ published the results of an extensive study of the digestive action of "Papoid," a therapeutic agent prepared from the various parts of the papaw plant, *Carica papaya*. The enzyme-like character of the preparation was clearly shown by the readiness with which it dissolved proteids like fresh and boiled fibrin, raw and cooked beef proteids and coagulated egg-white in neutral, alkaline and acid media, even in the presence of various antiseptic agents.

While the attention of this investigator was directed particularly to the conditions under which the proteolysis proceeds best, he incidentally made several observations with reference to the products formed. With coagulated egg-albumin, a peculiar albumose-like body, a deuteroalbumose, a fairly large amount of peptone and some leucin and tyrosin were isolated. With raw blood-fibrin and cooked beef-proteids similar results were obtained.² Particularly conspicuous was a soluble albumose formed in the fibrin digestions. It was completely precipitable from a neutral solution by heat and partook of the general character of heteroalbumose, being insoluble in water but completely insoluble in salt solutions as well as in dilute acids and alkalis. This substance recalls the "globulin-like" body described by Martin. While calling attention to the points of resemblance between the action of papoid and trypsin, Chittenden points out that the latter is ordinarily associated with an alkaline secretion, and as a proteolytic agent acts to advantage only in alkaline fluids. On the other hand, the action of papoid in neutral solutions is increased by the addition of a very small amount of hydrochloric acid. Wurtz³ has also stated that the liquid juice of the papaw is neutral in reaction. Chittenden therefore merely concludes "that the power possessed by papoid of dissolving various forms of proteid matter is dependent upon an ordinary digestive action akin to, or identical with, that of digestive ferments in general, whether animal or vegetable.

In a subsequent paper from this laboratory⁴ it was demonstrated that not only are true albumoses (in Kühne's sense) formed by various commercial papain preparations acting in different media, but

¹ Chittenden: Transactions of the Connecticut Academy of Arts and Sciences, 1892, ix, p. 298.

² We learn from Professor Chittenden that the quantities of leucin and tyrosin found by him were small at the most.

³ Wurtz and Bouchut: Comptes rendus de l'Academie des Sciences, 1879, lxxxix, p. 425.

⁴ Chittenden, Mendel and McDermott: American Journal of Physiology, 1898, i, p. 255. The references to the literature are given in this paper.

—contrary to the statements of several writers—peptones, *i. e.*, biuret-giving compounds not precipitable by ammonium sulphate or zinc sulphate, are formed in considerable amounts. The latter were separated from digestive mixtures and their physiological action was investigated. Previous to this Neumeister¹ only had directed attention to this point. His report is, however, very scanty, and the commercial preparation of “papayotin” which he used must have been rather inactive; for although it dissolved coagulated egg-white in an alkaline mixture, it failed to digest fresh fibrin or to act in acid or neutral solutions. He arrived at no definite conclusion regarding the nature of the enzyme.

The present investigation is the outcome of an attempt to isolate the end-products of the action of papain upon purified proteids. Relying upon such statements as have been introduced into the literature on this subject, we had expected to find a marked resemblance in character between the products formed by trypsin and those resulting from papain proteolysis. Our experiments, on the contrary, soon indicated that pronounced differences exist. From the data accumulated we feel justified in reporting some additional features regarding the action of the papaw enzyme. We have not been fortunate enough to secure specimens of the fruit itself for study; but the results obtained with four commercial preparations from different sources are fairly concordant and characteristic and give no occasion to suspect the extensive admixture of other enzymes. These preparations will be referred to below as Papain A, B, C, and D; they were bought under the names of “Papoid,” “Caroid,” “Papain (Lehn and Fink’s),” and “Papain (Merck’s)” respectively. Our observations will be considered under four chapters in the part following.

I. The Influence of the Reaction on the Proteolytic Action of Papain.

A survey of the literature on the action of papain shows that the observers have by no means been agreed regarding the conditions of reaction under which proteolysis proceeds favorably. Wurtz, the earliest careful investigator of this point, and Chittenden, who made the most exhaustive study (with “papoid”), both found the enzyme active in acid, alkaline and neutral media, as already indicated. Similar observations were made by Polak² with two papain prepara-

¹ Neumeister: *Zeitschrift für Biologie*, 1890, xxvi, p. 82.

² Polak: *Jahresbericht für Thierchemie*, 1882, xii, p. 254.

tions in the digestion of various proteids. While nearly all writers have found that weakly alkaline fluids favor the action of papaïn, there has been great diversity of experience regarding the influence of acid reaction.¹ Undoubtedly the conditions determining the character of the acid reaction, *i. e.*, the presence or absence of *free* mineral acid, are of decisive influence and have been overlooked in this connection, as frequently elsewhere, in discussions regarding enzyme activity.² Our own experiments confirm the results obtained by the three writers above named in showing pronounced proteolytic activity in digestive mixtures with various reactions.

Methods. The general course of these experiments has been to treat the proteid used with relatively concentrated solutions of the enzyme preparation under examination, enough sodium fluoride being dissolved in the mixture in every case to make the total strength of this antiseptic equivalent to at least one per cent. Previous trials had demonstrated that this salt does not interfere seriously with the action of papaïn.³ The digestions were carried on in an oven at 37° C. In the series of quantitative trials reported below ten grams of moist coagulated egg-white, finely comminuted, were used. To this, 50 c.c. of 0.2 per cent. HCl were added for the acid digestions, 50 c.c. of 2 per cent. HNaCO₃ solution for the alkaline digestions, and 50 c.c. of water for the neutral media. Finally 1.5 grams of papaïn were digested with 125 c.c. of water and 50 c.c. of the filtrate were employed in each digestion. Each digestion mixture was thus made up as follows :

10 grams of moist proteid (2.025 grams of dry proteid),	
100 c.c. of fluid containing 1 gram NaF,	
papaïn and	{
	0.1 per cent. HCl, or
	1.0 “ HNaCO ₃ , or
	water.

Control trials were simultaneously carried out with boiled papaïn solutions, and lastly the solvent action of the fluids used was ascertained.⁴ After allowing the digestive action to proceed at 37° C.

¹ For the literature references on this point see Oppenheimer: *Die Fermente und ihre Wirkungen*, 1900, p. 136; also Pickardt: *Centralblatt für Physiologie*, 1900, xiv, p. 351.

² *Cf.* Hanford: *American Journal of Physiology*, 1900, iv, p. 250.

³ *Cf.* Chittenden, Mendel and McDermott: *American Journal of Physiology*, 1898, i, p. 259.

⁴ The complete extent of digestive action is not always accurately represented in this way, since what is estimated as undigested residue may frequently be made up in part of transformation products, like antialbumid, resulting from the work of the enzyme.

with frequent agitation of the mixture for four hours, it was stopped by heating, and the undissolved residue filtered upon dried and weighed ash-free papers, then thoroughly washed with hot water and dried to constant weight at 105° C. From the figures thus obtained the percentage of proteid dissolved was calculated. The results are tabulated below.

PAPAÏN DIGESTION OF COAGULATED EGG-ALBUMIN.

(The figures indicate the percentages of proteid dissolved.)

Medium.	Papaïn A.		Papaïn B.		Papaïn D.		Controls with- out Papaïn Solution.
	unboiled	boiled	unboiled	boiled	unboiled	boiled	
0.1 per cent HCl,	8.7	2.3	14.5	2.9	40.6	5.4	6.0
1.0 " HNaCO ₃ ,	24.0	8.7	54.0	1.2	66.7	2.1	4.2
water,	16.6	0.8	41.7	4.0	72.7	6.1	2.4

In evidence of the statement already made regarding the activity of papaïn preparations in both alkaline and acid media, we might add many additional data. In numerous qualitative tests with various papaïn preparations acting on fibrin, casein, boiled and unboiled muscle tissue, in the presence of 2 per cent. NaF and in media acid with 0.1 per cent. HCl, or alkaline with 1.0 per cent. HNaCO₃ or 0.5 per cent. Na₂CO₃, or in approximately neutral fluids, vigorous solvent action was always observed. In considering the relatively weak digestive action noted above in the case of the acid mixtures, it should be borne in mind that the strength of acid here recorded is rather large¹ and by a selection of more appropriate conditions the solvent power could doubtless have been considerably increased.

II. *Are Leucin, Tyrosin and Tryptophan formed by Papaïn?*

When trypsin acts upon ordinary proteids, leucin, tyrosin and tryptophan (proteinochromogen) are speedily formed in considerable quantities. These compounds do not arise in appreciable amounts in pepsin-HCl digestion under ordinary circumstances, although some recent experimental work leads to the conclusion that relatively simple bodies (including leucin) may occur in prolonged proteolysis with pepsin. Thus Lawrow² found large quantities of leucin formed by the self-digestion of 12 kilos of pigs' stomachs with 35

¹ Cf. Chittenden: Transactions of the Connecticut Academy of Arts and Sciences, 1892, ix, p. 307.

² Lawrow: Zeitschrift für physiologische Chemie, 1899, xxvi, p. 513.

litres of 0.6 per cent. HCl at 40°–45° C. for two months. Experiments of this type will scarcely appeal to one as offering reliable evidence regarding the work of the enzyme pepsin, especially as no control experiments to show the influence of such large excesses of free hydrochloric acid are presented. How vigorously dilute acids alone may act on proteids has been shown by Fr. Goldschmidt.¹ More important, however, are experiments like those of Pfaundler.² This investigator showed that while in prolonged pepsin-HCl digestion there arise products which no longer give the biuret reaction, leucin and tyrosin cannot be found readily formed. Tryptophan, in particular, has always been regarded as a typical product of tryptic enzymes, although Malfatti³ has recently observed that it may be formed by extracts of the stomach. He gives no conclusive proof, however, that the action is due to the enzyme pepsin. Tyrosin has not been found among the products of pepsin-proteolysis.

Bertrand⁴ and others have shown that extracts of *Russula delica* and other species of fungi contain an oxidizing enzyme, which they named tyrosinase, and which brings about a black coloration when added to solutions containing tyrosin. The reaction is one of oxidation and may be observed with many genera. Harlay⁵ has subsequently asserted that this reaction is a delicate test for the presence of tyrosin and enables one to distinguish between the products of peptic and tryptic digestion. With peptic digestion mixtures the extracts of *Russula* yield a red, then green color; tryptic products turn red, then black. Applying this test to the products of papaïn digestion, Harlay⁶ has observed a resemblance in reaction to that obtained with the peptic digestion products. Although these observations, published during the progress of our experiments, were made with extracts of a different member of the papaw family, viz., *Carica hastifolia*, they lend additional evidence to the results which we have obtained with the closely related species.

¹ Goldschmidt: Ueber die Wirkung von Säuren auf Eiweissstoffe. Inaugural-Dissertation, 1898, Strassburg.

² Pfaundler: Zeitschrift für physiologische Chemie, 1900, xxx, p. 99.

³ Malfatti: Zeitschrift für physiologische Chemie, 1900, xxxi, p. 43.

⁴ Bertrand: Bulletin de la société chimique, 1896 (3), xv, p. 793. Bourquelot: Bulletin de la société mycologique de France, 1897, xiii, p. 65. Cf. also Green: The Soluble Ferments and Fermentations, 1899, pp. 299, 300.

⁵ Harlay: Journal de pharmacie, 1899 [vi] 5, p. 225.

⁶ Harlay: Abstract in Journal of the Chemical Society, 1900, Part I, July, p. 419.

We have searched for leucin, tyrosin and tryptophan among the products of papain digestion under a variety of conditions. In a very large number of experiments we have uniformly failed to detect them. They are therefore, in our opinion, not normal products of the proteolytic action of papain. Enzyme preparations from four different manufacturers were tested in solutions of differing reactions and on the following proteids: casein, fibrin, coagulated egg-albumin, muscle tissue (boiled and unboiled). Only in one series of experiments, viz., those with unboiled muscle tissue, did the products already referred to regularly appear. These cases will be considered in detail below.

Methods. The digestions were carried out at 35°–38°C. in the presence of two per cent. sodium fluoride, or thymol, to avoid bacterial decomposition. The reaction of the digestive mixtures varied as described on page 6. At the end of varying periods of time they were filtered and neutralized, when necessary; the fluids were then heated on the water-bath, and after the removal of the characteristic albumose-like body which usually separates out, they were concentrated to a small volume and set aside in a cool place to allow bodies like leucin and tyrosin to crystallize out. Finally the residues were extracted with warm alcohol to remove some of these latter compounds and eliminate the greater part of the soluble proteids. The alcoholic extracts were in turn concentrated, allowed to stand, and carefully examined under the microscope for crystals of leucin and tyrosin. Tryptophan was searched for by the bromine-water test both in the original concentrated neutralized solution and in the final alcoholic extracts.

The results of over sixty trials made with the four papain preparations (more particularly with papain A, B and D) and with the proteids mentioned, were entirely negative so far as the appearance or detection of leucin, tyrosin or tryptophan was concerned. The observations were so concordant in this respect, that it is scarcely necessary to enumerate the variations in time of digestion, the reaction of the digestive media, the quantity of enzyme used and other details. Comparisons with control trials always indicated a vigorous digestion in every case. In some instances the digestion was allowed to continue at 35°C. for over a month without altering the results noted. Only with fresh muscle tissue were these tryptic end-products obtained. When hashed muscle (lean beefsteak), washed free from blood with water, was digested with papain in the presence of two per cent. sodium fluoride, the tryptophan reaction was repeatedly

obtained in the acid digestions; and frequently typical leucin crystals, less often characteristic tyrosin crystals, could be detected with the microscope. There was no difference in the three papain preparations in this respect. The suspicion that the meat thus prepared long after the death of the animal might be contaminated with bacterial enzymes, led to the use of dog's and rabbit's muscle removed from the freshly killed animal immediately after perfusion of the blood-vessels with isotonic sodium chloride solution to wash out the blood completely. Precisely similar results were obtained with such material in the acid and neutral media. Finally trials were made with muscle tissue previously heated in boiling water. With the boiled muscle no leucin, tyrosin or tryptophan was ever obtained. These facts seem to indicate the existence of an enzyme in the muscle tissue which may assist in the proteolysis accomplished by papain on the fresh tissue and may carry the action to a stage where relatively simple products are formed. The self-digestion (autolysis) of muscle after exclusion of bacteria by the use of chloroform-water, was observed long ago by Salkowski.¹ He failed to find leucin and tyrosin among the products. More recently Jacoby² obtained large quantities of leucin, tyrosin and also tryptophan in the self-digestion of the liver. These observations indicate an explanation for the exceptional results obtained with fresh muscle tissue in our papain digestions, by referring to the muscle itself the active agent in the production of tryptophan, etc., in these cases—a conclusion which is supported by the uniformly negative results obtained with the heated tissue.

III. The Nature of some Products of Papain Proteolysis.

While the experiments just outlined indicate the marked difference between trypsin and papain-proteolysis so far as the end-products formed under ordinary conditions are concerned, a closer study of the primary products has shown them to resemble in many respects the bodies obtained under similar conditions in pepsin-hydrochloric acid digestion. Our investigation in this direction has been confined to the proteid casein, since this is readily obtained in large quantities in a state of considerable purity. The products formed from casein by pepsin-hydrochloric acid have been investigated by Chittenden³ and

¹ Salkowski: *Archiv für Physiologie*, 1890, p. 554; *Zeitschrift für klinische Medicin*, 1890, xvii, Supplementband, p. 77.

² Jacoby: *Zeitschrift für physiologische Chemie*, 1900, xxx, p. 162.

³ Chittenden: *Studies from the laboratory of physiological chemistry*, Yale University, 1887, ii, p. 156; 1889, iii, p. 66.

his pupils, and more recently by Fr. Alexander.¹ The latter employed the method of fractional precipitation introduced by E. P. Pick² for the albumoses. We have followed their scheme of analysis quite closely, and refer to the papers of the writers mentioned for the details of the method. The separation of the individual caseoses was made in the neutralized and somewhat concentrated digestion filtrates, after removal of the characteristic albumose-like substance which has already been referred to as precipitating when heat is applied. Instead of reproducing our protocols at length, we give an outline of one of several experiments with casein and then add a brief resumé of the main results ascertained from all the trials.

Experiment A. In this experiment $1\frac{1}{2}$ kilos of moist casein obtained from skimmed milk and purified by re-precipitating three times were treated with $2\frac{1}{2}$ liters of 0.25 per cent. Na_2CO_3 , 4 grams of papaïn A and strong alcoholic thymol solution. The mixture was kept at 38° C. for 11 days. During this interval portions had repeatedly been withdrawn and examined for leucin, tyrosin and tryptophan (as described on page 9) with negative results. Therefore 4 grams of papaïn were again added. After digesting for 7 days longer, during which time samples had again been withdrawn and examined for leucin, etc., with negative outcome, the material was filtered and neutralized with acetic acid, whereupon a very slight precipitate was obtained. The filtrates were then concentrated as already indicated, until they contained about ten per cent. of dissolved substance. On treatment of the carefully neutralized fluid with saturated ammonium sulphate solution, Fraction I., which began to be precipitated when a content of 2.6 c.c. of saturated ammonium sulphate solution in a total volume of 10 c.c. was reached, was completely separated when 6 c.c. of the sulphate solution were present. In a large portion of digestion material this fraction was then precipitated by mixing ten volumes of the digestive solution with nine volumes of ammonium sulphate solution (following Alexander),³ and after standing, this fraction was filtered off completely. In this filtrate the lower limit of precipitation was found to be 5.1 c.c., and the upper limit at 6.7 c.c. of ammonium sulphate solution. Fraction II. was then separated from a larger quantity of the original material by adding one volume of it to three volumes of saturated ammonium sulphate solution. For this filtrate obtained therefrom, lower and upper precipitation limits of 7.8 c.c., and about 9.5 c.c. of ammonium sulphate solution respectively were ascertained. Fraction III. was therefore removed by saturating the remainder of the original digestion material with ammonium sulphate crystals and filtering after some hours. When the salt-saturated fluid thus obtained was further treated with $\frac{1}{10}n$ sulphuric acid (saturated with ammonium sulphate) a precipitate, Fraction IV., separated. It was relatively large in quantity and was removed by adding one-half volume of the salt-saturated acid to the entire fluid. The filtrate still gave a strong biuret reaction, indicating the presence of pep-

¹ Alexander: *Zeitschrift für physiologische Chemie*, 1898, xxv, p. 411.

² Pick: *Zeitschrift für physiologische Chemie*, 1897, xxiv, p. 246.

³ Alexander: *Zeitschrift für physiologische Chemie*, 1898, xxv, p. 418.

tones. The latter were removed by precipitation with an equal volume of Lugol's solution saturated with ammonium sulphate. This peptone precipitate could always be divided into two fractions, one insoluble (V) and the other soluble (VI) in 95 per cent. alcohol. These portions both gave the biuret reaction.

Experiment B. This was carried out under precisely the same conditions as Experiment A, except that 2.2 liters of 0.02 per cent. HCl were added instead of the alkali. A total of 8 grams of papaïn A was added, and the digestion stopped after 28 days. No leucin, tyrosin or tryptophan were found. The results of the fractional analysis are given below.

Experiment C. Alkaline digestion containing 300 grams of freshly precipitated casein, 1500 c.c. of 0.25 per cent. Na_2CO_3 , 4 grams of papaïn B and thymol solution. Digestion at 38° C. for 26 days.

Experiment D. Acid digestion like Experiment C except that 1500 c.c. of 0.02 per cent. HCl were added in place of the alkali.

Experiment E. Alkaline digestion like Experiment C, the enzyme used being papaïn C. Digestion at 38° C. for 26 days.

Experiment F. Acid digestion like Experiment D, with papaïn C. Digested at 38° C. for 26 days.

A summary of the results of the fractional precipitation of the digestion products according to the general plan outlined under Experiment A follows. The figures given indicate cubic centimetres of saturated sulphate solution in a total volume of ten cubic centimetres.

FRACTIONAL ANALYSIS OF THE PAPAÏN DIGESTION.

Preparation Used.	Conditions of Experiment.	Limits of Fraction I.	Limits of Fraction II.	Limits of Fraction III.	Character of Fraction IV.	Character of Fraction V.	Character of Fraction VI.
Papaïn A	A. alkaline	2.6—6.0	5.1—6.7	7.8—9.5	light	more than VI	light
	B. acid	2.6—5.8	5.1—6.9	7.6—9.5	heavy		
Papaïn B	C. alkaline	2.4—?	5.3—?	7.8—9.5	"	" " "	"
	D. acid	2.2—?	5.5—?	8.0—9.5	light		
Papaïn C	E. alkaline	2.6—?	5.5—?	7.8—9.5	very light	light.	more than V
	F. acid	2.4—?	5.3—?	8.0—9.5	heavy		
Pepsin ¹	Acid	2.6—4.4	5.2—7.2	8.2—9.5			

The results obtained with different enzyme preparations and under varying conditions show a fairly close agreement with one another and a resemblance to those already published by Alexander for the gastric digestion of casein. He concluded that at least four caseoses and two casein-peptones are formed in the pepsin-hydrochloric acid proteolysis of casein. Our results indicate that similar products may arise through the action of papaïn, and they lend additional emphasis to the specific character of papaïn as an enzyme.

¹ Alexander: Zeitschrift für physiologische Chemie, 1898, xxv, p. 418.

IV. General Conclusions.

The observations recorded in this paper indicate that papaïn belongs to a class of enzymes which differs somewhat in type from the two proteolytic enzymes that have received most careful investigation in the past, viz., pepsin and trypsin. While the products of the papaïn digestion of proteids resemble quite closely those of pepsin so far as these have been examined in detail, the enzyme differs from ordinary animal pepsin in that it acts readily in both neutral and alkaline media. On the other hand, although papaïn is comparable with trypsin in exerting a solvent action in fluids of various reactions, the failure to form leucin, tyrosin and tryptophan in appreciable quantities—at least under conditions in which they are readily formed in large quantities by other tryptic enzymes—places it in a class of its own for the present.

The failure of papaïn to conform exactly with any of the standards set in the past for proteolytic enzymes need not surprise us. The more carefully such enzymes—especially those from vegetable sources—are being examined with reference to their activities, the more varied are found to be the manifestations which characterize and distinguish them. We may refer, for example, to bromelin, the proteolytic enzyme of the pineapple (*Ananassa sativa*), which has been studied very thoroughly by Chittenden.¹ Bromelin readily forms leucin and tyrosin in large quantities in both acid and neutral media, besides the characteristic proteoses and peptones.² This recalls the proteolytic enzyme of the yeast, discovered by Salkowski³ and quite recently found by Hahn and Geret⁴ in the yeast juice expressed by Buchner's method. It acts with intense vigor, giving rise readily to leucin and tyrosin; peptone is not obtained and albumoses occur only in traces; acid reaction is favorable, while alkalies retard digestion with it. The circumstance that the favorable reaction corresponds with the one best for pepsin, while the products formed resemble those resulting in trypsin proteolysis (the absence of peptones being unique), has led Hahn and Geret to classify this yeast enzyme by itself and to give it a new name: yeast endotrypsin.

¹ Chittenden: *Journal of Physiology*, 1893, xv, p. 249.

² In unpublished experiments by O. H. Schell, Ph.B. and one of us, tryptophan and other end-products were found in addition to those already described.

³ Salkowski: *Zeitschrift für physiologische Chemie*, 1889, xiii, p. 527.

⁴ Hahn and Geret: *Zeitschrift für Biologie*, 1900, xl, p. 117.

Similarly the enzyme found by Green¹ in the germinating seeds of *Lupinus hirsutus* acts in acid media, forming leucin and tyrosin; but the primary products are also found. Related enzymes have been described by others. The proteolytic enzyme of the pitcher plant, *Nepenthes*, which Vines² has studied, seems to resemble pepsin most closely; for it acts only in acid fluids, forming large quantities of albumoses, small amounts of peptone and only traces of leucin, if any. Tyrosin has not been obtained. In writing of various vegetable enzymes, Vines says: "It is a remarkable fact that, whatever may be the reaction of the medium in which they can work, all these enzymes are essentially tryptic in their mode of action; in fact it is not improbable that this may be a characteristic feature of all vegetable proteolytic enzymes whatsoever."³ On the contrary, we believe that the actual experiments of Vines, as well as the work recorded in this paper, make it more probable that plants, like animals, produce various kinds of proteolytic enzymes.⁴

APRIL, 1901.

¹ Green: Philosophical Transactions of the Royal Society, London, 1887, B, clxxviii, p. 39.

² Vines: Annals of Botany, 1897, xi, p. 563; 1898, xii, p. 546.

³ Vines: loc. cit., 1898, xii, p. 555.

⁴ Cf. Pfeffer: Pflanzenphysiologie, 1897, i, p. 511-512.

II.—ADDITIONS TO THE FAUNA OF THE BERMUDAS FROM THE YALE EXPEDITION OF 1901, WITH NOTES ON OTHER SPECIES.

BY A. E. VERRILL.

THE following additions to the fauna of the Bermudas are due almost entirely to the large collections made in the spring of 1901, by Mr. A. H. Verrill, who was there from March 7th to May 9th, and the writer, who took part in the work from April 10th to May 9th. Dr. W. G. Van Name joined us during the latter part of the time, but he worked chiefly on the Tunicata, which are not included in this article.

About 75 species of insects and 25 species of spiders were also obtained. Many of these were not before known from Bermuda, but they will be treated in subsequent articles. The numerous Isopoda and Amphipoda, and most of the Annelida, also remain to be studied, as well as many of the smaller shells, among which there are probably many additions to the fauna. There are also some additional land shells, Myriapoda, earthworms, etc.

I have added notes on some of the rarer or less known species, of those previously recorded,* where such information seemed particularly desirable, for the benefit of future students.

That so many species of comparatively large and conspicuous marine animals could be added in a few weeks to the fauna of a locality, where so many previous collections have been made, may seem strange. This is due, however, partly to a very careful scrutiny of the hiding places of those forms that depend upon concealment for their safety, partly upon the fact that localities were visited where we did not collect in 1898, in which certain species seem to be localized, and perhaps, in some cases, upon the earlier season of the year (March), when some of the new forms came into shallow water to spawn.

The illustrations are mostly from colored drawings, made from life, by Mr. A. H. Verrill. Others are from photographs made by him, either from living or freshly killed specimens. It is unfortunate that the colored figures could not now be reproduced in colors by the Academy, for in these groups of soft-bodied animals the colors are often highly characteristic, as well as beautiful.

The marine invertebrate fauna of the Bermudas, now known, includes about 900 species. The known fishes are about 200.

* Species previously recorded are in italic type. Those now first recorded (so far as known) are in black-face type.

CRUSTACEA.

DECAPODA.

Epialtus bituberculatus M. Edw. (?) var. *Bermudensis* Ver.

PLATE I. FIGURE 1.

This form differs so decidedly from the several so-called varieties of *E. bituberculatus* figured by A. Milne-Edwards (Crust. Reg. Mex., p. 137, pl. xxvii) that it seems necessary to give it, at the least, a varietal name. Indeed, the differences are so great as to indicate a distinct species, but, unfortunately, we obtained only a single example. It resembles the *E. Braziliensis* Dana, considered a variety by A. M. Edw., more than var. *affinis* Stimp. From both it differs in having a much longer and differently shaped rostrum; in the more transverse front edge of the carapax and the much deeper emargination on the sides; the more prominent lateral tubercles; the much longer legs and chelipeds; and especially in the much longer and differently shaped chelæ.

The length of the rostrum to that of the rest of the carapax is as 1:1.62; the length of the carapax (without rostrum) to its breadth is as 1:1.30; the length of the chelæ is equal to that of the carapax to base of rostrum; the length of the chelæ to the breadth is as 3:1, their distal portion being decidedly the larger. Total length of carapax and rostrum, 15.7^{mm}; greatest breadth, 12.3^{mm}; length of rostrum, 12^{mm}; of chelæ, 10.3^{mm}.

The sides of the carapax are deeply concave in outline between the two tubercles; the anterior tubercles are much the larger, but the posterior are a little more prominent and more acutely angular, their anterior edge being incurved. The rostrum is rather long with the outlines in front of the eyes distinctly incurved, but the tip is obtusely rounded; there is a pair of distinct angular denticles in front of the eyes, back of which the outlines are nearly parallel. The front margins of the carapax are nearly transverse, sloping but little from the orbits to the antero-lateral tubercles, which are bluntly rounded.

The color in life was brownish purple, becoming greenish anteriorly and grayish on the legs; on the posterior part of the carapax there is a large, broad T-shaped spot of cream-color. Chelipeds yellowish brown, the claws whitish.

Flatts Inlet, cut out of a deep hole in a ledge, one specimen only, April, 1901 (A. H. V.).

The *E. bituberculatus* is recorded from Chili, Panama, Florida (var. *affinis*), Brazil, etc.

Pericera subparallela Stimp.

Pericera subparallela Stimpson, Ann. Lyc. Nat. Hist. N. York, vii, p. 182 [54], 1860, (St. Thomas.) A. Milne-Edw., Crust. Reg. Mex., p. 54, pl. xiii, figs. 3-3d, (Gaudaloupe.)

A single specimen of this species, from Bermuda, was in the collection of 1898. It has been determined by Miss M. J. Rathbun.

Platypodia spectabilis (Herbst).

Cancer lobatus Milne-Edw., Hist. Nat. Crust., i, p. 375.

Attergatis lobatus Stimpson, Ann. Lyc. Nat. Hist. N. York, 1860, p. 74.

Lophactea lobata A. Milne-Edwards, Nouv. Arch. Museum, Mem. I, p. 249, pl. xvi, fig. 3; Crust. Reg. Mexico, p. 242. Rankin, Annals N. York Acad., xii, p. 529.

PLATE I. FIGURE 2.

Several specimens of this beautiful species were obtained under stones and among bright colored sponges. In life its colors are very bright, but imitative of sponges, etc. The carapax is bright orange-red with particolored, irregular, broad streaks, blotches, and angular or rounded ocellated spots of various sizes. These generally have a small, bright yellow center, surrounded by a wide white band, which is edged with bright blue and surrounded by a thin black line. The arrangement of the spots and blotches is variable. Sometimes small, round, ocellated spots, with the several colors distinct, occur on the large light blotches, either singly or in lines or groups; others are scattered over the carapax. The chelipeds and legs are colored in the same way, but here the spots mostly take the form of half-bands, or angular patches at the joints. The tips of the claws are black. The larger patches of color are often unsymmetrically arranged on the carapax, which tends to obscure its outline and increases the imitative effect.

Cardiosoma Guanhumii Latr. Great Land Crab.

M.-Edw., Illust. ed. Cuvier, pl. xx, figs. 1-1i. S. I. Smith, these Trans., ii, p. 143, pl. v, fig. 3, 1870.

In addition to the locality for this large land crab on Cooper's Island, mentioned in my former paper (vol. x, p. 573), we this year found its large holes in considerable numbers near the shore at Hungry Bay, on the south side of the Main Island. As the holes are very deep and generally excavated among stones and the roots of trees, it is very difficult to dig them out. They are said to come out of their holes in the night, in summer. If so they might, perhaps, be captured by torchlight.

Cyclois Bairdii Stimpson.

Cyclois Bairdii Stimpson, Notes on N. Amer. Crust., II, Annals Lyc. Nat. Hist. New York, vol. vii, p. 237 [109], 1860, (Cape St. Lucas.)

M. J. Rathbun, Proc. U. S. Nat. Mus., xxi, p. 610, 1898; Bull. Univer. Iowa, 1898, p. 290, (Bahamas.)

PLATE II. FIGURES 1, 2.

In life the carapax is pale yellow or yellowish white with several rows of lemon-yellow spots and with rather numerous smaller spots of bright red or crimson, chiefly near the lateral margins and on the antero-lateral teeth. Chelipeds and legs brighter yellow, banded and spotted with bright red. The chelæ have a large crescent-shaped spot of red on the inner side at the joint, and the tips and dorsal spines are red; two spots of red on the carpus. Ambulatory legs brighter yellow, with three or four bands of red and purple at the joints and with marginal lines of purple; eye-stalks orange and yellow. Two living specimens of this species, about two inches broad, were taken by A. H. Verrill, in shallow water on a sandy bottom, near "Waterloo," Castle Harbor, April, 1901. The cast shells, some of them of larger size, were also found on the north side of Long Bird Island, opposite the sand flats, in May.

It was originally described from Cape St. Lucas, where it is abundant. Specimens from Panama (Capt. J. M. Dow) are in the Museum of Yale University. Miss M. J. Rathbun has recorded it from the West Indies. She considers our specimens identical (judging from the photographs).

Olibanarius Verrillii Rathbun.

Amer. Journ. Science, xi, p. 328, April, 1901.

PLATE VIII. FIGURE 2, 3.

A few small specimens that appear to belong to this species were taken this year, at Hungry Bay. The figure, here given, is from one of the original types.

Albunea oxycephala Miers.

PLATE VIII. FIGURE 1.

A large and perfect living specimen of this fine species was dug out of the sandy beach, between tides, near Hungry Bay, February, 1901, by Mr. T. G. Gosling, and presented to us. The photograph, here reproduced, was from this specimen. No other example was found. It is probably rare at this season of the year, but like *Hippa*, it may be more common in summer. Its color, in life, was

yellowish white, or about the color of the shell-sand in which it lives.

Tozeuma Carolinensis Kingsley.

Tozeuma Carolinensis Kingsley, Proc. Acad. Nat. Sci., Philad., 1878, pp. 90, 328, 1879, p. 413, pl. xiv, fig. 8; Amer. Naturalist, xxxiii, p. 715, fig. 8, 1899.

A small, slender and delicate shrimp. Rostrum long, flat, and narrow, its edge nearly straight above, without teeth, above or below but with a fine spinule at the base, back of the eyes; at tip, which is subacute, there are fine spinules, and hair-like ones below.

Chelipeds much shorter than the other legs, with a short swollen claw and a short, round carpus. Second pereopods much longer and more slender, with a small chela and a short carpus.

Other legs long and slender, not chelate; eye-stalks are short, swollen at base.

Dredged in three fathoms, on a soft weedy bottom, in Castle Harbor, May, 1901.

Thor Floridanus Kingsley.

Thor Floridanus Kingsley, Proc. Acad. Nat. Sci. Philad., 1878, p. 95; op. cit., 1879, p. 421, pl. xiv, fig. 6; Amer. Naturalist, xxxiii, p. 718, fig. 20, 1899.

A small, stout-bodied, smooth shrimp, with large conspicuous black eyes, on stout stalks, and a short rostrum, not quite reaching the tips of the eyes, and having four or five acute denticles on the sloping upper edge; but none below. The anterior feet are stouter and shorter than the next pair, with small, rather short chelæ. Those of the second pair are decidedly longer and filiform, with minute chelæ and a very slender, 5-jointed carpus. The other legs are of about the same length, but stouter and subequal.

The body and legs are translucent whitish with minute specks of orange-red; eye-stalks, antennal scales, and outer maxillipeds tinged with orange in formalin (this color was not noted in the living specimens). Eggs rather large, not very numerous, orange in formalin.

Dredged in "The Reach," in two to three fathoms, shell-sand and mud, May 5th, 1901. Two females with eggs.

Gnathophyllum Americanum Guérin.

Gnathophyllum Americanum Guérin, in La Sagra's Hist. I. Cuba, vol. vii, p. xx; atlas, vol. viii, pl. ii, f. 14, 1857.

Verrill, Amer. Journ. Sci., vol. xi, p. 328 (note), April, 1901; *Pontonidæ*, sp., these Trans., x, p. 579.

The carapax is smooth, curiously banded with black and yellow. In the egg-bearing female it is much swollen laterally. The first and second legs are chelate. The first leg is smaller and somewhat shorter; its carpus is elongated and clavate, longer than the chela. The second leg is much shorter and rather larger, and its chela is strong but not much enlarged; carpus shorter than chela (about one-half as long); hand much longer than claw. Other legs simple, slender, subequal, the last two rather longer. Rostrum short, obliquely truncated; the tip is acute and reaches almost to the end of the ocular peduncle, or to the base of the eye; basal part of the upper edge is short and straight, smooth; it then slopes rapidly to the tip, with about five close teeth. Eye-peduncles project straight forward, and are of moderate length; a spine is situated below and back of its base and above the base of the antenna. The edge of the carapax is cut away at the bases of the antennæ and then extends forward. Abdomen is swollen and the edges overlap in an angle below it, so as to conceal the cluster of eggs.

Color, in life, is conspicuous and characteristic. The carapax and abdomen are covered with many narrow, transverse bands of bright yellow and black of about equal width. The telson is pale yellow with basal and terminal spots of orange. Antennæ purplish blue; eye-stalks light yellow; legs pale yellow, each with two dark blue bands edged with orange; chelipeds with a single, blue carpal band, edged with orange; chelæ pale yellow. This curious species, of which only a few poor specimens have been previously recorded from Bermuda (*Amer. Journ. Sci.*, xi, p. 328, 1901), was taken alive at Hungry Bay, April 5th, 1901, by A. H. Verrill, who made a colored sketch of it.

This specimen is a female carrying a large cluster of eggs.

STOMATOPODA.

Pseudosquilla ciliata Miers.

Pseudosquilla ciliata Miers, *Annals and Mag. Nat. Hist.*, Ser. V, vol. v, p. 108, pl. iii, figs. 7, 8, 1880. Brooks, *Voy. Chall.*, xvi, pp. 53-55, pl. xv, fig. 10, 1886. Bigelow, *Proc. U. S. Nat. Mus.*, xvii, p. 499, 1894. Rankin, *Annals N. York Acad. Sci.*, xii, p. 545, 1899.

P. stylifera Von Martens (t. Miers).

The color of this species is quite variable, like that of *Gonodactylus chiragra*, with which it is often associated. Frequently the colors are imitative of the sandy bottom, the back being variegated or specked with white on a gray or pale yellow ground; in other cases

it is dull yellowish green or dark olive-green, but nearly always there is a pale median dorsal stripe of light gray or whitish, and usually a similar, but less distinct, stripe on each side. Frequently there are three pairs of blackish spots; one pair on the thorax, one on the first abdominal segment, and another at the base of the telson.

It was not uncommon, swimming near the bottom, in shallow water at Hungry Bay and at Long Bird Island. It was also found in cavities in loose stones, below low-tide. Clusters of its eggs were found in such cavities, April 19th; they were greenish yellow and resemble those of *G. chiragra*, which were found at the same time. This species resembles the latter in form and appearance, but it is usually larger and swims more freely, so that most of our specimens were taken with a hand-net, while swimming. It was not taken by our party in 1898, for lack of information as to its habits.

It can be distinguished at once from *G. chiragra* by its lacking the bulbous enlargement of the chelipeds.

It has been recorded from various parts of the Indo-Pacific region, including the Hawaiian Is., and also from the West Indies.

ARTHROSTRACA.

Cyamus fascicularis V., sp. nov. Sperm-whale Louse.

PLATE VIII. FIGURE 4.

Specimens of a slender-bodied *Cyamus*, which is probably a new species, were taken from the body of a young sperm whale, taken off Bermuda and brought to St. George's for exhibition, in April.

This species is much more slender than those of the right whales and allied cetaceans. The two branchial segments are about as wide as the following ones, and bear fascicles of small, short, somewhat unequal branchiæ, scarcely longer than the segments. There are about 10 to 12 branchial filaments in each of the four groups.

The first segment is consolidated with the head, which is narrow and rather long, with conspicuous eyes. Antennæ are about $\frac{2}{3}$ the length of the head. First pair of legs small, beneath the second. The hands of the second pair are not much swollen, and have two strong denticles, besides a similar one at the distal angle of the carpus. The three posterior feet have a recurved denticle on the distal angle of the carpus.

Color, yellowish white; branchiæ have small black spots. The specimens described are females. No males were taken.

Length of body and head, 9^{mm}; greatest breadth of body, 3.5^{mm}.

Orchestia agilis Smith.

Report U. S. Fish Com. for 1871 and 1872, I, p. 555 [261], pl. iv, fig. 14, 1873.

This abundant New England Amphipod occurs in equal abundance at Bermuda, under decaying sea-weeds at high-tide mark, on all the shores.

CIRRIPEDIA.**Balanus declivis** Darwin, var. **cuspidatus**, nov.

Balanus declivis Darwin, Mon. Cirripedia, ii, p. 275, pl. vii, figs. 4a-4d, 1854.
(West Indies.)

Our specimens differ as a variety from the typical form described by Darwin, in having the summit of the rostrum divided into 4 or 6 acute denticles; it is very convex and considerably incurved. The summit of the carina is bilobed by a narrow incision. The base is membranous and very obliquely placed, owing to the downward prolongation of the rostrum, as in the type.

Long Bird Island, on the flats, imbedded in a blackish, massive keratose sponge (*Spongia*, sp.), which often lives half buried in the calcareous sand at low tide, and which also harbors a small *Alpheus* and several isopod crustaceans.

This is a very singular barnacle, remarkable for the peculiar oblique membranous base, and the pointed basal end of the rostrum, which are characters developed to suit its mode of life, imbedded up to its aperture in sponges. The type was from the West Indies, in sponges.

Tetraclita porosa (Gm.) Darwin.

Darwin, Mon. Cirripedia, ii, p. 330, pl. x, figs. 1-1m, 1854.

This is the common, small, sessile barnacle found on the rocks between tides, with the general appearance of some species of *Balanus*. It can easily be distinguished by the 4-parted shell.

Catophragmus imbricatus Sowerby.

Sowerby, Genera of Recent and Fossil Shells, Plate. Darwin, Monog. Cirrip., ii, p. 490, 1854.

PLATE VIII. FIGURES 8, 9.

Several specimens of this interesting barnacle were found on littoral rocks. They are all young (about 5 to 8^{mm} in diameter) and agree well with the young one described by Darwin, from Antigua. The eight primary mural plates are pointed and surrounded and partially concealed by about three alternating whorls of smaller, pointed plates, rapidly decreasing in size exteriorly. The opercular

scuta are strongly concentrically ribbed and have a deep, median radial sulcus. The base is calcareous, but thin. The color is pure white.

MOLLUSCA.

CEPHALOPODA.

Loligo Pealei (Lesueur) Ev. Squid.

Loligo Pealei Verrill, Annual Report U. S. Fish Com. for 1879 [pp. 132-161], plates xxvi to xxxii, 1882; Verrill, these Trans., vol. v, 1879, pp. 308-340, pl. xxix, figs. 1-4, pl. xxxvii, figs. 1-3, pl. xxxix, fig. 4; pl. xl; pl. xlv, figs. 3, 4.

A single specimen of this species, about 6 inches long, was found floating and nearly dead at Long Bird Island, near the shore, April, 1901.

Ommastrephes Bartramii (Les.) D'Orb. Flying Squid.

Sthenoteuthis Bartramii Verrill, these Trans., v, pp. 223, 288, 1881; Annual Report U. S. Fish Com. for 1879 [pp. 112-114], 1882.

I was told by the fishermen that schools of the flying squid (*O. Bartramii*) are often seen, and that it is sometimes used for bait.

In this connection, it is of much interest to record that among large numbers of the shells of *Spirula Peronii*, cast up on the beach at Elbow Bay, March 10th, several were found by A. H. Verrill with portions of the flesh still attached. Two of these were preserved in formalin, with the remnants of the animal. This proves that this species lives not far away from that shore, and it may be abundant just outside the reefs, in rather deep water.

GASTROPODA.

TECTIBRANCHIATA.

Dolabrifera ascifera (Rang) Morch.

Aplysia (Dolabella) ascifera Rang, Hist. Nat. Aplys., p. 51, pl. iv, figs. 7-9.

Dolabrifera ascifera Morch, Mal. Bl., xxii, p. 176. Sowerby, Conch. Icon., xvi, pl. i, figs. 6a, 6b. Pilsbry, Man. Conchology, xvi, pt. 63, p. 124, pl. xxxiv, figs. 17, 19, 20, 29; pl. lxxv, figs. 10, 11. Berg., Verh. k. k. Zool. Bot. Gesellsch., Wien, xxii, 1872, p. 441, pl. v, figs. 25-29; pl. vi, figs. 1-10, anatomy.

PLATE II. FIGURES 6a, 6b. PLATE III. FIGURE 2. PLATE IV. FIGURE 12.

A rather small, ovate, light-colored species, the body covered with small, low, rounded verrucæ; the head with small papillæ.

Body depressed, broadly rounded posteriorly; foot broad, the edges thin and undulated. Mantle-lobe over the gill-cavity is short, leaving an open sinus at each end of the cavity. Tentacles and rhinophores about equal in length and similarly folded, the tentacles broader or more expanded distally.

Color of upper surface pale yellowish gray and brown, or light fawn-color, mottled with yellowish white; head paler. Under side of foot blue with white spots.

Length, 60^{mm}, in life; breadth, about 30^{mm}. The shell is narrow, oblong anteriorly, elongated, with a much produced beak, which is tapered but blunt. The sinus is slightly concave and about $\frac{1}{2}$ the total length of the shell, ending in a very obtuse angle. The anterior and inner margins are nearly parallel, narrowing slightly anteriorly; the anterior edges obliquely truncate, with rounded angles.

Hungry Bay, April 5, 1901, under stones at extreme low-tide. Two specimens found together, as if breeding. (A. H. V.)

Dolabrifera virens V., sp. nov.

PLATE II. FIGURES 4a, 4b, 5a, 5b. PLATE IV. FIGURE 11.



FIG. 1.—*Dolabrifera virens* V. About $\frac{1}{2}$ natural size.

A rather large, yellowish green species, covered with small, elongated, conical, acute or distally branched papillae.

Body broad-ovate, broader and well rounded posteriorly; the whole upper surface of the body and head is covered with conical papillae, 1 to 2^{mm} long, part of which are acute at tip and part are divided at the end into 2 to 4 small branches. Rhinophores shorter and much smaller than the tentacles, deeply folded and enlarged at the ends. Tentacles very large, elongated, with broadly expanded ends, the edges undulated and thin. Mantle-lobe rather small, nearly semicircular, leaving a small open sinus at each end of the branchial cavity.

Color above, in life, dull yellowish green, with ill-defined blotches of pale brownish, and with white spots; the papillae are mostly lighter and more yellow; margin pale bluish with white specks; under

surface olive-green, spotted with white. Rhinophores green, with white spots and edges.

Length, in life, up to 100^{mm} ; breadth, about 50^{mm}.

The shell is firm, calcareous, rather oblong, with the beak produced and grooved or sometimes spoon-shaped, being concavely excavated ; the sinus is incurved and has the inner margin thickened ; anterior end obliquely truncated and angular ; a thin, high, median, vertical crest or keel runs about $\frac{1}{3}$ of the length, on the inside. Left margin nearly straight or slightly incurved. The outer surface is faintly radially ribbed. The shell varies considerably in form in the several examples examined, and especially in the ratios of length to breadth, as shown in the two figures given. The beak may be acute or spoon-shaped ; in one it was wholly lacking, due apparently to injury and partial repair. In one specimen the shell was in two parts, having been broken before death and only slightly repaired.

Hungry Bay, under stones at low tide, April 5, 1901, 5 specimens. (A. II. V.) Another specimen was taken in May by Mr. W. G. VanName.

Tethys (Aplysia) morio V., sp. nov.

PLATE III. FIGURES 5, 5a.

A very large species, over a foot long, dark umber-brown or nearly black, without definite spots, but with black stripes on the head, and with very large broadly overlapping lateral flaps.

Body thick and stout, swollen, very obtuse posteriorly. Head and neck thick and stout (but perhaps not seen fully extended). Lateral natatorial flaps very wide and overlapping about half their breadth, entirely free posteriorly, and extending to the end of the short foot. Rhinophores rather small and short, conical. Tentacles large and very broad, foliaceous, with thin expanded margins.

Color of body and exterior of flaps very dark umber-brown or brownish black, with few obscure dusky blotches on the sides of foot and with a purplish tinge along the edges of the flaps. Head, above and on the sides, covered with a number of narrow, purplish black, longitudinal stripes.

Length, in life, when not fully extended, 400^{mm} ; height, 145^{mm}.

The shell is very thin, transparent, pale yellow, oblong-ovate, obtusely rounded anteriorly, with the posterior sinus long and only slightly incurved ; beak rather prominent, scarcely incurved, with a reflexed membranous edge, which also extends along both posterior margins. In the formalin preparation there is no calcareous layer present. The surface is concentrically undulated and faintly longi-

tudinally grooved. Length to breadth as 3 : 2. Length, 60^{mm}; breadth, 40^{mm}.

No mantle-pore could be found, nor any distinct pore for the "opaline gland"; the latter probably discharges through many minute pores.

A single specimen was found in Castle Harbor, March 21, cast upon the beach but still living and not damaged. (A. H. V.)

This species resembles *T. megaptera* V., in the great size of its lateral flaps, but differs very decidedly in its colors and other characters.

Tethys (Aplysia) tarda V., sp. nov.

PLATE III. FIGURES 4, 4a, 4b.

A rather small, short, thick species, with relatively narrow side-flaps and short rhinophores; dusky yellowish brown, irregularly streaked with darker brown or blackish on the head and sides.

Body ovate, obtuse posteriorly, the foot not produced. Head small, emarginate; neck short and thick. Rhinophores short, subconical, tapered. Tentacles larger and rather longer, wide at base, deeply folded. Side-flaps unusually narrow, scarcely meeting over the back, and apparently not capable of being used for swimming, the edges undulated and free to the posterior ends, which extend nearly to the short tip of the foot. Branchial siphon elongated, expanded distally. Mantle over shell with a small, simple, nearly central pore, often with white streaks, or rows of white spots, radiating from it.

General color usually is dark dusky brown or umber-brown. The ground-color is a dull, dark yellowish brown on the sides and head, but irregularly blotched, striped and streaked with dark, dusky brown or sepia. The streaks on the head mostly take the form of narrow lines, those on the sides of the body are broader and more irregular, and are united by transverse lines, so as to form a coarse, irregular reticulation. Edges of side-flaps and siphon bluish gray with a purplish tinge, or grayish white. Inner surface of flaps dark brown with dark gray blotches. Shell-mantle dark brown, irregularly spotted with grayish white, some of the spots usually arranged radially around the central pore. Siphon similar in color. Tentacles and rhinophores light brown, with transverse patches or lines of dark brown.

Length, in life, 62^{mm}; height, 30^{mm}.

The shell is thin, translucent, pale yellow, ovate-elliptical, rather narrow, ratios as 3.2 : 2; the posterior end is produced, with the

beak rather acute, not incurved, but with a small, narrow, reflexed terminal and marginal fold; posterior sinus rather long, decidedly incurved, ending anteriorly in a broadly rounded angle; the anterior half of the shell forms about half of a regular ellipse. In the formalin preparation there is a thin, white posterior calcareous layer, that has mostly fallen off. The surface is slightly undulated concentrically. Length, 32^{mm}; breadth, 20^{mm}.

Cony Island, buried in sand nearly out of sight, April 4; also at Long Bird Island, in shallow water, in May, buried in sand, with only the back slightly exposed. (A. H. V.)

This species seems to live habitually nearly buried in sand. It is very sluggish and probably cannot swim freely, at least in confinement it made no effort to swim. Its back, as exposed, resembles in color a keratose sponge found in the same localities and partly buried in the sand.

In color and form this species somewhat resembles *T. Floridensis* Pilsbry (Man. Conch., xvi, p. 82, pl. xxxvii, figs. 15-19), but the latter is described as having the side-flaps "ample," while in the present species they are unusually small. The shell of *Floridensis* is wide, and quite different in form, being nearly as broad as long, while in our species it is unusually narrow. In respect to the form of the shell, *T. Braziliana* D'Orb. is much like this, but it has large side-flaps, a tubular mantle-pore, a long neck, and other differential characters.

Tethys dactylomela Rang.

Verrill, these Trans., x, p. 545, 1900.

PLATE III. FIGURE 3.

This was very common this year on the shores of Castle Harbor, breeding in April. Its eggs were laid in clusters of long thin, terete, yellow strings, attached by one end to weeds; the eggs are very small and very numerous, in 6 to 8 rows. The colors were generally as ordinarily described, the ground-color varying from light yellow to dark olive-green. A few that were nearly albinos were seen, and one that was melanistic, the ground-color being so dark that the round black spots were barely visible.

Placobranchopsis niveus V., sp. nov.

PLATE IV. FIGURE 10.

A very small, nearly pure white species. Mantle broad-elliptical, slightly emarginate anteriorly, and with a distinct lateral branchial

sinus; its surface is minutely papillose and rough. Head broad, with the angles somewhat produced into short, broad tentacles. Rhinophores stout, rather long, strongly folded, of nearly uniform breadth, obtuse. Foot wider than the mantle, and only slightly longer, the edges thin and undulated, the anterior angles a little produced but obtuse. Gill plumose, attached for about half its length, white. The mantle contains spicules, but, as preserved in formalin, it is soft and rather thick.

Color pale grayish white or translucent white, specked with flake-white, and with a purplish gray visceral organ showing through on the back.

Length, in life, 16^{mm}.

Harrington Sound, in shallow water, on the under side of a coral (*Isophyllia dipsacea*), April 9th; also in Castle Harbor, low-tide, under stones, in May.

Runcina inconspicua V., sp. nov.

PLATE III. FIGURE 6.

A very small dark green and brown species. Head bilobed and emarginate in front with a pair of small, round black eyes near the front edge. Mantle oblong or subelliptical, evenly rounded posteriorly. Foot wider than mantle, with thin undulated margins, well rounded posteriorly. Gill small with fine filaments situated under the right mantle-border, near the posterior end.

Color of mantle very dark green or greenish brown with a narrow orange border; upper side of foot light green, specked with white and edged with a narrow orange or violet line.

Length, 2 to 3^{mm} in life.

Castle Harbor, at low-tide, under stones, in May. Several specimens.

NUDIBRANCHIATA.

Elysia ornata (Swainson) Ver.

Thallepas ornatus Swainson, Treatise Malac., pp. 250, 359, 1840, from a drawing, (West Indies.)

Dalabrifera (?) *ornata* Pilsbry, Man. Conchology, vol. xvi, p. 126.

PLATE IV. FIGURE 5.

This beautiful species was originally imperfectly described, as indicated above, from the West Indies. The description was from a colored drawing only, and was so imperfect that the place of the species in the Mollusca has never been settled. The colors, as

described, are so characteristic and striking that there can be no doubt of its specific identity with our specimens.

The body, in life, is usually yellowish olive-green, but it varies from light yellowish green to dark olive-green; both surfaces of the flaps and the sides of the body are finely specked with black and flake-white dots, often appearing to be slightly raised above the surface. The side flaps are wide with thin flexible and usually undulated margins, which are elegantly bordered with a narrow bright orange band, outside of which the edge is marked by a black line. The folded rhinophores are large and long, with the posterior side orange and the edge black. There is often a white patch on the top of the head. Under side of foot paler green than the body.

This interesting species was found pairing and spawning in considerable numbers on the shore of Castle Harbor in March, by A. H. Verrill. It occurred mostly on a curious bright green alga (*Caulerpa clavifera*), on which it laid its eggs in a long coiled ribbon. According to the notes, the egg-band, when first laid, floated freely in the water, being attached only by the proximal end, but it was afterwards cleverly coiled up and attached for its whole length by the parent, before being left to its fate. The species became comparatively rare in a few days, perhaps retiring into deeper water. Only a very few could be found at the same place after my arrival in April. The last specimens seen occurred April 17th.

Elysia subornata V., sp. nov.

PLATE IV. FIGURE 4.

Head large; body elongated, acute behind; neck long in extension. Rhinophores large and long, folded and strongly expanded at the tip. Side flaps large, pointed posteriorly; their outer surfaces and the sides of the body are covered with small scattered verrucae.

Color of body and outside of flaps olive-green, finely mottled with grayish white. Close to the edge there is a very narrow orange-brown line; the extreme edge is darker brown. Inner surface of flaps dark green with pale dendritic and inosculating vessels. Rhinophores marked distally with brown; more proximally there is a gray patch; base green specked with gray.

Length, up to 25^{mm} in extension.

Castle Harbor, under stones, in May. Rare.

This species is evidently closely allied to *E. ornata*, but the latter was very constant in its markings, in over 200 specimens examined,

and did not show, in any case, the distinctly, though minutely, papillose surface of this species, which also appeared later and with somewhat different habits.

Elysia flava V., sp. nov.

PLATE IV. FIGURE 1.

Body much elongated in extension ; head relatively small, bilobed in front. Rhinophores rather small, about as long as the breadth of the head, folded but not much expanded distally. Side flaps moderately wide, undulated, rounded anteriorly, narrow posteriorly, and extending nearly to tip of the pointed foot.

Color of head, neck, rhinophores, back, and foot light yellow, with white specks on the back, and faint dull brown markings back of the head and on the sides of the neck. Outside of the flaps olive-green, specked with white and covered with very minute papillæ ; edges of flaps flake-white, with dendritic branches of white extending inward. Inner surface of flaps are almost black, due to the very dark or blackish green, arborescently branched internal organs.

Length, about 18^{mm} while living and in extension.

Castle Harbor, at Waterloo, under stones at low-tide, April 17, 1901. Rare.

Elysia picta V., sp. nov.

PLATE IV. FIGURE 2.

A small, very brilliantly colored species. Body rather stout. Head large and neck rather long ; rhinophores long, clavate, and deeply folded ; their length is equal to twice the breadth of the head. Side-flaps large and broad, their edges thin and strongly undulated ; they extend posteriorly to the tip of the foot.

Color of upper side of head, upper part of sides of neck, and whole of back and inner surface of flaps dark reddish brown, with a purplish spot between anterior ends of flaps ; front of head bright red ; a line of the same red runs back on each side of the neck and along the entire edge of the flaps to the end of the foot ; below this red border there is a band of bright blue ; middle of head and bases of rhinophores light yellow, and this color extends backward as a broad median stripe on the neck, thus forming a cross-shaped mark of yellow, which terminates posteriorly in a blue spot on the neck, and in a blue band on each rhinophore ; on the latter the blue is followed by a brown band, this by a wider red band, while the tip is brown. A blue spot centered with yellow surrounds the genital openings, on the right side of the neck.

Outer surface of lateral flaps olive-green below, becoming yellowish above, and nearly white next to the blue submarginal band ; its surface is thickly specked with yellowish white.

Length, 16^{mm} ; length of rhinophores, 3.5^{mm}.

Hungry Bay, April 5, 1901, under stones at low-tide ; two specimens, pairing. (A. H. V.) Very rare.

This species can be recognized at once by its many brilliant colors, and especially by the marginal bands of red and blue, and by the yellow cross on the head and neck. It can swim freely by means of its large side-flaps.

Elysia papillosa V., sp. nov.

PLATE IV. FIGURE 3.

A small, grayish, distinctly papillose species. Body rather elongated in extension ; head large ; neck long ; rhinophores large ; strongly folded and wide at the tips. Side-flaps large, thin, usually with the edges deeply undulated. Whole surface of body, head, and outside of flaps thickly covered with small conical papillæ.

Color of head, neck, and outside of flaps grayish blue, paler anteriorly, and spotted with darker gray on the outside of the flaps, and specked with flake-white over the whole surface. Inside of flaps darker ash-gray ; the edges bordered with white. Rhinophores are like the head, but with two indistinct transverse bands of orange-brown on the posterior side.

Length, about 12^{mm} in extension.

Hungry Bay, under stones, at a very low-tide, April 5, 1901. (A. H. V.) Rare.

This species can swim freely by means of its ample lateral flaps.

Lamellidoris aureopuncta V., sp. nov.

PLATE IV., FIGURE 9.

A very small, nearly white species, with a row of small, round, yellow spots near each lateral edge of the mantle.

Body elliptical, obtuse at both ends. The foot is longer and wider than the mantle ; anteriorly it is subtruncate with obtuse angles, posteriorly it is rather obtuse and not much produced. The mantle is evenly convex, nearly smooth, but hardened by spicules.

Rhinophores small, slender, acute, with many oblique plications and no distinct sheath. Gills 6 or 7, simply pinnate, with fine branches, retractile.

Color of mantle and foot and gills pale, translucent, yellowish white, with whiter specks, due to spicules; near each lateral margin of the mantle there is a row usually of five small, round, golden yellow spots, to which the name refers. A greenish visceral organ often shows through on the back. Rhinophores yellowish.

Length, 10^{mm}; breadth, 5^{mm}, in life.

Harrington Sound, in shallow water, under corals, April 28, 1901.

Lamellidoris miniata V., sp. nov.

PLATE III. FIGURE 1.

See figure 3, below.

A small, bright red, finely papillose species. Head rounded, emarginate in front, with a pair of slender oral tentacles. Body elliptical, strongly convex. Foot thin, wider and much longer than the mantle, its anterior angles produced into folded lobes. Rhinophores rather large, fusiform or subelavate; thick and strongly plicated, basal part smooth; tip naked, acute and white; no evident sheaths. Gills about eight, rather large, simply pinnate, with fine filaments, retractile. Surface of mantle covered with minute, conical, pointed papillæ.

Color of mantle bright red or deep orange-red, with an obscure median brownish stripe; gills and middle of rhinophores darker red, surrounded at base with grayish blue; the rhinophores are tipped with white. Foot and head paler orange or pinkish.

Length of foot, of largest, in extension, 10^{mm}; of mantle, 7.5^{mm}; another was 6^{mm} long, 3.5^{mm} broad.

Castle Harbor, under stones at low-tide, April 10th and 17th, 1901.

Lamellidoris lactea Ver.

These Trans., x, p. 548, 1900.

PLATE IV. FIGURES 8a, 8b.

A few additional specimens of this rare species were obtained. In these the dorsal surface of the mantle and the sides below its border were milk-white, spotted and specked with purplish gray or pale lavender, some of the spots near the middle being larger and roundish; there was a tinge of orange around the bases of the gills and on the low thick sheaths of the rhinophores. The gills are rather long, simply pinnate; about 7 to 9 were counted. The rhinophores are small, conical, dark gray.

Lamellidoris (?) *olivacea* V.

Doris (?) *olivacea* Verrill, these Trans., x, p. 548, 1900.

PLATE IV. FIGURE 7.

A larger and better specimen of this species was obtained this season. The central area of the back, in this example, is covered with small, conical, whitish or grayish papillæ. The rhinophores are long, tapered, subacute, with an orange ring at base. The wide undulated mantle-border contains spicules.

Chromodoris (?) *roseopicta* V.

These Trans., x. p. 549, pl. lxvi, fig. 1, 1900.



FIG. 2.—*Chromodoris roseopicta* V., gills in profile, enlarged. 2a.—The same, posterior view of gills. 3.—*Lamellidoris miniata* V. Head and front part of foot, enlarged.

Larger and better specimens of this beautiful species were obtained this year; they show that some of the characters of the type-specimens were due to immaturity or imperfect expansion.

In the best examples the mantle border is broad, strongly undulated, and projects beyond the margins of the foot. The back is everywhere covered with prominent rosy-tipped, rather blunt papillæ; some of these, larger than the rest, form three rows of 5 or 6 along the back, and these are surrounded at base with bright yellow specks. The rhinophores, in expansion, are clavate-fusiform, stout, subacute, plicated, bright red, striped with narrow lines of white spots. The gills are large and long, about 24; of these 12 or 14 are simple, long, tapered, pinnate plumes; behind and within these there is, on each side, a group of 5 or 6 smaller divergent plumes, which arise in a subspiral manner from a common stem.

The color, in general, is the same as in the type.

Harrington Sound, Hungry Bay, Long Bird Island, etc., usually on the under side of a massive, brown keratose sponge (*Spongia*, sp.)

Scyllæa pelagica (Linné).

A single large living specimen of this species was found at Long Bird Island, on the flats, in May. Its color was light orange, with a marginal band of deep orange, edged with white around the lateral lobes and along the upper lateral margins of the body; sides of body were specked with flake-white, but without purple spots. Back of rhinophores deep orange; edges white.

Length, 55^{mm}.

Facelina Goslingii V., sp. nov.

PLATE IV. FIGURE 6.

Body, in life, when extended, elongated and rather slender, tapered to an acute point posteriorly. Head large, rounded, with a pair of very long, slender, tapered, acute tentacles. Rhinophores much smaller, not half as long, acute, with strong plications on the distal portion, naked near the base. Foot with the anterior angles prolonged into a pair of long, tapered, tentacle-like organs, more than half as long as the true tentacles and similarly colored. Dorsal papillæ numerous, long, very slender, fusiform, acute, easily deciduous, arranged in numerous (about 10 to 12) double groups along each side, leaving a broad naked dorsal region. The anterior groups contain numerous crowded papillæ, in two or more transverse rows; the posterior groups gradually diminish till the last contain very few papillæ.

Color of back pale, translucent, grayish white, with a median stripe of white, edged with narrow red lines, and with a lateral stripe of orange on each side along the bases of the papillæ, which are white crossed by numerous bands of light rose-red or pink. Head white in front, tinged with pink around the mouth and with a median, usually Y-shaped streak of red on the front and extending between the tentacles, and an ocellated, round, blue spot at the upper base of each tentacle; back of neck with a median blue streak. Tentacles and tentacular processes of foot white proximally, then with a light red band followed by a wide blue distal band. Rhinophores nearly white. Foot edged with blue anteriorly.

The odontophore has but a single row of teeth; these have broad, thick bases and taper rather rapidly to the acute, naked, somewhat incurved tips. There are about 10 to 12 acute serrations on each edge, the distal ones becoming very small. The cutting edges of the jaws are brown and chitons with a submarginal rib; the two edges form nearly a right angle, when flattened by pressure.

Length, in life, 35 to 45^{mm}.

Taken in considerable numbers in the mangrove swamp at Hungry Bay, on a filamentous green alga, March 10th, 1901 (A. H. V.). In April (5th) both the alga and the mollusk had disappeared.

This is a very handsome and active species. It is difficult to preserve entire, for it casts its papillæ very readily when irritated in any way.

It is named in honor of Mr. T. Goodwin Gosling, of Bermuda, who first discovered it. I have referred it to *Facelina* with some doubt, for its anatomy has not yet been fully studied.

PROSOBRANCHIATA.

Volva uniplicata (Sowerby).

Orulum uniplicatum Sowerby, Proc. Zoöl. Soc. London, 1848, p. 135.

Volva uniplicata Tryon, Amer. Marine Conch., p. 93, pl. ix, fig. 93, 1873.

The purple variety of this species was found adhering to a purple specimen of *Gorgonia flabellum*, from Castle Harbor reefs.

PULMONATA.

Among the Pulmonata, apparently not before recorded, are the following:

Melampus bullimoides Mont. Shore of Hungry Bay.

?*Blaumeria heteroclita* Mont. Shore near Hungry Bay, under stones.

Also an undetermined, small, strongly depressed, smooth, helicoid shell, 8 to 10^{mm} in diameter; the aperture is simple, lunate; lip acute; umbilicus open and deep, but not very large. Hamilton, in gardens.

BIVALVIA.

Cardium medium Linné.

A single dead specimen of this West Indian species was found in the cavities of a stone fished up from about 100 feet deep, off the outer reefs.

ECHINODERMA.

Only one species, so far as positively determined, was added to the Echinoderma this year. This was an interesting simple-armed astrophytid (*Astroporpa affinis*), which was found clinging to a *Verrucella* from off the outer reefs.

Several other species of special interest were obtained, which we did not collect in 1898.

OPHIUROIDEA.

Astroporpa affinis Lutken.

Lutken, *Addit. ad Hist. Ophiur.*, II, p. 154, pl. v, figs 5a, 5b, 1859.

Four specimens of this rare species were found clinging to the branches of a large gorgonian (*Verrucella grandis* V.), brought up from about 100 feet, off the outer reefs, on a fisherman's hook. The color, as dried, after a few days, is light yellowish or grayish-brown on the raised annulations of the arms and ribs, and darker brown on the annular grooves.

ASTERIOIDEA.

Luidia clathrata (Say).

Asterias clathrata Say, *Journ. Acad. Nat. Sci. Philad.*, v, p. 141, 1825.

Luidia clathrata Lutken, *Vidensk. Meddel.*, p. 37, 1859. A. Agassiz, *N. Amer. Starfishes*, p. 117, pl. xx. Perrier, *Arch. Zool. Exper.*, v, p. 252, 1876. Sladen, *Voy. Challenger, Zool.*, vol. xxx, pp. 245, 353, 1889.

Several fine specimens of this species were taken on a white shell-sand bottom in shallow water, at Trunk Island, Harrington Sound. It also occurred at Long Bird Island and other localities, on shell-sand bottoms in shallow water. Its presence is indicated by a star-shaped impression in the sand. But it moves about under the sand with remarkable rapidity, when disturbed, by means of its large ambulacral tubes, so that it is not easy to capture it, after it has taken alarm.

Its color in life is generally light cream-color, often with a rosy or flesh-colored tint, and frequently with a darker grayish or greenish median streak on each ray. It becomes at least a foot in diameter at Bermuda.

Linckia Guildingii Gray.

Linckia Guildingii Gray, *Ann. and Mag. Nat. Hist.*, vi, p. 285. Perrier, *Arch. Zool. Exper.*, iv, p. 408, 1875. A. Agassiz, *N. Amer. Starfishes*, p. 105, pl. xiv, figs. 1-6. H. L. Clark, *Ann. N. York Acad.*, xi, p. 412, 1898. Verrill, *these Trans.*, x, p. 671. (*Ophidiaster*, by error, on p. 584.)

Ophidiaster ornithopus Müll. & Troschel, *Syst. Aster.*, p. 31, 1842.

Linckia ornithopus Verrill, *these Trans.*, vol. i, p. 367.

Several small specimens of this species were taken, mostly at Hungry Bay and Long Bird Island, under stones below low-tide. It is dull orange or orange-brown in life.

ECHINOIDEA.

The most interesting species of this group, taken this year, is the following :

Echinoneus semilunaris (Gm.) Lam.

Echinoneus semilunaris Lam., Anim. s. Vert., p. 19, 1816. A. Agassiz, Revis. Echin., p. 118 (Syn.), 333 (deser.), 550, pl. xiv, figs. 1-5, pl. xxxviii, fig. 26, 1872.

Echinoneus gibbosus Lam., Anim. s. Vert., p. 16, 1816.

Echinoneus elegans Desor, in Agassiz, Mon. Echin., p. 47, pl. vi, figs. 4-6, 1842.

Echinoneus conformis Desor. op. cit., p. 48, pl. vi, figs. 11-21, 1842.

This interesting species appears not to have been obtained there for many years, though it was recorded by Mr. A. Agassiz. Two living specimens were taken at Hungry Bay in March, by A. H. Verrill. They were found buried in sand and gravel, under stones, in small tide-pools, at extreme low-tide. Their color in life was purplish red or bright copper-red.

HOLOTHURIOIDEA.

Holothuria Rathbuni Lampert.

Holothuria, sp., Rathbun, these Trans., v, p. 141, 1879. (Description.)

PLATE I. FIGURES 6a, 6b, 7.

The most interesting holothurian was a large species of *Holothuria* which has the habit, unusual in this genus, of burrowing deeply in the sand at and below low-tide mark on the sand flats, much like the *Arenicola cristata*, with which it is usually associated. It makes a distinct mound of sand around the mouth of its burrow, which runs obliquely downward, often to the depth of two feet or more.

This holothurian itself, when expanded, was often 18 to 20 inches long and 1 inch to 1½ inches in diameter in the middle.

It is usually long-fusiform in extension, tapering gradually to each end. Its color is usually gray, pale grayish brown, or purplish brown, with irregular rows of roundish brown or purplish spots. It is often stained with rusty brown or yellow. The surface is papillose, and the integument is firm and tough.

This was not uncommon on the flats exposed at low-tide at Long Bird Island, and other similar localities. A single specimen was in Mr. Goode's collection of 1876, without special locality.

This is probably *H. Rathbuni* Lamp., recently recorded from Bermuda by Mr. H. L. Clark (Proc. Boston Soc. N. Hist., xxix, pp. 343, 344, May, 1901).

ANNELIDA.

CHÆTOPODA.

An important collection of marine annelids was made this year, but it has not yet been studied in detail. A number of new forms are known to be included in the lot. Among the additional genera are *Terebellides*, *Pterosyllis*, and others.

Several interesting species of earthworms were also obtained, but they have not yet been examined with care.

The following large and handsome new *Pectinaria* was found in considerable numbers:—

Pectinaria regalis V., sp. nov.

PLATE VIII. FIGURES 6, 7.

A large, stout species, with large groups of bright golden, acute opercular setæ, of which there are 11 to 13 in each group, the outermost and two to four of the inner ones much smaller than the rest.

Opercular disk broadly rounded, smooth, with the dorsal edge crenulated, and with a slender acute antenna on the ventro-lateral angles; a stouter, bent, obtuse lobule stands at the base of the ventral edge, on each side. The ventral lobe has about ten slender marginal papillæ on each half of the ventral edge, besides three or four smaller ones on the incurved lateral edges.

The buccal segment bears a pair of slender tentacular cirri, longer than the antennæ, and below these, on each side, four rounded prominent lobules. The gills are large, the anterior pair much the larger; below each gill there is a prominent transverse ridge separated below by a median glandular pad. Similar ridges occur on the next two segments, but the fourth ventral pad is bilobed.

On fifteen segments, following the 2d branchial, there is a conspicuous dorsal fascicle of golden setæ, largest on the 3d to 9th. The two next segments appear to lack dorsal setæ; the next (last thoracic) has a small group of recurved setæ on the dorsal side. The caudal region has five segments, besides the caudal, which is semicircular, with about 24 rounded marginal papillæ. Rows of uncini begin on the 4th post-branchial segment.

Length, up to 95^{mm}; diameter, 12–13^{mm}.

The tube is regularly tapered and considerably bent; it is composed of rather large, nearly uniform, rounded grains of calcareous sand. This fine species was found at Cony Island and the "Scaur," between tides, in shell-sand. Very local.

Arenicola cristata Stimpson.

Proceedings Boston Soc. Nat. Hist., v, p. 114. Webster, Bull. U. S. Nat. Mus., No. 25, p. 323, 1884.

This large species was very common at low-tide and down to three fathoms at several localities, especially at Long Bird Island on the flats, Castle Harbor at Waterloo and Tuckers Town, at Hungry Bay, etc. It makes a conspicuous burrow, at the mouth of which there is usually a long cylindrical or coiled roll of mucus, nearly an inch in diameter.

Fallacia protochona (Schmarda) Quatr.

Hesione protochona Schmarda, Neue Wirb. Thiere, I, p. 79, pl. xxviii, fig. 226, 1861. Quatrefages, Hist. Nat. des Ann., II, p. 98, 1865. Webster, op. cit., p. 311, pl. viii, fig. 21, 1884.

PLATE VIII. FIGURE 5.

Some large and fine specimens of this species were taken in 1901. Some of them were at least six inches (150^{mm}) long while living. They were mostly found under stones at low-tide at Hungry Bay, the Scaur, Cony Island, Castle Harbor, etc.

Some of the largest were found swimming rapidly at the surface, by rapid undulations of the body.

In life the color is pale brownish yellow, striped longitudinally with many fine dark brown lines.

GEPHYRÆA.

Sipunculus nudus Linné (?)

Selenka in Semper's Reisen in den Philippinen, ii, Bd. iv, 1883.
Ward, Bull. Mus. Comp. Zool., xxi, pp. 147-182, 1891.

A large species, 200 to 250^{mm} in length and 15 to 20^{mm} in diameter when expanded. It contracts variously in formalin, sometimes to a cylindrical form, 150^{mm} in length and 10 to 12^{mm} in diameter; in other cases the middle of the body is much narrower and both ends are bulbous.

The body is longitudinally sulcate, with about 32 grooves, separating wider muscular bands. These are crossed by numerous circular grooves and bands, which divide the surface into more or less conspicuous squarish or oblong areas, which are often distinctly raised, especially posteriorly. The posterior end is suddenly tapered to an obtuse point, the tapered portion being nearly smooth, but longitudinally sulcated; that portion of the base of the proboscis which is visible is closely covered with small broad-based, obtuse, conical, pale brown verrucæ.

The anus is a conspicuous transverse slit, on a slightly raised or thickened brownish area, covered with radial grooves. The nephridial pores are very distinctly transversely bilabiate; they are separated by about seven longitudinal muscular bands, and are situated on the eighth muscular band in front of the anal pore.

The color in life is brownish flesh-color, or light yellowish brown. In formalin it is dull, pale yellowish brown, a little darker on the posterior end and at the base of the proboscis, as well as around the anal pore; the surface has a glistening appearance.

One specimen is somewhat darker, being covered with fine dark brown specks, which form alternately lighter and darker, very narrow stripes on the body, two narrow dark lines being situated on each longitudinal muscular band.

The internal anatomy has not yet been studied sufficiently to determine positively whether this be identical with the European *S. nudus*, which has been reported also from Florida.

Sand flats of Long Bird Island, in deep burrows, April, 1901.

Physcosoma, sp.

A large species, 150 to 175^{mm} long, and about 8 to 10^{mm} in diameter, when expanded.

It was translucent flesh-color, finely specked with yellowish brown. The two long and large segmental organs showed through the integument as purplish folded tubes 20 to 30^{mm} long.

There are 20 wide muscular bands; seven on each side between the anal and nephridial pores and six between the two latter. The surface is covered with fine granule-like elevations; around the posterior end is a wide zone of larger, crowded, low, yellow, rounded verrucæ, not chitinous; a similar zone surrounds the base of the proboscis. On the inner surface of the longitudinal muscles are scattered, oblong, low, verruciform bodies, about .5^{mm} long. The intestine is long and large, forming about 45 spiral turns. The transverse muscles form thin narrow bands or lines, very near together.

Thalassema Baronii Greef.

Thalassema Baronii Greef, Acta Ac. Germ., xli, p. 151, 1879. Shipley in Willey's Zool. Results, part iii, p. 745, pl. xxxiii, figs. 1 and 7, 1899; Proc. Zool. Soc. London, 1899, p. 55. Selenka, Challenger Voy., Zool., xiii, p. 1.

PLATE V. FIGURE 9.

Length, in life, in extension, 50 to 65^{mm}, diameter 12 to 15^{mm}, but the form is very changeable. The color of the body was bluish-

green, striped longitudinally with about eight bands of bright pink or light violet-red, these stripes being of nearly the same breadth as the green ones. Proboscis similar to the greenish parts of the body, but rather lighter, or more distinctly bluish, without stripes.

The body, in expansion, was usually thick-fusiform or larger in front of the middle. The proboscis was usually short, stout and blunt, but changeable according to state of expansion.

Three specimens were collected on one of the serpuline atolls near Hungry Bay, at a very low tide in March. They were imbedded in loose sand and gravel. (A. H. V.)

TURBELLARIA.

POLYCLADIA.

Thysanozoön nigrum Girard.

Thysanozoön nigrum Girard, Proc. Boston Soc. Nat. Hist., vol. iv, p. 137, 1854 (from Cape Florida).

Thysanozoön Brochii, var. *nigrum* Lang, Die Polycladen, Fauna und Flora des Golfes von Neapel, p. 535, 1884.

A large, nearly jet black species, thickly covered above with large obtuse or subacute, unequal papillæ.

Body broad, oblong-elliptical, with thin undulated margins, used actively in swimming. Tentacular lobes elongated, projecting upward and forward, deeply folded. A small, roundish or cordate cerebral cluster of minute ocelli, surrounded by a small pale area. Whole dorsal side covered with rather closely crowded papillæ, part of which are much smaller than the others; they are mostly tapered and rather obtuse, but many are fusiform and subacute.

Color usually nearly pure black, sometimes with patches of dark gray and fine specks of white, and with faint yellowish reticulated lines anteriorly; under side light smoky brown. Papillæ blackish, often tinged with greenish yellow.

Length, in life, up to 60^{mm}; breadth, 30 to 45^{mm}.

Castle Harbor and Harrington Sound, in May, usually found swimming actively at the surface, but sometimes living under stones.

It was called "sea-devil" by some of the fishermen, probably owing to its black color.

Thysanozoön griseum V., sp. nov.

PLATE V. FIGURE 7.

Body usually oblong-elliptical or ovate in extension, but changeable. Length to breadth often as 2: 1. Dorsal surface thickly cov-

ered with elongated, acute, unequal papillæ. Tentacular folds prominent, not very near together. Cerebral ocelli form two slightly separated, small, nearly semicircular groups, surrounded by a pale area. Color of dorsal side mostly brownish gray, tinged with yellow, and with a broad median stripe of white, on which the papillæ are also white; the other papillæ are spotted with orange, white, and dark brown. Tentacles gray, spotted with flake-white. On their anterior edges there are, apparently, many minute black ocelli; other black specks that may be ocelli form a row on the front margin, between the tentacles and on the lateral margins as far back as the cerebral ocelli, or farther.

Length, 35 to 40^{mm}; breadth, 16 to 20^{mm}.

Harrington Sound, under dead corals, in April.

This may, perhaps, prove to be only a pale variety of *T. nigrum*, when a larger series can be studied, but aside from the difference in color, the separate groups of cerebral ocelli and the more prominent tentacles seem to be important characters. Only one specimen was taken.

Pseudoceros bicolor V., sp. nov.

PLATE V. FIGURE 5.

Body broadly elliptical with very thin undulated edges. Pseudotentacles are broad, short, rounded folds with a deep sinus between them, and with numerous minute ocelli on their front edges. Farther back than the bases of the pseudotentacles there is a round median group of numerous small cerebral ocelli. There are also two small light colored elevations.

Color of the central area very dark, almost black, with acute lobes of the same color extending toward the margin, which is translucent white, tinged with gray.

Length, about 30^{mm}; breadth, 15^{mm}, but the form is very changeable.

Long Bird Island, under stones at low-tide, April, 1901 (A. H. V.).

Pseudoceros aureolineata V., sp. nov.

PLATE V. FIGURE 6.

Body broadly elliptical, with thin undulated margins, but very changeable in form. Pseudotentacles broadly folded, bearing numerous small ocelli on the margin; rows of similar ocelli extend along the whole margin of the body. A round cluster of small cerebral ocelli is situated anteriorly.

Color, above, in life, light purplish-brown or purplish fawn-color, irregularly spotted and specked with white, and with a median row of white spots or small blotches; toward the margin is a row of greenish spots, about at the edge of the brown area. The margin is translucent white, with a narrow, bright, light orange line at the edge; Under side anteriorly specked with flake-white.

Length, about 25^{mm}; breadth, 18 to 20^{mm}.

Long Bird Island, under stones just below low-tide, April 19, rare.

Stylochus Bermudensis V., sp. nov.

Body oblong-elliptical in life, with thin undulated edges. Tentacles not long, rather far apart, situated about at the anterior fourth, conical and subacute in extension, short and blunt in partial contraction. Ocelli form a cluster in the base of each tentacle, and two or three marginal rows along the anterior part of the body, extending back past the middle.

Color, above, grayish green on a white ground color. The greenish color forms specks and blotches over the surface, with the white ground-color showing between them, and specked with flake-white. Just back of the tentacles there is a transverse row of three white spots, the median one the largest; under side white, mouth central.

Length, 18^{mm} in extension; breadth, 8 to 9^{mm}.

Harrington Sound, in shallow water, under corals, April 14, 1901.

The only specimen found was accidentally lost before a detailed figure had been made. The clusters of cerebral ocelli were not noted.

Discocelis binoculata V., sp. nov.

PLATE V. FIGURES 3, 4.

A long, narrow, very active and changeable species, with thin and much undulated edges; anterior end generally obtusely rounded; posterior end tapered. Breadth to length often as 1 to 6 or 8, in extension.

The cerebral ocelli form two distinct round clusters, separated by a space greater than their diameters.

No marginal ocelli could be seen in one specimen, but in others there seemed to be a row of very small ones anteriorly.

Ground-color, pale flesh-color; light pink; pale yellowish-orange; or salmon, paler and translucent toward the margins; a row of about 12 orange-brown, roundish spots along each side of the back,

about midway between the middle and the edges; outside and between these are numerous small specks of the same color. A median pale gastric streak extends from the ocelli to near the posterior end; it is usually bordered by a deeper colored, salmon or light orange band.

The stomach is long and narrow, occupying most of the length of the body behind the eyes. It gives off, mostly at right angles, a large number of narrow, lateral, dendritic branches. The pharynx is not very long, subcentral, lobulated.

Length in extension, up to 30 or 40^{mm}; breadth, 6 to 8^{mm}, but it often contracted to a shorter and broader form.

Under stones and dead corals, and in their crevices, at low-tide, Long Bird Island, April 19th and 29th. It is a very active species and creeps rapidly into holes and crevices, when disturbed.

This closely resembles, in color, general appearance, and in the cerebral eyes, the *Leptoplana Alcinoi* of the Bay of Naples, as figured by Lang (Polycladen, p. 486, pl. ii, figs. 2 and 5). But our specimens appeared to have a row of small, anterior marginal ocelli, that are not present in the former.

Discocelis cyclops V., sp. nov.

PLATE V. FIGURE 1.

Body usually much elongated, rather narrow, with thin, more or less undulated margins; anterior margin usually obtusely rounded; posterior end often tapered.

The two cerebral groups of ocelli are semicircular or semielliptical and very close together, so that they seem to form a single, rather conspicuous, rounded or elliptical eye, of larger size than usual in this group. Around the front margin there are also two or three rows of minute ocelli, which extend somewhat farther back than the cerebral groups.

Color of the body usually pale, translucent flesh-color or pale cream-color, but nearly white toward the margins; there is a rather wide median dorsal stripe of orange-brown, made up of minute round brown specks; similar specks are scattered over the whole surface, except near the edges, which are pale and translucent.

One specimen was, in general, reddish brown, due to the color of the dendritic gastric branches showing through. Another was nearly white, specked with orange. The dark median gastric stripe is often bordered with whitish.

The mouth is far forward, only a little behind the eyes.

The proboscis, which is often ejected in formalin solution, is large and clavate, four-lobed at the end, 12 to 14^{mm} long.

Length, up to 75 to 90^{mm}; breadth, 10 to 15^{mm}, in extension; it often contracts into much shorter and broader forms.

Harrington Sound, April 28th, on under side of dead corals, in shallow water. Castle Harbor, at Waterloo, low-tide, under stones, May 5th. The Scaur, under stones at low-tide, May.

This species is here referred to the genus *Discocelis* with some doubt, for its anatomy has not yet been sufficiently studied.

Trigonoporus microps V., sp. nov.

PLATE V. FIGURE 2.

Body thin, usually long and narrow, very extensile and changeable, the edges usually much undulated and very thin; both ends may be subacute in extension. When fully extended the body is very narrow, the breadth being about one-sixth to one-eighth of the length.

Cerebral clusters of ocelli are lacking; but numerous minute ocelli are scattered over the anterior dorsal region and along the anterior margins, becoming much more numerous and crowded into several rows close to the anterior end. The stomach is very long, extending through most of the length of the body, and it gives off very numerous, nearly transverse, lateral branches, which are subdivided into numerous dendritic branchlets.

Color of the body pale flesh-color or cream-color, the stomach and its branches showing through as rather darker pale ocher or brownish markings.

Length up to 50 or 60^{mm}; breadth, in extension, 5 to 10^{mm}.

Castle Harbor and "The Scaur," under stones at low-tide; May 1st to 5th.

This species closely resembles *T. cephalophthalma*, of the Gulf of Naples, (see Lang, Polycladen, p. 503, pl. ii, fig. 1), in form and in the arrangement of the ocelli. The latter, however, differs in color and, apparently, in the relative length of the median gastric cavity, which is about one-third the total length, yet when more fully studied they may prove to be identical. The internal reproductive organs of our species have not been studied, so that its generic position is not positively settled. I have placed it in *Trigonoporus* mainly because of its close resemblance to the Naples species, as to form of body and arrangement of the ocelli. In the latter the gastric streak is white, bordered and continued by orange-brown, otherwise the upper side is pale greenish gray.

Leptoplana lactoalba V.

These Trans., x, p. 595, fig. 9, 1900.

Numerous specimens of this species were taken in 1901, many of which differ from the typical form, in being more or less tinged with flesh-color or pale yellowish brown. For this variety it may be convenient to have a special name. No differences, except in color, were noticed.

Var. *tincta*, nov.

PLATE V. FIGURE 8.

Color of dorsal surface pale flesh-color, light salmon-color, or pale brownish yellow, due to numerous minute specks of pigment scattered in the tissues; margins paler; not very translucent. In this species the principal or most conspicuous cerebral ocelli form a pair of round clusters, well apart, on slightly elevated verrucæ. There is a simple row of two or three ocelli behind the round groups and a crowded, usually curved row in front. The stomach is not very long. No marginal ocelli were observed.

The form is very changeable and the species is very active, both in creeping and swimming.

Length up to 40 or 50^{mm}; breadth, 18 to 25^{mm}.

Long Bird Island; Harrington Sound; Castle Harbor, etc., under stones and corals. Common.

NEMERTINA.

Two or three additional species of Nemerteans were obtained in 1901, but they have not yet been fully studied.

The most interesting one was taken singly, two or three times, under stones, at low-tide. It was 150 to 175^{mm} long, and about 4 or 5^{mm} broad. It was somewhat flattened, except anteriorly. Its color was bright orange or scarlet; no eyes were seen. It appeared to be related to *Polia* or *Eupolia*.

A species of *Lineus* was found in May by Mr. W. G. Van Name, among algæ, in a rather brackish pond near Bailey Bay. It was dark grayish brown on the upper side, paler beneath. Length, 75 to 100^{mm}. It occurred in considerable numbers, but it has not yet been studied with care.

The terrestrial nemertean (*Tetrastemma agricola* W. Suhn) was found common in April, near Hungry Bay, under stones and burrowing in the soil like an earthworm. They were from 2 to 4 inches

long, when extended, but they are said to grow to the length of 6 inches. They are quite active and can be kept alive for a long time in jars of moist earth. They occurred not only near the shore, but on the uplands where the soil was almost dry. The larger ones, in life, were dark grayish brown or slate-color along the back, but the smaller ones were nearly white.

ANTHOZOA.

ACTINARIA.

Cerianthus natans V., sp. nov.

PLATE IX. FIGURE 6.

Body in extension when swimming, rather long, bulbous or clavate near the base and enlarged rapidly close to the disk. Outer tentacles about 38, subequal, tapered, not very long, thin, length usually less than one-half the diameter of the disk; they appear to form two or three rows. Inner or oral tentacles much smaller and more slender, about 24, apparently forming two series, owing to their alternate positions.

Color of body orange-brown, tinged with yellow. Outer tentacles reddish brown, crossed by five or six bands of white; disk yellowish around bases of tentacles with a brown spot in front of the base of each; central part of disk bluish gray. Oral tentacles nearly white; mouth yellow, with lines of red running in from between the oral tentacles.

Length, in life 110^{mm}; diameter of column, 10 to 22^{mm}; of disk and tentacles, 45^{mm}, length of outer tentacles, about 10^{mm}.

Cony Island, floating free among algæ, March 26, 1901. (A. H. V.)

This species, when kept in confinement, could swim about actively by expelling water from the pore in the bulbous base. Only one example was taken. The tentacles are much shorter than usual in this group.

Epicystis osculifera (Lesueur) Ver.

Verrill, these Trans., x, p. 556, 1900.

PLATE VII. FIGURE 1.

Numerous specimens of this elegant actinian were obtained, some of them of large size. These render it still more probable that this form is distinct from *E. crucifera*, for it seems to have a characteristic pattern of colors.

The column is usually streaked with light red and pale pink, much as in *crucifera*, but the tentacles are longitudinally striped with green and white, one of the green stripes on the outside and two on the inside being dark green, while the lateral ones are light green; there is often an inner median streak or spot of yellow or orange; the bases are surrounded by dark green lines which run in on the disk as radial lines. The disk is generally lined or striped radially with green and white, variegated with orange and dark green spots. The lips are bright yellow, edged with green. The suckers are bright red and form short rows on the upper part.

There are usually only 6 or 12 of the primary and secondary tentacles that have more or less evident transverse raised ridges on the inner face of the tentacles. One of these usually occupies the inner end of each of the six infoldings of the disk.

It is sometimes 150^{mm} or more in diameter.

Hungry Bay; Castle Harbor; Harrington Sound. It lives between stones and in crevices of rocks and corals.

Lebrunia Danæ (D. & M.) Ver.

Verrill, Amer. Journ. Sci., vii, p. 46, fig. 15, 1899. These Trans., x, p. 555, pl. lxvii, fig. 3; pl. lix, fig. 1, 1900.

PLATE VI. FIGURE 1.

A number of large specimens of this species were obtained. They varied considerably in color, but none were distinctly green like those obtained in 1898.

The column, tentacles, and disk were generally light yellowish brown or fawn-color. The branchiæ were usually darker brown, often light umber-brown or chocolate-brown. The tentacles often had pale tips. The gills in extension were usually much longer than the tentacles; they were much branched arborescently, but they had few or no distinct rounded aerorhagi.

In this last character and in color they differed decidedly from the 1898 specimens, described and figured by me in 1900, and agreed nearly with *L. neglecta*, as described by McMurrich, from the Bahamas.

Phellia simplex V., sp. nov.

Column slender, elongated, often vermiform, changeable, covered with a closely adherent, brownish or dirty epidermis, except close to each end.

Tentacles about 24; inner ones slender, tapered but little, longer and larger than the outer ones, and equal to the diameter of the disk; outer ones small.

Color of disk usually buff, with white radii; tentacles translucent buff with a broad proximal patch of flake-white, beyond which there are two or three transverse bands of dark reddish brown. The lowest of these bands is W-shaped; the others are simple annulations.

Length, in life, 18 to 24^{mm}; diameter, 4 to 5^{mm}.

Long Bird Island, under stones at low-tide, April 19th; also at Waterloo, Castle Harbor.

This species has the aspect of an *Edwardsia*, but its basal disk is well developed.

Phellia rufa Ver.

These Trans., x, p. 557, pl. lxxiii, fig. 2, 1900.

PLATE VI. FIGURE 5.

Numerous fine specimens of this species were found under stones in several localities, but it was particularly abundant and large at Waterloo, Castle Harbor, where the tidal streams from the adjacent caves flow out of the stony shores between tides.

At the latter locality specimens very much larger than the types were obtained. Some of these, in life, were 75 to 100^{mm} long, and 20 to 36^{mm} in diameter of body, with a correspondingly increased number of tentacles, which were often 96 to 120; the inner 12 are often erect and decidedly the largest. The form of the body is very changeable.

In nearly all cases the column is a deep brownish red or dull salmon-brown, and the tough epidermis, which adheres very closely and extends nearly to the tentacles, is wrinkled in contraction. The disk and tentacles vary much in color, but are nearly always handsomely variegated with red, salmon-brown, or purplish brown, and flake-white. The tentacles are generally banded with flake-white and often they have two or three W-shaped bands of dark purplish brown or reddish brown. The disk has radial stripes or spots of the same brown colors, alternating with white, or the brown spots may be V-shaped.

Aiptasia tugetes (D. & M.) Andres.

PLATE VI. FIGURE 6.

Verrill, these Trans., x, p. 557, pl. lxxvii, fig. 2, 1900.

This species was found very common in 1901, and numerous marked variations in its colors were observed.

The most prolific locality was the mangrove swamp at "Fairy Lands," where it occurred in great numbers, in April, attached to the fallen and floating mangrove leaves and twigs. At this place numerous color-varieties occurred. Many of the specimens had one or both of the directive tentacles longer than the rest and partially or wholly flake-white; a band of white also crossed the disk in line with these tentacles. The other tentacles and disk were variously spotted and barred with flake-white; most commonly the ground-color of the tentacles was pale umber-brown or greenish, crossed by two to five unequal half bands and crescents of flake-white, on the inside.

One nearly albino specimen occurred at Waterloo. This had a pale flesh-colored, translucent column, with white specks above. The long, slender, acute tentacles were pale yellowish, crossed on the inside, mostly near the middle, with 8-12 crescent-shaped, flake-white spots and intermediate specks; disk pale, with radial flake-white specks and spots.

***Anemonia elegans* V., sp. nov.**

PLATE VI. FIGURE 4.

Column smooth, in ordinary expansion short, cylindrical, expanded at the base and summit; basal disk large, with undulated edges. Tentacles not retractile, numerous, in three or four rows, the inner ones much the longer, about equal to the diameter of the disk, slender, but little tapered, obtuse. Disk usually depressed with the mouth raised, but it is very changeable.

Color of column pale, brownish yellow or light fawn-color, sometimes light orange; tentacles light yellow or pale orange-yellow, with light purple or pink tips, edged below with whitish, and with a red basal line on each side and behind the base, and a triangular spot of whitish on the inner base in some cases; lips light red or scarlet; inside of mouth darker red, with two whitish gonidial grooves; disk yellowish, with narrow radial red or brown lines.

Height of column, in life, 12 to 15^{mm}; diameter, 10 to 12^{mm}; length of longest tentacles, 10 to 12^{mm}.

Cony Island, March 26, 1901 (A. H. V.).

Castle Harbor, under stones at low-tide, in May. Rare.

In color this resembles some varieties of *Condylactis passiflora*, but it has much more numerous and smaller tentacles than the young of that species of similar size.

Actinia melanaster V., sp. nov.

PLATE VI. FIGURES 2, 3.

Column in life rather short and broad, nearly cylindrical, expanded at base, but probably capable of much greater elongation. Tentacles numerous (about 76), retractile, very unequal, forming three or more rows, the inner 24 much the largest and longest, tapered, acute, arising well in from the edge of the disk; outer ones not half as long and much smaller. Two gonidial grooves; lips raised.

Color of column, in life, dark reddish brown; disk with a large, dark brown, stellate central area, with about 24 tapered radii, which run out between the bases of the inner tentacles, and with narrow, pale radial lines; outer portion of disk, between the brown radii, and inner bases of tentacles light yellow. Tentacles, except at base, dark reddish brown, with a central lighter reddish brown stripe. Mouth red, the lips edged with bluish white.

Specimens preserved in formalin have the following characters:

Tentacles about 96, long, tapered, acute, strongly sulcated in formalin preparations, length of inner ones about half the diameter of the disk. They are not very unequal; the inner 24 are, however, larger and longer than the rest and set in considerably from the border of the disk, and rather swollen near the base. They form five cycles or more, and seem to stand in three or four rows. More or less of the outer ones are imperfectly developed and short. Below the tentacles there is a distinct fosse and a marginal fold. On the latter there is a circle of about 24 larger acrorhagi, alternating with smaller ones. The larger ones are prominent, verruciform, and slightly lobulate on the outer or lower side, but apparently not perforated. The column below the margin, as preserved, is strongly vermiculate and sulcate, with about 96 sulci, alternately larger and smaller. The ridges between the sulci are crossed irregularly and closely by strong transverse and oblique or zigzag wrinkles, giving them a vermiculate appearance. No distinct suckers could be seen.

Mouth has two strong gonidial grooves and numerous lateral folds.

Diameter of disk as preserved, 25^{mm}; height of column, 20^{mm}; length of tentacles, 10–15^{mm}.

Diameter of the column in life, 20 to 30^{mm}; its length, 40 to 60^{mm}; diameter of disk and tentacles, 40 to 50^{mm}.

Several specimens of this species were found at the entrance of Flagg's Inlet, deeply buried in crevices of the ledges, from which they could not be extracted except by cutting away the rock. (A. H. V.)

Condylactis passiflora (Duch. and Mich.).

Duchass. and Michelotti, Corall. Antilles, Snpl., p. 31, pl. v, fig. 7. Verrill, these Trans., x. p. 555, 1900.

Some additional color-varieties of this very common species were observed this year. The most remarkable one was a large specimen, over a foot in diameter when expanded, found at "Sans Souci," in the interstices of a sea-wall. In this the column was light red, as usual, but the tentacles were pea-green with bright blue tips, instead of the usual pink, magenta, or violet tips. The tentacles, as seen expanded, were large and swollen, three to four inches long, with enlarged, obtuse or swollen tips.

Some pale or nearly albino specimens were also observed. The tips of the tentacles frequently lack the bright colors.

Palythoa grandiflora Ver.

Verrill, these Trans., x, p. 564, pl. lxxviii, fig. 6, 1901.

PLATE VII. FIGURE 2.

Very extensive colonies of this species, several feet across, were found between tides, at Waterloo, in the course of the tidal streams. These were nearly uniform in color. The disk was generally orange-brown or dark yellowish brown, with paler radii and tentacles. A small portion of one of these groups was photographed while living and expanded, and this photograph is here reproduced.

GORGONIACEA.

Eunicea atra V., sp. nov.

PLATE IX. FIGURES 4, 5.

A black, rather large, much-branched species with the branches dichotomously divided, subparallel, often crooked, and very variable in size on the same specimen. The edges of the large calicles are only a little raised, and generally have a small, acute, angular lower lip, which may be obsolete. Most of the branches arise from near the base; many are rather long and cylindrical; others are more or less clavate, some are tapered and not more than two-thirds as large as the average. The calicles are variable in size and form; the larger ones are usually elliptical and rather close together.

Height, 12 to 16 inches (300 to 400^{mm}); breadth of the clusters of branches, about the same; diameter of branches, 10 to 12^{mm}; of calicles, 0.5 to 1.5^{mm}.

When living the color is black, and when first taken from the sea the water, mixed with mucus, that drips from the branches is almost ink-black and imparts a black stain to one's clothes and hands. This black coloring matter gives a black color to a large quantity of alcohol or formalin solution.

When dried the coral is black or dark umber. The polyps are yellowish brown, large and long in expansion. They contract rather slowly, but completely.

The spicules of the cœnenchyma (pl. ix) are mostly rather large and variable in form; the most characteristic are moderately stout, roughly warted spindles, sometimes with a side-lobe or branch; others are short thick spindles; with these are many others of smaller size.

This species was taken in about eight feet of water at "The Reach," where there is a rather strong tidal current.

The size and form of the calicles and slight development of their lower lip will distinguish this from the allied species.

Verrucella grandis V., sp. nov.

PLATE IX. FIGURES 1, 2, 3.

This is a large, dichotomously branched, arborescent, yellow species, that grows at least five feet high.

The trunk is 12 to 16^{mm} in diameter, and the axis is round, very hard, calcareous, light brownish yellow. The cœnenchyma is rather thin, but hard, deep ocher-yellow, or inclining to orange-yellow. It forks repeatedly, so that there are numerous long and rather slender terminal branches, 12 to 18 inches long (300 to 450^{mm}) and 2 to 4^{mm} in diameter. The branches are somewhat flattened and occasionally squarish, with a sulcation along each side. The verrucæ, on the trunk and larger branches, are low and broadly rounded, about 1 to 1.5^{mm} in diameter, crowded in 3 or 4 rows on each side; on the branchlets they are mostly in two alternating rows on each side and are more elevated; their wider bases are in contact; summit rounded.

The spicules of the cœnenchyma (figure 3) are orange-colored, and small; the most abundant are short, strongly warted, double spindles; with these are many short forms, not much longer than broad, with papillose ends; several other smaller forms also occur.

A single large specimen, five feet high, was brought up from the depth of about 100 feet, outside the North Reefs, on a fisherman's hook, May, 1901.

POLYZOA.

The following additional species of bryozoa have been noticed in the collections made this year. The nomenclature followed is that of Smitt, (*Florida Bryozoa*, 1872). See also *Amathia Goodei* Ver., described last spring (*Amer. Journ. Science*, xi, p. 329, Apr., 1901), but not figured.

Idmonea Atlantica Forbes.

Smitt, *Florida Bryozoa*, p. 6, pl. ii, fig. 7.

Off the North Reefs, 16 fathoms.

Mollia patellaria (Moll, as *Eschara*).

Mollia patellaria Smitt, op. cit., p. 12, pl. ii, fig. 72.

Off the North Reefs, 16 fathoms.

Porina subsulcata Smitt.

Op. cit., p. 28, pl. vi, figs. 136-140.

With the preceding.

Porina plagiopora (Busk).

Lepralia plagiopora Busk, *Crag Polyzoa*, p. 44, pl. iv, fig. 5.

Porina plagiopora Smitt, op. cit., p. 30, pl. vi, figs. 134, 135.

With the preceding.

Anarthropora minuscula Smitt, 1867.

Op. cit., p. 31, pl. vi, fig. 141.

With the preceding.

Gemellipora glabra Smitt.

Op. cit., p. 37, pl. xi, figs. 207-210.

With the preceding.

Hippothoa mucronata Smitt.

Op. cit., p. 45, pl. viii, fig. 169.

On under side of corals, shallow water.

Lepralia edax Busk.

Cellepora edax Busk, *Crag Polyzoa*, p. 59, pl. ix, fig. 6, pl. xxii, fig. 3.

Lepralia edax Smitt, op. cit., p. 63, pl. xi, figs. 220-225.

On under side of corals, shallow water.

Cellepora avicularis.

Smitt, op. cit., p. 53, pl. ix, figs. 193-198.

Off North Reefs, on *Verrucella*, 16 fathoms.

ENTEROPNEUSTA.

Balanoglossus, sp.

A species of *Balanoglossus* was found this year burrowing in the sand-flats on the north side of Long Bird Island. It was about 150^{mm} in length. Its color was ocher-yellow to dull orange-brown. Its structure has not yet been studied with care. No species of this group has hitherto been reported from the Bermudas.

LEPTOCARDIA.

Branchiostoma Caribæum Sund. · Lancelet.

Sundevall, Olfers, Vet. Akad. Forhandl., xii, 1853. Andrews, Synopsis Studies Biol. Lab., Johns Hopkins Univ., v, 4, p. 240, 1893. Jord. and Everm., Fishes Amer., i, p. 3, 1896.

Hitherto no locality for this *Amphioxus* has been known at Bermuda except on the west side of the inlet at the Flatts, where it was first discovered by Mr. Goode, in 1876. This year we dredged it on



Figure 4.—Lancelet (*Branchiostoma Caribæum*). $\times 1\frac{1}{2}$.

a bottom of hard shell-sand and mud, in Castle Harbor, about one-half a mile north of Castle Island, in 15 to 20 feet of water. This is also one of the localities for *Strombus gigas*. Another similar locality, near Tucker's Island, in Great Sound, where *Strombus gigas* is found, would very likely also yield the lancelet.

FISHES.

Carcharinus platyodon (Poey). Shark.

Squalus platyodon Poey, Memorias, ii, p. 331, 1861.
Carcharias platyodon Jordan and Gilbert, Proc. U. S. Nat. Mus., p. 243, 1882.
Carcharinus platyodon Jord. and Ever., Fishes N. Amer., i, p. 39, 1896.

A dead specimen of this species, about four feet long, was found on the south beach near Tuckerstown, in April. It was badly decomposed and only some teeth could be preserved. From these the species has been identified by Mr. Samuel Garman. The color of the upper side was grayish blue; white below.

It has been recorded from Cuba, Texas, and the Gulf of Mexico, where it grows to a much larger size (10 to 15 feet long).

Pseudoscarus guacamaia (Cuv.). Green Parrot Fish.

Searus guacamaia Cuv., Reg. Anim., ed. ii, vol. ii, p. 265, 1829.

Pseudoscarus guacamaia Jordan and Ever., Fishes North Amer., ii, p. 1657; iv, pl. 246, fig. 617. Evermann and Marsh, Fishes and Fisheries of Porto Rico, p. 245, fig. 68, 1900.

Many specimens of this species were found among the dead fishes on the beach of Long Bird Island, early in March, 1901. The turquoise-blue teeth were conspicuous. No other parts could be saved. (Coll. A. H. V.)

Eques lanceolatus (Linné) Gunth. Gnupena. Ribbon Fish.

Chatodon lanceolatus Linné, Syst. Nat., ed. x, p. 277, 1758.

Eques balteatus Cuvier, Reg. Anim., ed. 2, ii, pl. xxix, fig. 2, 1829.

Eques lanceolatus Gunther, Catal. Fishes, ii, p. 279, 1860. Jordan and Everm., Fishes N. Amer., ii, p. 1489, 1898.

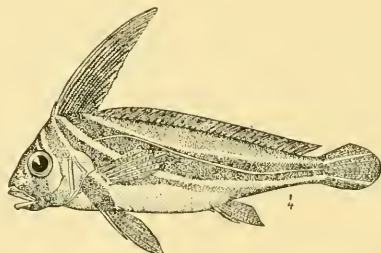


Figure 5.—Ribbon Fish. *Eques lanceolatus*. $\frac{1}{4}$.

One specimen, retaining its characteristic color-marks, was found among the dead fishes cast on the beach near Hamilton early in March, 1901. (A. H. V.)

Eupomacentrus fuscus (Cuv. and Val.) J. and Ever. Maria Molly. Brown Cock-eye Pilot.

Pomacentrus fuscus Cuv. and Val., Hist. Nat. Pois., v, p. 432, 1830.

Eupomacentrus fuscus Jord. and Everm., Fishes N. Amer., ii, p. 1552, 1898.

Everm. and Marsh, Fishes of Porto Rico, p. 224, pl. xxvii, colored, 1900.

Common in the mangrove swamp at Hungry Bay, April, 1901. (A. H. V.)

Scomberomorus maculatus (Mitch.). Spanish Mackerel. Carita.

Scomber maculatus Mitchell, Trans. Lit. and Phil. Soc. N. York, i, p. 426, 1815.

Scomberomorus maculatus Jordan and Ever., Fishes N. Am., i, p. 874, iv, pl. cxxxiv, fig. 368. Everm. and Marsh, Fishes Porto Rico, p. 123, pl. vi (colored), 1900.

I was told by some of the inhabitants that this species is occasionally taken, but I saw no specimens.

Lycodontis funebris (Ranz.) J. and Ever.

Green Moray. Black Moray.

Gymnothorax funebris Ranzani, Nov. Com. Ac. Sci. Bonon., iv, p. 76, 1840, Brazil.

Lycodontis funebris J. and Ever., Fishes N. Amer., i, p. 396, 1896. Ever. and Marsh, op. cit., p. 77, 1900.

One specimen of this species was found among the dead fishes on the shore, early in March. I have seen two large living specimens in the New York Aquarium, brought from Bermuda by Prof. C. E. Bristol and party, in 1899.

REPTILES.

Anolis principalis (Linné). Blue-tailed Lizard. American Chameleon.

Anolis Carolinensis Dum. and Bibron.

PLATE I. FIGURE 5.

A single specimen of this small lizard was recently found in a jar containing a mixed lot of marine invertebrates collected by Mr. G. Brown Goode, at Bermuda, in 1876.

The only label was "Bermuda," in Mr. Goode's handwriting. As the specimens in the jar had never been assorted and all the other things were common Bermudian species, we must infer that the locality label is correct. But since there is no special note in respect to the lizard, it is quite possible that Mr. Goode knew that it had been carried to Bermuda, in captivity. It is possible, however, that he did not distinguish it from the young of the common Bermuda species and for that reason made no special note of it. No other example has occurred, so far as I know, but that proves very little, for no systematic search for reptiles has been made by any one in Bermuda.

Mr. Samuel Garman has compared this specimen with those taken in the southern United States and Cuba, and finds no differences whatever.

It is quite possible that it has recently been introduced into Bermuda, either accidentally or intentionally, and that it has become locally naturalized there, in small numbers, like several foreign birds. This lizard was first mentioned by me in the Amer. Journ. Sci., xi, p. 330, April, 1901.

BIRDS.

A list of 17 species of birds that have been recently added to the fauna has been published by Mr. A. H. Verrill.*

Of these, five species are recent successful introductions by commerce, either intentional or accidental. These are the American Goldfinch, the European Goldfinch, the European Tree-Sparrow, the Wheatear, and the Mockingbird, all of which are now resident and breed. The others (12) are rare migrants that probably do not breed there, though it is possible that the Red-billed Tropic Bird,

* Amer. Journ. Sci., xii, p. 64, for July (issued June 22d to 28th), 1901. He has also printed a more detailed article in "The Osprey," v, pp. 83-85, for June, 1901, with figures of the three following species and of the Tropic Bird, photographed from life. In these articles he has described the Bermuda Cardinal Bird and the Blue Bird as new subspecies, peculiar to Bermuda. The Cardinal Bird is named *Cardinalis cardinalis Somersii*; the Blue Bird, *Sialia sialis Bermudensis*; the Ground Dove, *Columbigallina passerina Bahamensis*.

Outram Bangs and Thos. S. Bradlee have also published a paper on the Birds of Bermuda in "The Auk" for July, 1901, pp. 249-257, in which new names are given to some of these birds and others.

They name the Ground Dove, *Columbigallina bermudiana*; the White-eyed Vireo, *Vireo bermudianus*; the Catbird, *Galeoscoptes bermudianus*; the Cardinal, *Cardinalis bermudianus*.

Mr. Verrill's article appears to have been published a few days earlier than the latter.

To me it seems quite useless to regard these very slightly differentiated forms as distinct "species." The differences noted, especially in the Ground Dove, Catbird, and Vireo, are trivial and scarcely sufficient to constitute *varieties*. To consider them as "subspecies" is certainly a sufficient strain on the much-stretched meaning of the term "subspecies." I should, therefore, call them mere local varieties, scarcely differentiated.

In respect to the Ground Dove, there are reasons for believing that it was introduced to Bermuda from the Bahamas, since the settlement of the islands, like many other things. None of the earlier writers mentioned it in the lists of birds that they gave. This would hardly have been the case had it been present, for it is exceedingly tame and familiar.

A. K. Fisher, Bird Lore, Oct., 1901, p. 178, states that the original *Motacilla sialis* Linné, ed. x, p. 187, was from Bermuda. This is not true. He gave it as from "Bermudis & America calidore." He also quotes Catesby, Hist. Carolina, etc., p. 47, pl. 47, 1731. Catesby says that he had seen it in "Carolina, Virginia, Maryland, and the Bermudas." But he states in his preface that his birds were mostly drawn in Carolina and Georgia, where he spent several years in drawing them. A few were drawn in the Bahamas, where he spent about a year, mostly on the fishes and plants. He does not say that he made *any* drawings in Bermuda, where he probably made a mere passing visit. The Bluebird does not occur in the Bahamas. His figure clearly represents the common North American variety.

of which a few were seen, may breed in small numbers with the common species. I may add that the European Starling has been taken several times, and may have become naturalized, but if so it is still rare.

MAMMALS.

Phoca vetulina? (Linné). Common Harbor Seal.

A seal, apparently of this species, has been taken at Bermuda. A skin is still preserved in the local collection made by the late Mr. Bartram, at St. Georges. It may, however, be the young of the West Indian seal.

Orca gladiator Gray=*Orca orca* (Linné). Killer.

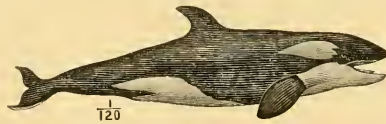


Figure 6.—Killer.

I was told by fishermen that this species is occasionally seen in Bermuda waters.

Grampus griseus Cuvier. Grampus.

This species is also found in Bermuda waters, according to the local whalers.

Delphinus delphis (Linné). Dolphin.

This common oceanic dolphin also occurs in the waters around the Bermudas and should be considered as belonging to its fauna.

Probably several other related cetaceans occur, more or less frequently, in the vicinity of the islands.

While we were at Bermuda, in April, 1901, a small sperm whale, about 30 feet long, was captured and brought to St. Georges, where it was put on exhibition for a few days.

Sperm whales are not rare in the waters a few miles from Bermuda, but they are far less common than they were formerly.

The Biscay Right Whale (*Balæna cisarctica* Cope=*B. Biscayensis* Gervais) is now very rare in these waters, where it was once common.

EXPLANATION OF PLATES.

PLATE I.

- Figure 1.—*Epiplatys bituberculatus*, var. *Bermudensis* V., new var. Photog. from life, $\times 1\frac{3}{4}$.
- Figure 2.—*Platypodia spectabilis* (Herbst). Photog. from life. $\times 1\frac{1}{4}$.
- Figure 3.—*Pagurias insignis* (Saussure) Benedict = *Petrocheirus insignis*, vol. x, p. 578.
- Figure 4.—*Calcinus sulcatus* Edw. Photog. from life. Natural size.
- Figure 5.—*Anolis principalis* (L.). Dorsal view of head and neck of a Bermuda specimen. Photog. from nature. $\times 3$.
- Figures 6a, b.—*Holothuria Rathbuni* Lamp. Photog. of two living specimens. $\frac{1}{4}$.
- Figure 7.—The same. Tentacles expanded. Drawn from life. $\times 1\frac{1}{4}$.

PLATE II.

- Figure 1.—*Cyclois Bairdii* Stimp. Photog. from life. $\times 1\frac{1}{2}$.
- Figure 2.—The same. Front view. Photog. from life. About natural size.
- Figure 3.—*Ophiolepis paucispina* M. and Tr. See vol. x, p. 585. Enlarged.
- Figures 4a, 4b.—*Dolabrifera virens* V., sp. nov. Dorsal and ventral sides of the shell. Photog. from nature. Natural size.
- Figures 5a, 5b.—The same. Shell of another specimen. Dorsal and ventral sides. Natural size.
- Figures 6a, 6b.—*Dolabrifera ascifera*. Shell, dorsal and ventral sides. Photog. from nature. Natural size.

PLATE III.

- Figure 1.—*Lamellidoris miniata* V., sp. nov. Type. From life. $\times 3$.
- Figure 2.—*Dolabrifera ascifera*. Dorsal side. From life. $\frac{3}{4}$.
- Figure 3.—*Tethys (Aplysia) dactylomela* Rang. Dorsal side. Photog. from living specimen. $\frac{1}{8}$.
- Figure 4.—*Tethys (Aplysia) tarda* V., sp. nov. Type. From life. Natural size.
- Figure 4a.—The same. Shell. Dorsal side. $\frac{3}{8}$.
- Figure 4b.—The same. Shell. Ventral side. $\frac{3}{8}$.
- Figure 5.—*Tethys (Aplysia) morio* V., sp. nov. Type. From life. $\frac{1}{4}$.
- Figure 5a.—The same. Shell. Dorsal side. $\frac{3}{8}$.
- Figure 6.—*Runcina inconspicua* V., sp. nov. Type. Dorsal side. From life. $\times 16$.

PLATE IV.

- Figure 1.—*Elysia flava* V., sp. nov. Type. Dorsal side. From life. $\times 2\frac{1}{2}$.
- Figure 2.—*Elysia picta* V., sp. nov. Type. Two specimens. From life. $\times 2\frac{1}{4}$.
- Figure 3.—*Elysia papillosa* V., sp. nov. Type. Side view. From life. $\times 3\frac{1}{2}$.
- Figure 4.—*Elysia subornata* Ver., sp. nov. Type. From nature. $\times 1\frac{1}{2}$.
- Figure 5.—*Elysia ornata* (Swain) Ver. Dorsal view, with side-flaps expanded. From life. $\frac{3}{4}$ natural size.
- Figure 6.—*Facelina Goslingii* V., sp. nov. Type. From life. $\frac{7}{8}$.
- Figure 7.—*Lamellidoris ? olivacea* Ver. Dorsal view. From life. $\times 3$.
- Figures 8a, b.—*Lamellidoris lactea* V., sp. nov. Type. Dorsal and side views. $\times 3$.

- Figure 9.—*Lamellidoris aureopunctata* V., sp. nov. Type. Side view. From life. $\times 3$.
- Figure 10.—*Pleurobranchopsis niveus* V., sp. nov. Type. Side view. From life. $\times 1\frac{3}{4}$.
- Figure 11.—*Dolabrifera virens* V., sp. nov. Type. Dorsal side. Photog. from a living specimen. $\frac{2}{3}$.
- Figure 12.—*Dolabrifera ascifera*. Dorsal side. Photog. from life. Natural size.

PLATE V.

- Figure 1.—*Discocelis cyclops* V., sp. nov. Type. Drawn from life. $\times 2$.
- Figure 2.—*Trigonoporus microps* V., sp. nov. Type. Drawn from life. $\times 2$.
- Figure 3.—*Discocelis binoculata* V., sp. nov. Type. Drawn from life. $\times 2$.
- Figure 4.—The same. Type. Drawn from life. $\times 2$.
- Figure 5.—*Pseudoceros bicolor* V., sp. nov. Type. Drawn from life. $\times 1\frac{2}{3}$.
- Figure 6.—*Pseudoceros aureolineata* V., sp. nov. Type. Drawn from life. $\times 1\frac{2}{3}$.
- Figure 7.—*Thysanozöon griseum* V., sp. nov. Type. Drawn from life. Natural size.
- Figure 8.—*Leptoplana lactoalba* Ver., var. *tincta* V. Drawn from life. $\times 1\frac{1}{4}$.
- Figure 9.—*Thalassema Baronii* Greef. Photog. from a colored drawing from life. Natural size.
- Figure 10.—*Golfingia elongata* Ver., vol. x, p. 670. Type. Photog. from nature. $\times 2$.

PLATE VI.

- Figure 1.—*Lebrunia Danae* (D. & M.) Ver. Side view. Photog. of a living specimen. $\frac{1}{3}$.
- Figure 2.—*Actinia melanaster* V., sp. nov. Type. From life. Natural size.
- Figure 3.—The same. Photog. of a living specimen. $\frac{2}{3}$.
- Figure 4.—*Anemonia elegans* V., sp. nov. Type. Specimen with the stomodæum protruded from the mouth. $\times 1\frac{1}{4}$.
- Figure 5.—*Phellia rufa* Ver. From life. $\frac{1}{2}$.
- Figure 6.—*Aipasia tagetes* (D. and M.) Andres. Photograph from life of two specimens attached to floating mangrove leaves. About $\frac{2}{3}$ natural size.

PLATE VII.

- Figure 1.—*Epicystis osculifera* (Les.) Ver. Photog. from a living specimen. $\frac{1}{2}$.
- Figure 2.—*Palythoa grandiflora* Ver. Photog. of a living group in expansion. Natural size.

PLATE VIII.

- Figure 1.—*Albunea oxyophthalma* Miers. (See errata.) Photog. from a preserved specimen. $\frac{2}{3}$.
- Figure 2.—*Clibanarius Verrillii* Rathbun, 1901. Type. Photog. from nature. Left side. $\times 1\frac{1}{2}$.
- Figure 3.—The same. Another specimen. Dorsal. $\times 1\frac{1}{2}$.
- Figure 4.—*Cyamus fascicularis* V., sp. nov. Type. Photog. from nature. $\times 4$.
- Figure 5.—*Follacia protochona* Schmarda. Photog. from a living specimen. $\frac{1}{3}$.
- Figure 6.—*Pectinaria regalis* Ver., sp. nov. Type, with tube. Photog. from a preserved specimen. Side view. $\frac{2}{3}$.
- Figure 7.—The same. Another specimen. $\frac{2}{3}$.
- Figures 8, 9.—*Catophragnus imbricatus* Sowerby. Two specimens. Photog. from nature. $\times 2\frac{1}{2}$.

PLATE IX.

- Figure 1a.—*Verrucella grandis* V., sp. nov. Part of a terminal branch of the type. Front view. $\times 1\frac{1}{2}$.
- Figure 1b.—Part of a large branch. Front view. Photog. from nature. $\times 1\frac{1}{2}$.
- Figure 2.—The same. Part of one of the larger branches, seen edgewise. $\times 1\frac{1}{2}$.
- Figure 3.—The same. Spicules, various forms. Camera drawings. $\times 170$.
- Figure 4a, b.—*Eunicea atra* V., sp. nov. Type. Distal portions of two branches from one specimen. About $\frac{3}{4}$ natural size.
- Figure 5.—The same specimen. Group of spicules of various kinds. From camera drawings. $\times 17$.
- Figure 6.—*Cerianthus natans* V., sp. nov. Type. Side view. From life. $\frac{1}{2}$.
- Figure 7.—*Polycarpa multiphiala* Ver. One of the gonads. Much enlarged. See vol. x, p. 591.
- Figure 8.—*Styela partita* (Stimp.), from the New England coast. See vol. x, p. 588. Gonads much enlarged.

[All the figures on the above plates are from photographs and drawings by Mr. A. Hyatt Verrill.]

ERRATA.

- Page 17, line 1. For *Pericera subparallela*, read *Macroceloma subparallellum* Miers.
- Page 18, line 8 from bottom. For *Albunea oxycephala*, read *Albunea oxyophthalma* Miers.
- Page 35, line 21. For *Blaumeria*, read *Blauneria*.
- Page 35, line 22. The undetermined helicoid shell may be *Helicina lucida* (Drap.) of southern Europe.

III.—VARIATIONS AND NOMENCLATURE OF BERMUDIAN, WEST INDIAN AND BRAZILIAN REEF CORALS, WITH NOTES ON VARIOUS INDO-PACIFIC CORALS.

BY A. E. VERRILL.

The following observations on a few of the common reef corals of the West Indian fauna are some of the results of my studies of the reef corals continued during the past forty years. During this period I have examined nearly all of the important collections of corals in the United States, including the types of Dana and others.* I have also had opportunities to study, in life, and to collect large series of several of the species here discussed.

The nomenclature of many of the corals is still unsettled. This is due largely to the natural difficulties of the subject. Perhaps there is no other group in which it is more difficult to determine the true characters of the genera and species and the actual limits of their variations. These difficulties cannot be overcome except by long and careful studies of large series of specimens of all ages and forms, grown under many diverse conditions. Good series of but few species can be found in most museums, even at the present time. Formerly, when most of the species were first described, series of specimens were generally unknown, and most of the species were described from a single specimen, or from very few, and these were often so beach-worn as to be nearly worthless for such a purpose.

In addition to these natural difficulties, the early literature is very unsatisfactory, for numerous species were often confounded under a single name, and a genus was often equivalent to one or several families, or even to the whole order.

In subdividing the old groups, later writers did not always take sufficient pains to follow the ordinary rules of zoölogical nomenclature, even in some cases when there could have been no reasonable doubt of the identity of the species and genera of the early writers.

* Among the collections studied by me are those of the Museum of Comparative Zoölogy, which I labelled and catalogued many years ago; those of the U. S. Nat. Museum, including most of Dana's types; those of the Museum of Yale University, also including many types of Dana and others; those of the American Museum, New York City; those of Professor Ward of Rochester, N. Y., now in the Field Columbian Museum of Chicago; of the Peabody Acad. Science, Salem, Mass.; of the Boston Society of Natural History, and many others.

The diagnoses of the Linnæan species are very poor and imperfect, and have led to much confusion. The longer descriptions of Pallas (1766) are excellent for that period.

In this article I have treated many of those genera and species that are among the most confused, but have not attempted to discuss all such cases, even among West Indian corals.

Mr. Vaughan (op. cit., 1901) has referred to the very poor character of the works of Duchassaing and Michelotti on the West Indian corals, which have led to much confusion and have very much retarded the elucidation of the synonymy. My own opinion of their works are entirely harmonious with Mr. Vaughan's. Fortunately Mr. Vaughan has been able to study the types of these authors that are in the Museum of Turin, and therefore he has been able to rectify many of their mistakes. In such cases I can but follow his determinations of their species, for I have not seen the types. I have, however, formerly studied a collection of corals sent to the Museum of Comparative Zoölogy by Duchassaing, as examples of their species. But I found that in very many cases the specimens sent did not at all resemble the species described under the same names, and concluded that Mr. Duchassaing himself was unable to identify their species.

Mr. Vaughan has also recently studied some of the types of Ehrenberg and of Edwards and Haime, and has thus been able to correct several errors.

That the nomenclature adopted by Dana, Edwards and Haime, and other standard authors is not in accordance with the strict rules of priority in zoölogical nomenclature, has been well known to me and others for many years.* Personally, however, I should have preferred to have left the current names undisturbed, considering that long usage gives sanction to many slight irregularities of this kind, in the earlier writings, and I have hitherto avoided making many changes in current names for such strictly technical reasons.

* I do not share the opinion expressed by Mr. Vaughan (op. cit., p. 4) that M.-Edw. and Haime were influenced by unworthy motives, or autoeratic ideas. Nor would I accuse them of changing names "arbitrarily" or "through ignorance." They did not hold precisely the same views of the rules of nomenclature that Mr. Vaughan follows, but they were in accord with the best usage of their period and country. Their great works are monuments of long, laborious, and faithful study, continued for over twelve years, and embracing all known corals. That they made a few mistakes is natural. We are all liable to do that. No one is infallible. I find it necessary to change 12 out of the 28 names of corals in Mr. Vaughan's revised list, p. 8.

But several recent writers, especially Mr. Gregory and Mr. Vaughan, have seen fit to make several radical innovations of this kind, changing the long current names of various genera and species to make them comply with more rigid modern rules of priority.

In a number of cases, however, they have been unfortunate in choosing or adopting the new names, so that their nomenclature has, in such instances, no more permanent foundations than the older ones they displaced, as will be shown later.

Therefore, I have thought it desirable to look more deeply into this subject, and to go as nearly as possible to the root of the matter, and so have made several necessary changes that otherwise I should have chosen to have left untouched.

The changes in the application of the names *Mæandrina*, *Mæandra*, *Manicina*, *Madrepora*, *Acropora*, *Favites*, etc., are among the more notable instances of this kind. However, if they *must* be made, the sooner the better.

MADREPORARIA.

Family **Mæandridæ** Ver., nom. nov.

Mæandrinidæ Verrill, Comm. Essex Inst., v, p. 32, 1866.

This family is intended to include all those meandriniform genera in which the zooids remain more or less united in series, and when living do not in expansion raise the disk above the calicinal walls or collines, and the astreiform corals that increase by fission.

The coral may have the calicinal centers scarcely distinct, along the bottom of more or less elongated calicinal grooves, and the tentacles not in circles around the mouths (subfamily *Mæandrinae*). Or they may be perfectly distinct and marked by the radiating arrangement of the septa, as well as by the aggregations of the columella, and the tentacles forming circles, (*Trachyphyllinae*, *Favitinae*).

The septa are rather finely dentate or serrulate and have a paliform lobe, with an emargination above it which marks the situation of the tentacles and border of the disk. The increase is chiefly by continuous incomplete fission, but in many cases exothecal budding also occurs (see pp. 68, 71). Most of the corals in this family are massive and some grow to great size. Nearly all are tropical reef-builders. The new name of the family is due to the necessary transfer of the name *Mæandrina* to the family *Eusmillidæ*, (see p. 66, note).

Subfamily **Mæandrinæ** Ver., nom. nov.

Mæandriform corals with indistinct calicinal centers and confluent zoöids. Tentacles mostly in parallel rows.

Mæandra Oken (emended.) Type, *M. labyrinthiformis* (L.). "Brain Corals."

Mycedium (*pars*) Brown, Civil and Nat. Hist. Jamaica, 1756; ed. 2, 1789, (*non* Oken).

Mæandra (*pars*) Oken, Lehrb. Naturg., p. 70, 1815.

Meandrina (*pars*) Lam., ii, p. 244, 1816, (not of 1801.)

Mæandra (*pars*) + *Manicina* (*pars*) Ehrenberg, Corall. Roth. Meeres, pp. 99, 101, 1834.

Meandrina + *Manicina* (*pars*) Dana, Zoöph. Expl. Exp., 1846.

Mæandrina + *Cætoria* + *Manicina* + *Diptoria* + *Leptoria* (*pars*) Edw. and Haime, Hist. Nat. Corall., ii, pp. 388-401, 1857.

Platyggyra + *Diptoria* + *Manicina* Vaughan, Fossil Corals of Curacao, etc., Sanml. Geol. Reichs-Mus., Leiden, Ser. 2, ii, i, pp. 45, 48, 1901.

A study of large series of various species of the above so-called genera, during many years, has convinced me that they should all be reunited into one genus, which would thus correspond more nearly with the genus *Meandrina* Lam. (1816) and to *Meandrina* of Dana + *Manicina*, *pars*.

If it be necessary to restrict *Meandrina** (Lam., 1801) to the type *meandrites* (L.) = *pectinata* Lam., as claimed by Vaughan and others, the next generic name, in order of publication, would be *Mæandra* of Oken, 1815, in which the first species (*areola* = *Manicina areolata*, authors), as well as the second and fourth, belongs to this group. Ehrenberg, also, definitely adopted this name nearly in the sense used here. Vaughan arbitrarily chooses to assume that *M. meandrites* should be considered the type of *Mæandra*, and therefore places that name as a synonym of *Meandrina*. This is not logical and is contrary to his method of reasoning in other similar cases (e. g. *Favites* Link, on p. 22).

* In establishing the genus *Meandrina* in 1801 (Syst. An., p. 372) Lamarck named but one species, *M. pectinata* = *Madrepora meandrites* L.: Ellis and Sol., which may properly be the type, though he added many other species in 1816. M.-Edw. and Haime referred to these facts (Corall., ii, p. 389), but preferred to take for the type *M. filograna*, on the ground that *denticulated septa* was given by Lamarck (1801) as a character of the genus.

It is certainly a legitimate question for doubt, whether the characters given to a genus are not of more importance than the particular species cited as an example by the older writers, who did not usually give them as "types" in the modern sense.

As a matter of fact, one of the *meandrites*-group was included by Oken in this genus by mere accident, it being erroneously referred to as a variety of a true *Mæandra* (*M. labyrinthiformis* (L.) = *Diploria*), while the four other species are of the *Diploria* and *Cœloria* groups. Moreover, he founded, in the same work, a new genus (*Pectinia*) for the *meandrites*-group. This of itself would show that he did not intend to include *meandrites* in *Mæandra*. The fact that a copied figure of *meandrites* was given, as an example, has no special significance in this case, for the publisher of such general works, rather than the author, is in many cases responsible for the selection of the illustrations, which, as is well known, are often misleading.

It would be far more consistent and correct to take either the first species (*M. areola* = *areolata*), or else the second species mentioned, for the type of *Mæandra*. *Meandrites* had already been eliminated by Lamarck, as Vaughan himself admits, when he named it as the type of *Meandrina*, in 1801. But Ehrenberg (1834), in adopting the genus *Mæandra*, used it in nearly the sense now proposed, though he eliminated Oken's first species, referring it erroneously to his new genus *Manicina*, which, as understood by him, included *Pterogyra* and also *Colpophyllia* E. and H. (See note, p. 85.) *Platygyra* was used by Ehrenberg as a subgenus of *Mæandra*. It included *Cœloria*, *Diploria*, and *Leptoria* E. and H., or the whole of his *Mæandra* except *Dendrogyra*. Therefore it is a synonym of *Mæandra* proper.

These eliminations of two of Oken's species clearly leave, as the real available type, *M. labyrinthiformis* (Linné) = *Diploria cerebriformis* E. and H., which is *var. a.* of Oken's second species. Therefore, should others still prefer to consider the latter the type of a special genus, on account of its usually double ridges, it should be called *Mæandra labyrinthiformis* (L.) Oken, but for those who do not thus restrict the Linnæan name it should be *Mæandra implicata* (Ellis and Sol.), or else *M. cerebriformis*. The forms *Stokesi* (E. and H.) and *geographica* Whitf., are mere growth-variations in the forms of the ridges and grooves.

The characters that have been used by authors to separate *Meandrina* E. and H., *Diploria*, *Cœloria*, and *Manicina* are due only to slightly different modes of growth. These several forms do not show any structural differences, such as should characterize genera. Young examples of *Diploria* can scarcely be distinguished from *Manicina*, of similar age, even by the forms of the grooves

and ridges. Many large specimens of typical *Diploria* have both single and double ridges on their different parts, or even side by side, and the same is true of *Manicina*. The calicles may form long series, more or less winding, or they may be short, or even circumscribed, equally in *Diploria*, *Cœloria*, and *Mæandrina* E. and H., and these variations are often seen on a single specimen of either group. They all form radial infoldings or collines at the margins, when young. Resorption of parts of the collines is frequent.

In *Diploria* and *Manicina* E. and H., and probably in the other groups, the ends or other parts of the growing ridges often expand and give rise to new zooids, and thus form new actinal grooves by extracalicial budding. Therefore the intervening ridges in such cases are necessarily simple for a time. See pl. x, figs. 1-3.

The genus *Mæandra*, as restricted above, would include the following four common West Indian species, two of which are found at the Bermudas.*

Besides these there are two or three other rare West Indian species that are not well known. One of these (*M. varia*), which was described by Dana as *Astræa varia*, is remarkable for having a large part of its surface covered with circumscribed polygonal calicles like those of *Goniastrea*, to which genus it has usually been referred.

But simple or multiple circumscribed calicles also occur, more or less frequently, in all the other species, and they are often due to extracalicial budding and subsequent division. There is a large specimen of *M. clivosa* in the Museum of Yale University which has a large part of its surface covered with simple angular calicles, while in other parts they are long and meandriniform, as usual. The same is true of some of the East Indian species of the *Cœloria*-group.

In the Indo-Pacific region, including the Red Sea,† there are a considerable number of nominal species of *Mæandra*, most of which have been referred to *Cœloria* and *Leptoria*.

* Nelson (Trans. Geol. Soc. London, v, p. 112) records the occurrence of *M. areolata* as a fossil in the older beach rock. Probably his specimens are the same that Mr. Vaughan has recently identified as *Mycetophyllia Lamarckana* (in coll. Geol. Soc.). Neither of these species has been found living at the Bermudas, but the older "beach rock" there contains also several West Indian shells that no longer exist in the Bermudas, indicating a period of warmer climate than at present. This rock may be post-glacial in age. It is overlaid by several forest or red-clay beds with much æolian limestone interstratified.

† See Klunzinger, C. B., *Die Korallthiere des Rothen Meeres*. Madrepোরaria. Berlin, 1879. In this excellent work there are good descriptions and photographic figures of five species and four varieties of *Cœloria* and of one species of *Leptoria*.

Among those of the section *Cœloria* are the following :

M. dedalca (Ellis). E. Indies.

M. dedalina (D.). = *Astrœa deformis*, pars, Dana, (non Lam.)

Fiji Is.

M. spongiosa (Dana). West Indies (?). Pl. xii, fig. 3.

M. pachychila Ehr. = *C. labyrinthiformis* E. & H., non Linné.

M. lamellina (Ehr., p. 99) + *M. leptochila*, Ehr., = *C. Bottai* and *C. Forskælana* E. and H. = *C. Arabica* Klz. Red Sea.

M. laticollis E. and H., (Corall., ii, p. 415, pl. D4, fig. 4, as *Cœloria*).

M. Sinensis (E. and H., Corall., ii, p. 416, as *Cœloria*). China.

M. stricta (E. and H., op. cit., p. 417). E. Indies.

M. astrœiformis (E. and H., op. cit., p. 417). Red Sea.

M. Esperi (E. and H., op. cit., p. 417). Red Sea.

M. leptoticha (Klz., as *Cœloria*). Red Sea.

M. laxa Ver., sp. nov. This has broad, distant, and very thin septa, with the edges sparingly and very irregularly toothed, and with the summits broad and rounded or subtruncate. Walls very thin. Valleys deep, mostly sinuous. Columella but little developed. Depth of calicinal valleys, about 7^{mm}; width about 5 to 8^{mm}. Kings-mills Islands.

M. elegans, *M. deltoides*, *M. Australiensis* (all Rehb.), Australia.

The following have been referred to *Leptoria* by Edw. and Haime, on account of the somewhat lamellose columella :*

M. gracilis (Dana). Fiji Is. ; *M. tenuis* (Dana). Tonga Is.

The following are, apparently, more closely related to the typical West Indian species :

M. rustica (Dana). Wakes Island.

M. valida (Dana). Locality unknown.

M. rudis Verrill = *M. phrygia* Dana, non Ellis and Sol.

M. delicatula (Ortman, 1888). Samoa.

The following species were referred to *Diploria* :—

M. crassior (E. and H., Corall., ii, p. 403). China Sea.

M. spinulosa (E. and H., op. cit., p. 404). China Sea.

He proposes *C. Arabica* Klz. to include *M. leptochila* and *M. lamellina* Ehr., + *C. Forskælana*, *C. Bottai*, and *C. subdentata* Edw. and Haime, as varieties.

This shows that the Red Sea species are quite as variable as the West Indian.

However, it seems to me undesirable to give a new name (*Arabica*) to this revised and extended species. It would be better to extend the sense of *M. lamellina* (Ehr.) so as to include all these forms.

* The structure of the columella is not essentially different in the two following species (types examined) from that of typical *Mæandra*, especially that of *labyrinthiformis* when the latter is poorly developed. It is not a continuous plate, but consists of small, irregular, interrupted laminae.

Mæandra labyrinthiformis (L.) V. Brain Stone. Brain Coral.

Madrepora labyrinthiformis (pars) Linné, Syst. Nat., ed. x, p. 794, 1758.

Madrepora meandrites, var. γ , Pallas, Elench. Zoöph., p. 292, 293, 1766.

Madrepora implicata Ellis and Solander, p. 164, 1786. Gmelin, op. cit., p. 3763.

Madrepora labyrinthiformis Esper, Pflanzenth., p. 74, pl. iii, 1789.

Mæandra meandrites (pars), including as var. *a*, *labyrinthiformis* (Linné), Oken, Lehrb. Naturg. Zoöl., i, p. 70, 1815.

Mæandrina cerebriformis Lamarck, Hist. Nat. Anim. s. Vert., p. 246, 1816.

Mæandra (*Platyygyra*) *cerebriformis*, vars. *a* and *b*, Ehrenberg, Corall. Rothen Meeres, Abhandl. Kgl. Akad. Wiss. Berl., p. 324 [100], 1834.

Mæandrina cerebriformis, p. 263, pl. xiv, fig. 2; + *Mæandrina truncata*, p. 264, pl. xiv, figs. 1, 1a, Dana, Zoöph. U. States Expl. Exped., 1846.

Diploria cerebriformis Milne-Edwards and Haime, Compt.-rend., xxvii, p. 493, 1848.

Diploria cerebriformis; + *Diploria Stokesi*, pl. D4, fig. 3; + *Diploria truncata* Milne-Edwards and Haime, Hist. Nat. Corall., ii, pp. 402, 403, 405, 1857.
? *Mæandrina labyrinthiformis* Pourtalès, Florida Reefs, Corals, pl. ix, figs. 10-12, 1880.

Diploria cerebriformis Pourtalès, Ill. Cat. Mus. Comp. Zoöl., No. iv, Mem. ii, p. 75; 1871; Verrill, these Trans., x, p. 552, 1900.

Diploria geographica Whitfield, Bull. Amer. Mus., N. York, xiv, p. 223, pl. xxxiii, xxxiv, 1901. (Types examined.)

Diploria labyrinthiformis Vaughan, Samml. Geol. Reichs-Mus., ii, p. 45, 1901 (non *Cæloria labyrinthiformis* Edw. and Haime).

PLATE X. FIGURES 1-3.

This species can usually be distinguished from the allied forms by the generally double ridges between the actinal grooves and by the presence on these ridges of a more or less wide intermural furrow, but the furrow may be lacking or obsolete, and the wall may be simple and solid on parts of many specimens.

While living, the color of the soft parts is usually dull orange-yellow, but it varies from light ocher-yellow to brownish orange. The structure and appearance of the tentacles, mouth, and disk are like those of *M. cerebrum* and *M. clivosa*.

This is the most abundant of the reef-corals at the Bermudas. When it grows under very favorable conditions it forms large, evenly hemispherical or dome-shaped masses, which are sometimes 5 or 6 feet in diameter, and nearly as high. Perfect specimens of this form, from 8 inches to 2 feet in diameter, are much sought after by collectors, and are, therefore, common in museums. Much larger numbers of specimens on the reefs take on irregular, broad, thick encrusting forms, due to less favorable conditions, injuries, and especially to crowding and coalescence.

A very extensive series of this species was collected, in 1898 and 1901, in order to study its variations. Over 300 specimens of all sizes from less than half an inch up to over five feet in diameter were studied by me.

The variations are very great in several directions:—as in the modes of growth; breadth and depth of the actinal grooves; and especially in the breadth of the intervening ridges and of the intermural or exothecal groove at their summits. The length, direction, and arrangement of the grooves and ridges vary in every possible way, often presenting the most diverse arrangements on different parts of a single large specimen, especially if it has grown in a more or less crowded or restricted position.

These common variations include those forms that have been named *Diploria Stokesi* Edw. and Haime, but which differ in no way from the typical forms, except in having unusually wide ridges, surmounted by a deep intermural groove, which often expands, especially at the end of a ridge, to the breadth of 10 to 15^{mm}.

Extracalicular budding frequently occurs in these wide intermural grooves. In life, many of these grooves show a distinct mouth, or a series of mouths, with rows of tentacles, before any marked changes occur in the underlying coral. But soon the bottom of the groove receives deposits of columellar tissues, and then paliform lobes and septa rapidly appear. Thus after a short period of growth, these grooves become true actinal grooves formed over the exothecal tissues of the walls, by true budding. They often become as deep and well formed as the other furrows before they break through, at one or more places, and thus become connected with the older grooves. Some of them, both long series and single calices, may remain isolated for a long time in some specimens.

As a matter of course, actinal grooves formed in this way must be separated for some time by simple walls only. This accounts for many of the cases where simple ridges are found mixed with double ones on the same specimen (pl. x, fig. 1). A single ridge may also, on this account, be double for a part of its length and single in other parts, or it may divide into two simple ones, in certain places.*

* Probably some of the confusion in respect to the synonymy of this species is due to the fact that this mode of growth has not been recognized by authors, and therefore specimens of this species with simple ridges have been referred to different species and to a different genus (*Meandrina*), for such specimens have all the characters of *Meandrina*, as contrasted with *Diploria*. (See p. 67.)

It is not improbable that the figures of *M. labyrinthiformis* Pourtalès (op. cit., Florida Reefs, pl. ix, figs. 10–12, 1880) were drawn from a specimen of this kind

This mode of increase, by exothecal budding, seems to occur most freely in young specimens 2 to 3 inches in diameter, though not exclusively so. In such specimens the ridges are often all or nearly all broad and deeply grooved, or just ready to divide (plate x, figure 3). Others, scarcely larger, may be found in which all or nearly all the ridges are narrow and single, without grooves, the divisions having already taken place (pl. x, fig. 2). Specimens in both these stages, and in various intermediate conditions, were collected by me in Bermuda, both in 1898 and 1901.

The stage in which broad and deeply grooved ridges occur has been named as a distinct species (*Diptoria Stokesi*) by Edwards and Haime. Some later writers have called it a "young stage"; others have called it a *variety*. It appears, from the facts just stated, that it is only a phase of growth, which may occur at various stages of development. *M. truncata* Dana seems to have been based on a phase following the division of the ridges and before the new grooves had developed on their summits. Such specimens are not rare. See pl. x, fig. 2.

Large specimens occur in which one part will show the *Stokesi* arrangement, while another part will be of the typical form; and still other parts will present simple or nearly simple solid ridges of the *truncata* phase. See pl. x, fig. 1.

Many oblong specimens show, especially on the sides, many long and nearly parallel, subradial, or nearly transverse ridges and grooves, while on other parts they present the ordinary convoluted arrangement.

The gyri are often in places more or less angular or zigzag, especially on the median or more crowded portions, thus showing that the form recently described and figured by Whitfield as *D. geographica** is only a form of growth, not of varietal value.

Many of the larger hemispherical and oblong examples consist of two, three, or more originally separate masses that have come in contact by growth and crowding, and have then grafted themselves together completely. The planes of union are usually shown only by a thin line of epithelial tissue. Some of these double specimens are as evenly and regularly hemispherical as the simple ones.

and not from *M. cerebrum*, as Vaughan supposed. The types from which the original plates of that Report were drawn were not separately preserved nor in any way indicated by labels. While I had charge of the coral-collections of the Mus. of Comp. Zoölogy (1860-1864), I tried in vain to identify the specimens that had previously been figured on those plates, which were then unpublished. Therefore any question of synonymy must be settled by the plates themselves. Fortunately they are very accurate.

* Bull. Amer. Mus., xiv, p. 223, 1901.

The characters of the septa and costæ are also variable, though more reliable than the form of the ridges. The septa are not very crowded, though more so than in *M. cerebrum*. Smaller, thin ones alternate with the larger and usually extend down below the paliform lobe. The larger septa are rather broad, generally with the inner edge perpendicular, and often sometimes broader above, usually with the summit broadly rounded and continued into prominent costæ which have rather regular conical or spiniform serrations on their edges. The paliform lobe is generally well developed and roughly serrulate; the inner edge of the septa bears numerous, small, close, irregular, elongated teeth, many of which are rough or forked at the tip; those toward the summit are longer, directed strongly obliquely upward and frequently incurved; those on the rounded summit are usually more regular and divergent. The sides of the larger septa are covered with rather few and scattered conical grains,—much fewer and smaller than in *M. cerebrum*.

The columella is variable, but usually well developed, composed of curled lamellose processes, and thickened at the centers. Sometimes it is larger and nearly solid or subvesicular.

In transverse section the walls vary in breadth, but are usually thick and solid. In those specimens that have thin and simple walls at the surface, a section made an inch or so from the surface usually shows most of the walls as thick as usual (about 3 to 5^{mm}). The septa in section are thin and sparingly spinulose laterally, quite unlike those of *M. cerebrum* in similar sections.

The actinal grooves vary considerably in breadth and depth, but they are always decidedly narrower and shallower than those of typical *M. cerebrum*, and have a more square-cut appearance. The breadth from wall to wall, at top, is generally 5 to 10^{mm}; of the open valley, septal edge to septal edge, 4 to 6^{mm}; depth, mostly 4 to 6^{mm}. Number of septa to a centimeter, usually 14 to 16. One variety (*compacta*) has unusually shallow and narrow valleys (3–5^{mm} wide), with crowded septa.

This species is the largest and most important of the Bermudian reef corals. It occurs abundantly on the inner reefs of Great Sound, Castle Harbor, etc., often close to the shores and in water only two feet deep at low-tide, and mostly in less than twenty feet. It is still more abundant on the outer reefs. It does not occur in Harrington Sound, probably owing to a slightly diminished salinity of the water, due to its nearly land-locked condition. It may form masses 6 to 8 feet in diameter and height.

It is found on the Florida reefs and throughout the West Indies.

- Mæandra cerebrum** (Ellis and Sol.) V. Brain Coral. Brain Stone.
Madrepora cerebrum Ellis and Sol., Nat. Hist. Zoöph., p. 163, 1786. Gmelin, in Linné, Syst. Nat., ed. xiii, vi, p. 3763, 1798.
Madrepora labyrinthica Ellis and Solander, Nat. Hist. Zoöph., p. 160, pl. xlvi, figs. 3, 4, 1786 (not of Pallas, which is *M. meandrites* Linné, ed. x.)
Meandrina labyrinthica (pars) Lamareck, Hist. Nat. Anim. sans Vert., ii, p. 246, 1816 (non *Mad. labyrinthica* Pallas).
Meandrina sinuosa LeSueur, Mem. Mus. d'Hist. Nat. Paris, vi, p. 278, pl. xv, fig. 4, and ? varieties *viridis*, p. 279, pl. xv, fig. 5; ? *appressu*, p. 280, pl. xv, fig. 6; ? *rubra*, p. 280, pl. xv, fig. 7; ? *rineola*, p. 280, pl. xv, fig. 8, 1820 (non *Madrepora sinuosa* Ell. and Sol. = *Mussa* or *Isophyllia*: nec *Meandrina sinuosa* Quoy and Gaimard).
 ?? *Meandrina dedalea* Les., op. cit., p. 281, pl. xvi, fig. 9, 1820.
M. labyrinthica Les., op. cit., pl. xvi, fig. 10, 1820.
Meandrina labyrinthica Lamouroux, Exp. Meth. Gen. Polyp., p. 54, pl. xlvi, figs. 3, 4 (reprint from plate of Ellis and Solander), 1821 (non Pallas).
Mæandra (Platygyra) labyrinthica (pars) Ehrenberg, Cor. Rothen Meeres, Abh. k. Akad. Wiss. Berl. for 1832, p. 323 [99], 1834. (Includes 5 species, mostly of *Cæloria*, t. Vaughan, from types.)
Meandrina labyrinthica, p. 256, pl. xiv, fig. 1; + *M. strigosa*, p. 257, pl. xiv, fig. 4a, Dana, Zoöph. U. States Expl. Exp., 1840.
Meandrina heterogyra, p. 392; + *M. sinuosissima*; + *M. serrata*, p. 393; + *M. crassa*, p. 394, + *Cæloria strigosa*, p. 418, Milne-Edwards and Haime, Hist. Nat. Corall., t. ii, 1857 (teste Vaughan, from types). See also *M. sinuosa* Les. and varieties, described on p. 389, foot note.
Leptoria fragilis Duchassaing and Michelotti, Mem. Corall. Ant., p. 351, 1861 (teste Vaughan, from type).
Meandrina strigosa Pourtalès, Flor. Reefs, Corals, Mem. Mus. Comp. Zoöl., vii, pl. ix, figs. 6-9, 1880.
Meandrina strigosa, pp. 10, 92; + *M. sinuosissima*, pp. 10, 91; + *M. labyrinthica*, pp. 10, 12, 91; + ? *M. sinuosa*, p. 12, Quelch, Reef Corals, Chall. Exp., vol. xvi, 1886.
Meandrina filograna (pars) Gregory, op. cit., p. 265 (non Esper).
Platygyra viridis Vaughan, Samml. Geol. Reichs-Mus., ii, p. 51, 1901 (after var. *viridis* Les.)
Platygyra sinuosa Vaughan, op. cit., p. 56, 1901.
Meandrina labyrinthica Whitfield, Bull. Amer. Mus. Nat. Hist., N. York, xiv, p. 221, pl. xxxi, xxxii, 1901. (Abnormal, type studied.)

PLATE X. FIGURE 4. PLATE XII. FIGURE 4. PLATE XIV. FIGURES 4, 5.

This species usually forms evenly convex, thick, encrusting masses, or when well grown, large even hemispheres, sometimes a yard or more in diameter, with intricately convoluted gyri. Its actinal grooves are usually wider and more open than in the preceding species, while the mural ridges are generally high, narrow, solid, and rather thin in sections, and they usually appear acute at the crest, owing partly to the fact that the septa are generally narrowed

toward the summit; but also because the wall itself is generally (but not always) reduced to a thin solid lamina, which, as seen from above, runs as a zigzag line from septum to septum. The larger septa usually alternate with small very thin ones, most of which do not extend half way to the paliform lobes, thus leaving wide interseptal spaces below. The large septa are usually thin and rather narrow, with the inner edge rapidly sloping or nearly perpendicular to the well marked paliform lobe, so that the actinal grooves are generally deep and often more than twice as wide as the ridges, the width decreasing gradually to the level of the paliform lobes. The summits of the septa are only slightly prominent above the thin wall, and may be evenly but obtusely rounded, or they may have a gothic form, narrowing rather abruptly, giving a rather acute form to the ridges. Their inner edges are strongly and usually rather regularly serrulate, the teeth are often angular and sharp like saw-teeth, but are frequently more elongated and uneven, some of them having minutely forked or lacerate tips; the teeth are directed obliquely upward, but are seldom incurved, as is so often the case in the preceding species. The paliform lobes are a little thickened and roughly serrulate on the sides and edges. The sides of the septa are almost always very roughly spinulose or hispid, being thickly covered with small, acute, spiniform grains, much more numerous and conspicuous than in the allied species. This is usually a good diagnostic character, and is available even in worn specimens, for these lateral septal spinules are conspicuous on the thin septa in transverse sections. The columella varies considerably; it is usually well developed and composed of numerous, small, thin, contorted laminae, sharply spinulose laterally, and united into a nearly continuous but uneven series, with thickenings at irregular intervals. In some cases the columella is much less developed and composed of few laminae. The gyri in large specimens are long and intricately convoluted in every direction, but in smaller examples they may be more or less radial, or parallel for long distances, especially on the sides. In some specimens, though rarely, short gyri occur, and in some instances isolated, round or elliptical, *Astraea*-like calicles may be found, due to intermural budding, but these are much less common than in *labyrinthiformis* and *clivosa*. Pl. xiv, fig. 4. Double mural ridges are rarely seen, but they sometimes occur, especially near the margins of the smaller specimens.

In sections the coral is rather cellular; the walls are relative thin and nearly solid, being seldom more than 1.5 to 2^{mm} thick, while the

septa are alternately thicker and thinner, and show numerous lateral spinules, as mentioned above. See pl. x, fig. 4.

This species can usually be easily recognized by its evenly convex surface and the long convoluted simple, often gothic ridges, with the crest of the wall, thin, solid, and often in a zigzag line; by its rather open grooves, generally wider than the ridges, and usually showing rather open interseptal spaces and thin unequal septa; and especially by the strongly spinulose lateral surfaces of the septa.

The width and depth of the actinal grooves varies considerably, but is almost always greater than in *labyrinthiformis*. The breadth from wall to wall is generally 8 to 14^{mm}, rarely as little as 6^{mm}; open space between septal edges, near summit, mostly 6 to 10^{mm}; depth of grooves mostly 6 to 10^{mm}, usually about 8^{mm}. Number of septa to a centimeter, usually about 24 to 28, when the smaller ones are developed.

The color of this species, in life, so far as observed by me at the Bermudas, is dull yellow, ochre-yellow, or brownish yellow. It appears not to have the orange-yellow color, so general in *labyrinthiformis*. In the Bahamas it is more variable in color.

I think it very improbable that all the various color-varieties, named by Lesueur from the color alone, pertain to this species. But in any case they cannot be determined from color alone, for the color of such corals is variable and uncertain. Therefore *M. viridis* of Lesueur rests on no valid characters.

This species is not abundant in the Bermudas. It is sometimes, though rather rarely, found on the inner reefs, associated with the preceding species, but it occurs more commonly on the extreme outer reefs. Most of the larger specimens that I have seen were from the vicinity of the North Rocks, where it becomes one to two feet or more in diameter. It is common in the West Indies and on the Florida Reefs, where it grows to a large size. I have seen specimens over a yard across.

At least two forms of simple ridged *Mæandrax* occur on the outer reefs of the Bermudas. Whether they represent more than varieties of the above species may be doubtful, for no one has yet obtained a sufficiently large series of them for study. Those that I have seen appear to me to belong to two species, for they differ decidedly as to the form and denticulation of the septa and in other ways. The more common form seems to be the abundant West Indian and Florida species, named above.

I am not prepared to admit that all the described West Indian

forms, referred to this species by Vaughan, really belong to one species. It is certain that too many species of this group have been admitted by Edw. and Haime; Duch. and Michel.; and others. But Gregory has gone to the opposite extreme in uniting *M. elivosa* = *filograna*, etc., to this species, from which it differs very plainly. The latter does not occur at the Bermudas.

Much diversity of opinion has prevailed as to the correct name for this species, as shown by the above synonymy. Apparently none of the names in use for members of this genus in works previous to Lesueur's memoir are available, except *M. cerebrum* Ellis and Solander, which was evidently based on the most common form of this species. Their description, though brief, is characteristic, and they also give the vernacular name, "Brainstone," which is still in use in the Bahamas and the Bermudas. But it was also undoubtedly included by Linné, Pallas, Ellis and Solander, Esper, and other writers of the 18th century under several other names that now apply more strictly to different species.

It appears to me that *M. sinuosa* of Lesueur could be retained for this species, were it the first available name that clearly applies to it. Vaughan rejects it because Lesueur referred *doubtfully* to the *Madrepora sinuosa* of Ellis and Solander (probably from memory alone). But the latter belongs to a widely different genus, and has no particular resemblance to this species, so that there can be no danger of confusion in this case. Lesueur described his species under a different genus, as if it were new. His erroneous and useless synonym, given with doubt, should not invalidate his name.

Moreover, Vaughan adopts *viridis*, the name of one of the color-varieties described by Lesueur, for the species. There can be no certainty that this variety pertains to *M. sinuosa*, for Lesueur gave to it no characters except the green color. It is well known that the green color, so frequent in coral animals, is generally due to a parasitic, unicellular, vegetable organism and it may occur in almost any species of reef corals, so that one could never be certain of the difference or identity of two allied corals having this color, even in the same locality, without studying the hard parts. On this account also, the name *viridis* should not be adopted for this species. In this case the name *viridis* is not connected directly with any specific characters and therefore has no claims for recognition. The same remark would apply to the other "varieties" of Lesueur. They are not recognizably characterized. The next distinctive name, not based on color, appears to be *strigosa* Dana, 1846.

I have seen the type of Dana's *strigosa* and consider it this species from personal study of it. The figures published by Pourtalès (op. cit., 1880) are excellent.

Whitfield (op. cit., 1901*) has described and figured an interesting abnormal specimen of this species from the Bahamas, which he thought a case of union between a *Ctenophyllia* and *Mæandrina*. But the central part, which he called *Ctenophyllia*, is not that genus. It has serrate septa and is only a variation of this *Mæandra*, in which the ridges and valleys have become unusually wide, the latter varying from about 12 to 15^{mm}. Similar cases are not rare.

Mæandra clivosa (Ellis and Sol.) Ver.

Madrepora clivosa Ellis and Solander, Nat. Hist. Zoöph., p. 163, 1786.

Madrepora filograna Esper, Pflanzenth., p. 139, pl. xxii, figs. 1, 2, 1789.

Madrepora clivosa Gmelin, Linné, Syst. Nat., ed. xiii, p. 3763, 1790.

Mæandrina filograna Lamarek, Hist. Nat. An. s. Vert., t. ii, p. 248, 1816.

Mæandrina interrupta, p. 258, pl. xiv, fig. 18; *M. filograna*, p. 262; *M. mammosa*, pl. xiv, figs. 10, 10a; Dana, Zoöph. U. States Expl. Exp., 1846.

Mæandrina filograna; *M. grandilobata*; *M. superficialis* Milne-Edwards and Haime, Ann. Sci. Nat., ser. iii, xi, pp. 280, 281, 283, 1849, (t. Vaughan).

Mæandrina filograna; *M. grandilobata*; *M. superficialis* and *M. ? mammosa*, p. 396, Milne-Edwards and Haime, Hist. Nat. Corall., ii, pp. 390, 391, 396, 1857, (t. Vaughan from types).

Mæandrina clivosa Verrill, Bull. Mus. Comp. Zoöl., i, No. 3, p. 48, 1864; Proceed. Bost. Soc. Nat. Hist., x, p. 323, 1865.

Mæandrina superficialis; *M. interrupta*; *M. grandiloba*; and *M. filograna* Duchassaing and Michelotti, Mem. Corall. Ant., p. 74, 1860, (t. Vaughan, from types).

Mæandrina clivosa Pourtalès, Ill. Cat. No. iv, Mem. Mus. Comp. Zoöl., ii, p. 74, 1871.

Mæandrina clivosa Pourtalès, Florida Reefs. Corals, Mem. Mus. Comp. Zoöl., vii, No. 1, pl. ix, figs. 1-5, 1880.

Mæandrina filograna (*pars*) Gregory, Quart. Jour. Geol. Soc. Lond., vol. li, p. 265, 1895.

Platygyra clivosa Vaughan, op. cit., p. 57, 1901.

This species is easily distinguished by its narrow actinal grooves and generally simple, solid ridges; by the crowded septa, alternately larger and smaller, and not rising much above the wall; by the number of septa to a centimeter, which is 28 to 36, usually about 30; by the narrow, interrupted columella; and by the nodose, gibbous, or lobulated character of the coral, except when young.

* Notice of a Remarkable Case of Combination between two different Genera of Living Corals, Bull. Amer. Mus., xiv, p. 221. I have recently examined this specimen, with Mr. Whitfield.

Gregory (op. cit., 1895, p. 265) erroneously united this and the preceding species. They are certainly clearly distinct. The name *clivosa* has unquestionable claims to priority.

This coral does not occur at the Bermudas, but it is very abundant and large on the Florida reefs and at the Bahamas, as well as farther south, throughout the West Indies, and at Colon.

This species varies extensively in the length and form of the calicinal grooves. Usually they are long and very sinuous, but in many specimens part of them are, in certain parts, shorter and circumscribed, with some oval or angular astreiform calicles, especially on the flat or depressed portions, between the nodules.

Var. *dispar* V. nov.

I have already alluded (p. 68) to a Florida specimen in the Yale Museum that has a large part of the flat basal mass covered with more or less short and circumscribed angular calicles, much like those of *M. Agassizii*. But on the nodules they are long and sinuous, as usual. Florida Reefs, coll. E. B. Hunt.

Var. *explanata* V. nov. Plate xiv, figure 2.

When young this may form rather than encrusting plates, often with their spreading, or even free and foliaceous edges somewhat resembling a *Merulina*. In this condition the septa are more loosely arranged and obliquely inclined; the collines become small, narrow, and sharply triangular, close to the edge, and the valleys become shallow and flat, most of them having short, rudimentary collines dividing them into two. Detached fragments of this form might easily be mistaken for a distinct species.

Colon, Yale Museum, coll. F. H. Bradley.

Mæandra varia (Dana) Ver.

Astræa (Fissicella) varia Dana, Zoöph. U. States Expl. Exp., p. 236, pl. xii, figs. 13a, 13b, 1846.

Prionastræa ? varia Edw. and Haime, Hist. Nat. Corall., ii, p. 524, 1857.

Goniastræa varia Verrill, Bull. Mus. Comp. Zoöl., i, p. 48, 1864.

Of this rare species, supposed to be West Indian, I have seen only few specimens and have none at hand for figuring. Dana's type I have not seen. He does not state where it was placed. However, Dana's description and figures indicate that this is a *Mæandra* with mostly circumscribed, *Goniastræa*-like calicles, much as in the next, but with a more cellular structure.

Mæandrina spongiosa Dana is entirely unlike this species, to which Dana thought it might be united as a variety.

The type of the former is in the Museum of Yale University. It is one of the *Caloria*-group, with larger, open, mostly polygonal calicles, rather few septa, and with a very cellular texture, as seen in sections. Its origin is very uncertain. I do not think it probable that it came from the West Indies, as Dana supposed. No recent collector has found it in American waters, so far as I know. See pl. xiv, fig. 3.

Mæandra Agassizii (Edw. and Haime).

Astræa reticularis Dana, Zoöph., p. 237, pl. xii, figs. 9-9c (non Lam.)=*Prionastræa*? *Agassizii* Edw. and Haime, Hist. Corall., ii, p. 524, 1857.

PLATE XIV. FIGURES 1, 1a.

This rare species when well grown forms compact, even, hemispherical masses, a foot or more in diameter. Such a mass, from the Bahamas, in the Museum of Yale University, is ten inches across and about six thick. A large part of the calicles are simple, astræiform, angular, often hexagonal or pentagonal, like those of a *Goniastrea*, separated by narrow rather acute walls. But in many places, especially toward the borders, they form more or less elongated, mæandriniform grooves, which often become branched and convoluted, as in typical *Mæandra*. Some of these actinal grooves become one to two inches long (25 to 50^{mm}); 2.5 to 4^{mm} wide; they are separated by regular ridges, similar to those of *M. clivosa*, but smaller and more regular. The mæandriniform grooves are often mixed with astræiform calicles, and all intermediate forms may occur on one specimen. The ridges are rather high, rounded or with a gothic profile, and have a simple, solid wall; they are about 2 to 3^{mm} wide. The septa are numerous, very thin, close, pretty regular, about 25-30 to a centimeter, and they project but little above the wall. The edge is finely serrulate and there is a small but distinct paliform lobe. The columella is well developed, spongy, composed of small convoluted laminae, as in most other species of the genus.

On those parts where most of the calicles are simple and regular, they are mostly from 4 to 7^{mm} in diameter; double ones are from 12-14^{mm} long.

This species has not been found at the Bermudas and probably not on the Florida Reefs. Most specimens that I have seen have been from the Bahamas, where it seems to be rare. It is generally mistaken for a *Goniastrea*, which it often closely resembles, but it is closely related to *M. clivosa*.

Mæandra areolata (Linné).

Madrepora areolata (*pars*) Linné, Syst., ed. x, p. 795, 1758. Pallas, Elench. Zoöph., p. 295, 1766; ? Ellis and Sol., Nat. Hist. Zoöphytes, p. 161, pl. xlvii, figs. 4, 5, 1786.

Madrepora areola (*pars*) Linné, Sys. Nat. ed. xii, p. 1274, 1767. Esper. Pflanz., i, pp. 76, 84, pl. v, figs. 1-4, young, worn; and *Madrepora mean-drites* (*pars*), pl. iv, figs. 1, 2, adult, 1788.

Mæandra areola Oken, Lehr. Naturg., i, p. 70, 1815.

Mæandrina areolata Lam., Hist. Anim., ed. i, vol. ii, p. 247, 1816 (*non* Linné, ed. x). ? Lamouroux, Expos. Method., p. 55, pl. xlvii, fig. 5, 1821 (reprint of plate of Ellis and Sol.).

Manicina hispida + *Manicina prærupta* + ? *Manicina manica* Ehrenberg, Corall. Rothen Meeres, p. 336, 337 [102, 103] 1834 (*non* *M. areolata*, p. 103).

Manicina areolata Dana, Zoöph. U. S. Expl. Exp., p. 191, pl. ix, fig. 3, 1846. Edw. and Haime, Corall., ii, p. 397, 1857. Verrill, Bull. Mus. Comp. Zoöl., i, p. 48, 1864. Pourtalès, Florida Reefs, Corals, Mem. Mus. Comp. Zoöl., vii, pl. v, figs. 1-22, pl. vi, figs. 1-7, 1880.

Manicina ? *dilatata* + *M. prærupta* + *M. hispida* Dana, Zoöph. Expl. Exped., pp. 191-193, pl. ix, fig. 3, 1846.

Manicina strigilis + *M. hispida* + *M. Danai* + *M. Valenciennesi* Edw. and Haime, Hist. Corall., ii, pp. 399-401, 1857.

PLATE XI. FIGURES 1, 2. · PLATE XII. FIGURES 1, 2, 3.

This very common Florida and West Indian species does not occur at the Bermudas.*

It varies greatly in form and in the height, breadth, and form of the actinal grooves and intervening ridges. These are generally more or less regular infoldings while the coral is young, but in large specimens they become forked and more or less convoluted, finally assuming, in old specimens, the meandriniform arrangement. The actinal grooves are, however, always much wider, deeper, and more open than in either of the three preceding species. The septa are generally strongly granulated or subhispid on the sides and roughly denticulated on the edges, with a broad basal paliform lobe. It is pedicellate when young, but usually becomes free when old.

Some of the nominal species, quoted in the synonymy, were based on beach-worn specimens, which look very unlike fresh ones.

The name *Madrepora areolata* was first applied by Linné (Syst., ed. x, p. 795, 1758) chiefly to the East Indian coral now generally known as *Trachyphyllia amarantum* Edw. and Haime. Ehrenberg's *Manicina areolata* was probably the same or a related species (*P.*

* The fossils mentioned by Nelson as belonging to this species were probably *Mycetophyllia* (see p. 68, note).

Geoffroyi E. and H.). The former should be called *Trachyphyllia amaranthus** (Müll.).

Linné evidently had the East Indian species in view when he established the species *M. areolata*, for he quoted a recognizable figure of it (Rumphius, Amb., 6, p. 244, pl. 87, fig. 1), and gave "O. Asiatico" as its habitat. His diagnosis is so indefinite that it would apply to either species. This name should properly have been restricted to the East Indian coral, but in view of the whole history of the name, and especially in consequence of the early application of the name, *amaranthus*, by Müller, 1775, to the oriental species, the name *areolata* should continue to be used for the American coral.

Linné, however, quoted Petiver, *Pterigraphia Americana*, pl. xx, fig. 16, 1712, which undoubtedly refers to the American species. In the ed. xii, p. 1274, he arbitrarily changed the name to *areola*, keeping the same diagnosis, with slight changes.

Pallas (1766, p. 275) added the American species to that of Linné, and quoted references to both in earlier books, though his diagnosis applies best to the East Indian species.

Esper's name (*areola*) was applied mainly to the West Indian species, which he figured. His additional figure on pl. iv, figs. 1, 2, erroneously referred by him to *meandrites*, represents an old specimen with more or less convoluted grooves, such as are of frequent occurrence in favorable situations. It is represented with wide grooves; serrulate septa; and narrow subacute ridges, double in some places.

Dana's *M. dilatata* was based on a figure in Ellis and Solander, pl. xlvii, fig. 4. He apparently had no specimen. The figure is not determinable with certainty. It looks like a young *Trachyphyllia amaranthus*. But it might have been made from a poor drawing of a beach-worn, young *M. areolata*. Hence I place *M. dilatata* here as a doubtful synonym. In either case the name is useless.

The most important variations in this species are those that are due to the number and closeness of the septa; the amount of

* According to Bruggmann (*Abhand. naturwiss. Vereins, Bremen, 1878, 549*) the name *Madrepora amaranthus* was given to this coral by Ph. L. S. Müller in 1775 (German ed. Linné, *Syst. Nat.*, vi, ii, p. 682, which I have not seen), and he proposed to call it *Trachyphyllia amarantus*. But it seems more desirable to follow Müller's spelling and call it *T. amaranthus* (Müll.). "Sea amaranth" was its ancient vernacular name. The specific name *amarantum*, as it was given by Dana, was based on a mistake in spelling. Rumphius called it *Amaranthus saxeus*.

columnella; and the solidity or vesicular character of the collines. Some of these forms are, perhaps, worthy of varietal names:

Var. *hispidula* (Ehr.) = *M. prerupta* Dana (non Ehr.).

The type of Dana's *M. prerupta* is in the Yale Museum. It is a variety of *M. areolata*, with the collines mostly solid, narrower than usual, and partly sinuous. Septa rather narrow, thickened at base, emarginate, hispid laterally, roughly serrulate; columnella largely developed, finely lamellose. The collines are thin and simple in some places, but double in others. The valleys are mostly broad and open, 12 to 20^{mm} wide, usually about 15^{mm}; collines mostly 4 to 6^{mm} wide. Pl. xii, fig. 2, type of Dana.

Florida Reefs.

Var. *confertifolia* V., nov.

PLATE XI. FIGURE 2.

Form as usual. Collines generally wide, double, truncate or sulcate, sometimes simple, rather compact. Septa numerous and crowded, alternately wider and narrower, about 11 to 12 wider ones to a centimeter, not very hispid laterally, finely and pretty regularly serrulate, usually wide and rounded distally, and with a broad basal paliform lobe. External costae numerous, pretty evenly spinulose. Columnella usually well developed, spongy or finely lamellose. Calicinal valleys wide and open, mostly about 20^{mm} wide, sometimes 25^{mm}; collines mostly 10 to 12^{mm} broad.

Florida Reefs. Yale Museum.

Var. *larifolia* V., nov.

PLATE XII. FIGURE 1.

Form as usual, but generally with lobulate margins. Valleys usually narrower than in the preceding variety, rather deep, often with perpendicular walls. Collines short at first, but branched and sinuous when older, mostly narrow, generally double, often becoming simple when older, usually with very cellular exotheca. Septa fewer than usual, and less crowded, about eight or nine wider ones to a centimeter, with small ones alternating, so openly placed that the interseptal spaces appear unusually wide and conspicuous, rather wide and rounded distally, moderately hispid laterally, pretty evenly and sharply serrulate, but the large, rounded paliform lobe is often lacerate-toothed. Columnella well developed, finely lamellose. Exterior costae prominent, sublamellar, sharply serrulate. Valleys mostly 10 to 13^{mm} wide; collines 5 to 12^{mm} wide.

Florida Reefs and St. Thomas. Yale Museum.

Var. *columellaris* V., nov.

Form as usual. Septa numerous, crowded, much thickened toward the base and very strongly hispid laterally, edges roughly serrulate and lacerate. Columella highly developed, broad, trabecular or finely lamellose, the lamellæ often largely coalescent and rough on the surface. Valleys usually wide and open. Collines either single or double, often sulcate. This is near var. *hispidu* (Ehr.), in the hispid character of the septa.

Florida Reefs. Yale Museum.

Var. *angusta* of Dana, p. 196, I have not seen. It may have been based on a young example of *M. labyrinthiformis*.

Mæandra conferta Ver.

Favia conferta Verrill, these Trans., vol. i, p. 355, 1868.

Favia conferta (*pars*) Vaughan, op. cit., pp. 39, 40, 1901.

PLATE XIII. FIGURE 6.

Although this species has the aspect of a *Favia*, near *F. fragum*, when the calicles are mostly simple and elliptical, other specimens, and often even different parts of the same specimen, have more or less elongated, narrow cells or valleys, with several indistinct actinal centers, nearly as in *M. Agassizii* and parts of *M. clivosa*. These short valleys are often curved, or bent a little in sigmoid shape, but are not sinuous. They are then separated by small, narrow, solid collines.

It is evidently closely related to *M. varia*, but has much narrower calicles and valleys, and still more of the valleys are circumscribed. The septa are thinner and more numerous, rather regularly serrulate.

Brazil, at Pernambuco, Bahia, the Abrolhos Reefs, etc. Yale Mus., coll. Hartt; Rathbun.

Vaughan (op. cit., 1901) thinks that this species is not distinct from *Favia gravida* Ver. It seems that they must be referred to distinct genera. (See p. 91.) I have figured one of the types.

Subfamily **Trachyphyllinæ** Ver., nov.

Mæandriiform corals that have distinct calicinal centers and radiating septa. (See p. 65.)

Manicina versus **Colpophyllia**. Type *M. gyrosa* Ehr.

Podasteria (provisional name) Ehr., p. 101, 1834.

If we consider *M. areolata* (L.) as congeneric with *Mæandra*, as above explained (p. 67), the name *Manicina* must either be dropped altogether for a genus, or else applied to some other type. By the

process of elimination, the last subdivision of *Manicina* Ehr. to receive a name was the group named *Gyrosmitia* in 1851. This was based on *M. interrupta*, the second species under *Manicina* in Ehrenberg's list,* pp. 101-103.

But *Gyrosmitia* is generally regarded as inseparable from *Plerogyra* E. and H., 1848 (*Euphyllia, pars*, Dana, 1846). It is doubtful whether *Plerogyra* can be kept as a genus distinct from *Euphyllia*, from which it differs chiefly in the loose union of the walls.

On p. 102, under *M. gyrosa*, Ehrenberg states that *gyrosa* does not agree with the generic characters, and proposes for it a provisional generic name (*Podasteria*). This might take the place of *Colpophyllia*† according to strict rules of priority, but he gives no definition of the generic characters, nor does he refer to it his *fixsa* (sp. 6) and *mæandrites* (sp. 7), though they are probably all forms of the same species (*gyrosa*).

It seems best, therefore, to restrict the name *Manicina*, if it is to be retained for a genus, to the group named *Colpophyllia* E. and H., with *M. gyrosa* as the type. *Podasteria* and *Colpophyllia* would thus become strict synonyms of it. It is doubtful whether more than one species is known, most, if not all, of the several named species being mere forms of *gyrosa*.

This would surely produce the least disturbance in the current nomenclature. The only alternative would be to restore it to the second and third species = *Plerogyra* + *Gyrosmitia* E. and H. But in case these should be united to *Euphyllia* D. (1846), as is likely, the name would again lapse or else come back to *Colpophyllia*.

Another view may, possibly, be reasonably held. *Manicina* (E. and H.) by some may be thought worthy of recognition as a section or subgenus of *Mæandra*, with *M. (Manicina) areolata* as the type. But I know of no structural characters by which such a group can be distinguished.

* The 1st species is a *Mussa* (E. and H.); the 2d is type of *Gyrosmitia*, 1851 = *Plerogyra* E. and H., 1848; 3d is *Plerogyra*; 4, 6, 7 are *Colpophyllia* E. and H., 1848 = *Podasteria* Ehr., 1834; 5th is *Mæandrina* (revis.) = *Pectinia* Oken; 8, 9, 10 are *Mæandra*, restr., Oken; 12 is *Tridacophyllia* Blainv., 1830. The 11th, *M. areolata* Ehr. (non L.), is doubtful. Edw. and H. refer it to *Trachyphyllia Geoffroyi*, but the description in Ehr. does not apply to a *Trachyphyllia*, for it implies true sulcated collines, "*truncatis, passim fissis.*" It is indeterminable from the description.

† Ehrenberg's three species, Nos. 4, 6, 7, all belong to *Manicina (Podasteria) gyrosa* (or *Colpophyllia gyrosa* E. and H.), according to Vaughan, who has recently examined the types of Ehrenberg, in Berlin.

The principal distinctions between *areolata* and *Colpophyllia* is the presence of well defined calicinal centers and radial septa in the latter, while in the former they are indistinct, as in *Mæandra*; and the absence of a columella in *Colpophyllia*.

Callogyra V., gen. nov.

Coral pedicelled; calicles large and with very distinct centers in deep valleys, mostly united in short series. Collines large, with simple or double walls united by exotheca. Septa with paliform lobes; edges finely serrulate. Columella trabecular. Outer surface naked, covered with spinulose costæ. Endotheca not abundant, deep within the interseptal spaces.

This genus is like a *Trachyphyllia* with coalesced walls, and might, indeed, be considered a section of that genus if intermediate conditions were known. It bears about the same relations to that genus that *Symphyllia* does to *Mussa*, or *Pterogyra* to *Euphyllia*.

In form, the type resembles the *Manicina areolata* of authors, but differs widely from it in its large, distinct calicles, and finely and evenly serrulate septa. It also has a general resemblance to *Meandrina (Pectinia) Braziliensis*, but the latter has entire septa and the calicinal centers are not distinct.

It is also nearly allied to *Manicina*, emended = *Colpophyllia* E. and H., but the latter forms more massive and cellular corals, without a columella, and has different exterior costæ, and less distinct calicles.

Callogyra formosa V., sp. nov.

PLATE XXIV. FIGURES 1, 2.

The coral is narrowly pedicelled, glomerate, elliptical, with lobed margins and with high radial collines, more or less forked and curved, much as in *Isophyllia* and young *Mæandra*. Between the collines are large marginal calicles, which render the margin lobulate; two large calicles occupy the central valley. The valleys are deep and rather wide, the central ones with perpendicular walls. The calicinal centers are very distinct and occupied by a loose trabecular columella. The collines are simple in some places, with a thin wall, but in most places they are double with two thin walls near together; their summits are obtusely rounded.

The septa are thin with wide interspaces; their breadth is moderate; lengths very different, corresponding to the five cycles to which

they generally belong, the smallest being quite short. The larger ones have wide but slightly marked paliform lobes and are broadly rounded at the summits; their surfaces are finely granulate, and costulate close to the border; their edges are very finely and regularly denticulated.

The under side is covered with elevated, lamellate, radial costæ, which are sharply and closely dentate on their edges, the teeth being small and spiniform.

Length of the coral, 75^{mm}; breadth, 60^{mm}; width of the valleys mostly 13 to 25^{mm}; depth, 10–18^{mm}.

The type is from an unknown locality, but was supposed to be West Indian. It belongs to the American Museum, New York.

From its affinities with *Trachyphyllia*, I think its origin is more likely Indo-Pacific.

There is a smaller worn specimen in the Museum of Yale University, locality unknown.

Subfamily **Favitinæ** Ver., nom. nov.

This subfamily is intended to include all the astreiform corals that normally or chiefly increase by fission or by intracalicular budding, for these two methods intergrade completely and often coexist on the same coral. It is thus nearly equivalent to *Fissicella* of Dana. Paliform lobes or teeth are generally present.

This group is very closely related to *Mæandrinæ*. The principal difference consists in the more complete fission of the zooids and the rapid and usually complete isolation of the calicles, which may be either circular or angular.

Perhaps it would have been thought better by many to have considered the group a distinct family near *Mæandridæ*, under the name *Favitidæ*. But the study of such species as *Favia gravida* and *F. fragum*, in comparison with *Mæandra conferta*, *M. Agassizii*, and *M. clivosa*, var. *dispar*, shows that the two groups nearly intergrade.

The occasionally isolated calicles of *Mæandra* are structurally identical with those of *Favia*. Perhaps the two groups are not even of subfamily rank.

I have used *Favites* as the typical genus from which to form the family name, because the ultimate fate of *Astrea* and *Favia* is still uncertain. (See p. 89.)

Favia Oken, 1815, restricted by Edw. and Haime, 1857. Star Corals.

Astrea (1st section) Lamarek, Syst. Anim. s. Vert., p. 371, 1801; (*pars*) Hist. Anim., ii, p. 60, 1816.

Favites (*pars*) Link, Besch. Nat.-Samml., Univ. Rostock, iii, p. 162, 1807.

Favia (*pars*) Oken, Lehrb. Naturg., i, p. 67, 1815.

Astrea, subgenus *Fissicella* (*pars*) Dana, Zoöph., p. 220, 1846.

Parastrea Edw. and Haime, Compt.-rendus, xxvii, p. 495, 1848; Ann. Sci. Nat., xii, 1850.

Favia Edw. and Haime, Hist. Nat. Corall., ii, p. 426, 1857; Verrill, these Trans., i, pp. 353-355, 1868.

Astrea Verrill, Comm. Essex Inst., v, p. 33, 1865; Verrill, in Dana, Coral Islands, pp. 380, 388, 1874.

Astrea Quelch, Reef Corals, Chall. Exped., xvi, 1886.

The name of this large genus has been much in question for a long time. This is due to several reasons. When *Astrea* was first proposed by Lamarek (1801) he gave it two sections with a single species as an example of each. His first section had *A. rotulosa* as its type. The second section had *A. galaxea* (= *radians*) as the type. Properly the name should have been retained for the former, as the more typical and first named.

But Oken, 1815, made two divisions similar to, but not the same as those of Lamarek, and applied the name *Favia* to the group more like the first of Lamarek's sections, and *Astrea* to the second. Blainville, in 1830, named the latter *Siderastræa*.

But under *Favia* Oken named three species, which belong to three modern genera, viz: 1. *F. anmas*=*F. fragum*; 2. *F. cavernosa*=*Orbicellu cavernosa*; 3. *F. favites* or *favosa*=? *Prionastræa abdita* E. and H.=*Favites* Link.

The true relations of *A. rotulosa* Ellis and Sol., Lamarek's first type of *Astrea*, are still doubtful. It was referred to *Favia* by Edw. and Haime, perhaps erroneously. Their species, thus named, may very likely be different. It has much larger calicles, more numerous septa, and they place it in the section with feeble pali. The general appearance of the original figure is more like an *Orbicella* or *Plesiastrea*. It has a circle of very distinct, prominent pali, in which it agrees with *Plesiastrea*. The calicles are regular and circular and the septa are few and very prominent. I have never seen a perfect specimen of it. A few beach-worn West Indian corals that I have seen may belong to it, but they are not positively determinable.

It may be an East Indian coral of the *Plesiastrea*-group. In that case *Astrea*, if retained, should be restricted to this, as the original type, and thus it would be distinct from *Favia*.

The name *Favites* was given by Link, 1807, to a genus nearly equivalent to *Astrea* Lam. and *Favia* Oken, of which it could be considered a synonym. It included four genera. Vaughan (op. cit., 1901, p. 21) proposed to restore the name for a part (the *favosa*-group) of Link's genus, and thus use it in place of *Prionastrea*. It might have been substituted, equally as well, for *Favia* (in the usual sense) for the latter was practically synonymous. But Vaughan is justifiable in considering *favosa*=*abditata* as the proper type.*

There is an additional reason why *Astrea* is rejected by some writers, as by Vaughan (op. cit., 1901, pp. 60, 61).

Bolten used the name *Astrea* for a group of gastropod shells in 1798. His genus was not properly defined and has never come into use. It included species usually referred to *Turbo* (L.) and *Xenophora*. Whether it should be restored for any of these shells is very doubtful. Bolten's work was a mere catalogue, not a scientific work in any legitimate sense, and it is extremely rare. Still his names are recognized by many malacologists.

The difference in the original spelling of the two names would, perhaps, be a sufficient reason for retaining both, if not otherwise invalid.

It seems to me necessary to wait for the re-examination of the true *Astrea rotulosa* before the status of *Astrea* can be settled.

However, it would evidently lead to less confusion to reject *Astrea* altogether, on the ground of its prior use by Bolten, than to use it for *Siderastrea*, as some have done, for the latter does not belong to the group *Astræidæ*, but is a fungian coral.

Astrea is said to have been used by Gmelin, 1789 (see L. Agassiz, Nomencl. Zoöl., and Gregory, op. cit., p. 278). The latter cites it as on p. 3767, under *M. astroites*. But the name is used there only as a part of a polynomial name quoted from Browne (Hist. Jamaica, 1756, p. 392), with other descriptive quotations, and in no sense as a generic term. Browne gave several species of *Astrea*, but he used the term only as a part of his *polynomial* descriptive names.

* *Favites* Link (*pars*)=*Fissicella* (*pars*) Dana=*Prionastrea* Edw. and H. + *Metastræa* E. and H. For a review of the principal species see p. 92.

Favia fragum (Esper) Edw. and Haime.

Madrepora ananas (*pars*) Pallas, Elench. Zoöph., p. 321, 1766 (not of Linné, Syst. Nat., ed. x, 1758, p. 797, which was a palæozoic fossil (*Acervularia*), from Gothland.

Madrepora ananas (*pars*) Linné, Syst. Nat., ed. xii, i, p. 1275, (not of ed. x,) 1767.

Madrepora ananas Ellis and Solander, Nat. Hist. Zoöph., p. 168, pl. xlvii, fig. 6, 1786.

Madrepora fragum Esper, Pflanzenth., Fortsetz., i, p. 79, pl. lxiv, figs. 1, 2, 1797 (*non Madrepora ananas* Esper, Pflanzenth., pp. 128-131, pl. xix, which is a *Dichocenia*.)

Favia ananas (*pars*) Oken, Lehrbuch Naturgesch., Zoöl., i, p. 67, 1815.

Astrea ananas Lamarck, Hist. Nat. Anim. s. Vert., ii, p. 260, 1816.

Astrea ananas LeSueur, Mem. Mus. Hist. Nat. Paris, vi, p. 285, pl. xvi, fig. 12, 1820.

Astrea ananas Lamouroux, Exp. Meth. Gen. Polyp., p. 59, pl. xlvii, fig. 6, (after Ellis and Sol.)

Favia ananas and *Favia fragum* Milne-Edwards and Haime, Hist. Nat. Corall., ii, pp. 435-439, 1857.

Favia incerta, p. 351 [75], pl. x, figs. 13, 14; + *Favia coarctata*, p. 352 [76], pl. x, figs. 17, 18; + *Favia ananas*, p. 352, Duchassaing and Michelotti, Mem. Corall. Ant., 1861 (t. Vaughan, from types).

Favia ananas Verrill, Bull. Mus. Comp. Zoöl., i, p. 48, 1864.

Favia fragum Verrill, these Trans., i, p. 355, 1868.

Astræa ananas and *A. coarctata* Quelch, Narrative Chall. Exp. Zoöl., i, pt. i, foot-note, p. 146, 1885.

Astræa coarctata, pp. 9, 12, 98; + *Astræa incerta*; + *Astræa ananas*, p. 12, 98; + *Astræa fragum*, pp. 13, 98, 99, Quelch, Reef Corals, Chall. Exp. Zoöl., xvi, 1886.

Favis ananas Gregory, Quart. Jour. Geol. Soc. London, li, p. 260, 1895.

Favia fragum Vaughan, Samml. Geol. Reichs-Mus., Leiden, ii, p. 24, 1901.

PLATE XIII. FIGURES 1, 2.

The name *ananas*, as applied to this species, dates from Pallas, 1766, who described it very well indeed. But the name, as used previously by Linné (Syst., ed. x, p. 797) was particularly applied to a Gothland fossil coral of the genus *Acervularia*. So it should, without doubt, be dropped for this living species, to which it has been so long applied. However, this name has also been applied, by the earlier writers, to other existing species, so that its synonymy is complex. Fortunately the early name *fragum* is available and has, apparently, not often been applied to other species, so that its use for this one can hardly lead to any confusion. My own experience, based on a study of large numbers of specimens, living and dead, is in accord with that of Mr. Vaughan, as to the necessity of uniting the several forms described by Duch. and Mich. and by Quelch as

distinct species. The differences noticed are due to slight variations in growth, and especially to the greater or lesser crowding of the calicles. Sometimes the intervening spaces are very narrow; in other specimens, and more commonly, they are rather wide. The calicles may be circular, angular, or elliptical. The extreme forms occur associated together in tide-pools at the Bermudas, but intermediate specimens also occur in the same places. In life, the soft parts agree in color and structure.

My figures (pl. xiii, figs. 1, 2) are from photographs of two Bermuda specimens, found together. They show nearly the extreme forms of variation. The color of the soft parts, in life, is light yellow.

This coral is common on the Florida Reefs, and throughout the West Indies in shallow water. It is also abundant at the Azores. (t. Queleh.) It never becomes large.

Favia gravida Ver.

Favia gravida Verrill, these Trans., i, p. 354, 1868.

Favia conferta (pars) Vaughan, op. cit., pp. 39, 40, 1901 (non Verrill).

PLATE XIII. FIGURE 3.

This Brazilian species is nearly allied to *F. fragum* of the West Indies. I do not think it is so closely related to *M. conferta* as Vaughan supposes, for he has united the two forms under the latter. (See p. 84.) I have never found mæandriniform calicles or valleys as in the latter, and the septa, columella, and sections of the walls are different.

I have here figured one of the types.

Abrolhos Reefs, Bahia and Pernambuco, coll. C. F. Hartt; R. Rathbun.

Favia leptophylla Ver.

Favia leptophylla Verrill, these Trans., i, p. 353, 1868.

PLATE XIII. FIGURES 4, 5.

This species is very unlike any of those forms related to *F. fragum*. It has double walls and vesicular exotheca between the calicles. The proper walls are thin, continuous; those of adjacent calicles are separated by a loose, vesicular structure, with thin dissepiments. The septa are rather few, very thin with rather prominent summits. This species produces some intermural buds, but it increases mainly by fission.

The photographs here reproduced are from the original type, now in the Museum of Yale University.

Abrolhos Reefs, Brazil, coll. C. F. Hartt.

Favites Link, 1807, restricted.

Favites Link (*pars*), op. cit., p. 162, 1807.

Favia (*pars*) Oken, Lehrb. Naturg., i, p. 67, 1815.

Fissicella (*pars*) Dana, Zoöph., p. 220, 1846.

Prionastræa Edw. and Haime, Comptes-rend., xxvii, p. 495, 1848.

Prionastræa and *Metastræa* Edw. and Haime, Hist. Corall., ii, pp. 513 and 525, 1857.

Calicles usually angular or polygonal, separated by nearly solid walls, which often contain a single series of cellules, more distinct toward the base. The division of the calicles is generally excentric, or near the margin, by unequal fission or intracalicular budding, but it may also be by median fission, where the calicles become crowded, or in the central parts. Septa rather numerous, denticulated, the larger teeth usually proximal. Columella developed more or less, spongy or trabecular. Pali usually distinctly developed.

The history of the name of this genus has been discussed on page 89.

This large genus appears to be absent from the West Indian fauna. The American species, hitherto referred to it, belong in other groups, so far as I have seen them. Among the better known Indo-Pacific species are the following, most of which I have studied personally:—

Favites favites (Pallas, *not M. favosa* L., ed. x, which was a fossil) = *P. abdita* (Lam.) E. and H. East Indies; Singapore.

F. profundicella (E. and H.).

F. crassior (E. and H.).

F. magnifica (Bv.; E. and H.) (*non* Dana). Batavia.

F. magnistellata (E. and H.).

F. obtusata (Lam.; E. and H.). Tongatabou; Fiji.

F. sulfurea (E. and H.). Vanikoro.

F. Quoyi (E. and H.). New Ireland; Fiji.

F. Ellisiana V. (nom. nov.) = *M. favosa* Ellis and Sol., Hist., p. 167, pl. 1, fig. 1, 1786, *non* Linné = *Prionastræa favosa* E. and H., *non* Linné.

F. fusco-viridis (Q. and G.; Dana). Tongatabou; Fiji.

F. virens (Dana). Fiji.

F. flexuosa (Dana). Fiji.

F. spectabilis (Ver.) = *Astræa magnifica* Dana, *non* Blainv. = *P. spectabilis* Ver. East Indies.

F. sinuosa (Dana). Fiji.

F. favulus (Dana). Fiji.

F. coronata (Studer, 1881) Singapore.

F. robusta (Dana). Fiji; Amboina.

F. valida (Ver.)=*Astræa heliopora* (*pars*) Dana, p. 246, pl. xiii, figs. 11a, 11b. Wakes I.

F. tessellata Ver., nom. nov.=*A. tessrifera* Dana (*non* Ehr.).

F. Chinensis (Ver.)=*Prionastræa Chinensis* Ver., Comm. Essex Inst., v, p. 35, 1866. Hong Kong.

F. armata (Ver.)=*Astræa intersepta* Dana, Zoöph., p. 246, pl. xiii, figs. 12a to 12d (*non* Esper,=*Stephanocœnia*)=*Plesiastrea armata* Ver. in Dana, Coral Is., ed. ii, p. 381.

F. coronella Ver., sp. nov. = *Astræa parvistella* (*pars*) Dana, Zoöph., p. 244, but not the figures. One of Dana's specimens differs from the type. Calicles small, (2.5 to 3.5^{mm}), angular, separated by narrow, nearly solid walls. Septa unequal, in three cycles or more, usually 24 to 30, those of the 3d cycle very narrow, the larger ones roughly serrate and strongly granulated; six prominent pali before the primary septa; columella nearly solid. Endothecal dissepiments regular, nearly horizontal, not crowded. This and the next preceding might be referred to *Goniastræa* about as well as to *Favites*. Fiji.

The following are from the Red Sea :

F. gibbosa (Klunz., p. 40, pl. iv, fig. 10, as *Prionastræa*).

T. pentagona (Esp.; Klz., *non* Ehr.,=*P. melicerum* E. and H.

F. spinosa (Klunz., p. 39, pl. iv, f. 7, pl. x, f. 5).

F. vasta (Klunz., p. 38, pl. iv, f. 8, 12, pl. x, f. 4a, 4b, as *Prionastræa*).

F. tessrifera (Ehr.; Klz.; E. and H.).

F. Ægyptorum (Edw. and H.)=*Metastræa Ægyptorum* E. and H. Recent and fossil.

Family **Orbicellidæ** Ver. Star Corals.

This family will include the astreiform corals that have circular or nearly circular calicles, and increase by mural or exothecal budding. The polyps, when expanded, are exsert.

Orbicella (Dana), restricted.

Astræa, subgenus *Orbicella* (*pars*), Dana, Zoöph. Expl. Exped., p. 206, 1846.

Heliastrea Edw. and Haime, Hist. Corall., ii, p. 456, 1857.

Orbicella Verrill, Bull. Mus. Comp. Zool., i, p. 47, 1864. Verrill, in Dana's Corals and Coral Islands, ed. 1, p. 380, 1872; ed. 2, pp. 380, 388, 1874; ed. 3, pp. 421, 429, 1890.

Corallites cylindrical or nearly so. Costæ well developed and serving, with more or less cellular intercostal exotheca, to unite the corallites. Septa exsert; paliform teeth and columella are present.

Orbicella annularis (Ellis and Sol.) Dana. Star Corals.

- Madrepora astroites* Pallas, Elench. Zoöph., p. 320, 1766 (not of Linné, ed. x, p. 796, which was a palæozoic fossil, nor of ed. xii).
- ?? *Madrepora acropora* Linné, Syst. Nat., ed. xii, p. 1276, 1766. (Probably not this species, perhaps a *Solenastrea*, but indeterminable.)
- Madrepora annularis* Ellis and Solander, Nat. Hist. Zoöph., p. 169, pl. liii, fig. 1, 2, and *Madrepora favolata*, p. 166, pl. liii, figs. 5, 6, 1786.
- ?? *Madrepora acropora* Esper, Pflanzenth., Fortsetz., i, p. 21, pl. xxxviii, 1797, (non Linné, Syst., ed., xii, p. 1276.)
- Astrea annularis* Lamarek, Hist. Nat. Anim. s. Vert., ii, p. 259, 1816.
- Astrea annularis* Lamouroux, Exp. Meth. Genres de Polyp., p. 58, pl. liii, figs. 1, 2, and *Astrea favolata*, p. 58, pl. liii, figs. 5, 6, 1821.
- Astrea (Orbicella) annularis* Dana, Zoöphytes U. S. Expl. Exp., p. 214, pl. x, fig. 6, and ? *A. (O) stellulata*, p. 215, pl. x, fig. 7, (variety,) 1846.
- Heliastrea annularis* Milne-Edwards and Haime, Hist. Nat. Corall., ii, p. 473; and ? *Heliastrea acropora*, p. 477, 1857.
- Heliastrea annularis*; + *H. acropora*; + *H. Lamareki* Duchassaing and Michelotti, Mem. Corall. Antilles, p. 352, [76], 1861 (t. Vaughan from types, non *H. Lamarekana* E. and H.).
- Orbicella annularis* Verrill, Proc. Boston Soc. Nat. Hist., ix, p. 33, 1862, rate of growth.
- Phyllocenia sculpta* + *P. limbata* + *Cyphastrea costata (pars)* + *Astrea Barbadiensis* Duncan, Quart. Journ. Geol. Soc. London, xix, pp. 432-444, pl. xv, figs. 6, 6a, 1863, all fossils, (t. Vaughan from types).
- Plesiastrea ramea* Duncan (fossil), op. cit., xx, p. 39, 1864 (t. Vaughan).
- Orbicella annularis* Verrill, Bull. Mus. Comp. Zoöl., i, p. 48, 1864; Pourtalès, Flor. Reefs, Cor., Mem. Mus. Comp. Zoöl., vii, No. 1, pl. iv, figs. 1-10, 1880.
- Orbicella annularis* A. Agassiz, Bull. Mus. Comp. Zoöl., xx, No. 2, p. 61, pls. i, ii, 1890, rate of growth. Verrill, these Trans., x, p. 553, 1900.
- Orbicella acropora (pars)* Gregory, Quart. Jour. Geol. Soc. Lond., li, p. 272 (non Linné.); + *Cyphastrea costata*, p. 274; + *Echinopora Frauski*, p. 274, pl. xi, figs. 2a, 2b, 1895, (teste Vaughan from types).
- Orbicella acropora* Vaughan, Bull. Mus. Comp. Zoöl., xxviii, No. 5, p. 275, 1899; Samml. Geol. Reichs-Mus., ii, p. 22, 1901, (not of Gardiner, 1899).

PLATE XV. FIGURE 1.

This common and well known species was admirably figured by Professor L. Agassiz in the plates of Florida Reefs, published by Pourtalès, 1880.

It shows considerable variations in the size of the calices; in the extent to which they are crowded together; in the prominence of their borders above the intervening exotheca; in the prominence of the septa above the walls; and in the extent to which the small septa of the third cycle are developed. But yet these variations, so far as I have seen, never go so far as to render difficult the recognition of the species, unless the specimens are badly worn.

The specimens from which the figures of *annularis*, *favcolata*, *stellulata*, and *pleiades* were made, in the work of Ellis and Solander, were all badly worn. Hence there has always been much uncertainty as to their identification. However, there seems to be no doubt but that their *annularis* was really this species, and their *favcolata* was probably the same species, more eroded. There is more doubt about *stellulata*. It may be the same thing, but it might be a *Solenastrea*. (See p. 97.)

It seems best, however, to let Dana's determination of the latter stand, for it is as likely to be correct as any other, and is based on types still preserved.

The *M. acropora* of Linné is utterly indeterminable. The locality is unknown, and the diagnosis is so brief and vague that it applies equally well to any one of a dozen or more species of small astrean corals, both Pacific and Atlantic. Nor does the author refer to any figure in earlier works. It is useless and unfortunate to try to apply the name to the present species and to displace a valid and long established name by one of extreme uncertainty, as has been done recently by both Gregory and Vaughan. I do not know any good reason for such a course, in this case. The name *acropora* (L.) should be discarded as indeterminable, both generically and specifically. If used at all it should only date from *H. acropora* E. and H.

There is no certainty nor probability that the Linnæan species was the same as *annularis*, nor is there any good reason to believe that the *acropora* of Esper, or of Edw. and Haime was the same as the *acropora* of Linné. Even if the *acropora* of Edw. and Haime should prove to be only a variation of *annularis* (which may still be doubted), it does not follow that the name should be adopted as from Linné (ed. xii), for Edw. and Haime applied this name arbitrarily to the particular form that they had in view. They could have had no more knowledge of this Linnæan species than Esper, Lamarek, Dana, and others, for there is nothing definite on which to base any such knowledge. It is certain that the contemporaries of Linné, like Pallas and Ellis, did not thus identify this species, for they described the *annularis* under other names. The *acropora* of Esper may or may not be the same as *annularis*, but in either case the latter has several years priority. Had this species been what Linné had before him, he would undoubtedly have referred to Pallas, who had already well described it as *M. astroites*, for he referred to the other species described by Pallas. That Pallas had the *annularis* particularly in view, instead of *cavernosa*, in his description of *astroites*, is evident

from what he there says of the size of the calicles, and also when, on p. 326, he compares the stars of *M. porites* with those of his *astroites*, and says they are subequal.

This species occasionally shows certain calicles larger than usual, and with more septa. Such calicles may subdivide by regular fission, as is the case with the similar unusually large cells in some species of *Porites*, *Madrepora*, *Pocillopora*, etc., in which fission is elsewhere very unusual. One of our Bermuda specimens shows such a cell in the very process of subdivision, (pl. xv, fig. 1, Δ).

This coral occurs on the outer reefs of the Bermudas, but it is not common there. It is very common and grows to a large size on the Florida Reefs, in the Bahamas,* and throughout the West Indies.

When well grown it forms hemispherical or spheroidal masses, up to five feet or more in diameter. But it also grows in irregular incrusting plates, and sometimes in nodose or lobulate masses, or even in branched forms.

Mr. A. Agassiz in the work quoted, 1890, has given some interesting data as to its rate of growth. Other data were given by me in Proc. Boston Soc., x, p. 862, and in Dana's Coral Islands, p. 125.

Variety, *stellulata* (Dana, ex. Ellis and Sol.).

Heliastrea stellulata Edw. and Haime, Hist. Corall., ii, p. 473, 1857.

? *Cyphastraea oblita* Duch. and Mich., Corall. Ant., p. 77, 1860.

PLATE XV. FIGURE 2.

The two types of Dana's *stellulata* are in the Museum of Yale University. They are beach-worn specimens of a true *Orbicella*, more or less infiltrated with calcium carbonate, to which the unusual solidity of the walls and exotheca, in some parts, as seen in sections figured by Dana, seems to be partly due. In other parts the structure is nearly as in *O. annularis*, to which it probably belongs, though there are differences in the sections not due to infiltration. Its septal arrangement is the same as in ordinary specimens of the latter, those of the third cycle being distinct, but narrow and thin. The borders of the calicles seem to have been but little raised, and the septa rather thinner than usual, and not much exsert, but the poor condition of the specimens renders these characters rather uncertain.

The calicles are rather smaller (2 to 2.5^{mm} in diameter) than is usual in *O. annularis*. The thin septa are in three regular cycles; those of the third cycle are very thin and reach only one-fourth or one-

* There is a fine Bahama specimen, about four feet in diameter and three in height, in the Amer. Mus., New York (coll. R. P. Whitfield).

third to the columella, which is well developed. The septa are a little thickened at the wall; their faces are only slightly granulated. There are a few irregular small teeth on their inner edges where best preserved; upper ends are all worn off; some have a paliform tooth at the base. The costæ are well developed, inosculating, with irregular exothecal dissepiments between them, as in *O. annularis*. But in some vertical sections the walls appear as narrow, solid structures, (where unaltered); in the sections the columella region is loosely filled with stout ascending trabeculæ; the endotheca consists of small, very thin, nearly horizontal dissepiments, inclining downward a little, and often in two series. No. 4266.

Their origin is uncertain, but it appears to be West Indian. They are in the same beach-worn state as several other types of West Indian corals studied by Professor Dana. Apparently most West Indian corals, in good condition, were scarce in American museums at the time when he wrote his great work.

It appears to be a small or somewhat dwarfed variety of *O. annularis*. I have seen fresh specimens of a similar variety from the Florida Reefs.

This may well be identical with *M. stellulata* Ellis and Sol., but the latter cannot be determined with any certainty from the figure, which represents a badly worn specimen. Its calicles, as figured, are mostly even smaller than in Dana's type, and somewhat unequal in size; the walls appear to be as solid as in the latter; the calicles project slightly as in *annularis*; 12 to 15 septa are figured, all perfect; columella is as in *annularis*. There is much more reason for calling this a variety of *O. annularis* than there is for identifying it with *Solenastrea hyades*, as Gregory has done. There is no evidence that it is a *Solenastrea*.*

* Gregory (op. cit., p. 273, 1895) adopts the name *Solenastrea stellulata* (ex. Ellis and Sol.) for *S. hyades* (Dana), and refers *O. stellulata* Dana and *Heliastrea stellulata* Edw. and Haime to it as synonymous. It is probable that Edw. and Haime knew their own genera and that their *stellulata* was not a *Solenastrea*. To me it seems perfectly identical with Dana's form, and only a variety of *annularis*.

It seems strange that Gregory should have tried to restore such indeterminate and badly described species as the *stellulata* Ellis and Sol. and *aeropora* Linné, in new senses, while he rejected others, much better described, like *M. cavernosa* Linné, *M. clivosa* Ellis and Sol., because insufficiently characterized. He says of *cavernosa* that the diagnosis "is so imperfect and inadequate that it is absolutely useless." This remark, if true, would apply much better to the diagnoses of *aeropora* (see p. 95) and *stellulata*, which he adopts, though in doing so he discards well established later names, based on good descriptions.

Orbicella excelsa Dana. Star Coral.*Astræa (Orbicella) excelsa* Dana, Zoöph., p. 212, pl. x, fig. 16, 1846.*Heliastrea ? excelsa* Edw. and Haime, Hist. Corall., ii, p. 478, 1857.*Solenastrea excelsa* Verrill, in Dana, Coral Is., ed. 1, p. 380, 1872; ed. 3, p. 421, 1890.*Solenastrea excelsa (pars)* Pourtalès, Deep Sea Corals, p. 77, 1871.

PLATE XV. FIGURE 4.

Dana's type of this species, in the Boston Society of Natural History, was carefully studied by me a number of years ago, and descriptions were made at that time. The type is apparently slightly beach-worn, but so little that the natural surface of the cænenchyma and costæ and the summits of the septa are well preserved in most parts, and there is no evidence of post-mortem alteration by infiltration to account for the solidity of the cænenchyma, referred to by Dana, and which is, indeed, quite remarkable in most parts. The coral is very solid and heavy as contrasted with *O. annularis* or *Solenastrea hyades*.

A fragment, apparently of the same specimen, and which appears to have been used by Dana in describing the details, is preserved in the Museum of Yale University. From this the accompanying photograph has been made. (Pl. xv, fig. 4.) The coral grows in irregular, often upright, lobed or gibbous masses, up to 100 to 150^{mm} or more high, but when young it must be encrusting. No. 1729.

The type specimen is so strongly lobed that the lobules in some places look like incipient branches. But these may possibly be due to the coral growing over the tubes of invading bivalves or annelids, though none can be seen without sections. The calicles are more closely crowded on the lobules, especially at the obtuse summits, where they become angular and are separated by thin walls and cellular exotheca. Elsewhere the calicles are nearly circular, scarcely elevated, and separated by exothecal spaces usually about equal to the radii of the calicles, but toward the base often equal to their diameters. The exotheca and walls are very solid in most parts.

The 24 costæ are subequal, thickened, only slightly raised, faintly or almost microscopically granulated; those of adjacent calicles are

So under *Cyphastrea costata* Duncan = *C. oblita* D. and M. (p. 274, op. cit.) he says: "it was named by Duchass. and Mich. two years previously; but they gave so inadequate a diagnosis that their name has no claim to precedence." Yet the latter diagnosis consists of six lines, giving details of the septa, costæ, columella, pali, granulations, etc., that were never mentioned by Linné, Ellis and Sol., and other early writers on whose briefer diagnoses he bases radical changes in accepted nomenclature.

usually separated at the surface by a slight intermediate groove, forming polygonal areas around the calicles. The exotheca is nearly level with the edges of the walls and costæ, flat or slightly concave, minutely granulated or nearly smooth, sometimes slightly vesicular at the surface, but usually almost solid and blended with the costæ and walls; near the tips costæ unite and exotheca is cellular.

In a transverse section, near the surface, the entire partition between the calicles may be perfectly solid, whether thick or thin, but in many cases one or two rows of small rounded or crescent-shaped vesicles can be seen, and sometimes, close to the surface, vesicular dissepiments are visible between the small costæ, while close to the basal margin of the coral the exotheca may be decidedly vesicular, appearing almost like miniature honey-comb in transverse sections. But this basal portion is formed by the thin, down-growing margin, where the new calicles are very short, oblique, and far apart, as in many other corals that have a thin, proliferous margin.

The septa are generally 24, subequal, in three regular cycles; those of the first two cycles are nearly equal in height and thickness; those of the third cycle are thinner and narrower, and generally bend to the right and left in pairs to join the straight septa of the second cycle, usually at a point more than half-way to the columella, and often very near it. The summits of all the septa are narrow and only slightly raised above the walls. The edges are irregularly serrulate, two to four of the basal teeth being the larger. The sides are distinctly granulated. The septa are all thin, but slightly thickened toward the wall, and all are narrowed above the base, so as to leave a cup-like calicular cavity. The columella is small, trabecular, papillose, and often nearly wanting. In transverse sections of some calicles it is solid, and formed by the union of the inner edges of the septa, but in most it is small, porous, trabecular.

Diameter of the calicles 2.5 to 3^{mm}; breadth of intercalicinal spaces, usually 1 to 2^{mm}, sometimes 3 to 4^{mm} or more, near the base.

Origin uncertain, supposed to be West Indies. Several irregular gibbous masses of this species, 3 to 5 inches in thickness, in the Amer. Mus., New York, were found near Osprey, West Florida, cast on the beach after a storm, by R. P. Whitfield (No. 485). I have also seen specimens from Key West.

This species, in the form and structure of its calicles and septa, resembles *Solenastrea hyades*, but the latter has cellular exotheca and rudimentary costæ, characteristic of *Solenastrea*, while this has the costæ and exotheca of *Orbicella*, though the exotheca and walls

become more solid and heavy than usual in that genus, but not more so than in *O. hirtella* and some other species. In both this and *hyades* the septa of the third cycle are well developed and bend toward and join those of the second cycles; in both the septa are thin and but little prominent above the wall; and the columella is usually well developed in both. But *hyades* lacks the radial costal ridges on the exotheca and the bounding polygonal grooves between the calices. The differences in sections are very marked. However, there are places, near the base, where the exotheca becomes more cellular in this species, and in sections of the under side it is composed of angular exothecal cells separated by thin dissepiments only.

In some respects this species is intermediate between *Solenastræa* and *Orbicella*, and raises the doubt whether a larger series might not compel us to unite the two genera.

I have seen no specimens truly intermediate between this and *hyades*, and as they can be distinguished by structural characters generally held to be generic, it is necessary to keep them separate here, but they may eventually prove to be one species. In that case *Solenastræa* cannot be maintained as a distinct genus.

From *O. annularis* and var. *stellulata* it can at once be distinguished by the thinner and much less projecting septa, and by the wider septa of the third cycle, which do not bend toward and join the septa of the second cycle in those forms.

Orbicella hispidula V., sp. nov.

PLATE XV. FIGURES 3, 3a, 3b.

Coral an encrusting mass over 125^{mm} across, and from 5 to 20^{mm} thick. The texture is rather solid and heavy, there being much solid exotheca between the calices, which are rather far apart, the interspaces being mostly equal to, and often exceeding, their diameter.

The calices are round, regularly stellate, a little prominent, with swollen, sloping, costate rims, much as in those of *O. annularis*, which they resemble in size, though distinctly larger. The septa are in three very regular cycles: the twelve principal ones are wide, nearly equal, all reaching the rather large columella; their edges are perpendicular and finely, sharply serrate, with slender rough teeth, which extend also over their prominent, obtuse or subtruncate summits, giving them a rough appearance under a lens; their surfaces are also rough or hispid with numerous conical grains. The septa of the third cycle are narrow, straight, and usually reach about half-way to the columella.

The costæ are thick, not very high, meeting or inosculating between the calicles, and covered with a single row of small, slender, rough spinules. The columella is well developed, formed of contorted trabecular processes, and often having a small pit in the center and a few erect spinules, similar to the slender, rough, paliform teeth that often (but not regularly) stand at the base of some of the 12 larger septa.

In sections the walls are very thick and nearly solid. The endothecal dissepiments are small, thin, irregularly convex or flat above. The calicles are not filled up below, or only slightly encroached upon, by a deposit between some of the septa. Diameter of the calicles 3 to 3.5^{mm}; distance between them mostly 2 to 4^{mm}, often more.

Florida Reefs (Maj. E. B. Hunt), Yale Museum, No. 98. Near Nassau, N. P. (coll. R. P. Whitfield), Amer. Mus., New York.

This has the general appearance of *O. annularis*, but with calicles larger than usual and decidedly farther apart. The walls and exotheca are much thicker and more solid, and the endothecal cells are fewer and less regular. The sharply spinulose and hispid septa and costæ are also characteristic. The exothecal deposits are nearly as solid as in *Oculina*.

A Nassau specimen, in the American Museum, is an irregular rounded mass, about five inches in diameter and three to four thick, with a lobulated surface. The coral is heavy and solid; the surface of the cœnenchyma is spinulose; the costæ well developed. The calicles are more variable in size than in the type, in some places being one-half smaller and closely crowded. Coll. R. P. Whitfield.

Orbicella Brazilianæ Ver., nom. nov.

Orbicella cavernosa Quelch, Voy. Chall., xvi, p. 106. 1886 (*non* Lam.).

I propose this name for the form taken by the Challenger, off Barra Grande, Brazil, in 30 fathoms.

According to Quelch it forms rounded masses two feet in diameter. Its exotheca is so vesicular as to partly hide the costæ; the septa are uniformly thickened. As he refers it to *cavernosa*, it should have large calicles with four cycles of septa. Since nearly all the other Brazilian corals are distinct from the West Indian, the locality and depth where this was found, as well as the characters mentioned, indicate a species distinct from the common West Indian reef species.

Orbicella cavernosa (Linné) Ver.

Madrepora cavernosa Linné, Syst., ed. xii, p. 1276, 1766. Esper, Fortsetz, i, p. 18, pl. xxxvii, 1797.

Madrepora radiata Ellis and Sol., Zoöph., p. 169, pl. xlvi, fig. 8, 1786.

Favia cavernosa Oken, Lehr. Naturg., p. 67, 1815.

Astrea radiata and *A. argus* Lam., Hist. Anim. sans Vert., ii, pp. 258, 259, 1816; ed. 2, p. 404. Lamouroux, Encyl. Meth., pp. 57, 131, pl. xvii, fig. 8, 1824. (Reprint of plate of Ellis and Sol.)

Astrea cavernosa Schweig., Naturg., p. 419, 1820. Edw. and Haime, Brit. Fossil Corals, p. xxxix, 1850.

Astrea (Orbicella) argus and *A. (O.) radiata* Dana, Zoöph., pp. 206, 207, pl. x, figs. 1a, 1b, 1846.

Astrea cavernosa, *A. radiata*, and *A. conferta* Edw. and Haime, Ann. Sci. Nat., vol. x, pl. ix, figs. 1, 1a, vol. xii, pp. 97, 101, 102, 1850.

Heliastrea conferta, *H. cavernosa*, and *H. radiata* Edw. and Haime, Hist. Corall., ii, pp. 460, 463, 470, 1857.

Orbicella cavernosa Verrill, Bull. Mus. Comp. Zoöl., i, p. 47, 1864. Proc. Boston Soc. Nat. Hist., x, p. 323, 1865. These Trans., x, p. 553, 1900. Pourtales, Florida Reefs, p. 76, 1871. Queleh, Reef Corals, Chall. Exp., xvi, pp. 12, 103, 1886.

Orbicella radiata (pars), Gregory, Quart. Jour. Geol. Soc., li, p. 270, 1895.

Orbicella cavernosa Vaughan, op. cit., p. 27, 1901 (Syn. and description).

Vaughan adds to the synonyms the following fossil forms described by Duncan:

A. endothecata, *A. cylindrica*, *A. antiquensis*?, *A. intermedia*, *A. antillarum*?, *A. brevis*.

Much of the confusion in regard to the name of this species is due to the fact that it was generally described and figured from badly beach-worn specimens by the earlier writers. Such specimens have the septa and calicles worn away and the hard exotheca thus becomes prominent around the excavate calicles, so as to greatly change the appearance of the coral. Another cause is the rather wide variations in the size of the calicles.

The normal or average specimens have the calicles about 6 to 8^{mm} in diameter, but occasionally a specimen occurs in which part or all of them may be 9–10^{mm}, or rarely, even 11^{mm} in diameter. Sometimes, on crowded parts of large specimens, the diameter may be only 4 to 5^{mm}. The degree of elevation of the calicles is also more or less variable on a single specimen.

The calicles may be pretty close together, where crowded, but in other cases they are separated by spaces of 4 to 6^{mm} or more. The costæ are usually well developed as denticulated, rounded, radial ribs, usually 48 in number.

The septa are generally about 48, arranged in four regular cycles, but several of those of the last cycle are often rudimentary or lacking, reducing the number to 40–44. They differ in breadth and

thickness according to the cycles; those of the last cycle are very thin and often bend toward and join those of the third cycle. The principal septa are exsert, denticulated, and thickened at the wall. The columella is usually well developed and broad. The paliform teeth are distinct, but not very prominent. It sometimes forms hemispherical masses four to five feet or more in diameter.

This species appears to be rare at the Bermudas, and probably occurs only on the outermost reefs. The only specimen seen by me from there was from near the North Rocks. (Centennial collection.) It is a hemisphere about 11 inches in diameter, of the typical form. It is common on the Florida reefs and throughout the West Indies, Bahia, Brazil; (Yale Mus.);= var. *hirta*, nov., with elevated corallites; roughly serrate, thin costæ and septa; calicles deep, 5-6^{mm} broad; septa narrow, perpendicular within, usually 40-44. Pl. xxxiii, figs. 2, 2a.

Orbicella aperta Verrill.

Heliastrea aperta Verrill, these Trans., vol. i, part 2, p. 356, 1868.

PLATE XXXIII. FIGURES 1, 1a.

This species is remarkable, not only for its thin, lacerately toothed, and strongly exsert septa, but also for its very thin walls and abundant and very cellular exotheca, so that the coral is very light, as compared with *O. cavernosa* and *O. annularis*. There are usually four cycles of septa, those of the third being very narrow.

The costæ are rather feeble and those of the fourth cycle are rudimentary or lacking.

The calicles average somewhat smaller than in *O. cavernosa*, but decidedly larger than in *O. annularis*. They are about 6 to 8^{mm} in diameter. The interseptal loculi are deep and wide. The columella is rather wide, but is loosely trabecular and lamellar.

Having recently reëxamined the original type of this species, in comparison with large series of *O. cavernosa*, I must adhere to my original opinion that it is a distinct species.

Mr. Gregory (op. cit., p. 271) thinks it is only a form of *O. cavernosa*. Mr. Vaughan (op. cit., p. 31) thinks it a strongly marked variety, if not a distinct species.

Both species occur on the coast of Brazil, in shallow water, and apparently in the same region, but perhaps not in the same stations.

The type was from the Abrolhos Reefs, Brazil, in three to four feet of water. According to Mr. R. Rathbun, it is abundant in the Bay of Bahia, as at the Island of Itaparica, where it is collected to be burned into quicklime, with other corals. No. 1518.

Solenastræa hyades (Dana) D. and Mich.

Astræa (*Orbicella*) *hyades* Dana, Zoöph. U. States Expl. Exp., p. 212, pl. x, fig. 15, 1846.

Heliastrea ? *hyades* Edw. and Haime, Hist. Nat. Corall., ii, p. 478, 1857.

Solenastræa Bournoni Edw. and Haime, Ann. Sci. Nat., xii, p. 121, 1850; Hist. Corall., ii, p. 497, 1857.

Solenastræa hyades + ? *S. micans* + ? *Heliastrea abdita* Duch. and Mich., Corall. Antill., pp. 76, 77, pl. ix, figs. 9, 10 (not 10 and 11, as in text), 1860. (On pl. ix there are two figures numbered 9, one by error for 10.)

Solenastræa hyades Verrill, in Dana, Coral Islands, ed. 1, p. 280; ed. 3, p. 421, 1890.

Solenastræa excelsa (*pars*) Pourt., Deep Sea Corals, p. 77, 1871.

?? *Solenastræa stellulata* (*pars*) Gregory, Quart. J. Linn. Soc., li, p. 273, pl. x, figs. 4a, 4b, 1895 (*non* Ellis and Sol.).

PLATE XV. FIGURES 5. 5a.

The types of *Orbicella hyades* Dana and *O. excelsa* Dana are in the Boston Society of Natural History, where I carefully studied them several years ago.

Very similar specimens of *hyades*, from St. Thomas, attached to stones, are in the Yale Museum. These form convex masses, encrusting and thin at the margins, where the newly formed calicles are very oblique. (Pl. xv, fig. 5.) No. 1586b.

Calicles circular, or nearly so, mostly 3 to 3.5^{mm} in diameter; borders generally distinctly elevated above the exotheca, often to the height of .5 to 1^{mm}. Younger and smaller calicles, 1.5 to 2.5^{mm} in diameter, are scattered between the full grown ones. In the middle of the convex summit the calicles are so crowded that the walls are in contact, and here they often become angular by crowding, and when not in contact their edges may not be elevated. On other parts they may be separated by intervals of 2 to 3^{mm} or more. The walls are very thin. The costæ are thickened and roughly minutely serrulate; they are very narrow and mostly confined to the wall, never extending across the exothecal spaces, when these occur. The surface of the exotheca is smooth or vesicular; in sections the exotheca is openly vesicular.

Septa 20 to 24, mostly 24 in mature calicles; 12 extend to the columella; those of the third cycle are also wide, but thinner, and most of them bend toward and join the larger ones about midway between the wall and columella. The septa all become thin and curved toward the columella, but thickened at the wall; the summits are narrowed and rather prominent above the walls; inner edge irregularly and roughly serrulate, especially distally; sides

roughly granulated. Paliform lobes small and thin. Columella usually rather small and loose; formed of small twisted processes from the inner edges of the septa, but variable in size.

Thickness of the larger mass from St. Thomas, about 50^{mm}; diameter, 125^{mm}; diameter of calicles mostly 3 to 3.5^{mm}; rarely 4^{mm}.

This species is found on the Florida Reefs and throughout the West Indies. It has not been found at the Bermudas. St. Thomas (coll. C. F. Hartt, Yale Mus.). In the Amer. Museum, New York, there is a large turbinate mass, 12 to 14 inches in diameter and about 10 inches high, from Jamaica.

Mr. Pourtales put *Madrepora pleiades* Ellis and Sol. and *M. stellulata* E. and H., as doubtful synonyms of this species. The original descriptions and figures of both those species are too imperfect for definite determination, having been based on badly beach-worn specimens, superficially examined, and rudely figured.

Mr. Gregory adopted *stellulata* as the name of this or an allied fossil species, and put *hyades* under *Orbicella acropora*. Yet Dana's description and figures are vastly better than those of Ellis and Solander. It seems incredible that such an error should have been made in so recent a work. The *stellulata* of Dana (ex. Ellis and Sol.) is an *Orbicella*, and is quite likely to be the same species named *stellulata* by Ellis and Sol. Surely Dana had as good reasons for his opinion as Gregory had. Therefore, it seems best to follow Dana's determination of that name, as being the prior one, and also because it eliminates a very doubtful and useless name. See p. 97.

As for *pleiades* (Ellis and Sol.), that is so doubtful a form that it has been interpreted in many different ways. According to Edw. and Haime it is the same as their *Heliastrea acropora*, and this seems to be the prevailing opinion. But the description and figure would apply just as well or better to certain East Indian species of *Solenastrea*. Hence it is best to eliminate the name by considering it the same as *Solenastrea pleiades* (Dana). There is no reason for thinking that it was a West Indian coral.

The fossil *Solenastrea stellulata* of Gregory may not be this species, for it has larger costæ, and much thicker and more solid exotheca and walls, while the septa of the third cycle are represented as narrow and straight. The figured sections resemble more nearly some of those seen in *Orbicella excelsa*, to which I am inclined to believe that his figured specimens belong.

The *Madrepora hyades* Ellis and Sol. was a *Siderastrea*, and has no relation to Dana's species.

Plesiastrea Goodei Verrill.

These Trans., x, p. 553, pl. lxxvii, fig. 1, 1900.

In addition to the type, I have seen another fine Bermudian specimen of this species, in the American Museum, New York, collected on a reef in Bailey Bay, at the depth of about 20 feet, by Mr. R. P.

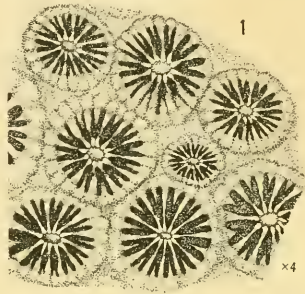


Figure 1.—*Plesiastrea Goodei* Ver. Part of type. $\times 4$.

Whitfield, in 1897. It is about 10 inches in diameter, in the form of a somewhat irregular and lobulated hemisphere.

The same museum has two smaller specimens, in the form of subconical masses, 3 to 4 inches in diameter, obtained in the Bahamas by Mr. R. P. Whitfield. These also agree very closely with the type in all essential points, but some of them have the calicles more crowded, smaller, and subangular in some areas.

Stephanocœnia intersepta (Esper.) Edw. and H.

Madrepora intersepta Esper, Pflanz., Forts., I, p. 99, pl. lxxix, 1797.

Astrea intersepta Lam., Hist. Anim. s. Vert., ii, p. 266, 1816; ed. ii, p. 417, (non Dana).

Stephanocœnia intersepta and *S. Michelini* Edw. and Haime, Ann. Sci. Nat., x, pp. 300, 301, pl. 7, fig. 1-1b, 1849; Hist. Corall., ii, pp. 265, 266, 1857.

Gregory, Quart. Jour. Geol. Soc. London, li, p. 276, pl. xi, figs. 5a, 5b, 6, 1895. Vaughan, op. cit., p. 20, 1901.

Antillastrea spongiformis Duncan, Revision Mad., p. 108, 1884, (t. Gregory from type).

The recent specimens that I have seen from the West Indies agree better with *S. Michelini*, which is, perhaps, only a massive variety of *S. intersepta*.

The American Museum, New York, has a large lobulated mass, over a foot in diameter, from Jamaica. This has six large rounded lobes, the largest about 6 inches in diameter, rising from a common basal mass.

The septa are much exsert, narrow, entire, and with the inner edge perpendicular, leaving a narrow central cup. The columella is

small, lamellose, sometimes with a minute central tubercle. The calicles vary considerably in size, being smaller and more crowded, sometimes angular, at the bases of the lobes. The distance between them is also variable. The diameter of the calicles varies from 1.75 to 2.5^{mm}, but most of them are about 2 to 2.5^{mm}.

Throughout the West Indies, but not recorded from Florida nor from the Bermudas. Fossil in the elevated reefs of many of the West Indies.

Cyphastræa nodulosa Ver., sp. nov.

PLATE XXXI. FIGURES 2, 2a, 2b.

The coral forms small nodular masses, about 55 to 65^{mm} in diameter and 35 to 45^{mm} high, consisting of numerous small, rounded or short, subclavate nodules, rising like incipient branches from a common thick, irregular base. It is compact and heavy, with small circular calicles.

The corallites, where not much crowded, project distinctly above the cœnenchyma and have a rather thin rim and feebly costate wall. In other parts they are not at all raised and the calicles may be immersed in the cœnenchyma, which is very compact, with the surface sometimes covered with low rounded granules, in radial costal lines, but in other parts it is often nearly smooth.

The calicles are small, but rather open and deep, owing to the narrow septa. They are mostly from 1.25 to 1.50^{mm} in diameter, and are often separated by spaces of 1 to 2^{mm}.

The septa are in three cycles, consisting of 12 narrow, subequal ones, of the two first cycles, alternating with 12 very narrow or rudimentary ones of the third cycle. These last are often lacking, or invisible without a lens, in some of the systems.

The larger septa are narrow, usually much exsert, with an obtuse, serrulate apex, and a perpendicular inner edge, which is finely serrulate or subentire; their proximal portion is very thin and denticulate. The paliform tooth is very small, but distinct, papilliform. The columella is small, minutely trabecular with one or more minute papillæ on the surface.

In sections the walls and exotheca are often entirely compact, especially near the surface, but in other parts there may be exothecal cellules; the septa are thin and divided into numerous fine trabecule; the dissepiments are numerous, very thin, nearly horizontal, often subtabular; columella loosely trabecular.

Bahamas,—R. P. Whitfield; three specimens, No. 542, Amer. Mus.

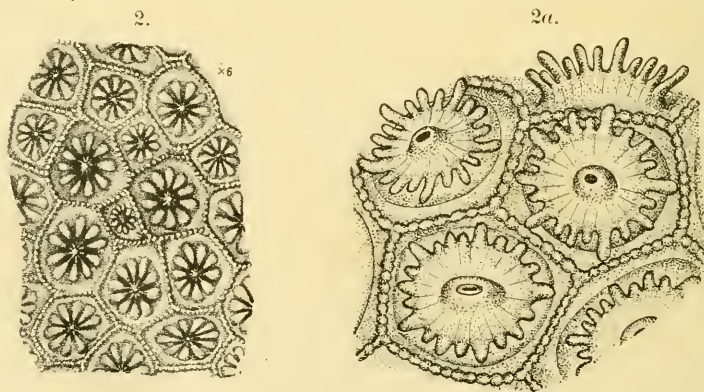
Family **Stylophoridae** Ver.*Stylophorinae* Edw. and Haime, Hist., ii, p. 132, 1857.*Stylophoridae* Verrill, these Trans., i, p. 514, 1867.

Corals mostly branched, often encrusting when young; sometimes lobulate or massive, increasing by budding. Calicles small, stellate, immersed, usually separated by rather abundant exothecal cœnenchyma, not entirely solid, and often granulated or striated on the surface. Septa generally either 10 or 12. Loculi between the septa not filled up below by stereoplasm. Columella various. Polyps exert in expansion, usually with 12, 20, or 24 tentacles.

This family is chiefly Indo-Pacific, where it is represented by numerous species of *Stylophora*.

Madracis decactis (Lym.) Ver.*Astrea decactis* Lyman, Proc. Boston Soc. Nat. Hist., vi, p. 260, 1859.*Madracis decactis* Verrill, Bull. Mus. Comp. Zool., i, p. 45, 1864. Poutalès, Deep Sea Corals, pp. 28, 67, pl. vii, figs. 1-4, 1871. Quelch, op. cit., p. 53, 1886. Gregory, op. cit., p. 258, fig. 1, 1895. Verrill, these Trans., x, p. 554, pl. lxxvii, figs. 8, 10, 1900.*Reussia lamellosa* Duch. and Mich., Corall. Antill., p. 339 [62], pl. ix, figs. 7, 8 (as numbered on plate, not 8, 9 as in text), 1860 (*non Stylophora mirabilis*, p. 61, pl. ix, figs. 6, 9, as numbered, not 6, 7, as in text).*Stephanocornia dendroides* Duncan, Quart. J. Linn. Soc., xix, p. 432, 1863, *non* Edw. and H. (t. Gregory).*Arhelia decactis* Vaughan, op. cit., p. 8, 1901.? *Madracis asperula* Moseley, Voy. Chall., ii, p. 182, 1880, from S. W. Bank, off Bermuda, 30 fath. (? *non* E. and Haime).

This species occurs in thin crusts, irregularly massive, nodose or lobulated, and also both in slender, and in short, stout, branched

Figure 2.—*Madracis decactis* (Ly.) Ver. Part of the dry coral. $\times 5$.Figure 2a.—The same, with the polyps expanded. $\times 12$.

forms. The animals have been described both by Poutalès and myself and were figured by me. (These Trans., x, pl. lxxvii, fig. 10.)

The general color of the coral, in life, is yellow, yellowish brown, or purplish brown; disk often purplish, with white radii, forming a star around the mouth; lips and tips of tentacles white.

As stated by Pourtalès, and figured by me in 1900, there are three pentamerous cycles of tentacles (5, 5, 10) and two equal cycles of septa (5, 5). Sometimes a few rudimentary septa of the third cycle appear. One Bermuda specimen has several very large calicles, with 20 to 30 regular septa. Pl. xiv, fig. 6.

Duncan (Revision, p. 45, 1884) united *Axohelia* E. and H. with this genus, under the name of *Madracis*. Several others have done the same. Vaughan, however (op. cit., pp. 5, 8), proposes to unite them under the name *Achelia*. Both names are of the same date. Therefore, if they are to be united, Duncan's choice of names has precedence and should be upheld. Kent gave it the name *Pentalophora*, as a substitute for *Reussia* (preoccupied).

However, these genera seem to me sufficiently distinct. *Axohelia* lacks the definite bounding ridges of the calicles and the granulated exotheca. Its exothecal surfaces are smooth or striated, and show no partitions between the calicles.

Perhaps the *Madracis* taken by the Challenger, on the S. W. Bank, in 30 fathoms, and recorded by Moseley as *M. asperulu*, was *M. decactis*, which is not uncommon on the reefs in shallow water.*

Some of the lobulated or branched clumps are 6 inches or more high and broad, but they are very brittle and not often obtained entire. Several large and fine specimens of this kind are preserved in the American Museum, New York, as well as a slender, dichotomously branched variety. Both forms occur at the Bermudas.

It is found on the Bermuda Reefs and throughout the West Indies. It also occurs as a fossil in the raised reefs of many of the islands. Gregory (op. cit.) records it as a Pleistocene fossil from Bermuda, (probably from Nelson's collection in Geol. Soc., London). The age of such Bermuda fossils, from the "beach rock," is however very uncertain, but they are probably postpliocene, or post glacial.

Portalès was evidently wrong in referring to this species the *Stylophora mirabilis* Duch. and Mich. Probably he was misled by errors in the numbering of the plate (ix). On that plate there are two figs. 9. One of these is a misprint for 7, and represents the enlarged calicles of the *mirabilis* (fig. 6), and shows 18 to 24 equal septa. The other fig. 9 is a *Solenastraea* and should have been 10. Other errors in numbering occur on this plate.

* Pourtalès (Deep Sea Corals, p. 27, pl. vii, fig. 4, and in later papers) records *M. asperulu* Edw. and Haime, from the West Indian region, in 36-280 fathoms.

Axohelia Schrammii ? Pourt., Mem. Mus. Comp. Zoöl., iv, p. 41, pl. viii, fig. 2, 1874.

PLATE XVIII. FIGURES 3, 4.

Coral small, arborescently branched, the terminal branches slender, tapered, acute; the larger stems are about 12–15^{mm} in diameter. The coral is hard; the cœnenchyma is abundant in the larger branches, and its surface is covered with long, curved septocostal striæ, between which it is microscopically granulated, but there are no lines of granules bounding the calicinal areas, as in *Madracis*. Septa 10, equal, narrow, slightly prominent. Columella small, solid, tubercular.

Several specimens are in the Museum of Yale Univ. They are attached to pieces of a cable. (Coll. H. A. Ward.) Guadeloupe (Pourt.).

Its calicles agree better with *A. myriaster* (?) Pourt., pl. viii, fig. 3, which may not be distinct. No. 5662.

Family **Oculinidæ** Edw. and Haime, restr.

Oculinidæ Verrill, these Trans., i, p. 514, 1867.

Corals generally branched, increasing by budding. Calicles round, stellate. Septa 12 to 48 or rarely more, unequal, usually entire or subentire; pali often present. Interseptal loculi become filled up and obliterated below by a solid endothecal deposit, or stereoplasm. Usually a solid cœnenchyma, with curved costal striations on its surface, separates the calicles, especially in the older parts of the coral, where it is often abundant.

Madrepora (Linné) Oken, restr. (*non* Lam.). Type, *M. oculata* Linné.

Madrepora (*pars*) Linné, and of all writers before 1801 (not of Lamarck, 1801, nor of 1816; not of Ehrenberg, 1834).

Matrepora, restricted (altered spelling), Oken, Lehrb. Naturg., p. 72, 1815.

Oculina (*pars*) Lamarck, Hist. Anim. sans Vert., ii, p. 284, 1816.

Amphelia and *Lophelia* Edw. and Haime, Comptes-rendus, xxix, p. 69, 1849.

Amphihelia and *Lophohelia* Edw. and Haime, Hist. Nat. Corall., ii, pp. 116, 118, 1857.

Lophohelia Pourtalès, Deep Sea Corals, p. 25.

It is well known that Linné (Syst. Nat., ed. x, 1758) did not include in his genus *Madrepora* any recognized species of the Lamarekian genus of that name, but placed by an error *M. muricata* (in which several species were included) in his genus *Millepora*, although it agrees with his definition of *Madrepora*. He corrected this mistake in the ed. xii, p. 1279, where *Madrepora muricata* appears. Pallas, (Elenchus, p. 327, 1766) had previously made the same correction.

No valid attempt to subdivide the great genus *Madrepora* seems to

have been made until 1801, when Lamarck (Syst. Anim., pp. 369-375) divided it into eight genera.* Unfortunately he restricted the name *Madrepora* to the group that included *M. muricata* and *M. porites* Pallas. The latter was made the type of *Porites*, by Link, 1807.

The next restriction of the name was by Oken (Lehrb., 1815), who established a number of additional generic subdivisions and restricted *Madrepora* (which he spelled *Matrepora*†) to four species, one of which, *M. ramea*, became the type of *Dendrophyllia* Bv., 1830; the others were earlier (1816) placed in *Oculina* by Lamarck. One of these (*M. oculata* Linné), which is the long-known and officinal "white coral" of the Mediterranean, the "*Madrepora vulgaris*" of Tournefort, may well be taken as the true type of *Madrepora*, not only on account of Oken's restriction, but also because of the rule, advocated and followed by many naturalists of the Linnæan period, that the type of a genus should be the most common or officinal and well-known species, if such were included. Certainly *M. oculata* would answer well to this requirement, and so would *M. prolifera*.

Moreover, in following the principle of elimination, this was one of the very last of the determinable Linnæan species to receive a special generic name (1849). *M. prolifera*, the second species of Oken, and the type of *Lophohelia* E. and H., is now made congeneric with *M. oculata*.

Therefore, it appears that *oculata* should be taken as the true type of the restricted genus *Madrepora*, if the Lamarckian nomenclature must, in this case, be abandoned, as argued by Vaughan‡ and other recent writers.

* These genera are as follows:—*Cyclolites*, p. 369; *Fungia*, p. 369; *Caryophyllia*, p. 370; *Madrepora*, p. 371; *Astrea*, p. 371; *Meandrina*, p. 372; *Parona*, p. 372; *Agaricia*, p. 373.

† That Oken, in using *Matrepora*, did not intend it as a new name, but only as a corrected spelling of *Madrepora*, is proved by the fact that in citing the Linnæan names of species under various genera, he invariably quotes them as "*Matrepora*" or "*Mat.*" of Linné. The generic divisions of *Madrepora* proposed by Oken are as follows:—*Astrea*, p. 65 = *Astrea* (*pars*) Lam., 1801; *Acropora*, p. 66; *Turbinaria*, p. 67; *Faria*, p. 67; *Pectinia*, p. 68 = *Meandrina* Lam., 1801; *Undaria*, p. 69 = *Agaricia*, Lam., 1801; *Mycedium*, p. 69; *Mwandra*, p. 70; *Matrepora*, p. 71 (includes 4 species, viz.—*M. ramea*, *M. prolifera*, *M. virginea*, *M. oculata*); *Galaxea*, p. 72 (with 4 species); *Mussa*, p. 73 (2 species); *Fungia*, p. 74, 2 sp. = *Fungia* Lam., 1801.

Probably Lamarck's *Système Anim. sans Vert.*, 1801, was not known to Oken, for he makes no reference to it. The coincidences in some of the names were probably due to the influence of the older specific and polynomial names. Neither does he refer to Link's work of 1807.

‡ Samml. Geol. Reichs-Mus., ii, p. 68, 1901.

Ehrenberg, in 1834, definitely restricted *Madrepora* to a group that included *Porites* and *Montipora*, while he called the Lamarckian genus, *Heteropora*. His nomenclature cannot be followed: 1st, because *Porites* had been separated and named by Link, 1807, and Lamarck, 1816; 2d, no recognizable species of *Montipora* was included in *Madrepora* by Linné, ed. x; 3d, *Heteropora* had previously been used by Blainville for a bryozoan; 4th, Oken's restriction has priority.

For several reasons, it seems to me doubtful whether, under the rules of priority usually accepted, it will not be thought by many unnecessary to abandon the name *Madrepora* for the *muricata*-type, as restricted by Lamarck, for the following reasons:—

1st.—By Linné and all other writers of his period *Madrepora* was used as a collective name for all corals of the order *Madreporaria*. It was rather an order or suborder than a genus, and therefore it seems useless to apply the rigid modern rules of priority to such a group name.

2d.—*Madrepora muricata* L. had been referred to *Madrepora* by Linné, as *M. spinosa*, before the date of ed. x (*Mus. Tessin.*, p. 118), and its reference to *Millepora* in the later work was clearly an error speedily corrected.*

3d.—Linné, in ed. xii, gave his more mature and corrected views as to his own genera. Therefore, for the discussion of *generic* nomenclature, it might be better not to go back of that edition.

4th.—It is possible that at least one of his species in the ed. x, viz. *M. polygama*, No. 28, p. 795, belongs to the Lamarckian genus *Madrepora*, for it was described as having cylindrical, 12-rayed calices, though the larger cells, mentioned by him, were probably parasitic barnacles. This species is probably indeterminable. It may have been a *Montipora*.

Should *M. polygama* L. be hereafter positively identified as a species congeneric with *M. muricata*, as is possible, this fact alone would, perhaps, make valid Lamarck's restriction of the name *Madrepora* in the opinion of many. Such a determination is not impossible, though this species has hitherto remained very doubtful.

In the meantime many persons will doubtless prefer to take the more recent and radical course, and apply some other name to Lamarck's *Madrepora*. Vaughan (*op. cit.*, p. 68) has adopted *Isopora*, first used under *Madrepora* as a subgeneric name by Studer,

* By another error he referred the "red coral" (*Corallium rubrum*) to *Madrepora* (*M. rubra*, p. 797).

in 1878. Under this name he included the whole extensive genus. This name would surely be a very inappropriate one, so far as its significance is concerned, nor would Studer's definition apply to the genus, as a whole. Moreover, it may become necessary to separate *Isopora*, in Studer's sense, as a genus. I believe that *Aeropora* Oken has much better claims for adoption in place of *Madrepora*. (See below.)

As restricted above, the genus will include branching oculinoid corals that increase by lateral or marginal buds; with turbinate corallites, and deep cup-like calices. The cœnenchyma is usually abundant and solid in the main branches and trunk, but may be very scanty in the terminal branches. Pali lacking. Septa broad, entire. Columella small or lacking.

Besides the type and *M. virginica* (L.), which is considered identical with it by Edw. and Haime, the genus *Madrepora*, as restricted above, would include the following species and others:

M. venusta E. and H., Australia.

M. exigua (Pourt., as *Lophohelia*). Off Florida, 36–79 fathoms.

M. Carolina (Pourt., as *Lophohelia*). Off Havana.

M. prolifera (L.). Boreal and Arctic, and in deep waterto Florida.

M. infundibulifera Lam. (as *Oculina*). Kent, fig., 1871; Queleh, p. 53. Ternate.

M. subcostata (Edw. and H.). Locality unknown.

M. Defrancei (E. and H.). Pliocene of Europe.

M. candida (Moseley, 1881, as *Lophohelia*). Off Sombrero I., 450 fathoms.

M. tenuis (Moseley, 1881, as *Lophohelia*). Philippine Is.

M. anthophyllites (Ellis and Sol.); E. and Haime, as *Lophohelia*. E. Indies. Type is in Hunterian Mus., t. Young.

M. ornata (Duncan). North Atlantic.

Family **Eusmillidæ** Verrill, 1866.

Eusmillince (*pars*) and *Euphylliaceæ* Edw. and Haime, *Hist. Corall.*, ii, pp. 144 and 183, 1857.

Corals dichotomous, glomerate, or massive, often meandriniform or astreiform, increasing chiefly by fission, complete or incomplete. Septa entire or nearly so, sometimes very finely serrulate. Pali-form lobe, feeble or lacking. Columella variously developed, often lacking. Zoöids actiniform, much exsert in expansion.

Eusmilia aspera (Dana) Edw. and Haime.

Euphyllia aspera Dana, Zoöph. U. S. Expl. Exp., pp. 164, 720, pl. ix, fig. 7, 1846.

Eusmilia aspera Edw. and Haime, Hist. Corall., ii, p. 187, 1857.

Eusmilia Knorrii Edw. and Haime, Mon. Aster., Ann. Sci. Nat., Zoöl., ser. 3, x, p. 265, pl. v, fig. 2, 1849.* Gregory, op. cit., p. 261, 1895. Vaughan, op. cit., p. 13, 1901.

Dana's figured type is in the Yale Museum. The description is good and the outline figure is very correct. It represents a branch with three calieles, broken from a larger specimen, also in the Yale Museum. No. 466.

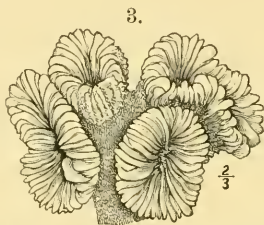


Figure 3.—*Eusmilia aspera* (Dana). Part of type, $\frac{2}{3}$ natural size.

This specimen has the columella well developed in most of the calieles, though small in some of the younger ones. It consists of variously contorted thin laminae. The costæ are alternately large and small; the larger ones are thick, angular, uneven or lobed, often cristate near the calieles, and irregularly dentate, with small rough teeth.

There can be no doubt of its identity with *E. Knorrii* E. and H., as these authors themselves admitted in their Hist. Corall., 1857. Therefore it seems strange that both Gregory and Vaughan should have tried to restore this discarded later name without any legitimate reason.†

* Gregory (op. cit., p. 261) quotes the date of *Knorrii* Edw. and Haime, Monog., as 1848. Edw. and Haime themselves quote it in Hist. Corall., ii, 188, as 1849. Gregory also quotes *aspera* Dana as 1848. It is well known that his report was published in 1846. But Gregory repeats this wrong date under various other species, so that we cannot reckon it a typographical error. Edw. and Haime give the date as 1846, correctly.

† Gregory's statement that Dana's species was "so inadequately diagnosed that there can be no certainty regarding it," is obviously erroneous. Edw. and Haime certainly were able to recognize it. The figure and description are far better than those of most corals before Dana's work. Moreover, the type, duly labeled, was in the same case and on the same shelf with other specimens that Mr. Gregory examined when he made his very hasty visit to the Yale Museum, (see p. 145). He could have studied it and various other types of Dana, had he taken the necessary time.

Family **Mussidæ** Ver.

Fasciculate, glomerate, massive, and sometimes simple corals, increasing by fission, and with strongly dentate or spinose septa, without a paliform lobe. Calicles generally large, sometimes united in short or long series, but always with distinct centers and radial septa. Polyps much exert in expansion, actiniform, with large tentacles.

Isophyllia Edw. and Haime (emended*). Rose Corals. "Cactus Corals."

Mussa (*pars*) Dana, Zoöph., p. 173, 1846.

Symphyllia (*pars*) Edw. and Haime, Ann. Sci. Nat., xi, p. 236, 1849; Corall., ii, p. 373, 1857; Duch. and Mich., Corall. Antill., p. 69, 1861.

Isophyllia Edw. and Haime, Pol. Foss. Paleoz., p. 87, 1849; Hist. Corall., ii, p. 974, 1857.

Mycetophyllia (*pars*) Edw. and Haime, Compt.-rend., xxvii, p. 491, 1848; Hist. Corall., ii, p. 375, 1857 (2d section).

Lithophyllia (*pars*) Duch. and Mich., Corall. Antill., pp. 67, 68, 1860, young, (*non* Edw. and Haime).

Utophyllia (*pars*) Bruggmann, Ann. and Mag. Nat. Hist., Oct., 1877, p. 312.

Symphyllia (*pars*) Duncan, Revision, Journ. Linn. Soc., xviii, p. 91, 1884.

This genus, as now restricted, includes a group of *Musside* in which the calicles, when mature, are large and open, isolated or in series, with numerous large, strongly serrate septa; the serrations are either subequal, or else larger toward the columella, which is

* The genus, as here limited, corresponds with that of Edw. and Haime of the same name, plus certain forms referred by them to *Symphyllia* and to *Mycetophyllia* (*M. Danaana* E. and H., Hist., p. 377, pl. D4, fig. 2). Most of their species of *Symphyllia* are simply *Mussæ* with coalescent walls. So *Symphyllia* and *Isophyllia* cannot be united in bulk, as was done by Duncan and by Pourtales, under either name. *Symphyllia* should be dropped and its species should be distributed to *Mussa* and *Isophyllia*, according to their structure. But if retained at all, even as a subgenus, it should be used for the typical East Indian forms, like *S. radians* E. and H.

I cannot distinguish in *Mycetophyllia Danaana* E. and H. any characters apart from *Isophyllia*.

Nor can I find any good reason for separating *Utophyllia*, or at least the typical species, widely from *Symphyllia* and consequently should consider such species as nearly related to the massive *Mussæ*. The only difference from *Symphyllia*, as stated by Edw. and Haime, consists in the denticles of the septa being larger toward the columella, while in the latter the distal ones are the larger. But I have studied specimens of *crispa*, the typical species, (see p. 131) and have found the teeth variable in this respect; in some calicles the larger teeth were distal, in others proximal, in one specimen, and these differences may be observed on the septa of a single calicle. The fossil forms of Edw. and

formed of loosely arranged processes of the septa. The costæ are distinct, but narrow, serrulate ribs. The primary collines are radial, dividing the margin, at one stage of growth, into several (normally six) calicinal lobes; they may be solid, with a simple wall, or they may be double, with intermural exotheca and a groove on the summit. These variations often occur on one specimen. The union of the walls may also be so incomplete that they stand separately in many parts of some examples. The calicles vary greatly in size, form, and degree of union into series, even on one specimen of most species, when full grown.

The relative number and closeness of the septa, the granulation of their surfaces, the general character and size of their serrations, and the character of the costæ and their serrations afford much better characters for specific distinctions. But all these vary more or less, so that a large series must be studied with great care before one can reach an intelligent opinion as to the limits of any of the species of this group.

The figures that have been published of the species of this genus are entirely unsatisfactory. Even the beautiful lithographic figures drawn by Sonrel for Professor L. Agassiz (see Pourtalès, Florida Reefs, pl. vii) are by no means correct enough for systematic purposes.* Photographs alone can properly represent corals of this character. After a most careful study of the large series of *Isophyllia* in my own collections and others that are in the Yale Museum, the Museum of Comp. Zoölogy, the American Museum, New York, and several other large collections, I am convinced that far too many species have been recognized. In the Bermudian series

Haime I have not seen. The absence of spinose costæ seems to be a character of more value for distinguishing true *Ulophyllia* than the position of the larger teeth. But the Red Sea species figured by Klunzinger look more distinct, on account of their acute, nearly naked collines, which thus approach those of *Tridacophyllia*. The American species that have been called *Ulophyllia* belong to *Isophyllia*.

In our Bermuda *Isophyllia* similar variations in the position of the larger teeth often occur, as will be noted in the descriptions. Indeed, the larger teeth are more frequently the proximal ones.

It may eventually be necessary to reunite all these groups under the original genus *Mussa*, if a few additional intermediate forms should be discovered.

* This is due to the impossibility of drawing by hand, with accuracy, the vast number of unequal septa and their numerous variable denticles. All the figures are, therefore, generalized or idealized by the artist, so that the septa and their teeth are much too regular and uniform, and for the same reason, they also appear too numerous and too crowded.

I can find no evidence of more than three species, and I am not certain that more than two of these can eventually be kept apart. Quelch, however, with a much smaller series, recorded (op. cit., pp. 10, 11) eight species from Bermuda, including the young forms that he called *Lithophyllia*. Probably all his Bermuda forms belong to *I. dipsacea* and *I. fragilis*.

When young, all species of this genus and of *Mussa* (including *Symphyllia*), etc., have a simple, more or less cup-shaped coral, attached by a rather broad base. These may become in some cases 25 to 40^{mm} in diameter before they begin to form marginal infoldings, as a commencement of the process of fission.

Such simple young forms have been put in a special genus (*Scolymia* Haime, 1852, or *Lithophyllia* Edw. and Haime, 1857). The type of this genus was *M. lacera* Pallas. It appears to be the young of *Mussa carduus* (Ellis and Sol., sp.).*

Therefore *Lithophyllia* is a synonym of *Mussa*, rather than of *Isophyllia*, though several species described by Duch. and Mich. unquestionably belong to *Isophyllia*, as indicated in the synonymy above. All the Bermuda simple forms are young of *Isophyllia*, and mostly of *I. dipsacea* and *I. fragilis*. Pl. xix, fig. 5.

The generic relations of these simple young forms can usually be told by the character and spination of the costæ. In *Mussa* the costæ are generally imperfect, with rows of strong, sharp spines, often recurved. In *Isophyllia* the costæ are generally raised and continuous ribs, often lamelliform, and their spines are small and more regular, usually more like serrations of the edge. In *Mussa* the septa are also more strongly and more unevenly serrate or lacerate, especially toward the outer end.

At a later stage, but varying in size, even in the same species, the edge of the cup begins to be undulated or lobed; most commonly there are six outfoldings and six infoldings at first, corresponding to the primary and secondary septa, but the number may vary from three to seven, or even eight or more. When four lobes are formed the coral is apt to be squarish. (See pl. xvii, fig. 4.) These primary folds and lobes may continue to grow regularly for some time, till several large marginal calicles, usually five or six, develop around the central, stellate, primary calicle (pl. xvii, figs. 1-2). This is the most normal and regular mode of growth for all the species of this

* This large species should, therefore, be called *Mussa lacera* (Pallas) Oken. The calicles are often 40 to 60^{mm} broad, mostly isolated; costæ strongly spinose. It is found throughout the West Indies, to South America, but not at the Bermudas. See below, p. 130.

genus. The infolding of the margin is often delayed till the calicle is 25 to 40^{mm} across.

But frequently the first outfoldings of the margin begin much sooner than usual to form secondary folds of the same nature, before the first series of calicles is fully formed. This gives rise to the early formation of a much larger number of calicles, some of which may long remain incomplete and united in series. For the same reason the calicles in such a coral will be, for some time, smaller in size than those that divide more slowly, thus giving them a very different appearance. But both conditions may exist at the same time on some specimens, and many irregularities constantly occur. (See pl. xvii, figs. 5, 6.) Some species, however, normally divide more rapidly than others. (Pl. xx, fig. 1.) The outfoldings of the margin may not much affect its regular circular outline, as in pl. xvii, figs. 1, 2, (*I. fragilis*). But in other cases they may be so extensive as to produce a deeply lobulated outline, when seen from below, as in pl. xvii, fig. 3, (*I. fragilis*). Large specimens of either species (see pl. xvii, figs. 5, 6 of *fragilis*) generally have a large number of calicles, irregularly arranged, many of them isolated, but mostly in short series.

Resorption of parts of the walls and septa or of the entire thickness of the collines frequently takes place, and thus alters the appearance. In some cases this results in breaking up the collines into detached portions or isolated columns. This I have seen in *I. fragilis*.

The genus is chiefly, or perhaps entirely, American. The simple form described as *I. australis*, first from Australia, was considered the type of a special genus, *Homophyllia*, by Bruggmann, 1877. The species described by Klunzinger from the Red Sea as *I. erythraea* appears to me to belong rather to *Ulophyllia* or *Mussa*.

Isophyllia dipsacea Dana. Rose Coral.

Mussa dipsacea Dana, Zoöph., p. 184, 1846.

Symphyllia dipsacea Edw. and Haime, Corall., ii, p. 373, 1857.

Isophyllia dipsacea Verrill, Bull. Mus. Comp. Zoöl., i, p. 49, 1864; Pourtalès, Deep Sea Corals, p. 71, 1871; Florida Reefs, pl. vii, figs. 1-8, 1880.

Isophyllia australis (pars) Edw. and Haime, Corall., ii, p. 375 (young), 1857.

? *Symphyllia anemone* + *S. comferta* + *S. aylæ* + *S. helianthus* + *S. Thonasiæ* + *S. aspera* + *S. cylindrica* + *S. Knoxi* + *S. verrucosa* (abnormal) Duch. and Mich., Corall. Antill., pp. 71, 72, 1860.

? *Lithophyllia argemone* + *L. cylindrica* Duch. and Mich., op. cit., p. 68, pl. ix, fig. 121, pl. x, fig. 15, pl. ix, figs. 17, 18, 1860, (young).

Isophyllia australis + *cylindrica* + *Knoxi* + *Lithophyllia Cubensis* + *L. lacera* (non Pallas) + *L. argemone* Quelch, Voy. Chall., Zoöl., xvi, pp. 10, 11, 12, pp. 83-86, 1886.

PLATE XVIII. FIGURE 2. PLATE XIX. FIGURES 2, 3. PLATE XX. FIGURE 2.

This species occurs in abundance at the Bermudas, in shallow water (1 to 20 feet) on nearly all the reefs, and also along the shores attached to rocks, and even to small stones on shell-sand bottoms, where other corals do not grow. It is very abundant even in Harrington Sound, where but few species of corals are found, owing to the less density of the water.

I have personally collected and studied hundreds of specimens of this and the following species, and have kept large numbers alive, to ascertain, if possible, whether two or more species occur there, and to learn the character and extent of the variations.

Probably no coral varies more than this in form, mode of growth, union and separation of the calicles, and consequently in the size and form of the calicles, character of the columella, number and size of the teeth of the septa, extent of the epitheca, etc.

Therefore many nominal species have been founded, especially by Duch. and Mich., on mere stages of growth and on ordinary individual variations in the mode of growth, union of the walls, etc.

The colors of the living animals of this and *fragilis* are also extremely variable, and often very beautiful. Most commonly they are variegated with gray, lavender-blue, green, and flake-white in variable proportions. But specimens often occurred, especially in 1898, rarely in 1901, that were largely or wholly bright emerald-green, or grass-green. I have had some that were bright green over one-half the surface, and lavender and gray on the other half. The difference in the external appearance of the animals of this and *fragilis* are slight. Therefore the color of the animal cannot be used to distinguish species nor even varieties.

The same is true of the isolation and union of the calicles in series, for a single specimen often shows the extreme conditions on its different parts. The collines generally have simple, solid, rather thick walls, but sometimes they are double with a groove on the summit, as is the case more commonly in *fragilis*.

This species has a heavier and more solid coral than *fragilis*, with stronger and thicker walls. It can best be distinguished by the decidedly thicker and closer septa, which have stronger, stouter, and more regular, spiniform teeth on their edges, the size of the teeth decidedly increasing toward the columella, where the septa are also usually distinctly thicker.

The calicles, when well grown, are generally broader, more flaring, and more shallow. The costae are less prominent, thicker,

closer, and strongly spinulose, with small, but strong, acute, rough spines. The collines are radial at first, but may soon become sinuous. They may be solid, or they may be double with a groove on top, more or less wide and deep. In many large specimens a considerable proportion of the calicles are simple.

A medium specimen, 80^{mm} across, has usually 10 to 12 septa to the centimeter, of which 7 or 8 are larger ones, the others being much smaller. The larger calicles are 20 to 25^{mm} wide, but others on the same coral are not over 15^{mm}; they are 8 to 10^{mm} deep. This example has double walls. The columella in this is made up of few strong trabeculae and angular spines. In this specimen the larger septa are thickened toward the columella and bear on that part large, thick, spiniform teeth; more distally the teeth are smaller, decreasing to the margin. Pl. xviii, fig. 2.

A very well grown Bermudian specimen, 100^{mm} in diameter, has five pretty nearly circumscribed large marginal calicles; four of them are just beginning to have marginal infoldings, for new collines. In this the diameter of the undivided calicles is 28^{mm}, but some that are beginning to divide are 30 to 33^{mm} across, transversely, but 40 to 45^{mm} across the broadest parts; depth 10 to 13^{mm}. The collines are double-walled in most places, with a wide, deep, intermural groove.

The septa are numerous, close, rather thick, especially toward the columella; the edges are strongly and rather regularly toothed, the teeth being mostly acute and thickened, generally decreasing in length toward the margin of the calicles. The costae are thickened, little elevated, roughly spinose, with small acute spines.

This coral was attached by a small central pedicel and the under side is six-lobed and imperfectly covered with epitheca to within 4 to 8^{mm} of the margin. The columella is formed of rather slender, loose trabecular and spinous processes. Pl. xix, fig. 2.

A Bermudian specimen with six unusually large and open, nearly simple, marginal calicles has six large, regular marginal lobes, conspicuous on the under side; only one of these has begun to infold the margin, for secondary divisions. The collines are thick and nearly solid. The five undivided marginal calicles are 22, 23, 28, 32, and 35^{mm}, in transverse internal diameter, from wall to wall; the one that has just begun to divide is 40^{mm} across and 52^{mm} long; the most regular one is 32^{mm} wide and 40^{mm} long; the central calicle is about 20 by 25^{mm} across, and 15^{mm} deep; the marginal calicles are about 8 to 10^{mm} deep. (Pl. xx, fig. 2.)

The septa are strong, thickest toward the columella, where they bear large, stout, angular, acute teeth, often irregular and united by their bases. Small thin septa usually alternate with the larger ones, and have long, thin, sharp teeth. There are usually about five larger and four smaller septa to a centimeter. The columella is small and composed of many slender processes in some of the calices, and of fewer, stouter ones in others. The costæ are thick, not much elevated, roughly spinulose, with small acute spines.

This specimen is quite different from most, in appearance, owing to the great size, shallowness, and regularity of its calices, but it seems to be simply a specimen that has delayed its secondary divisions longer than usual, so that its calices have grown broader.

A few examples of this species have very shallow calices, the inner surface of the cup being nearly flat, but in other respects they agree with the ordinary forms.

Two or more specimens, crowded when young, may graft themselves together and later form a solid coral similar to the normal ones, but usually somewhat more irregular.

Abnormal specimens, owing to injuries or disease, may have the septa very much thickened and often hollow, and their spines may be hollow, swollen, or even bulbous at the tips. *S. verrucosa* D. and M. was evidently based on a specimen of this kind.

Our largest perfect specimens are 150 to 200^{mm} (six to eight inches) in diameter, but larger and less perfect ones were often seen, perhaps the largest were 10 inches across.

This species is found from Bermuda and the Florida Reefs, southward, throughout all the West Indies.

Isophyllia fragilis (Dana) Ver. Rose Coral. Lettuce Coral.

Mussa fragilis Dana, Zoöph. Expl. Exp., p. 185, pl. viii, fig. 9, 1846.

Isophyllia fragilis Verrill, in Dana, Coral Islands, ed. 2, p. 380, 1874, ed. 3, p. 424, 1890. Queleh, Voy. Chall., Zoöl., xvi, p. 84.

Symphyllia Guadalupeensis Edw. and Haime, Ann. Sci. Nat., xi, p. 256, 1849; Hist. Corall., ii, p. 373, 1857. (Young.)

Isophyllia Guadalupeensis Pourtalès, Deep Sea Corals, p. 71, 1871.

Symphyllia ? *strigosa* + ? *S. anemone* + ? *S. marginata* Duch. and Mich., Corall. Antill., pp. 70, 72, pl. x, fig. 16, 1860. (Indeterminable from the descriptions.)

PLATE XVI. FIGURES 1, 2.

PLATE XVII. FIGURES 1-7.

PLATE XVIII. FIGURE 1.

PLATE XIX. FIGURES 1, 4, 5.

This species, which is about as common as *dipsacea* at Bermuda, and lives with it, can best be distinguished from the latter by the thin, lacerate-toothed, very unequal principal septa, which are not

crowded, but have rather wide interseptal spaces, in which are the much thinner and narrower small septa; by the usually deep, steep-walled calicles; and by the prominent, thin, lamelliform, rather distant, and only slightly serrulate external costæ.



Figure 4.—*Isophyllia fragilis* (D.). Portion of a specimen having many of the calicles isolated, with the polyps partly contracted. Photographed from nature. About $\frac{2}{3}$ natural size.

Figure 4a.—The same, with the polyps. A specimen having two calicles isolated and the rest in a long connected series. About $\frac{2}{3}$ natural size.

The collines may be high, steep, and narrow, with a thin solid wall, or they may be double-walled, with a groove on top; or they may be entirely disunited in some specimens, up to 2.5 inches (65^{mm}) in diameter. But these variations in the collines may occur on a single specimen. The septa are decidedly thinner, fewer, and much more openly arranged than in *dipsacea* of the same size, and the latter has shorter, much stouter, and more regular septal teeth, and less prominent, closer, thicker, and more spinulose costæ.

The original type* of Dana belongs to the Museum of Yale

* Vaughan (op. cit., pp. 41, 42, 1901) erroneously refers this species to *Colpo-phyllia gyrosa*. He says that from the descriptions "no specific distinction between the two can be discovered." This statement seems absurd, for the *Mussa fragilis*=*Isophyllia* was very well described and figured by Dana. He also described and figured the strong, spiniform teeth of the septa. Such a mistake seems unaccountable, and the more so because Quelch had already referred it to *Isophyllia*, in addition to my previous determination of it. The type of *I. fragilis*, in the Yale Museum, I have now figured. (See pl. xvi, fig. 1.)

University. It is attached to a stone on which the name and locality (Bermuda) were written in Dana's handwriting. The stone is of granitoid character, but it may have been taken to Bermuda in ballast, as often happens there. It belonged to the Redfield Bermuda collection, which was presented to Yale University many years ago. No. 4298.

This specimen, owing to its growing upon an angular corner of a stone, is quite irregular in form; one side is closely adherent to the stone, almost to the edge, while the other side is free from 10 to 35^{mm}, and shows very well the thin lamellate costæ, finely, unevenly serrulate, especially distally where they are highest. They are about one-third as thick as the width of the intercostal spaces. The collines are irregular and crooked; most of them are double-walled, with a slight groove on top, the walls themselves being thin; in some places the walls are simple, or nearly so. The valleys are unequal; most are elongated, deep, and narrowed by crowding; others are nearly circular and less deep; the longer ones are 14 to 20^{mm} wide, from wall to wall; the larger circular ones are about 24^{mm} broad (in other specimens they are often 30^{mm} broad).

The septa are very thin, very unequal, openly arranged; their edges are irregularly and sharply dentate, with long, thin, flat, acute or lacerate teeth, unequal in length and breadth, rough on their sides and ends; the larger teeth are near the columella. There are about six principal septa to a centimeter, with four or five much thinner ones. The columella is open and loose in structure, composed of slender, irregular, rough spiniform processes from the septa. This coral is 80^{mm} broad and 49^{mm} high, where thickest (pl. xvi, fig. 1).

A somewhat younger, turbinate specimen from Bermuda (coll. 1901), agreeing very closely with the type in the characters of the septa, dentations, costæ, etc., has deeper and more flaring calicles of somewhat large size, 20 to 30^{mm} in diameter. In this the walls are in nearly all cases separate; they have united partially in some of the collines, leaving a wide furrow, but in two collines they form only a very thin and simple wall, showing that this is a matter of small importance. This specimen was attached by a small pedicel, leaving the lobulated outer wall free for 30 to 35^{mm} all around; the costæ are thin, high, laminar, and very finely serrulate. (Pl. xix, fig. 1.)

Other regular young specimens, when attached by a small pedicel, have an imperfect epitheca that covers most of the under side, except within 4 or 5^{mm} from the edge, and the base may be flat and horizontal, circular or lobed. (Pl. xvii, figs. 1-3.)

Simple young specimens, 20 to 25^{mm} in diameter, are low, shallow, nearly circular, and usually show no trace of division or lobulation of the margins. They may have five cycles of septa, with the larger ones lacerately toothed as in the adult. Plate xix, fig. 5.

The radial lobes and collines vary greatly with age; the most regular young ones, 40 to 65^{mm} across, usually have six regular, radial calicinal lobes, with six radial collines, and a central primary calicle, but the primary lobes are often five, more rarely four or three. The collines are frequently solid or nearly so, without a groove on top. (Pl. xvii, figures 1-3.)

In ordinary adult specimens the septa are thin, generally rather broad, unequal, and not very close together. The number to a centimeter may be eight to twelve, in fully formed calicles, but in imperfectly formed calicles there may be ten to twelve or more. The larger ones are normally thin, but firm, broadly rounded toward the margin, and not very prominent above the wall. But the form varies greatly in different calicles. The serrations are generally numerous, unequal, and mostly rather long, the larger teeth being flat, not very wide at base, and with the tips mostly acute, but sometimes forked or lacerate. Those toward the outer ends of the septa are usually decidedly shorter than the inner ones, but they are irregularly larger and smaller on the whole edge. The columella may be rather large and spongy, or it may be small and trabecular or laminose even on the same specimen.

The costæ are well developed, and like raised, thin ribs, separated by regular grooves, and with the edges sharply and rather regularly serrate, with the teeth very much smaller than those of the septa. Sometimes the costæ are sublamellar. They may be confined to a narrow zone close to the edge, or they may be more than 25^{mm} long, according to the variable extent of the epitheca.

This species is more apt to have part of the corallites isolated and nearly circular than *I. dipsacea*. Frequently many of them are dis-united for much of their length. The larger round calicles may sometimes become 40^{mm} in diameter before they begin to divide.

One of our Bermudian specimens has, on one side, a simple, curved, linear valley, five inches long (125^{mm}), containing a row of uniform, united calicles, while on the other side the calicles are partly isolated, and partly in short groups of two or three, and of various forms.

In the form and colors of the soft parts this species does not differ materially from the last. Its colors are equally variable, but per-

haps the bright green colors are more common in this species. The tentacles are less numerous.

When full grown this species is often 6 to 8 inches (150 to 200^{mm}) in diameter and 4 to 5 inches thick.

When the calicles are crowded resorption of portions of the collines may break them up into detached cone-like or columnar portions, or may simply cause interruptions of their continuity.

Specimens partially killed by injury to the calicles may repair themselves by budding out new cup-shaped calicles from the mutilated parts, and then the new growth may go on just as in the case of young ones arising from eggs.

During the spring of 1901, owing to a period of unusually cold and stormy weather in February and March, many dead or partly dead specimens of this species and *I. dipsacea* were seen, in place, and even those that seemed to be uninjured refused to expand, though in previous years they expanded very freely in confinement. They expand best in bright sunshine and during hot days.

This species is common at the Bermudas, in shallow water. Florida Reefs. West Indies to St. Thomas. Probably generally distributed in the West Indies.

In most collections this species is confused with *I. dipsacea*, usually under the latter name. It is not always easy to distinguish the two, without careful examination. It is possible that the two forms may eventually have to be united as varieties of one species. But all the numerous specimens of this group that I have hitherto studied can be pretty definitely arranged under the two species, by the differences in the septa and costæ.

The following species seems to be so different that it can hardly be confused with either of the preceding, unless when young.

***Isophyllia multiflora* V., sp. nov.**

? *Isophyllia multilamella* Pourt., Deep Sea Corals, p. 70, 1871 (*non* Duch. and Mich.)

PLATE XX. FIGURE 1. PLATE XXV. FIGURE 1.

This species is remarkable for the rapid division of the calicles, and the unusually small size of the calicles, which are very crowded, and many of them are isolated or in very short series.

The collines are mostly irregular, simple, narrow, with a thin solid wall, but in the larger examples they are often meandrimiform. The calicles are rather deep, mostly decidedly stellate, generally 14 or 15^{mm} in diameter, but varying from 12 to 18^{mm}; depth 6 to 8^{mm}.

Septa rather narrow and thin, closely arranged, their edges covered with numerous rather slender, acute, rough teeth, the proximal ones usually the larger. The sides of the septa and teeth are covered with numerous, sharp, rough, conical grains, giving them a rough or hispid appearance, under a lens. The columella is well developed, rough, porous, composed of small, irregular, contorted and hispid lamellæ and spinous processes of the septa. There are usually 11 or 12 well-formed septa to a centimeter, besides some rudimentary ones. The costæ are not much elevated, except close to the edge, slightly thickened, hispid laterally, and sharply serrate with small rough spinules. The epitheca is imperfect, but usually covers much of the lower side.

The animals of this coral are smaller than in the other species, and they form elegant crowded groups, when expanded. The colors are similar to those of *dipsacea* and *fragilis*, but emerald-green is perhaps a more common color in this.

Our largest Bermudian specimen (pl. xx, fig. 1) is 40^{mm} thick and 85^{mm} across, with a nearly flat upper surface. This has 27 distinct calicinal centers, of which only five or six are isolated, most of the others forming series of two or three. The margin has about twelve small lobes.

A very regular small specimen (pl. xxi, fig. 1) is about 55^{mm} broad and 25^{mm} high, with twelve small marginal lobes and twelve radial collines, six of which are primary and extend to the central calicle in sinuous lines, mostly uniting to the five-lobed colline surrounding the central calicle, while the short secondary collines are nearly radial and unequally developed. Each of the six primary marginal calicles has already divided into three, more or less separated calicles, and the secondary central calicle has formed four smaller ones around itself, so that it is 5-lobed. Thus there are now 23 distinct calicinal centers on this small specimen. No. 4009.

A considerably larger one of *I. dipsacea* or *I. fragilis* would usually have but seven calicles. This rapid increase in the calicles seems to be characteristic of this species, which often resembles an astrapan coral, such as *Acanthastraea*, in the size and shape of its calicles and septal teeth, though many of the calicles are not isolated, like those of the latter.

I am unable to refer this rather rare species to any of those described by Duch. and Mich., or others,* unless it be the form

* The *Isophyllia Danaana* (Edw. and H., as *Mycetophyllia*, Hist., ii, p. 377. pl. D4, fig. 2) resembles this species in the width of the calicles and valleys, and in its septa, but the valleys are long and sinuous; the collines low and obtuse; and the columella is feebly developed.

briefly described by Pourtalès as *multilamella*, which seems quite distinct from the species to which he doubtfully referred it.

Bermuda and the Florida Reefs. Occurs also in the West Indies, at the Bahamas, etc. It occurred on the Serpuline Atolls, near Hungry Bay, and in Great Sound, Bermuda.

Mussa (Symphyllia) hispida V., sp. nov.

Astræa dipsacea Dana, Zoöph., p. 225, pl. xi, figs. 4-4d, 1846 (*non* Lam.)

Acanthastræa dipsacea Verrill, in Dana, Coral Islands, ed. 1, p. 380; ed. 3, p. 421, 1890, *non* E. & H.

PLATE XXI. FIGURES 2, 2a, 2b, 2c.

Dana's type of this species is preserved in the Museum of Yale University in good condition. No. 4287.

It is an astreiform, hemispherical mass, about 100^{mm} in diameter. The calicles are mostly simple and clearly circumscribed; some are circular, but many are elliptical or irregular; some are elongated and have 2, 3, or 4 centers in a series, as in *I. multiflora*.

The walls between the calicles are double and separated by an openly vesicular exothecal structure, the proper wall being thin and solid. The septa are thin, sharply granulated laterally, deeply lacinate, especially near the columella, and have long, rough, lacerate and hispid teeth, largest toward the top. The columella is large, loosely and coarsely trabecular, with rough spines on the surface. In a section the coral appears very cellular; the endothecal dissepiments are compound, long, and much inclined; septa are perforate and trabecular.

Diameter of calicles, 8 to 18^{mm}; the elongated calicles with two or three centers may be 25 to 30^{mm} long; 10 to 12^{mm} wide; depth 7-10^{mm}; distance between them, 2 to 4^{mm}. West Indies (t. Dana). Rare in collections.

This species resembles *Acanthastræa*, in which I formerly placed it, but it has the structure of a *Mussa*. The double wall and vesicular exotheca are not found in *Acanthastræa*, nor the elongated calicles with several centers, dividing by fission.

The locality of Dana's type was uncertain, but was supposed to be West Indian. A similar species is found at Pernambuco, Brazil. See below; List of Brazilian Corals, and pl. xxi, f. 3.

Mussa (Symphyllia) rigida (Dana) Ver.

Astræa (Fissicella) rigida Dana, Zoöph., p. 237, pl. xii, figs. 8a-8d, 1846.

Prionastræa? rigida Edw. and Haime, Hist. Corall., ii, p. 523, 1857.

Isophyllia rigida Verrill, Bull. Mus. Comp. Zoöl., i, p. 50, 1864; Coral Islands, ed. 3, p. 422 (*non* Pourtalès).

PLATE XXV. FIGURES 2, 3.

The *Isophyllia rigida* Verrill (Bull. Mus. Comp. Zoöl., i, p. 50, 1864) was based on *Astrea rigida* Dana (Zoöph., p. 237, 1846). The type of the latter is in the Museum of Yale University. It is a badly beach-worn, astreiform specimen, with irregular polygonal calicles, mostly 10 to 12^{mm} across. The walls are very solid, often 3 to 4^{mm} thick. The edges of the septa are entirely destroyed. In sections it resembles an *Isophyllia* with unusually well isolated calicles. Its origin is unknown; West Indies? No. 4297.

Several fresh specimens from the Bahamas (coll. R. P. Whitfield), Amer. Mus. and Yale Mus., are apparently of this species. These have deep, roundish or irregular, isolated calicles, 10–15^{mm} in diameter; many are dividing; septa about 30, stout, exsert, strongly spinose-dentate, the distal teeth larger, divergent; upper ones erect, prominent, acute; columella small, trabecular. Walls entirely united, nearly solid. The larger hemispherical masses are 90–100^{mm} across. No. 6616. Plate xxxiii, fig. 4.

Allied to *M. Harttii*, var. *conferta*, but septa are thicker, with the distal erect teeth much stronger; walls more solid.

Mussa Harttii Verrill.

Mussa Harttii + *Symphyllia Harttii* Verrill, these Trans., i, pp. 357, 358, 1868.
R. Rathbun, Proc. Boston Soc. Nat. Hist., ii, p. 40, 1878; Amer. Naturalist, xiii, p. 542, 1879.

PLATE XXII. FIGURES 1-2.

PLATE XXIII. FIGURES 1, 2.

PLATE XXV. FIGURE 4.

PLATE XXXIII. FIGURE 3.

A larger series of this species than that first studied has convinced me that both the forms originally described by me, provisionally, as distinct, are really only extreme growth-forms of one variable species. In the Museum of Yale University there are several intermediate specimens, some of which I have now figured. (Pl. xxii, figs. 1, 2.) It occurs with all the corallites united to their summits by a vesicular exotheca (*Symphyllia*-form, pl. xxiii, fig. 1), var. *conferta*; in dichotomous groups with the calicles and branches disunited, and without exotheca (fig. 2), var. *laxa*; in masses with the corallites free for only a short distance, leaving only deep grooves between (pl. xxii, fig. 1); in groups in which the corallites are free for $\frac{1}{2}$ or $\frac{1}{3}$ their lengths, with exotheca below (fig. 2), var. *intermedia*; and in various other intermediate forms.

One specimen (pl. xxxiii, fig. 3) consists of a cluster of seven calicles of the *Symphyllia*-form, arising from a dichotomous branch of the typical *Mussa*-form. No. 4545.

The calicles generally separate rather quickly in all the forms, and a large part of them are circular and irregularly elliptical, or hour-glass shape, owing to imperfect division. The size of the calicles, even when circular, is quite variable, but is mostly between 12 and 18^{mm}; the elliptical ones are often 25 to 30^{mm} long.

The septa are generally very thin, deeply lacerately toothed, the longer teeth being on the wider and rounded upper portion. They are usually rather openly spaced, about 9 or 10 wide ones to a centimeter, with as many very narrow or rudimentary alternating ones. In some specimens there are 12 large septa to a centimeter.

In the extreme form, var. *confertifolia* (fig. xxii, fig. 1), there are 16 larger and 16 smaller, very thin septa to a centimeter.

The columella is generally well developed, very porous, composed of numerous rough, irregular trabecular processes, with free spines on its surface. But sometimes it is coarsely, rudely trabecular and very loosely arranged, or it may be almost lacking.

The costæ are usually rather thin and not much elevated, but they are covered with numerous, rather close, sharp, elongated, often recurved spinules. These costal spines are very characteristic for this species, but in some specimens they become fewer, more irregular and less elongated, on some parts at least.

Brazil, from Pernambuco to Abrolhos Reefs; Victoria; Porto Seguro, Bahia, Mar Grande, etc., common.—C. F. Hartt; R. Rathbun. According to Mr. Rathbun the clusters are sometimes 2 feet across.

Var. *confertifolia* Ver., nov.

PLATE XXII. FIGURE 1.

The type of this variety is much more delicate than usual, with much more numerous, thinner, and crowded septa (about 16 larger and 16 smaller septa to the centimeter); they are covered with long, slender, sharp teeth. The columella is well developed and finely trabecular. The costæ are small, close, and crowdedly spinose, with small acute spinules, much as in the typical form, but smaller.

The corallites are short, pretty closely crowded, circular, elliptical, and some are irregular and rather smaller than usual. They are united for only a short distance, or not at all, by exotheca.

Pernambuco, Brazil,—Derby and Wilmot, 1870. No. 4551.

Mussa lacera (Pallas) Oken.

Madrepora lacera Pallas, Elench. Zoöph., p. 208, 1766. Esper, Pflanz., i, p. 148, pl. xxv, fig. 2, 1791.

Madrepora carduus Ellis and Sol., Zoöph., p. 153, pl. xxv, 1786.

Mussa lacera Oken, Lehr. Naturg., p. 75, 1815.

Caryophyllia carduus Lam., Hist. Anim. sans Vert., ii, p. 229, 1816; ed. 2, p. 357.

Caryophyllia lacera (pars) Ehr., Corall. R. Meeres, p. 92, 1834. Edw. and Haime, Ann. Sci. Nat., ii, p. 238, 1849.

Mussa carduus Dana, Zoöph. Expl. Exp., p. 175, 1846. Edw. and Haime, Hist. Corall., ii, p. 334, 1857.

Lithophyllia lacera Edw. and Haime, Hist. Corall., ii, p. 291, 1857 (Young) + *L. Cubensis*, op. cit., p. 292.

Scolymia lacera Haime, Mem. Soc. Geol. France, iv, p. 279, 1852. Bruggmann, Ann. and Mag. Nat. Hist., xx, p. 303, 1877. Vaughan, op. cit., pp. 6, 34, 1901.

This large species is common in the Bahamas and southward to Curacao.

On the Florida reefs it seems to be rather rare. It has not been found at the Bermudas. It forms dichotomous clumps, often more than a foot high and broad. The calices, when full grown, are mostly isolated and nearly circular. They are from 40 to 65^{mm} in diameter, and sometimes more, but mostly about 50^{mm}. The calices vary in depth, some being shallow, others rather deep. The septa are numerous and strongly toothed, but the teeth vary widely in form; usually the distal ones are much the larger. The larger septa are usually pretty thick, but sometimes they are thin and fragile. The exterior is covered with rows of strong, acute costal spines.

I regard the simple forms with broad calices and wide base, referred by Edw. and Haime to *Lithophyllia lacera*, as the young of this species before fission takes place. The two forms occur in the same localities. It is certain that all the species of *Mussa* and *Isophyllia* have such a simple young stage, before they begin to divide, in which the diameter of the cup equals or exceeds that of the adult calices after division. The size of the calices and the number and character of the septa and their denticulations all correspond well in the two forms. Moreover, I have seen specimens of the simple *Lithophyllia*-form in which infoldings of the margin had already taken place, to begin the process of fission.

If this form be not the young of "*carduus*," as I believe, then its young have not been discovered, which would be remarkable in the case of such a large and common species.

Pallas described both forms and considered them the same, under the name of *M. lacera*. The type of *carduus* is still in the Hunterian Mus. (t. Young).

Probably the *Lithophyllia Cubensis* Edw. and Haime is only a slight variation of the same young form, for similar variations occur in the adult calicles.

Mussa angulosa (Pallas) Oken.

Madrepora angulosa Pallas, op. cit., p. 299, 1766. Esper, op. cit., i, p. 92, pl. vii, 1791.

Mussa angulosa Oken, Lehr. Naturg., p. 73, 1815. Dana, Zoöph., p. 176, 1846. Edw. and Haime, Hist. Corall., ii, p. 329, 1857.

This species is closely allied to *M. lacera*. It differs from it in the smaller size of the branches and calicles, which are usually from 25 to 50^{mm} in diameter, and are apt to be crowded and angular. The principal septa are generally rather wide and exsert. A study of a large series of specimens might, perhaps, compel us to unite them in one species.

It is much less common in collection than *M. lacera*, and most specimens are beach-worn. It ranges from Florida to the Antilles, but seems to be rare on the Florida reefs.

Ulophyllia crispa (Lam.) Edw. and Haime.

Oulophyllia crispa Edw. and H., Ann. Sci. Nat., ser. 3, xi, p. 268, 1849.

Ulophyllia crispa Edw. and H., Hist. Corall., ii, p. 378, 1857.

I have studied a fine large specimen from Singapore, in the Ward collection, now in the Field Columbian Museum, at Chicago.

This is 12 × 8 inches across, and about 6 inches thick. The valleys are mostly 15 to 20^{mm} wide, but some are 25 to 30^{mm} across in the widest places; depth 10 to 15^{mm}.

The septa are rather loosely arranged, usually 9 or 10 to a centimeter, mostly wide and strongly toothed at base, projecting but little above the walls, and not much thickened; narrow ones alternate in some places between the wider ones, but not regularly. The large teeth of the wide septa are mostly broad at base, triangular, about as broad as high, subequal; usually the larger ones are on the basal part, but not infrequently the larger ones are above the middle. The ridges or collines are angular, broad at base, thin and simple at the summit. Columella variable, sometimes well developed, trabecular, sometimes open or rudimentary. Exterior of the coral lobulated at the margin, faintly costulate, nearly smooth, and without spines.

This is not a West Indian species, as some writers have supposed. All specimens that I have seen were from Singapore.

Several other, apparently distinct species, have been described from the Indo-Pacific region. Among them are the following:—

U. aspera Queleh, op. cit., xvi, p. 88, pl. iii, figs. 5-5b. Banda.

U. cellulosa Queleh, op. cit., p. 87, pl. iii, figs. 6-6c, 1886. Banda.

U. maxima Rehberg, Abh. Geb. Naturw. Ver., Hamburg, xii, p. 18, pl. i, fig. 12, 1892. Duke of York Island.

U. Stuhlmanni Rehb., op. cit., p. 17. Zanzibar.

Addenda to Favitinae.

The following species should have been inserted on page 91.

Favia Whitfieldi Ver., sp. nov.

PLATE XXV. FIGURE 5.

This coral forms rounded masses, up to four inches (100^{mm}) in diameter. Calicles a little elevated, rather large, 8-12^{mm} in diameter, mostly nearly circular; some are elliptical and undergoing fission; a few are irregularly lobed. Their cavities are rather deep, funnel-shaped, narrow at the bottom.

Septa somewhat exsert, rounded at the summit, and roughly serrate; paliform lobe well developed, serrate. Columella small, lamellose or trabecular; walls thick, solid, separated by dense exotheca having few cellules in one row.

Nassau, N. P.,—coll. R. P. Whitfield. Two good, fresh specimens are in the American Museum Nat. Hist., New York. No. 543. I have seen other specimens that are beach-worn.

This species is quite unlike any of the other West Indian species of *Favia*. Its general appearance, and especially its large, round calicles cause it to resemble some of the East Indian species. Its septa are more roughly serrate than in most species.

Family **Echinoporidae**. Emended.

Coral usually foliaceous or frondose, sometimes branched, rarely encrusting, generally thin, with the exotheca or cœnenchyma sparingly developed and usually cellular, but sometimes solid (*Acanthopora*). Corallites short, often obliquely appressed; increasing chiefly by marginal, basal, or intercostal budding, generally scattered irregularly and only on one side of the foliaceous species, but sometimes on both sides, and not forming collines, but sometimes arranged in short rows.

Septa often strongly exsert, dentate or lacerate, the distal ones usually continuous with the costæ. Common base often thin, but firm, imperforate, irregularly costate, often echinulate.

These corals often resemble fungian corals, like *Agaricia* and *Podabacia*, but they have distinct and often large exothecal dissepiments and lack synapticulae.

To this family I now unite the genus *Mycedium* Oken, as emended, = *Phyllastræa* Dana.

Mycedium (Oken) Edw. and Haime. Type *M. elephantotus* (Pallas; Esper.)

Mycedium (*pars*) Oken, Lehr. Naturg., i, 69, 1815.

Agaricia (*pars*) Ehr., Corall., p. 105, 1834 (*non* Lam.)

Phyllastræa Dana, Zoöph. Expl. Exped., p. 269, 1846.

Helioseris (*pars*) Edw. and Haime, Compt.-rend., xxix. p. 72, 1849.

Mycedium (*pars*) Edw. and Haime, Ann. Sci. Nat., xv, p. 130, 1851; Hist. Nat. Corall., iii, p. 72, 1860 (*non Mycedia* Dana, 1846).

The coral in this genus usually forms thin, foliaceous, often contorted fronds, simple or clustered. They may be unifacial or bifacial. The calicles are rather large, one-sided, oblique or appressed, stellate, usually scattered, not in long series. Collines rudimentary or lacking. Septa rather few, thickened, serrate or laciniate, exsert, prominent externally, continuous from calicle to calicle, as septo-costæ. Costæ coarse, rough, serrate. Under side of coral rather coarsely costate.

Much unnecessary confusion has arisen as to the characters of this genus.

This has been due chiefly to the fact that most writers have failed to recognize the true characters of the type species, *Mudrepora elephantotus** of Pallas, and have had very different species under this name, including two or more West Indian species of *Agaricia*, as will be shown under that genus, which have nothing to do with the true *elephantotus*. Milne-Edw. and Haime had, however, a more correct idea of the nature of the original genus, and their interpretation of it must hold good, even though they included some species that may better be placed elsewhere. But their species described as *elephantotus* is not the species of Pallas.

* It has been suggested by Quélch that this spelling was a typographical error for *elephantopus*, but the allusion is plainly to the resemblance of a broad foliaceous coral to an elephant's ear, not to the foot. Some of the early polynomial writers gave these foliaceous corals the vernacular name "Elephants Ears." See Voy. Chall., xvi, p. 116, foot note.

The *M. elephantotus* of Pallas was not an *Agaricia*, and was from "Oceanus Indicus." It belongs to a strictly Indo-Pacific group of corals. It was carefully described by Pallas, who said that he had seen but a *single* specimen. So that there was here no confusion due to an original mixture of several species. Such confusion was due to the confounding of other very unlike species with it by subsequent writers, even down to the present year.

Vaughan (op. cit., pp. 63, 64, 67, 1901) identifies it with a West Indian species very close to "*M. fragile*," from which he thinks it may be distinct (p. 67), and he states that he has seen good specimens, but does not give the characters. Therefore we can only infer that he considers it a West Indian foliaceous *Agaricia*.

Gregory (op. cit., pp. 280, 281, 1895) unites it definitely with the species *A. fragilis*, without a mark of doubt.

But the species described by Pallas, as plainly stated by him, was a widely different coral. He stated that the stars (calicles) are scattered, nearly in quincunx; that they are prominent and lacerate; that the exterior of the coral has rather remote, rough, longitudinal costæ; and that it seems intermediate between *M. agaricites* and *M. lactuca*.

None of these characters apply to the *Agaricia fragilis* and its allies, nor to any true *Agaricia*. His description* clearly indicates a coral with large, well-defined, stellate, scattered calicles, having lacerate septa, continuous distally with the subparallel, radial, granulated costæ, and with a coarse, roughly costate exterior surface, instead of one with the fine and even striations characteristic of *Agaricia fragilis* and its allies.

Pallas does not state that the calicles are in series, nor does he mention transverse sulci or collines, though these characters are carefully described by him under *M. agaricites* on a previous page. Hence we must conclude that they did not exist in his species, especially as he also says that the stars are nearly in quincunx. This is also the case in Esper's *elephantotus*.

* The original Latin description (Elench. Zoöph., p. 290) is as follows:—

"Madrepora conglomerata subturbinata, intus lamellis granulosis parallelis stellisque lacero-prominulis sparsis.

Corallium format laminam tennem, subturbinatam, undato-crispam, lacinosam, sessilem, extus longitudinaliter porcis remotiusculis striatam; intus præditam lamellis longitudinalibus, subparallelis, obtusis atque granulosis, quæ passim interruptæ sunt stellis rariusculis, fere in quincunces sparsis, lacero prominulis; harum lamellæ istæ longitudinales quasi radii sunt. Locus: Oceanus Indicus.

Est quasi medium inter *M. Lactuam* & *agaricites* quasdam varietates."

In fact, the description calls for a coarsely costate and rough coral, having scattered, stellate calicles, without collines.

The genus *Phyllastræa* Dana, based on *P. tubifera* Dana, corresponds to it in many respects, and is evidently congeneric with it, as noted by Edw. and Haime. Several other allied species are known to me.

Unfortunately, Edw. and Haime described as *elephantotus* a very distinct species, with very fine, close, equal costal striae on the under side, and this has helped to perpetuate the confusion.

Esper (Pflanz., i, pl. xviii, figs. 1-4) figured as *M. elephantotus* Pallas, from the East Indies, a foliaceous species, with thin, clustered, convoluted fronds, strongly radially costate and serrate, but not echinate, below. Calicles stellate, appressed, raised proximally, with coarse, serrate, angular septa. This may well be the real *elephantotus* Pallas. It corresponds to it better than does any other figure.

Dana (Zoöph., p. 339) referred to a specimen of this species that he had seen in Peale's Museum, Philadelphia. This museum was burned many years ago, but Dana's sketch of this specimen is in the collections of the Yale Museum, with other unpublished drawings of corals presented by him.

It is probably of Indo-Pacific origin.

Ehrenberg described in 1834 a different species under the name of *Agaricia? elephantotus*.* It had calicles six lines in diameter, which is much larger than those of Esper's species.

The *Mycodium Okeni* Edw. and Haime (Hist., iii, p. 75, pl. D12, figs. 1a, 1b (not 2)), also has large calicles, 10^{mm} in diameter, and is probably very close to *elephantotus*, if not the same. It has rough, dentate, angular septa and the calicles somewhat in series. There is evidently an error in the numbering of the figures on the plate. Queleh (op. cit., p. 116) referred this species to *Phyllastræa* Dana.

As for *M. cucullata* Ellis and Sol., it seems to be a species of *Agaricia* that cannot yet be positively identified. I have seen no specimens like it, nor do any of the modern descriptions agree very well with it. It is certainly *not* the same as *elephantotus* of Pallas, though it may be the species wrongly called by that name in some modern books; possibly it is the *M. elephantotus* of Edw. and Haime, but the latter is not the *elephantotus* Pallas. Gregory puts it as a synonym of his erroneous *elephantotus-fragilis*. The *A. cucullata* Dana is probably *A. purpurea* Les., described below.

* Doubting its real identity with the Pallasian species, he gave it the provisional name of *megastoma*, as noted also by Dana. It is perhaps a *Tridacophyllia*. Edw. and Haime, ii, p. 381, consider it the young of *T. lactuca*.

Some of the species of *Podabacia* resemble the *M. elephantotus* rather closely in form. This is particularly the case with an apparently undescribed species.*

Mycedium explanatum Verrill.

Phyllastræa explanata Verrill, Bull. Mus. Comp. Zoöl., i, p. 53, 1864.

PLATE XXIX. FIGURES 1a, 1b, 1c.

Additional specimens of this species show considerable variations from the type.

The fronds may be 8–10^{mm} thick, but become very thin, about .05^{mm}, at the margin. The under side is covered with unequal, raised, rounded, dichotomous costæ, the larger ones separated by three to six smaller ones; they are not serrulate nor echinate. On the older parts of the upper side, the corallites are large, often crowded, sometimes erect, but usually much inclined, mostly 8–10^{mm} in diameter. The septa vary from less than 12 to 18. Most commonly there are about 12 larger, subequal, very thick and prominent ones, with several much thinner ones of the 3d cycle. The large ones are perpendicular within, acute-angular at the summit, and con-

* *Podabacia dispar*, sp. nov. Coral thin, foliaceous, in broad fronds, often concave above, and very thin at the edges. Common wall thin but compact, with few or no perforations, and covered with unequal, slightly raised, but continuous, costæ; often every 4th or 8th one is larger than the intermediate ones, which decrease in size according to the cycle of the septa with which they correspond, the smallest extending only a short distance from the edges. Their edges are finely granulated, and sometimes the larger ones are sparingly denticulate with very small, rough, irregular teeth, very much smaller than those of *P. crustacea*. The calices are irregularly scattered; the larger ones are stellate, with a well developed columella, made up of irregular rough processes, sometimes united into a nearly solid mass. Septa thin, in three cycles, with some very thin perforated ones of the 4th cycle on the distal side. Usually there are nine to twelve larger septa; but in the outer calices there are usually but six. The principal septa are wide, rise abruptly, and form a prominent, somewhat thickened lobe or angle at the summit, beyond which the edge is concave, thin, finely and sharply serrate, and continuous with the long septo-costæ. The prominent angle is often lacerate-toothed, but more frequently it is subintere. The septo-costæ are of several sizes, but generally the alternate ones are very thin, deeply lacerate, and much perforated close to the edge. The synapticulae are large and conspicuous. Plate xxix, figs. 5, 5a.

Diameter of the larger calices, 4–6^{mm}; thickness of coral, 1.5 to 2 inches from edge, 6–8^{mm}.

Samoa Is. (Coll. H. A. Ward). Museum of Yale Univ., No. 6178, and Field Columb. Mus., Chicago.

vexly rounded externally, where they pass into thick, stout costæ, bearing several conical, rough, often hollow spines.

The summit is roughly serrate or spinulose; the inner edge and sides sharply and roughly granulated. The septo-costæ are often long, becoming thinner between the corallites than on their walls, and alternately thicker and thinner; they bear rather fine, strong, suberect, acute or lacerate spines. Toward the margin of the coral the corallites are smaller, more appressed, but circular, and have 6 to 12 larger, thick, prominent, exsert, acute, lacerate or spinose septa. The septo-costæ here become thinner and higher, with erect, rough or lacerate, rather distant spines. The columella is generally pretty well developed and roughly trabecular.

In sections (fig. 1c) the exotheca is pretty compact, with numerous rather small dissepiments, much smaller than in the next species.

Tahiti; Mus. Comp. Zoöl.; Yale Mus.; Field Columb. Mus.

For the older, thick form, with stout, swollen or rounded corallites, I have used the variety name, *turgida*. It often looks like a distinct species, but it grades into the thinner form. The differences are probably due to age.

Mycedium tenuicostatatum Ver., sp. nov.

PLATE XXIX. FIGURES 2, 2a, 2b, 2c.

Coral forms a large foliaceous frond, more or less bent and irregular, considerably thickened and cellular in the older parts, but thin at the margin.

Exterior dichotomously costate; the costæ are unequal, 1 to 3 or 5 smaller ones between the larger; all are broadly rounded, more than twice as wide as the narrow intervening grooves; their surfaces are slightly rough with minute granules.

Corallites, toward the center of the upper side, are large and much crowded, expanded, prominent, often erect; the larger ones are 15 to 18^{mm} across, with very exsert, excurved, very roughly lacerate and spinose septa, which are thick and broad at the summit, with the inner edge flaring and roughly dentate and the outer or costal portion lacerately dentate. There are often 24 septa, in three cycles, but frequently only 12 to 18 are present; those of the third cycle are thin and narrow; sometimes smaller septa of the fourth cycle appear. Many corallites are but little prominent, with the septa thinner and not much exsert, angular at the summit, and roughly

spinulose. The septo-costæ are very thin and high, separated by spaces 4 to 6 times as wide, with few angular teeth.

In sections (fig. 2*c*), the exotheca is abundant, coarsely cellular; the dissepiments are convex and numerous. Singapore (?); Mus. Yale Univ.; Field Columb. Museum.

Echinopora elegans Ver., sp. nov.

PLATE XXIX. FIGURE 3.

The coral forms broad, thin, contorted, foliaceous fronds, sometimes 20 inches (500^{mm}) broad and 10 inches high, while the average thickness of the foliæ may be 3 to 4^{mm}, becoming very thin and translucent toward the margins, but yet compact and strong. Under side has rather loosely scattered small calicles in some parts, but toward the margins they are absent and the surface is evenly and closely covered with very small, nearly equal costæ, roughened with minute granules.

The upper side is roughly echinulate, and bears larger and more prominent calicles, which are rather crowded in some parts, but irregularly arranged, and becoming more scattered toward the margins, where the intervals are often equal to three or four times their diameter.

The larger corallites are verruciform, 3 to 4^{mm} in diameter, with very roughly echinulate septa and costæ.

The septa, in the larger calicles, form three very unequal cycles. The six primaries are much exsert, a little thickened, hispid laterally, and with the edges finely lacerately toothed. Usually they consist of two or three deeply divided lobes, the outer one standing on the outer thecal margin; the next, just within the calicle, is a little wider; the third, usually smaller, may represent the paliform lobe or tooth. Those of the second cycle are smaller and thinner, but lobed in the same way. Those of the third cycle are very small and narrow, or often rudimentary.

The septo-costæ are numerous, even, and rather close, represented, in general, by rows of small, upright, echinulate or lacerate spinules of about equal size; toward the margins the costulæ become more elevated, with the edge echino-lacerate.

The columella is usually well developed, finely trabecular or spongy.

Samoa (coll. Ward); Mus. Yale University and Field Columbian Museum. No. 6180.

Echinopora concinna Ver., sp. nov.

PLATE XXIX. FIGURE 4.

The coral forms large, thin, foliaceous, bent fronds, a foot or more across, becoming very thin but firm at the edges. Both surfaces bear similar calicles in the type.

The septo-costæ are fine, very regular, only slightly raised, and each bears a row of regularly spaced, not crowded, small, erect, rough spinules, which give a neat and very regularly spinulose character to the surface.

The calicles are small, low, verruciform, rather open, with deep and conspicuous interseptal loculi. The septa are in three cycles, the smallest very thin and narrow. The larger ones are wide, thickened at the walls, a little prominent, angular at the summit, and lacerately toothed.

The columella is well developed and finely trabecular or spongy.

Diameter of calicles about 4^{mm}; their height about 1 to 2^{mm}.

Pelew I.,—coll. Ward; Yale Museum and Field Colum. Mus., Chicago. This is allied to *E. striatula* Studer, (Monatsb. Kong. Akad. Wiss., Berlin, 1877, p. 644, pl. iii, figs. 10a, b,) from New Britain.

Family *Agaricidæ* Ver., 1867.

Fungidæ (pars) Dana, Zoöph., p. 283, 1846.

Lophoserinæ (pars) Edw. and Haime, Compt.-rend., xxix, p. 71, 1849. Hist. Corall., iii, p. 35, 1860.

Lophoseridæ Duncan, Revision, p. 146, + *Plesiofungidæ (pars)*, p. 133, 1884.

Agaricidæ Verrill, these Trans., i, p. 542, 1867.

Corals generally compound, increasing mostly by marginal budding, often thin foliaceous or frondose, either unifacial or bifacial, sometimes in thick plates or massive. Calicles small and shallow, often without definite solid walls. Septa usually numerous, low, finely serrulate or subentire, more or less of them continuous, as septo-costæ, with those of adjacent calicles.

Synapticulæ exist between the septa, and in thick or massive forms there are also dissepiments. Outer wall compact, imperforate, usually with slender, serrulate costal striations, seldom echinate.

Polyps short, scarcely exsert, with small, short, verruciform, blunt or clavate, or often rudimentary tentacles.

Agaricia Lam. (emended). Type *A. undata* Ellis and Sol.*

Agaricia (pars) Lamarck, Syst. Anim. sans Vert., p. 375, 1801 (1st species is "*M. cucullata* Ellis and Sol.," 3d species is *M. undata*; 2d species is now *Merulina ampliata*).

Undaria Oken, Lehr. Naturg., p. 68, 1815 (includes 1st, *agaricites*; 2d, *undata*).

Agaricia (pars) Lam., Hist. Anim. s. Vert., 1815.

Agaricia (subgenus *Mycedia*) Dana, Zoöph., pp. 333, 335, 1846 (non *Mycedium* Oken, 1815).

Agaricia and *Mycedium (pars)* Edw. and Haime, Corall., iii, pp. 72, 80, 1860. Duch. and Mich., Cor. Antill., pp. 80, 81, 1860.

Agaricia Queleh, Voy. Chall., Zoöl., xvi, p. 116. Gregory, op. cit., p. 279, 1895. Vaughan, op. cit., p. 63, 1901.

This genus cannot be divided into two, on account of the character of the unifacial or bifacial corals, as many writers have tried to do, nor on the character of an encrusting mode of growth, as distinguished from the *pedicelled*, cup-shaped or turbinate, and foliaceous corals, formed by several of the species, and perhaps by all under certain conditions, and when young. Better generic and specific characters are to be found in the finely striated under side of the coral, when it is free, and in the distinctly stellate calices, usually arranged in concentric lines or grooves, often separated by ridges or collines, around the primary calicle, but this arrangement may become irregular, obscured, or wholly lacking, in parts of very old or crowded specimens of some species, like *A. agaricites*.

The septa are but little prominent, usually in two to four cycles, and are usually finely and rather evenly serrulate. The calices are usually rather small or of moderate size, much larger and far more distinctly stellate than in *Pachyseris*, but not so large and prominent as in *Mycedium* (true sense). The septa and costæ are not coarse and not spinose, nor lacerately toothed, as in the latter.

The calices often resemble those of some species of *Parona*† very closely and so does the frondose structure of the coral.

The mistake of confounding true *Mycedium* with this genus has already been discussed above (pp. 133-135).

* I take *A. undata* as type, because there is still much doubt as to the real affinities of *cucullata*. The latter has been identified with *M. elephantotus* by many, and hence put under *Mycedium*. *A. undata* is evidently closely allied to *A. fragilis*. The original type is still in the Hunterian Mus. (t. Young, Ann. Mag. N. H., xix, p. 116, 1877).

† *Parona* Lam., 1801, p. 372, but spelled *Paronia* Lam., 1816; Dana, 1840, etc. The two examples given, in 1801, were 1st, *P. cristata*, with reference to Ellis and Sol., pl. 63; 2d, *P. lactuca* (Pallas). Edw. and Haime, Corall., iii, p. 81, 1860, and Gregory, op. cit., p. 279, 1895, quote *P. cristata* Lam., 1801, as a synonym of *Agaricia agaricites*. If this were so, then *Parona* and *Agaricia*

Much confusion has always existed as to the number and characters of the species included in this group. Gregory and Vaughan, among recent writers, have gone too far in uniting diverse species, so as to reduce the number of American species to two or three only. Gregory (op. cit., pp. 279, 280) united with *agaricites*, not only *cristata*, but also *undata* (E. and S.); *purpurea* Les.; *gibbosa* D.; *Lessoni* D. and M.; *vesparium* D. and M.; and even "*A. arthrophyllum*" Horn.* (i. e. *anthophyllum*), which has no resemblance to *agaricites* and belongs to *Pachyseris*. Probably some of the other species that he lumped together, perhaps rather hastily, may also be distinct.

Vaughan (op. cit., 1901) followed Gregory pretty closely, but was inclined to keep *fragilis* and *elephantotus* separate, and he was doubtful about *anthophyllum*. But under *agaricites* he puts *Lamarcki*, *Danai* (D. and M.), and with doubt, *Sancti-Johannis* D. and M. He has studied the types of *Danai* D. and M.; *Lessoni*; and *vesparium* at Turin, and his opinion is important as to these. But the *Danai* and *Sancti-Johannis* are referred to the *elephantotus-fragilis* group by Gregory.

This genus is almost exclusively West Indian, but *A. Forskali* Edw. and H. is a fossil from the recent deposits of the Red Sea. Quelch (Voy. Chall., xvi, p. 118) described *Agaricia regularis* from Levuka I. In the Indo-Pacific fauna it is mostly replaced by *Paronia* and *Pachyseris*, with numerous species.

would be synonymous. But Edw. and Haime refer the *M. cristata* of Ellis and Sol. to *Lophoseris* (op. cit., p. 66), which is synonymous with *Paronia* of authors. So the reference, first named, is doubtless an error. On the same page "*Madrepora agaricites* Dana" is quoted, by error. The original definition of *Paronia* would apply equally to that genus and to some species of *Agaricia*, like *A. agaricites*. *Agaricia* was then separated wholly on account of the unifacial coral—a character of minor importance.

* *Pachyseris anthophyllum* (Horn, 1860) Ver. The type of this species was studied by me in the Philadelphia Acad. Nat. Science a number of years ago. It is a typical *Pachyseris*, closely allied to *P. monticulosa* Ver., and is doubtless of Indo-Pacific origin, like all the related species. The surface is covered with lobes and monticules, much as in certain examples of all the other species. The septa are laterally covered with numerous close and prominent, rough or crisped, flat or irregular granulations, which fill up much of the space between them, the granulations being often nearly in contact across the interseptal spaces, giving the septa a crowded and thickened appearance, though the septa themselves are rather thin for the genus, and alternately unequal. The ridges or collines are somewhat irregular, obtusely rounded, or somewhat angular, not very elevated, nor very close together. The calicinal centers are indistinct. The calicinal groove is narrow and deep, and contains a columella-lamella of variable thickness. The under surface of the frond is finely and regularly costulate.

Agaricia fragilis Dana. Hat Coral. Shade Coral.

- Agaricia (Mycedia) fragilis* Dana, Zoöph. U. States Expl. Exp., p. 341, 1846.
Mycedium fragile Verrill, Bull. Mus. Comp. Zoöl., i, p. 55, 1864. Pourtalès,
 Deep Sea Corals, pp. 48, 82, 1871. Florida Reefs Corals, pl. xi, figs. 1-10
 (series of young), pl. xiii, figs. 1-5 (adult), pl. xiv, figs. 1-9 (details), 1880.
Mycedia fragilis Edw. and Haime, Corall., iii, p. 83, 1860.
 ?*Agaricia Lamareki* and ?*A. undata* (non Ellis and Sol.) Edw. and Haime,
 Hist. Corall., iii, pp. 82, 83, 1860.
Agaricia fragilis Quelch, Challenger Voy., Zoöl., xvi, p. 116, 1886. Vaughan,
 op. cit., p. 67, 1901.
Agaricia elephantotus (pars) Gregory, Quart. Journ. Geol. Soc. London, li, p.
 280, 1895 (non Pallas).

PLATE XXVI. FIGURES 1a-1d.

This elegant species has been so fully and beautifully illustrated by Sonrel in the plates of the Florida Corals Reefs, by Louis Agassiz, edited by Pourtalès, quoted above, that little need be added, except as to its synonymy and habits, and some special variations. It is the *only* species of *Agaricia* found at the Bermudas, where it is very common in very shallow water, as well as in two to four fathoms. So that Gregory's idea that it is a deep water variety is not valid. In Harrington Sound, where there is scarcely any tide, it can often be gathered by hand from water not over a foot deep, especially under the shade of overhanging cliffs, but it is most abundant in six to twelve feet of water. It generally lives in sheltered localities, where heavy surf does not occur. It often occurs in colonies.

In the spring of 1901, many recently dead and partly dead specimens, mostly of large size, were seen in Harrington Sound. This was due, without doubt, to a period of unusually cold and stormy weather in February and March, which also killed vast numbers of fishes, etc., in Bermuda waters.*

No forms like *M. elephantotus*, nor like *A. agaricites*, are ever found here, which is good evidence that they are distinct and more tropical species.

Hundreds of specimens from Bermuda, studied by me, show but slight variations, aside from those due to ordinary growth and to injuries. The specimens here are always pedicelled, with a broad, thin, delicate, cup-shaped, saucer-shaped, or salver-shaped frond, when normally grown; rarely the edges bend down all around, and the upper side may then be flat or concave. After injuries the frond may become irregular, or even much deformed, owing to unequal repairs, but it never becomes truly encrusting.

* See Amer. Journ. Sci., xii, p. 88, 1901.

In some instances the coral has been penetrated by the double siphon-tubes of *Gastrochana*, which may rise one to two inches above the upper surface. In such cases these tubes become covered to the tips with an encrusting growth of the coral, as is usual with corals of this and other groups, thus forming conical or chimney-like structures. These are the only instances in which I have seen this species assume, even in a small part, an encrusting mode of growth, but this does not affect the general form of the frond.

This coral does not become thick, except close to the region of the pedicel. Frequently, bilobed specimens occur, with two primary or large calicles around which the concentric circles of calicles have been formed (see pl. xxvi, fig. 1c). Large specimens at Bermuda are sometimes a foot across, but these are usually deformed, owing to injuries. Perfectly regular specimens are seldom more than half that size (150^{mm}).

Sometimes two or more specimens, coming in contact when young, graft themselves together by their edges, which are always very thin and fragile.

The calicles are always small, generally with their edges somewhat elevated. They are always plainly stellate. The septa and costa are thin, nearly even, and finely serrulate. The collines vary considerably in height and the distance between them, but they are generally long, rather regular, rounded, and not much elevated, the calicles being mostly in long concentric series, but frequently they are isolated or form short series. The color of the animal, in life, is rich chocolate-brown or purplish brown. The tentacles are whitish, very small and short.

In respect to the size of the collines, this species often resembles the figure of *A. undata* in Ellis and Sol. But that figure represents a coral with less defined and smaller calicles, and having a thicker frond, quite unlike the delicate fronds of this species. Of course this may have been due to the fault of the artist, but the plates of that work are generally pretty accurate. Hence I believe it to be a distinct, much larger, and more massive species, probably inhabiting deeper water.* The type is still extant. See p. 140, note.

* It is doubtful whether many recent writers have seen specimens of the true *A. undata*, though Pourtalès said that he had seen it in Cuba. I am not sure that I have myself seen a specimen that I could refer to that species with confidence. But that does not prove that such a species does not exist. I have studied large numbers of undescribed West Indian *Aleyonaria* from moderate depths. Numerous unknown or rare corals are probably to be found in those waters. The early collections often contained rare and little known species, seldom seen in modern collections. Some of these were doubtless brought up on anchors or on the hooks of fishermen, a prolific source for obtaining rarities in all seas.

Dana (*Zoöph.*, p. 336, pl. xxi, fig. 8) refers to two large specimens of *undata* that he had seen. One of these was in the American Museum, New York. The other in the Mus. Acad. Nat. Sciences, Philadelphia. I have been unable to find either of these specimens, but there is an unpublished sketch of the latter, by Dana, in the Yale Museum. Dana states that it was 15 inches long and 8 broad. The former was 18 by 12 inches, and was from Key West.

The "American Museum" referred to is not the present museum of that name. It was a small private museum that was destroyed by fire many years ago.

The coral described by Edw. and Haime (*Hist.*, ii, p. 83) as *A. undata* does not seem to me to be the *undata* of Sol. and Ellis. It was described as very thin and fragile (thickness of frond 2^{mm}). The calicles are in series, separated by small, distinct collines, but they have only 10 to 12 septa, and are smaller than those of *fragilis*, the diameter being 1.5^{mm}. It is evidently near the latter and may be only a variety of it with smaller calicles and fewer septa than usual. *A. fragilis* usually has 15 to 20 septa, sometimes 24. But in the absence of a figure, it is hardly possible to decide this question, without a reëxamination of the type.

A. Lamarcki Edw. and Haime (*Hist.*, iii, p. 82) = *A. undata* Lam., 1816, ? *non* Ellis and Sol., has been placed as a synonym of *agaricites* by Vaughan, but according to the original description it agrees pretty closely with *fragilis* and *undata*. It was described as growing in a thin (7–8^{mm} thick), expanded frond, undulated and very finely costellate below, and with broad, low, obtuse, unequal, concentric collines above. Calicles numerous and close, 2^{mm} broad, with 16–20 septa, and a large columella; septa pretty thin, close, very finely denticulated. Collines 19^{mm} apart.

This description applies very well, in many respects, to some specimen of *fragilis*, though the thickness of the coral is rather too great. In this respect and others it seems to be more like the true *undata* Ellis and Sol., where Lamarck placed it. Vaughan does not say that he saw the types of either of the last two species. Had he studied the types, his opinion of these species would be entitled to great weight, in each case. The *undata* Dana is another species.

A. Danai (Duch. and Mich.), *non* Edw. and Haime, was placed by Gregory under his *elephantotus; fragilis* group. But by Vaughan (from types) it was put under *agaricites*. Quelch (op. cit., p. 116) puts it down as a thick variety of *A. fragilis*. It forms a thick and solid, largely free frond, adherent at the center, but the original

description is very brief and poor, giving no account whatever of the calicles, septa, costae, etc. I have seen examples of *agaricites* growing in the same form, but the same is true of *A. purpurea*.

The name was preoccupied by Edw. and Haime (*Corall.*, ii, p. 84), who applied it to *A. cristata* Dana (*non* Lam.). This last belongs to the frondose *agaricites*-group. A part of the type is still in the Yale Museum (see p. 146, fig. 6, and pl. xxvii, fig. 5).

Gregory also makes the same disposition of *M. Sancti-Johannis* and *A. frondosa* Duch. and Mich. But Vaughan refers the former doubtfully to *agaricites* (types not seen). He does not mention *frondosa* D. and M.; Quelch thought it distinct. (See p. 149.)

Mr. Gregory also studied the types of some of the species of Duch. and Mich., at Turin, but unfortunately he does not state which particular species he examined,* so that one cannot tell whose opinion has most value, as in the cases cited above, when he and Mr. Vaughan disagree.

Agaricia crassa Ver., sp. nov. "Pineapple Coral."

PLATE XXX. FIGURE 6.

PLATE XXXIV. FIGURE 2.

Coral massive, very heavy, forming compact, spheroidal or hemispherical masses, up to 150^{mm} in diameter and 100^{mm} thick, covered with areolated and reticulated collines.

Calicles deep, rather crowded, 2-3^{mm} in diameter, with about 30-36 rather thin, finely serrulate, scarcely exsert septa; the 12 larger ones vary but little in thickness and alternate with narrower and slightly thinner ones. Many calicles are isolated or in short rows of two to six. The collines, which are variable in height, form curiously and intricately reticulated patterns, consisting of angular or rounded areas, bounded by high, acute collines, each enclosing numerous smaller, sunken areas of various sizes and shapes, bounded by lower, irregularly reticulated collines. Exotheca and walls, in sections, nearly solid; endotheca cellular, with numerous transverse dissepiments; columella solid.

Bahamas (coll. R. P. Whitfield), six or seven specimens, all much alike; Amer. Mus., No. 514; and Yale Museum, No. 6617.

* Mr. Gregory states also (op. cit., p. 256) that he examined the collection in the Yale Museum. Unfortunately his visit to New Haven was made in vacation, when I was not in town. Apparently he overlooked various type of Dana which were in the cases that were opened for him. His examinations were very brief. See p. 114.

Agaricia agaricites (L.) E. and Haime.

Madrepora agaricites (*pars*) Linné, Syst. Nat., ed. x. p. 795, 1758; ed. xii, p. 1274, 1767. Pallas (*pars*) Elench. Zoöph., p. 287, 1766. Ellis and Sol., Zoöph., p. 159, pl. lxiii, 1786. Esper, Pflanz., i, p. 132, 1789.

Undaria agaricites Oken, Lehrb. Nat., p. 69, 1815.

Paronia agaricites Lam., Hist. Anim. s. Vert., ii, p. 239, 1816.

Agaricia (*Mycodia*) *agaricites* Dana, Zoöph., p. 342, 1846.

Agaricia agaricites Edw. and Haime, Ann. Sci. Nat., xv, p. 127, 1851; Hist. Corall., iii, p. 81, 1860. Pourtales. Deep Sea Corals, p. 82, 1871; Florida Reefs, pl. xi, figs. 11-13, pl. xii, figs. 1-3, 1880.

Agaricia agaricites (*pars*) Gregory, op. cit., p. 279, 1895 (synonymy). Vaughan, op. cit., p. 64, 1901.

Agaricia (*Mycodia*) *gibbosa* Dana, Zoöph., p. 341, 1846 (var. from type).

Agaricia (*Mycodia*) *cristata* Dana, Zoöph., p. 343, 1846 (large celled var., from type), and var. *tennifolia*.

Agaricia Danai Edw. and Haime, Corall., iii, p. 84, 1860=*cristata* Dana, *non* Lam. (*non Mycedium Danai* Duch. and Mich., 1860). Large celled variety.

Mycedium Danai Duch. and Mich., Corall. Antill., p. 81, 1860 (t. Vaughan, from type.) *non* Edw. and Haime. Lamellate variety.

Mycedium Lessoni and *M. vesparium* Duch. and Mich., op. cit., p. 81, 1860, (t. Vaughan, from types). Reticulated, encrusting varieties.

? *Mycedium Sancti-Johannis* Duch. and Mich., op. cit., Supl., p. 187, 1866, (t. Vaughan, but not from types).

? *Agaricia frondosa* Quelch, op. cit., p. 118, 1886. (? *non* D. and Mich.).

PLATE XXVI. FIGURES 2, 3.

PLATE XXVII. FIGURES 1-3, 5-7.

This species varies greatly in mode of growth and form, and also in the size of the calicles and their arrangement, and in the character and size of the collines, which are nearly abortive in some cases.

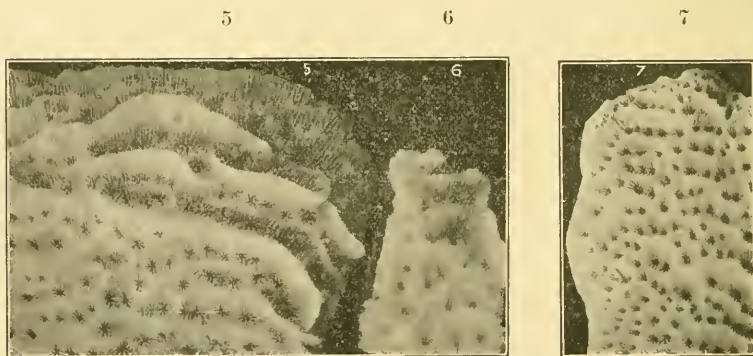


Figure 5.—*Agaricia agaricites*, var. *Danae*. Part of a frond of a well-grown Bahamas specimen, natural size. Fig. 6.—The same. Part of the original type of Dana, natural size. Fig. 7.—*Agaricia agaricites*, var. *agaricites*. Part of a frond of a large, loculate, West Indian specimen, natural size.

Therefore it is natural that there should have been much confusion as to the limits of the species. It is even quite possible that two or more species are included in the above synonymy. Several of the forms referred to differ so much that no one would unite them did not intermediate specimens occur.

Hence it seems best to treat the following forms as varieties :

Variety *a.*—*agaricites*. Typical. Fig. 7.

PLATE XXVI. FIGURE 2. PLATE XXVII. FIGURES 7, 7a.

This usually has the base largely encrusting or attached, at first, but when larger it has more or less erect, crest-like, rounded or irregular, bifacial fronds, rising from the upper surface. Sometimes, in very large examples, these unite and form loculi. The edges of the basal part may be more or less free and unifacial, with the under-side finely costulate. Calicles of medium size, when full grown mostly 2 to 3^{mm} in diameter, but variable on a single specimen. Septa usually 24 to 36, narrow, crowded, and subequal. Collines usually numerous, more or less developed, mostly transverse, or parallel with the edges of the fronds and crests, and mostly with angular or acute summits, but often reticulate. The valleys are angular, rather deep and narrow; calicles plainly stellate, mostly in series, but often isolated or in pairs, and then usually pentagonal. Septo-costae are small, numerous, closely crowded, finely and closely granulated, not conspicuously unequal, with very narrow spaces between them. Pourtalès (Florida Reefs, Corals, pl. xii, figs. 1, 2) gives excellent figures of this form.

It is common from Florida southwards. I have seen several specimens over a foot across, with frondose loculi, and folia over six inches high. A large and typical specimen of this variety 12 to 14 inches across and 8 to 10 high, from near Nassau, N. P. (coll. Whitfield), is in the Amer. Museum, New York. (Fig. 7, p. 146, No. 5671.)

Var. *b.*—*Danae* E. and H. (*non* D. and M.); = *A. cristata* Dana. Figs. 5, 6.

PLATE XXVI. FIGURE 3. PLATE XXVII. FIGURES 5, 6.

This grows nearly like the preceding, but the coral is thicker and more massive, and the fronds are often very large and thick, usually rounded, with the edges bifacial and acute. The collines are usually strong and acute, often rising into sharp crests, but where the calicles are crowded on the basal parts, the collines may be nearly abor-

tive and some of the calicles may be in pairs or isolated, polygonal, and astreiform, separated only by angular walls. The principal distinction is in the much larger size of the calicles, which, when full grown, are usually 3.5 to 4^{mm} in diameter, and in the smaller number and marked inequality of the septa, the primary and secondary ones being thickened and so wide that they leave only a small central pit, while the smaller septa are much narrower and thinner, and are lacking in part of the systems. The columella is usually solid. Septo-costæ are strong, thin, conspicuously alternately unequal, not crowded, finely granulated. No. 4301, type of Dana.

Florida Reefs, etc.; Yale Museum. Large frondose specimens, 12-15 inches broad and about 10 high, from the Bahamas (coll. Whitfield) are in the Amer. Mus., New York. Single fronds may be 225^{mm} wide; 200 high; 44 thick. No. 275.

Var. *c.*—*gibbosa* (Dana) = ? *vesparium* D. and M.

PLATE XXVII. FIGURES 1, 1a.

This forms irregular, encrusting, nodular or lobulated masses, without distinct crests. The common base, in the type, is free, striated, and unifacial for some distance, and the edge is thin. The collines are low, mostly reticulated, or very irregular, and often lacking. The calicles are in short irregular series, or isolated, and angular or astreiform. They are nearly as large as in var. *Danae*. (See pl. xxvii, fig. 1, from type.) No. 1860.

Var. *d.*—*pusilla* V. = ? *M. Lessoni* (D. and M.).

PLATE XXVII. FIGURE 3.

This form is almost entirely encrusting, often with the collines abortive, or nearly so, but when present they are small and near together, concentric or reticulated, rounded or obtuse. The calicles are generally irregularly arranged or in short series, crowded, and many are isolated; they are unusually small (mostly about 1 to 1.5^{mm}, rarely 2^{mm}) but otherwise they resemble those of typical *agaricites*. The septa are about 20 to 24, alternately unequal, rather thick, crowded. The small size of the calicles is the most important character. (Pl. xxvii, fig. 3.) No. 1489.

Var. *e.*—*tenuifolia* Dana (under *A. cristata*). Forms thin, foliaceous fronds; calicles small, 1.5^{mm} across, stellate, scattered, scarcely seriate, collines low, rounded. Similar to var. *d.*, but foliaceous.

The relations of *Lamarcki*, which Vaughan refers here, have been discussed under *fragilis* (p. 144). If it really belongs to *agaricites*,

which I doubt, it should receive the variety name *Lamarecki* (E. and H.) on account of its thin, pedicelled fronds and small calicles.

A. frondosa (Duch. and Mich.) Quelch, is also a doubtful form, which Quelch thinks distinct. According to Quelch it forms solid crests; the collines are irregularly arranged, close, and not acute. The calicles have about 30 septa, seldom more. This seems to me to be near *Danai* of Edw. and H. = *cristata* Dana (our var. *b*), but it may not be the same as the type of D. and Mich.

This common species and its varieties are found on the Florida reefs and throughout the West Indies to South America and Colon. From Colon I have received varieties *a*, *b*, *d*. They were all found in shallow water, under similar conditions. None of these forms have been found at Bermuda. A small form, near var. *d*, is found at the Abrolhos Reefs, Brazil, and a small, more nearly typical specimen near var. *a*, from Pernambuco, is in the Yale Museum.

Agaricia purpurea (Les.) Dana.

Agaricia purpurea Les., Mem. Mus. Hist. Nat. Paris, vi, p. 276, pl. xv, fig. 3, *a*, *b*, *c*, 1820. Dana, Zoöph., p. 340, 1846 (unifacial variety).

? *Mycedium Danai* Duch. and Mich., Corall. Antill., p. [81], 1860 (*non* Edw. and Haime).

PLATE XXVII. FIGURES 4, 4a, 4b.

This species usually forms broad, thick unifacial fronds, generally attached near the middle or else partly encrusting. The fronds may be flat or cup-shaped. The collines are usually narrow, acute, short, and often irregular or reticulated. The calicles are large and open, deep, angular, often isolated, and deeply sunken between the sharp walls or collines. They are oblique and often so deep and curved that the wide bottom cannot be seen. The septa are thin and narrow, leaving a wide, open, central space, and wide spaces between them; there are usually 24 to 36, alternately very unequal. (Pl. xxvii, fig. 4.)

In sections a small, solid, papilliform columella is present in some calicles, and there are well formed tabular dissepiments in the thicker parts, which extend quite across the calicles. The common wall is very solid, but it has some radial, angular cavities in the thick basal portion near the pedicel. The costæ of the under side are slender, pretty even, and regular.

This differs so much from the several varieties of *agaricites*, described above, that it seems probable that it is distinct. It is remarkable for the large and very deep, open, angular calicles, separated by rather thin, acute walls, and for the tabulate dissepiments.

The figured specimens are from Colon (Yale Mus.). They differ somewhat from Lesueur's type, in the size and depth of the calicles. This form may be distinguished as var. *fiveolata* Ver. It was attached by a stout pedicel. No. 1201.

Agaricia nobilis Ver., sp. nov.

? *Mycedium elephantotus* Edw. and Haime, Hist. Corall., iii, p. 74, 1860.
(Syn. excl., non Pallas sp.)

PLATE XXVIII. FIGURES 1, 2.

Coral grows in the form of broad, rounded, thin, foliaceous fronds, attached by a central pedicel. The frond may be flat, or concave, or variously bent and lobed, but when young and normal it is round and cup-shaped or salver-shaped. It is very hard and translucent, so that though very thin, especially towards the margins, it is stronger than most thin corals. The under side is finely and nearly evenly covered by fine costal riblets and striæ; these costæ are finely granulated on their edges.

The upper side is loosely covered with rather large, deep, prominent, appressed, stellate calicles. These are irregularly arranged; many stand singly; but most are in pairs, or series of three to six or more, in front of short, rather prominent, curved, obtuse-angled collines, having the longer proximal slopes concave and often lobulated, with swellings corresponding to each calicle. The short collines, when supporting one to three calicles, are crescent-shaped in outline, and look like curved brackets.

The calicles are inclined strongly outward, except those near the center; the central pit is rather large and deep, usually without a columella, but some of the calicles may have a small, solid, tuberculiform one.

The septa are alternately larger and smaller; usually there are 36 to 48 in the larger calicles, of which 16 to 24 are much the larger and thicker. The summits are prominent and angular; the inner edges of the outer septa descend abruptly, while those of the outer side are angulated at the top and concave above, and usually below, the angle. The edges of the septa are very finely serrulate or granulate.

The septo-costæ are of variable length, but usually rather long, especially towards the margin; their lengths are from 5 to 12^{mm} or more, but mostly about 10^{mm}. They are regularly alternately larger and smaller, the larger ones being distinctly thickened, while the smaller ones are thin and much lower. Their edges are very evenly, microscopically serrulate or granulate.

Breadth of the type, which is a single frond, 400^{mm} by 150^{mm}; thickness 5^{mm} to 0.5^{mm} or less; at 25^{mm} from the edge, about 1^{mm} thick; diameter of larger calicles, mostly 4 to 6^{mm}.

The type is from Turk's Island, W. I. (Mus. Yale University). It is a rare species in American collections. No. 850.

This is, perhaps, one of the species that have been confounded under the name of *elephantotus* Pallas, a very different East Indian species, and the type of *Mycelium* (see p. 134 above). The present species is destitute of the rough serrations and spinules of that species and differs in many ways, though it grows in a similar form. This may, however, be the *elephantotus* Edw. and Haime; but their synonymy does not apply to it.

Whether this is the form united to *A. fragilis* by Gregory under the name of *elephantotus* I do not know. Neither can I tell whether it be the *elephantotus* of Pourtalès, or of Vaughan (op. cit., p. 67), for they give no descriptions. But it is not the *elephantotus* of Oken, nor of Ehrenberg, nor of Dana, nor of Esper.

It is quite distinct from *A. fragilis*, though it grows in similar shaped, thin fronds. But the fronds of this species are much larger, thicker, and firmer. The calicles are much larger, more appressed, more prominent proximally, and much deeper. The collines are much shorter, larger, higher, and much more irregular. The septa and septo-costæ are also quite different.

Siderastræa siderea (E. and Sol.) Blainv.

Madrepora siderea Ellis and Sol., op. cit., p. 168, pl. xlix, fig. 2, 1786.

Astrea siderea Lam., Hist., ii, p. 267, 1816. Lesueur, op. cit., p. 286, pl. xvi, fig. 14, 1820. Lamx., op. cit., p. 60, pl. xlix, fig. 2, 1824. Edw. and Haime, Hist. Corall., ii, p. 509, 1857. Gregory (*pars*), op. cit., p. 278, 1895.

Siderastræa siderea Blainv., op. cit., p. 335, 1830; Man. Actin., p. 370, 1834. Edw. and Haime, Monog., p. 141, 1849. Verrill, Bull. Mus. Comp. Zool., i, p. 55, 1864. Pourtalès, Reef Corals, p. 81, 1871. Vaughan, op. cit., p. 62, 1901. Verrill (*pars*), these Trans., x, p. 554, 1900.

Pavonia siderea Dana, Zoöph., p. 331, 1846.

Siderastræa grandis Duncan, op. cit., p. 441, pl. xvi, figs. 5a, 6, 1863, fossil, (t. Vaughan).

PLATE XXX. FIGURES 2, 3.

This coral forms large, compact, hemispherical masses up to 2 feet or more in diameter.

The calicles are usually deep, narrow at the bottom, and larger than in either of the other American species (usually 5–6^{mm} in greater diameter when full grown). They are angular, mostly pentagonal

or hexagonal, usually with a definite, raised, acute or subacute bounding wall between them, which may show as a thin zigzag line between the ends of the septa. Usually 3 or 4 rows of synapticulae show on each side of the wall, between the septa, with conspicuous loculi between them.

The septa are in five cycles, the last cycle being incomplete. There are usually, in well formed calicles, 50 to 64 septa; the average number being about 58. But specimens often occur in which the number seldom exceeds 48 or 50.

The septa are finely serrulate and pretty even in height, though those of the different cycles can easily be distinguished by the gradations in breadth and thickness. Those of the last cycle are thin and often bend toward and join those of the preceding cycle. The columella is small, at the bottom of a small central pit. It usually consists of about 3 to 6 unequal papillae.

It is very common on the Florida keys and reefs and throughout the West Indies. Also at Colon, Col. (variety *nitida*); and at the Bermudas (variety?). It is hardy and can live in muddy situations, and where exposed at low tide, like *S. radians*, though it seems more partial to the reefs.

The Bermudian specimens that have been referred to this species, so far as I have observed them, are not of the typical form, and may be an extreme variety of *S. radians*. The calicles are not so large nor so deep as in the Florida form, nor are the septa so numerous, (about 42-48).

Var. *nitida* V., nov. Plate xxx. Figure 3.

The Colon specimens (Yale Mus.) are convex, encrusting plates. Their calicles are not quite so large as in the typical forms, and are much more shallow, while the bounding walls are less distinct, lower, and more rounded, so that the calicles seem less angular and more blended. The septa are numerous (about 50), crowded, and rather equal, giving the calicles a neat and even appearance. No. 1028.

When well grown this species seems quite distinct from *S. radians*. It has decidedly larger, deeper, and more angular calicles, which have more elevated and distinct walls. Usually there are about 5, sometimes 6, calicles to 2 centimeters, when in rows. The septa are more numerous (usually 50 to 60) and more equal in elevation.

But impoverished specimens occur, which are not always easy to distinguish from some of the varieties of *S. radians*.

For the reasons for retaining *Siderastraea* as the name of this genus, see above, pp. 88, 89.

Siderastræa radians (Pallas) Ver.

- Madrepora radians* Pallas, Elench. Zoöph., p. 322, 1766.
Madrepora galaxea Ellis and Sol., Zoöph., p. 168, pl. xlvii, fig. 7, 1786.
Astrea galaxea Lam., Syst., p. 371, 1801; Hist., ii, p. 267, 1816. Lesueur, op. cit., p. 285, pl. xvi, fig. 3, 1820. Lamx., op. cit., p. 60, pl. xlvii, fig. 7, 1821.
Astrea radians Oken, Lehr. Nat., p. 65, 1815.
Astrea (Siderastræa) galaxea Blainv., Dict. Sci. Nat., lx, p. 335, 1830; Man. Actin., p. 370, 1834.
Astræa radians Edw. and Haime, Hist. Corall., ii, p. 506, 1857. Gregory, op. cit., p. 277, 1895.
Siderina galaxea (pars) Dana, Zoöph., p. 218, pl. x, figs. 12, 12*b*, 12*c*. (Type examined.)
Siderastræa galaxea Edw. and Haime, Ann. Sci. Nat., xii, p. 139, 1850. Pourtalès, Reef Corals, p. 81, 1871; Florida Reefs, pl. xi, figs. 14-21, young, pl. xv, figs. 1-12, 1880. Quelch, op. cit., p. 113, 1886.
Siderastræa radians Verrill, Bull. Mus. Comp. Zoöl., i, p. 55, 1864; Coral Reefs and Islands, p. 380; ed. 3, p. 421. Vaughan, op. cit., p. 61, 1901.

PLATE XXX. FIGURE 1.

This coral usually forms rounded spheroidal or hemispherical masses, which may become 12 to 15 inches (400 to 500^{mm}) in diameter; but it is often encrusting, especially when young, and it often grows in broad irregular masses; not infrequently it is almost globular and lies loose on the bottom, with calicles developed on all sides. Such loose masses are most commonly 2 to 5 inches (50-125^{mm}) in diameter. They were doubtless all attached when very young, but perhaps only to small bits of shell, etc.

The calicles are deep in the center and small, their diameter when full grown is mostly 2.5 to 3.5^{mm}, the average size being about 3^{mm}, rarely 4^{mm}. They are angular with rounded corners, and usually appear as if separated by thick walls, owing to the low rounded summits of the walls, which are, however, actually rather thin, with one or two rows of small synapticulæ showing on each side.

The septa are decidedly unequal in width and thickness, those of the first two cycles standing out very plainly from the others. They form three complete cycles, with part of the fourth cycle developed, so that the number is usually 36 to 40, in the larger calicles, (rarely 48). But the size of the calicles and the number of septa vary considerably on a single specimen, according to the amount of crowding, or the rapidity of growth.

The septa are closely arranged, with very narrow loculi. The larger ones are wide, broadly rounded, somewhat exsert, with all the edge pretty evenly serrulate, though the distal serrations are apt to be rather larger. The six primaries are distinctly larger than the

secondaries, and those of each cycle are successively narrower and thinner; all are nearly straight and seldom united. The proximal half of the inner edge is nearly perpendicular, thus producing a deep central pit. The columella is small and papillose.

The polyps are but slightly exserted; the tentacles are small, short, cylindrical, or clavate; they form several circles, and appear somewhat scattered, those of successive cycles being in different circles and decreasing in size.

But they are not bilobed, nor trilobed, as Agassiz and Pourtalès supposed.* This appearance is due to a smaller one standing on one or both sides of a larger one, and close to it.

The general color in life is dull gray, yellowish gray, ocher-yellow, or rusty brown, sometimes tinged with a purplish rosy tint; the polyps are paler, with the lips and tips of the tentacles whitish.

This species, which is abundant at the Bermudas, is more hardy than most reef corals, for it can live and grow well in shallow water on mud flats, where it is laid bare by nearly every tide, and where most other corals would be smothered in the mud, though *S. siderea* and some forms of *Isophyllia fragilis* are usually found with it in such places.

It is often partly buried in the white calcareous mud of the flats, and yet seems healthy there. It is also abundant in the small, shallow pools left on the flats by the tide. But it is equally common on the reefs, where it often grows larger. It is also found well grown in Harrington Sound.

Exposure to the dry air, or even to the hot sun, for an hour or so, does not kill it, if it be wet beneath. Probably its porosity enables it to absorb sufficient water to prevent drying up.

It is equally common on the Florida reefs and flats, and throughout the West Indies to South America and Colon.

The decidedly smaller size of the calicles, fewer septa, and the conspicuously larger primary and secondary septa serve to distinguish this species from *S. siderea*.

But it varies considerably in all these characters, so that some specimens may occur that seem almost intermediate between the two species. In all such cases the *average condition* of the full grown calicles must be considered as of primary importance.

* The observations of Prof. L. Agassiz on the polyps of this genus, in 1850, and his figures in "Florida Reefs," pl. xv, figs. 1-7, relate to *S. radians*. In my note on this subject (these Trans., x, p. 554, 1900), I referred to it under *S. siderea*. But my studies of the polyps included both species. They are very similar, but *S. siderea* has larger polyps and more tentacles.

New buds appear chiefly between the angles of the calicles. Fission of the larger calicles occurs occasionally.

Siderastræa stellata Ver.

These Trans., i, p. 352, 1868. Rathbun, R., Amer. Naturalist, xiii, p. 541, 1879, (habits). Vaughan, op. cit., p. 62, 1901.

PLATE XXX. FIGURES 4, 5.

This species is related to *S. radians* and has the same ability to endure impure shallow waters and exposure to the air and sunshine, without injury.

It is widely distributed on the coast of Brazil; Bahia, Abrolhos Reefs, etc.,—coll. C. F. Hartt; R. Rathbun.

I have figured one of the types, from a photograph. No. 1464.

Var. *conferta* Ver., op. cit., p. 353.

PLATE XXX. FIGURE 5.

This peculiar Brazilian form has not yet been figured. Therefore I have reproduced a photographic figure of one of the types,—the extreme form. No. 1464a.

Asteroseris Verrill.

This genus seems to be related to *Plesioseris* Duncan.*

Dana described in 1846 a rare, thin, laminar or foliaceous coral (*Agaricia planulata*) that is the type of this genus.

I have studied a fragment of the original type, which is here figured (pl. xxvii, fig. 8). No. 4309.

The genus is remarkable for the low, reticulated collines, enclosing polygonal areas in which there are usually two or several stellate calicles. Each of these groups consists of a parent calicle from which the others around it have been produced as buds from it. These calicles of a group are not at first separated by definite boundaries, the costæ being continuous from one to another. Columella is a minute tubercle, or is lacking. Under side naked, finely striated. Calicinal walls solid. Synapticula and trabeculæ few or lacking.

The type of that genus (*Mændroseris Australiæ* Rouss., from Australia) is a convex, gibbous, encrusting coral. But as both encrusting, massive, and foliaceous species occur in allied genera (*Pavonia*, *Agaricia*, etc.), it is possible that they might also occur

* *Mændroseris (pars)* Rousseau, Voy. Dumont d'Urville, Zoöl., v, p. 121, 1854. Edw. and Haime, Hist. Corall., iii, p. 61, 1860. *Plesioseris* Duncan, Jour. Linn. Soc., Zoöl., xvii, p. 309, 1883; Revision Scler. Zoanth., op. cit., xviii, p. 161, 1884.

in this. But the type of *Plesioseris* has distinct synaptacula and a well developed papillary columella, which are not found in our genus.

The resemblance to the fossil genus *Oroseris** is very close, in the form and mode of grouping of the calicles, and in the low, irregular collines, as well as in the foliaceous form of the coral. But *Oroseris*, according to Duncan, does not have solid mural and colline walls, these parts, as seen in sections, being trabecular. Were it not for this character, I should have considered this coral a living species of *Oroseris* or *Comoseris*, which it certainly closely resembles.

The grouped arrangement of the calicles is somewhat like that of *Polyastra venosa* Ehr., † p. 106, 1874, but the latter seems to form a massive, astreiform coral. It is, however, only imperfectly known, the description being very incomplete and without a figure.

The form, general appearance, and the characters of the septocostæ are somewhat like those of *Pachyseris*, but the latter does not have stellate calicles and its collines are much larger and more regular.

Asteroseris planulata (Dana) Ver.

Agaricia (*Mycedia*) *planulata* Dana, Zoöph., p. 338, 1846.

Agaricia ? *planulata* Edw. and Haime, Hist. Corall., iii, p. 84, 1860.

Asteroseris planulata Verrill, in Dana, Coral Islands, ed. i, p. 383, 1872; ed. 3, p. 424, 1890.

PLATE XXVII. FIGURE 8.

The type specimen was a broad, thin frond, half a line thick, attached only at one point. Dana states that it was in the Museum of the Lyceum of Natural History, Utica, N. Y.

A fragment of this specimen, used by him for figuring the details, and now preserved in the Yale Museum, affords the following description:—

The calicles are polygonal and very shallow or superficial, being only slightly concave, except at the minute central pit, which is deep; they are about 4 to 4.5^{mm} broad when full grown, but many are only 2 to 2.5^{mm}. They are often placed singly, with a slightly raised solid wall over which the septa are confluent and in part

* *Oroseris* Edw. and Haime, Pol. Foss. Palæoz., p. 130, 1851; Hist. Corall., ii, p. 78, 1860.

† This genus is probably identical with *Tichoseris* Quelch, (Ann. and Mag. Nat. Hist., xiii, p. 295, 1884). The type of the latter is an astreiform coral from the Fiji Islands.

geniculate; many are in pairs, either equal or unequal, due to immediate budding; others form small groups of three to five, evidently resulting from budding from the larger one of the group. Such groups are surrounded by low, solid, reticulating collines, only a little larger than the walls around isolated calicles, and arranged without order. Rarely the calicles are in short rows of three or more.

The septa are numerous (24 to 36), very close, thickened, especially toward the inner ends, and closely, finely granulated or crispate on the sides, as in *Pachyseris*; their exposed, nearly horizontal edges are minutely and roughly serrulate or granulate, but the inner ends of the larger ones descend nearly perpendicularly at the minute central pit, and this portion, as seen in section, is rather regularly and finely serrulate. The septa are very unequal and form four pretty regular eyes, sometimes with some of a fifth cycle. The primary and secondary ones are decidedly larger and thicker than the others and most of them reach the central pit, but the secondaries are a little the shorter and thinner; those of the third and fourth cycles are successively shorter; the smallest are very short and extend inward only a short distance in some of the systems, but are often quite long and curved in the lateral systems. All the septa rise to about the same level. The columella, when present, is a minute solid tubercle, or sometimes two.

The under side is naked, with small concentric undulations, and also with shallow radial valleys, between which the surface is slightly convex; these convex parts are covered with fine, divergent radial striæ, which run obliquely to the valleys on either side in a fan-like manner.

These costal striæ are only slightly raised, closely crowded, and distinctly granulated. In vertical sections the coral is nearly solid, except close to the upper surface. The interseptal spaces fill up very quickly with a solid deposit and the interseptal walls are thick and solid.

The original type, according to Dana, was a thin frond ten inches broad and one-eighth of an inch thick. Thickness of the fragment, described above, 3 to 5^{mm}. The habitat is unknown, but it is probably Indo-Pacific.

The *Merulina ampliata* (E. and Sol.) Ehr. was included in the West Indian fauna by Duch. and Mich. (op. cit., p. 80, 1860), but not as from personal observation. It is found only in the Indo-Pacific region, like all the other species of the genus.

Family **Poritidæ** Dana, 1846.

Poritinæ (subfamily) Edw. and Haime, Corall., iii, p. 173, 1860.

Poritidæ Verrill, these Trans., i, p. 503, 1867.

Corals very porous, branched, encrusting, lobulate, or massive, increasing chiefly by budding. Calicles mostly small, shallow, stellate, circular, or angular, usually all of one kind, closely united, or not separated by much cœnenchyma, sometimes without evident walls. Septa more or less perforated, or fenestrate, often imperfect, mostly 12 to 24. Pali often present. Dissepiments few, sometimes tabulate. The calicles are generally all equal, but in some species of *Porites* a few larger ones, with more than 12 septa, appear irregularly and may divide by fission. The branches do not have a large leading or axial zoöid. Polyyps much exert in expansion. Tentacles 12-24, rarely more.

Porites polymorpha Link.

Madrepora porites (pars) Pallas, Elench. Zoöph., p. 324, 1766. Linné, ed. xii, p. 1279, 1767. Ellis and Sol., p. 172, pl. xlvi, figs. 1, 2, 1786.

Porites polymorphus Link, Besch. Nat. Samml., Rostock, p. 162, 1807.

Porites clavaria Lam., Hist. Anim. sans Vert., ii, p. 270, 1816. Dana, Zoöph., p. 554, 1846. Edw. and Haime, Corall., iii, p. 174, 1860. Pourtalès, Florida Reefs, pl. xii, figs. 4-6, 1880. Rathbun, Proc. U. S. Nat. Mus., x, pp. 356-361, pl. xvi, pl. xvii, fig. 2, pl. xix, fig. 1, 1887. Gregory (*pars*), op. cit., p. 282, 1895.

Porites porites Vaughan, op. cit., p. 73, 1901.

PLATE XXXI. FIGURES 3, 3a.

The above synonymy includes only the leading references to the more typical form generally called *P. clavaria* Lam. Mr. Gregory has given a very full list of references to this and the other branched forms of West Indian *Porites*, all of which he masses together under the name of *P. clavaria*. Mr. Vaughan (op. cit., p. 73) also gives some additional synonyms and localities.* No doubt too many "species" have been named, but I very much doubt whether they should all be united into one species. However, I do not propose to discuss that question at this time.

* Mr. Vaughan states that he has examined the type of *P. nodifera* Klunz., and found it identical with *P. clavaria*. He thinks, like Rehberg, that the locality "Red Sea" is due to a wrong label. He also unites *P. valida* Duch. and Mich. with this species.

But, as having an important bearing on the subject, I will state that while *clavaria* (auth.), growing in irregular, stout-branched clumps, is abundant at the Bermudas, in a variety of stations, both in shallow water and on the reefs, and also in Harrington Sound, *P. furcata* has never been found there by me, nor by others so far as I can learn. This would certainly indicate that the latter is a distinct species, with a different physiological nature, or with a different embryology. It either requires warmer water, or else its free-swimming larvæ are too short-lived to reach the Bermudas in the northward currents. Were the two forms the same species, differing merely in form of growth, due to environment, they should both be found at the Bermudas, for the conditions are varied there.

Mr. Richard Rathbun (op. cit., 1887) has very fully described and figured most of the various varieties of these two species.

As for the name of this species, I cannot follow Vaughan in adopting *Porites porites* for it, for such a course would be contrary to the ordinary principles of elimination, which he, himself, employs in similar cases.

It is true that Pallas and all writers previous to Link (1807) included nearly all the species of *Porites* then known under the name *Madrepora porites*, which was a collective or generic group. Esper eliminated one species as *M. conglomerata*, and another as *M. arenosa*. Link eliminated another, the present form, by naming it *polymorphus*. Therefore, the specific name *porites*, if used at all, should be applied to one of the remaining species of those mentioned by Pallas, as varieties.*

* Pallas mentions *first* in his description (p. 324) a massive, gibbous species "massæ, gibbæ, tuberosæ, tunicatæ," and on p. 325, "Notæ," he speaks first of "massas informes, gibbas," "ex India," with stars subequal to those of *Mad. astroites*=*Orbicella annularis*.

This East Indian, gibbous, massive species, with large stars, was, without much doubt, a *Rhodaræa*, probably *R. calicularis* (Lam.) E. and H., but possibly the Chinese and East Indian form named *R. Lageneii* E. and H. (diameter of calicles 4^{mm}), which may not be distinct from the former.

Therefore, it seems to me best to restrict *porites*, as a species, to the former and call it *Rhodaræa porites*, thus avoiding the repetition of *porites* and conforming with the principle of recognizing prior eliminations at one and the same time. None of the species of true *Porites* have the "stars" much more than 1.5^{mm} in diameter, rarely 2^{mm}.

Porites astreoides Lam.

Madrepora porites (*pars*) Pallas, Elench. Zoöph., p. 324, 1766.

Porites astreoides Lam., Hist. Anim. sans Vert., ed. 1, ii, p. 269, 1816; ed. 2, ii, p. 435, 1836. Lamx., Expos. Meth., p. 651, 1824, (*non* Ehr., 1834).

Porites astroides Lesueur, Mem. Mus. Hist. Nat., Paris, vi, p. 287, pl. xvi, fig. 15, 1820. Edw. and Haime, Hist. Corall., iii, p. 178, 1860.

Porites astræoides Dana, Zoöph. U. S. Expl. Exp., p. 561, 1846. Verrill, Bull. Mus. Comp. Zoöl., i, p. 42, 1864. Pourtalès, Reef Corals, Mem. Mus. Comp. Zoöl., ii, p. 85, 1871; Florida Reefs, pl. xvi, figs. 1-12, 1880. Queleh, Voy. Chall., xvi, pp. 11, 13, 182, 1886. Rathbun, Catal., Proc. U. S. Nat. Mus., x, p. 354, 1887. Gregory, op. cit., p. 284, 1895, (synonymy).

Porites superficialis, *P. incerta*, *P. Guadalupeensis*, and *P. agaricus* Duch. and Mich., Corall. Antilles, pp. [82, 83] 358, 359, 1860 (t. Vaughan from types).

Neoporites titoralis, *N. superficialis*, *N. Guadalupeensis*, *N. agaricus*, *N. incerta* Duch. and Mich., Supl. Corall. Ant., pp. 191-193 [97-99], 1866 (t. Vaughan from types).

Neoporites Michelini, *N. astræoides*, *N. subtilis*, and *Cosmoporites levigata* Duch. and Mich., op. cit., pp. 192, 193 [98, 99], pl. x, figs. 7-10, 12, 16, 1866 (t. Vaughan, but types not examined).

Porites Collegniana Duncan, Quart. Jour. Geol. Soc. London, xix, p. 437, 1863; xxiv, p. 25, 1868 (t. Vaughan from types, fossil).

Porites astreoides (*pars*) Vaughan, op. cit., pp. 74-77, 1901.

PLATE XXXI. FIGURE 4.

This coral is encrusting when young, but it soon forms thick rounded masses, with more or less raised lumps or low nodules over the surface, but it never becomes branched. It may form masses 2 feet or more in diameter.

When living its color is usually lighter or darker yellowish brown, or dull brownish yellow; sometimes it is yellowish gray, or even bluish gray.

The calicles are larger, deeper, and more distinct than in *P. clavaria*, and their walls are higher, thicker and more distinct at the surface. The 12 septa are also more distinct and less porous. The columella is rather small and porous, often with a small, central, irregular papilla, which may be lacking and is easily broken. The interseptal loculi are rather large and deep for this group. Small paliform papillæ are sometimes present, but more often are absent or rudimentary. The inner tooth or lobe of the septæ is often very distinct, erect, and paliform. The upper part of the wall is thin and divided into small, rough, flat denticles at the edge, higher than the septa, but it becomes thicker and rather solid a little farther down.

Well-formed calicles are from 1.25 to 1.50^{mm} in diameter; when in series there may be about 6 to a centimeter.

It is abundant both in shallow water and on the reefs at the Bermudas. It also occurs even in Harrington Sound. It is still more abundant on the Florida Reefs and throughout the West Indies to Colon, Columbia. A variety occurs at Pernambuco, Brazil. See below, Revised List of Brazilian Corals.

Quelch (op. cit., pp. 181, 182) has recorded two of the forms described by D. and Mich., as from the Cape Verde Islands. But the identity of his forms needs confirmation, by comparison of types. The descriptions and figures of D. and M. are too poor for determination.

I am not at all sure that all the forms described by Duch. and Mich., and referred to this species by Vaughan, are one species, though I have placed them among the synonyms on his authority. If his opinion be correct, then this species is more variable in the Antilles than it is at the Bermudas and Florida reefs, from whence I have examined large series.

There can be no doubt, however, that they have made too many species, by far, in this group. I have seen only two or three forms that could be recognized even as varieties, and doubt if more than two massive species are included in their list, even if all be not forms of *P. astreoides*.

But I believe that Mr. Vaughan is wrong in uniting *P. solida* Ver.=*P. Verrillii* Rehb. to this species. Possibly he has not seen the true *P. Verrillii*, for both species occur on the coast of Brazil.

Porites Verrillii Rehb.

Porites solida Verrill, these Trans., i, part 2, p. 358, 1868.* Rathbun, op. cit., p. 365, 1887, (*non* Forskal, sp., 1775=*P. solida* Klunz., p. 42.)

Porites Verrillii Rehberg, Abh. Naturw. Ver., Hamburg, xii, p. 48, 1892. Vaughan, op. cit., p. 76, 1901.

PLATE XXXI. FIGURE 5.

Mr. Vaughan (op. cit.) considers this only a form of *P. astreoides*, but as the latter occurs with it on the coast of Brazil, he may not have studied a genuine example. I believe they are quite distinct. I have, therefore, figured a portion of the original type.

* The *Porites solida* (Forsk.) Klz., from the Red Sea, is a different, solid, massive species, of which the Yale Museum now has an authentic example. The use of the same name for the Brazilian coral was due to an oversight, on my part, in overlooking Forskal's name,—not to any intention of uniting the two species.

This coral is much heavier and more solid than *P. astreoides*. Its calicles are larger and deeper, and separated by thicker, more prominent, and more solid walls. The details of the calicles are also different, as best shown by enlarged photographic figures.

The 12 septa are well developed and wider than usual. The columella is large, nearly solid, and usually has a central tubercle. Pali are rudimentary or lacking.

That abnormal or imperfectly developed calicles of *P. astreoides* or *P. clavaria* (auth.) may resemble normal calicles of this or other species, is not sufficient proof that they are identical, as Mr. Gregory and Mr. Vaughan seem to think.

If we should use this as a crucial test, then all known species of *Porites* could be rennited into one polymorphic species, for all sorts of variations of this kind can be found in every species of the genus. The same is true of many other genera of corals, e. g. *Madrepora* = *Acropora* V., where the existence of imperfect or unusually formed calicles is a feature found in most of the 200 species.

The only reasonable way to group such corals into true species is to compare calicles that are normally and naturally developed, and those that are fully grown. Starved specimens or calicles, and those that are dwarfed or abnormal from other unfavorable conditions, are very liable to mislead, in this and many other genera, and should not be made too much of.

So the *average size* of *well-developed* calicles is generally characteristic of species, even though the *dwarf* calicles of one might not exceed the average calicles of another. The same rule will apply to all other characters, for all the characters are variable.

According to Mr. R. Rathbun, this species is common on the coast of Brazil, from Parahyba do Norte to the Abrolhos Reefs, and is abundant at Pernambuco. But perhaps part of his specimens were *P. astreoides*, variety. See p. 161. The type was from the Abrolhos Reefs,—coll. C. F. Hartt. No. 4539.

Porites Branneri Rathbun.

Porites Branneri Rath., Catal. Porites, Proc. U. S. Nat. Mus., vol. x, p. 355, pl. xix, fig. 2, 1887. Vaughan, op. cit., p. 77, 1901.

PLATE XXXI. FIGURES 6, 6a.

Two Brazilian specimens in the Yale Museum agree well with Mr. Rathbun's description. They are regularly and evenly rounded, very porous masses, formed by a thick encrustation over other species

of dead rounded corals (*Mavandra conferta* in one case), but they show no trace of branching.

The calicles are unusually small and shallow, nearly uniform in size, mostly closely crowded, polygonal, and separated by thin fenestrated walls. The septa are 12 narrow, thin, roughly echinolate and fenestrated, often a little exsert; their inner edges unite to a wide columelliform ring, leaving a circle of very small loculi; in the center of the ring-like columella there is a small pit. The pali are very slender, erect, lacerate, mostly 3 to 5, sometimes 6; frequently all are absent or broken off.

The whole surface of the coral has a delicate, lace-like appearance, owing to the uniformly small size of the calicles and the thinness and porosity of the walls.

The masses are 3 to 5 inches in diameter; breadth of the calicles 0.9 to 1.2^{mm}, mostly about 1^{mm}; when in rows there may be 9 to a centimeter.

Parahyba do Norte and Pernambuco, Brazil,—R. Rathbun. Our specimens are from Pernambuco,—coll. C. F. Hartt. No. 4552.

Mr. Vaughan suggested that this might be a young stage of *P. clavaria*. To me they seem to be perfectly distinct.

Family **Acroporidae** Ver., nom. nov.

Madreporidae Dana, Zoöph., p. 431, 1846.

Madreporidae (pars) and *Poritidae (pars)* Edw. and Haime, Corall., iii, pp. 89, 207, 1860.

Madreporidae Verrill, these Trans., i, p. 501, 1867.

Corals very porous, usually branched or foliaceous, sometimes lobed or massive, encrusting when young, increasing by budding, rarely by fission. Cænenchyma abundant, porous, often spinulose. Corallites cylindrical, small, generally of two sizes, which may differ in structure. The larger ones may form the terminal or parent calicle of the branches, or occupy only the upper side of foliaceous species.

Calicles small, deep; septa usually 6 or 12; sometimes more in larger sporadic calicles; usually continuous, but perforated. Dissepiments few. Polyps much exsert in expansion; tentacles slender, tapered, generally 12, rarely more.

The genus *Acropora* is the only one in the West Indian fauna, where it has but one species. *Montipora* and *Anacropora* are wholly Indo-Pacific; the former has about 100 species.

Acropora Oken (restr.). Type, *A. muricata*.

Madrepora (*pars*) Lam., Syst. Anim., p. 371, 1801 (*non* Linné, ed. x). Lam., Hist. Anim. s. Vert., ii, p. 277, 1816. Dana, Zoöph., p. 435, 1846. Edw. and Haime, Hist. Corall., iii, p. 132, 1860 (*non* Ehr.).

Acropora (*pars*) Oken, Lehr. Naturg., p. 66, 1815 (type, 3d species=*A. muricata*).

Heteropora Ehr., Corall. Rothen Meeres, p. 333, 1834 (*non* Blainv., a Polyzoan).

Madrepora Rathbun, R., Catal. Genus *Madrepora* in U. S. Nat. Mus., Proc. U. S. Nat. Mus., vol. x, pp. 10-19, 1887. Klunz., Corall. Roth. Meeres, ii, p. 2, 1879.

Madrepora Brook (with ten subgenera), Cat. Mad. Brit. Mus., i, p. 22, 1893. *Isopora* Vaughan, op. cit., p. 68, 1901.

On pp. 110-113 I have discussed the use of the name *Madrepora*, and its inapplicability to this great genus for which it has so long been used, if we are to follow the strict rules of priority and go back to ed. x of Linné.

The substitute-name that has the prior claim for adoption, and which seems available, is *Acropora* Oken, 1815. This originally included three generic types. The 1st is *Pocillopora damicornis*; 2d is a *Porites*; 3d is *A. muricata* (L.).

The first two having been eliminated by Link and Lamarek, *Acropora* can be restricted to the third species, which is the true West Indian *muricata*.

Vaughan used the much later and objectionable name *Isopora* Studer, 1878, originally applied to a small section of the genus in which the axial corallites are indistinct or clustered. This is so exceptional a character that the group may hereafter be separated as a genus. *Heteropora* Ehr. was preoccupied by Blainville.

The most prominent character of the genus *Acropora* is the existence of a special axial corallite, at the end of each branch, usually larger and more symmetrical than the radial corallites that bud out from its sides and cover the lateral surfaces of the branches.

The latter are various in shape, but are nearly always more or less one-sided and bilabiate; except a few that are to become axial corallites of new branches.

On the under surfaces or on the bases of the branches, or in crowded positions, where the conditions are unfavorable, their prominent margins may be obsolete, or nearly so, or they may be wholly immersed in the cænenchyma.

The septa are usually in two cycles, those of the second cycle being smaller, and often rudimentary or lacking. In the lateral corallites the directive septa are usually wider than the others.

Acropora muricata (Linné) Oken.

Millepora muricata (*pars*) Linné, Syst., ed. x, p. 792, 1758.

Madrepora muricata (*pars*) Pallas, Elench. Zoöph., p. 327, 1766. Linné, ed. xii, p. 1279, 1767. Esper (*pars*), Forts., i, p. 53, pl. 50, pl. 51. Lamarek, Syst., p. 371, 1801.

Acropora muricata Oken, op. cit., p. 66, 1815.

Madrepora cervicornis + *M. prolifera* + *M. palmata* + *M. flabellum* Lam., Hist. Anim. s. Vert., pp. 278, 281, 1816. Ditto, Dana, Zoöph. Expl. Exp., 1846. Edw. and Haime, Hist. Corall., iii, pp. 136, 139, 160, 1860. Dana, Coral Islands, ed. iii, pp. 99, 113, 124, 127. (Growth, etc.) Pourtalès, Deep Sea Corals, pp. 83, 84, 1871; Florida Reefs, pl. xvii, pl. xix, 1880. Gregory, Ann. and Mag. N. Hist., vi, p. 20, 1900.

Madrepora subaquilis and *Madrepora perampla* Horn, Proc. Acad. Nat. Sci. Philad., 1860, p. 435, (=var. *palmata*, and *alves* auth., types examined).

Madrepora cornuta and *Madrepora Thomasiana* Duch. and Mich., op. cit., 1860, p. 82, (=var. *surculo-palmata* and *palmata*).

M. ethica D. and M., op. cit., p. 82, 1860, but not the figures, (=var. *prolifera*, young or dwarfed).

Madrepora Mexicana Rehb., op. cit., p. 38, pl. iii, fig. 16, 1892.

Madrepora muricata and varieties, Brook, Cat. Mad., i, pp. 23-30, 1893. Vaughan, op. cit., p. 69, 1901.

Madrepora palmata Whitfield, Bull. Amer. Mus., x, p. 463, pl. xxiv. (A very large and fine example.)

PLATE XXXII. FIGURE 1.

The name *muricata* should properly be restricted to this varied West Indian form, as has been done by Brook, Vaughan, and others.

That the five nominal West Indian species: *cervicornis*, *prolifera*, *alves*, *palmata*, and *flabellum*, formerly universally believed to be distinct, are really only variations of one species, must now be admitted, in view of the more careful studies of larger series made during recent years.

This view had been suggested several times, during many years, but Brook was the first modern writer to definitely unite them and consider them all varieties of *muricata*. My own experience had led me to the same conclusion some years ago, for I had seen many intermediate specimens.*

* Gregory, in Ann. and Mag. Nat. Hist., ser. 7, vol. vi, 1900, p. 20-31. dissents from this view, and objects to the use of *muricata* for any American species. The "American branched forms were, however, certainly included under *muricata* by Linné, Pallas, Esper, and all other early writers, and Brook had a perfect right to restrict it to the American species. His usage must be followed, according to the ordinary rules of nomenclature.

The most remarkable specimen that I have studied is now figured (pl. xxxii, fig. 1). It is preserved in the Museum of Yale University.

In most parts it is a typical specimen of variety *palmata*. But growing out of the upper side of one of its palmate fronds there is a cluster of typical branches of the variety *prolifera*. The two forms are in perfect continuity and there is no evidence of injury or other physical cause for this abrupt alteration in the character of the growth at this particular place. No. 6621.

Many specimens of var. *palmata* have the distal ends of some of the fronds divided into digitate branches of variety *prolifera*, but in such cases the change is gradual. Such subvarieties may be designated as *palmato-prolifera*, for convenience.

Var. *palmata*, when growing vigorously, often produces small, ascending, or incipient branchlets over the whole or part of its upper surface, which is then very uneven. Some of these branchlets sometimes become 75 to 100^{mm} long, and agree with *prolifera*. The large specimen from the Bahamas, in the American Museum, figured by Whitfield (op. cit.) is one of this kind. I have named this subvariety, *sarculo-palmata*. *M. cornuta* D. and M. seems to have been based on a specimen of this kind.

Specimens intermediate between variety *cervicornis* and variety *prolifera* are to be found in many American collections, but I have never seen specimens clearly intermediate between *palmata* and *cervicornis*, though such probably exist. They seem to be the extremes of the variations in form.

Variety *flabellum* grows like *palmata*, but forms much thinner fronds than usual.

Many specimens occur, especially in the Bahamas, intermediate between *flabellum* and *prolifera*. In some of these there may be on one side of the same clump, broad frondlike branches of the flabelliform type, while on the other side digitate clusters of *prolifera* may occur; or a flabelliform branch may end in free digitations; or free branches, proximally of the *prolifera* form, may, farther out, coalesce into a flat frond, and distally may again split up into *prolifera* branchlets. The American Museum; New York, has a good series of such intermediate forms, from the Bahamas, (coll. R. P. Whitfield).

For these intermediate forms, I use the name *flabello-prolifera*.

Var. *infundibulum* Ver., var. nov.

This is similar to *palmata*, but it forms broad cup-like or funnel-shaped corals with a nearly even rim, without prominent lobes or digitations. Florida Reefs, Bahamas, etc.

Variety *alces* (auth.,? non Dana) = *perampla* Horn, is like *palmata*, but with longer and narrower, thick, digitate fronds.

The name, *M. alces*, was first applied by Dana to specimens said to have been collected in the East Indies by the U. S. Exploring Expedition. I believe that these specimens are still in the U. S. National Museum, where I saw them many years ago, but without careful study. A careful reëxamination of the types would be required to determine whether they be identical with the West Indian form usually called *alces*. Possibly the locality given by Dana was erroneous. But he also gives special differences in the form of the corallites, which he says are tubular and not nariform. Therefore it seems best to use *perampla* for this variety.

Var. *columnaris* Ver., var. nov.

This variety forms large, cylindrical, or long-conical, tapering columns, sometimes 6 to 10 inches in diameter at base, and 4 to 6 feet or more in height, without branches. There is a large conical specimen from Cumana in the Mus. of Comp. Zoölogy.

Varieties *palmata* and *alces* = *perampla* grow to great size. The trunk may become 12 to 18 inches in diameter, with the fronds spreading out to the breadth of 15 to 20 feet, and sometimes attaining a height of 16 to 20 feet or more. The broad, spreading fronds of adjacent trees of this kind may come in contact and partially join themselves together, so as to form large submarine arches. Divers describe the appearance of such growths, when seen from below, as somewhat resembling the trunks and branches of large forest trees. (See also Dana, Corals and Coral Islands, ed. ii, pp. 126, 127, 1874; ed. iii, pp. 126, 127, 1890.)

Var. *cervicornis* also grows to a large size, though much less massive than *palmata*. Tree-like specimens are often 10 feet high and broad, but are difficult to transport. The American Museum has three large ones from the Bahamas. They are about four to five feet high and six feet broad, with the main trunk about three inches (75^{mm}) in diameter. The terminal branches are long and divergent,

round, 35 to 20^{mm} in diameter, regularly and gradually tapered, often curved or even hooked. They grow isolated on a bottom of shell-sand and mud, in 12 to 15 feet of water, near Nassau, N. P.,—coll. R. P. Whitfield.

This species, in its several varieties, is abundant on the Florida Reefs and throughout the West Indies. It is also common as a fossil in the raised reefs of various islands. It does not occur at the Bermudas, nor on the Brazilian coast.

It has been recorded from the East Indies, etc., by Brook and others, but perhaps all such records are erroneous. I have seen no authentic example of either variety from the Indo-Pacific region.

It does not occur at Panama, nor elsewhere on the Pacific coast of America. The *genus* is absent from that coast, except *A. crassa* (E. and H.), recorded from the Galapagos Is.

Gregory (Ann. and Mag. Nat. Hist., 1900, pp. 20–31) gives details of the Indo-Pacific specimens, recorded by Brook, after an examination of the types, and concludes that none of them belong to either of the West Indian varieties, but to distinct species. The Singapore specimen, referred by Brook to *palmata* (No. 93, 4, 7, 24), may be the true *alces* of Dana. According to Gregory, it is distinct from *palmata* in its calicles and cœnenchyma, but grows in the same form.

The *Madrepora ethica* D. and M. (op. cit., p. 82, 1860) seems to be a dwarfed or young, slender form of var. *prolifera*. But the figures referred to it (pl. x, figs. 7, 8) do not agree with the description at all. They appear rather to represent a *Millepora*.

This species, in all its diverse forms of growth, retains pretty constantly the characteristic forms of its axial and radial or lateral calicles, and the characteristic porous and roughly echinulate texture of the cœnenchyma. The radial corallites and their calicles are larger than in most species of the genus. The corallites are rather openly nariform or tubo-nariform, costate, and porous. The septa are well developed, the directives wider. The axial corallites are stout, tubular, usually much exsert, not swollen; walls porous and strongly costate externally; calicles large, tubular; primary septa well developed, subequal; secondaries narrower; the septa form a distinct, 12-rayed star.

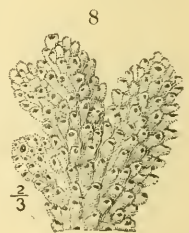


Fig. 8.—*Acropora muricata*, var. *prolifera*. After Pourtalès, the axial corallites are too small and short.

ERRATA.—Page 51, line 3 from bottom, for Flaggs read Flatts.—Page 128, line 17, for xxxiii, fig. 4, read xxv, fig. 3.

[For explanation of plates, see end of Article IV.]

IV.—COMPARISONS OF THE BERMUDIAN, WEST INDIAN, AND BRAZILIAN CORAL FAUNÆ. BY A. E. VERRILL.

PLATES X-XXXV.

1.—*Characteristics of the Bermudian Coral Fauna.**

THE coral-fauna of the Bermudas must be regarded as a detached colony of the more hardy species that have migrated from the West Indies through the agency of the northward currents, by which their free-swimming larvæ have been carried to these islands.

Therefore the particular species that have become established there, have been determined both by the duration of their free larval stages and by their ability to endure the cooler waters of this area.

It has been a process of natural selection, in this sense, though it probably has not yet gone far enough to differentiate a single new species nor even any marked varietal forms.†

Probably most of the species have migrated directly from the Bahamas. How long a time is required for drifting objects to travel from the Bahamas to the Bermudas is not known. The distance is rather more than 700 miles, but any floating object would not travel in a straight line, so that it would, most likely, travel nearly 1,000 miles in such a journey. At the rate of 1 mile per hour the northward drift would be 1008 miles in 42 days, or 720 miles in 30 days. Probably the average rate of the current, in this region, may not be much greater than this.

* After this article was in type I received the important report by Dr. T. W. Vaughan on The Stony Corals of Porto Rican Waters (Bulletin U. S. Fish Comm. for 1900, ii, pp. 289-320, with 38 plates, Dec., 1901). Hence I am able to make use of it only by inserting, in the synonymy, references to it, and especially to the important plates, reproduced from photographs.

But as Mr. Vaughan uses the same nomenclature and repeats the same arguments to sustain his conclusions that he published in his preceding paper of 1901 (Fossil Corals of the Elevated Reefs of Curacao, etc.), a better opportunity to refer to his work would have involved no changes in my own conclusions.

† Two new species that I have now described from the Bermudas (*Mussa annexans* and *Mussa (Isophyllia) multiflora*) are not yet known from the West Indies, but they will probably be found there when carefully looked for.

But if floating forms should escape from the western Bahamas and pass directly into the full current of the Gulf Stream, where the velocity is three to four miles an hour, a large part of the northward journey could be made in a much shorter time. Then we may suppose that by eastward surface currents, caused by the prevailing southwest winds, such forms could easily be driven eastward from the Gulf Stream to the Bermudas. By this course it is probable that the journey might be made in less than four weeks, under favorable conditions.

That this course is taken by many forms of marine life is certain, for after every period of strong southwesterly winds large numbers of Gulf Stream species of animals are cast ashore on the Bermudas, especially on the southern side. Among these are *Physalia*, the Gulf-Stream crabs and shrimp, etc.

Probably the larval period of many corals is too brief to permit them to make this journey. Others may arrive there that are not able to endure the low temperature of the water during the winter.

Thus it happens that many of the West Indian genera and species are not found at the Bermudas.

The absence of all varieties of *Aeropora* (*Madrepora*) *muricata* is particularly noteworthy, for these are among the most abundant and important of the West Indian reef corals.

Other important West Indian genera that are lacking are *Colpophyllia*, *Mæandrina* (= *Pectinia* auth.), *Dendrogyra*, *Dichocenia*, *Eusmillia*, *Stephanocenia*, and *Solenastræa*.

The absence of certain very common species of West Indian corals, and the presence of others of the same genera, is also noteworthy. Thus *Mæandra clivosa* and *M.* (*Manicina* auth.) *areolata* are absent, while two other species are present in abundance. *Agaricia agaricites* is absent, while *A. fragilis* is common. *Porites furcata* is unknown, while *P. polymorpha* (= *clavaria*) and *P. astreoides* are common.

On the other hand, some genera and species appear to be more abundant than in most parts of the West Indies. Thus the subgenus *Isophyllia*, so abundant here, seems to be less developed elsewhere. The same is perhaps true of *Oculina* and *Madracis*, as well as of *Agaricia fragilis* and *Mæandra* (*Diploria*) *labyrinthiformis*. The latter is here the prevailing reef coral, but it seems to be relatively less abundant in the West Indies. But Mr. Whitfield informs me that it is very abundant at the Bahamas.

Revised List of Bermudian Corals.

MADREPORARIA.

Family **Mæandridæ.** See p. 65.

Favidae Vaughan, Stony Corals of Porto Rican Waters, p. 302.

Mæandra labyrinthiformis (L.) Oken. See p. 70.

PLATE X, FIGURES 1-3; PL. XII, FIG. 5.

Common Brain Coral. Brain Stone.

Very abundant on nearly all reefs, except in Harrington Sound.

Mæandra cerebrum (Ellis & Sol.) Ver. See p. 74.

Platygyra viridis Vaughan, op. cit., p. 306, plates ix-xiii.

PLATE X, FIG. 4; PL. XII, FIG. 4; PL. XIV, FIGS. 4, 5; PL. XIX, FIG. 7.

Brain Coral. Brain Stone.

Common on the outer reefs; rare near the shores; absent from Harrington Sound.

Favia fragum (Esper) E. & H. See p. 90.

Favia fragum Vaughan, op. cit., p. 303, pl. viii, figs. 1, 2.

PLATE XIII, FIGURES 1, 2.

Small Star Coral.

Common in shallow water and on the reefs; also in tide-pools.

Family **Orbicellidæ.** See p. 93. Vaughan, p. 300.

Orbicella annularis (E. & Sol.) Dana. See p. 94.

Orbicella acropora Vaughan, op. cit., p. 301, plates vi, vii.

PLATE XV, FIGURES 1, 1a.

Star Coral (with small stars).

Outer reefs, not common; rarely on inner reefs. (See figure 9, p. 173.)

Orbicella cavernosa (L.) Ver. See p. 102.

Great Star Coral (with large stars).

Outer reefs, near North Rocks, rare.

Plesiastræa Goodei Ver. See p. 106, cut 1.

PLATE XXX, FIGURES 1, 1a.

Small-eyed Star Coral.

Outer reefs, at North Rocks, rare ; Bailey Bay reefs, rare.

Family **Stylophoridæ**. See p. 108.

Madracis decactis (Ly.) Ver. See p. 108, cuts 2, 2a.

PLATE XIV, FIGURE 6.

Ten-rayed Star Coral.

Outer and inner reefs, common ; Harrington Sound, 0.5 to 2 fath., not rare.

Family **Oculinidæ**. See p. 110.

Oculina (Lam., restricted) ; Dana (*pars*) ; Edw. & Haime.

"Ivory Corals."

The genus *Oculina* is common at the Bermudas, and especially so in Harrington Sound, where it occurs in several forms usually considered as distinct species.

During both my trips to the Bermudas I made large collections of this genus, in order to ascertain, if possible, the number of species and their variations. But I have not as yet had opportunities to devote the requisite amount of time to this subject.

Some of the species of *Oculina* grow at considerable depths. I was told by fishermen that they had occasionally hooked up living branches from 20–25 fathoms, on the hard grounds outside of the outer reefs, but I did not see any of these specimens.

It is certain that all the species are highly variable in general appearance, size of trunk and branches, mode of branching, prominence and size of the calicles, presence and character of the costal striations, amount of cœnenchyma, etc. The number and character of the septa and pali and the size of the columella are also more or less variable. Thus it becomes very difficult to limit the species.

I feel certain that too many species of *Oculina* have been recognized among the Bermuda corals, especially by Quelch, who records seven species. Apparently all my specimens can be arranged in four species, at the most, and perhaps in three. Therefore I now give the following species only provisionally :

Oculina varicosa Lesneur.

Oculina varicosa Les., Mem. Mus. Paris, vi, p. 291, pl. xvii, fig. 19, 1820. Dana, Zoöph. Expl. Exp., p. 67, fig. 28, and p. 394, 1846, type examined. Verrill, Bull. Mus. Comp. Zoöl., iv, p. 46, 1864. Pourtalès, Reef Corals, p. 66, 1877; Florida Reefs, pl. i, figs. 1-4; pl. ii, figs. 3, 4; pl. iii, figs. 8, 9, 1880. Quelch, op. cit., p. 48, 1886.

PLATE XXXII. FIGURES 2, 3, 4.

Large Ivory Coral. Tree Coral.

This is much the largest and finest species of *Oculina*, as well as the most distinct, but it is comparatively rare, and not often found in very shallow water.

It branches very distantly, in an irregularly arborescent manner, the few branches being usually crooked, rather long, and tapering. The main trunk may be 30 to 50^{mm} in diameter; many of the larger branches are 20 to 25^{mm} in diameter, in large specimens.



Figure 9.—*Orbicella annularis* D. Group of calicles, somewhat enlarged, after Sonrel. Both figures from Webster's International Dictionary.

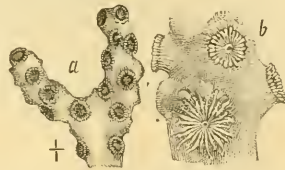


Figure 10.—*a*, *Oculina varicosa* Les., tips of two branches with polyps expanded, natural size; *b*, part of a branch, more enlarged, after Sonrel, in Agassiz, Florida Reefs.

The cœnenchyma is abundant, very solid, white, and nearly smooth in the trunk and larger branches, but it becomes small in amount on the tapering terminal branchlets, especially near the tips.

The calicles are mostly of rather large size. The corallites on the principal branches are usually mammiform, with large swollen bases, abruptly narrowing to the cylindrical distal portion, often with the summit and calicle somewhat contracted. But they may vary greatly in the amount of swelling of the base, even on the same specimen. In some cases the bases are very large and much swollen, so as to be nearly hemispherical and in contact proximally. In other cases they are much higher than broad, and subconical, but these may also be in contact proximally. On the under sides of the branches and in other unfavorable places, the calicles may be only slightly raised, and the swollen base may be wanting, or even replaced by a slightly sunken area or fosse, surrounded by a raised border, as in *O. robusta* Pourt. and some of the other species.

On the smaller branches and branchlets the swollen bases of the corallites gradually decrease in size, till they may disappear. In such cases the distal corallites are cylindrical, somewhat prominent, and they stand at a rather wide angle to the branch, even to near the tips. But quite often the bases are distinctly swollen nearly to the tips of the branches.

The costal striae are often well developed, about 24 in number, radiating on the sides, but often curving at the sutural lines, when the latter are distinct between the bases of the corallites. On the larger branches and trunk the costal striae and sutural grooves are often entirely lacking and the whole surface appears smooth.

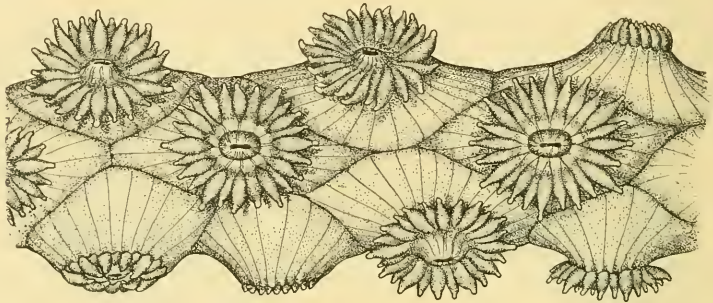


Figure 11.—*Ocutina varicosa* Les. Part of a branch with the polyps expanded; much enlarged. From a drawing by A. H. Verrill.

The septa are mostly 24 to 36, varying in width and thickness according to the cycles. The 12 larger ones are usually distinctly thicker and wider than the others, subentire, and only a little exsert, broadly rounded at summit, thick at the walls.

The pali are generally 10 or 12, rather small and thin, and not very prominent. The columella is of moderate size and papillose.

On our largest specimen there are several scattered, abnormally large corallites, having 40 to 56 or more septa. These are exsert and have large and deep calices with narrow septa. Their calices are 5 to 7^{mm} in diameter.

The ordinary calices are mostly about 2.75 to 3.50^{mm} in diameter, rarely 4^{mm}, but on the thicker branches and trunk their diameter is often only 2^{mm}, being smallest in those corallites that have very swollen bases; these large bases are often 10 to 13^{mm} in diameter and 6 to 8^{mm} high.

Our largest specimen was about 400^{mm} (16 inches) high, when entire.

Bermuda, 6–12 fathoms; in Harrington Sound, etc. Rare on the Florida Reefs and in the West Indies.

Var. *conigera* Ver., nov.

Oculina varicosa, var., Pourtalès, Florida Reefs, pl. ii, fig. 3, 1880.

PLATE XXX. FIGURE 3.

A remarkable variety, from Bermuda, has large and very prominent conical corallites, sloping continuously from the margin of the calicle to the base, with a smooth, even surface; no costal striae. Their bases are in contact and they stand out at nearly right angles to the branch. The calicles are small and contracted, rather shallow, with 24 thin, unequal septa, those of the third cycle being very narrow and thin. Pali small; columella poorly developed. Only one branch is in the collection. A larger specimen has been well figured in the Report on Florida Reefs.

Oculina diffusa Lam., 1816.

Oculina diffusa Dana, Zoöph., p. 397, 1846. Edw. & Haime (*pars*), Corall., ii, p. 107, 1857. Pourtalès, Reef Corals, p. 65, 1877; Florida Reefs, pl. iii, figs. 10–13, 1880. Quelch, op. cit., p. 47, 1886, descr.

Oculina diffusa Vaughan, op. cit., p. 294, pl. i, figs. 5, 5a, 1901.

Ivory Coral. Bush Coral.

This is the most abundant species, both here and at the Florida Reefs. It usually forms densely branched clumps, with numerous slender ascending branchlets. But it also grows in open, arborescently branched forms. The calicles are rather large, usually 3 to 4^{mm} in diameter. The corallites are more or less prominent, becoming oblique toward the tips of the branches, but on the larger branches they may be surrounded by a depression and outer ridge, or become circumvallate. The septa are usually 24, rather narrow, little exsert. Columella well developed.

Oculina pallens Ehrenberg.

Corall. Rothen Meeres, p. 79, 1834. Dana, Zoöph., p. 67, fig. 29, p. 395, 1846. Pourtalès, Reef Corals, p. 66, 1877; Florida Reefs, pl. iii, figs. 14–17, 1888. Quelch, op. cit., p. 48, 1886, (descr.).

? *Oculina speciosa* Edw. & Haime, Monog., p. 67, pl. iv, fig. 1, 1850; Hist. Corall., ii, p. 106, 1857. Quelch, op. cit., p. 50, (descr. and notes on the original type, examined).

Ivory Coral. Tree Coral.

This forms rather handsome arborescently branched corals, about a foot high, with the branches rather few, long, divergent, and tapered. The corallites are of medium size, 2.5 to 3^{mm} in diameter,

rather prominent, somewhat enlarged proximally. They usually stand at a large angle to the branches. The septa are exsert, usually 24; pali are not very well developed; and the columella is rather large and papillose.

It is common in Harrington Sound in 1 to 8 fathoms; Bailey Bay, 2 to 6 fathoms, etc.

Oculina Valenciennesi Edw. & Haime.

Monog. Oculinidæ, p. 69, 1850; Hist. Corall., ii, p. 108, 1857.

? *Oculina Banksi* Edw. & H., Monog., p. 68; Hist. Corall., ii, p. 107, 1857.

? *Oculina Bermudiana* Duch. & Mich., Supl. Corall. Antilles, p. 162 [68], pl. x, figs. 1, 2 (poor), 1866. Quelch, op. cit., p. 51 (as *Bermudensis*).

PLATE XXXII, FIGURE 5.

Ivory Coral. Tree Coral.

This species forms openly and irregularly branched, or rather straggling arborescent corals, a foot or more high, with the branches rather long and crooked. The larger branches are from 12 to 20^{mm} in diameter, in large specimens; corallites mostly circumvallate.

The distal corallites are usually a little prominent, but those on the larger branches and trunk are mostly low, and scarcely exsert; their bases are usually surrounded by a shallow, circular depression, outside of which there is a wide and low surrounding ridge. The depressions and ridges are crossed by the curved, radial costal striations. Common at the Bermudas, especially in Harrington Sound, 1 to 8 fathoms.

The singular looking coral described by Edw. & Haime as *O. Banksii* may be only an older and more developed form of this species, with calicles larger and more deeply sunken in a fosse than usual, and with higher investing ridges. The locality of the type was unknown, but it was from the collection of Sir Joseph Banks.

Catesby (Hist. Carolina, etc., Introduction) states that he made a collection of corals in the Bahamas and afterwards presented them to Sir Joseph Banks, who was one of his patrons. It is probable, therefore, that this type was from the Bahamas.

I have seen a fine specimen, agreeing well with the original description of *Banksii*, in the Amer. Mus. Nat. Hist., from the Bahamas (coll. R. P. Whitfield), but have not had an opportunity to study it carefully.

I can find nothing in the brief description and poor figure of *O. Bermudiana* by which to distinguish it from the present species.

Oculina coronalis Quelch.

Voy. Challenger, xvi, p. 49, pl. i, figs. 6-6c.

Ivory Coral.

This is an openly branched arborescent species, with the branches long, often divaricate and contorted, spreading in all directions, seldom coalescent.

The most important character is the corona-like, close group of 12 erect, stout pali, which seem to be rather more developed than is usual in any of the other species. The columella is well developed, papillose. Septa 24, unequal, very granulated, little exsert. Calicles distant, 2 to 3^{mm} in diameter.

I have seen no specimens agreeing perfectly with this form, which may be a distinct species. But in most respects it agrees pretty closely with some specimens of *O. pallens*, from which it may not be distinct.

Family **Mussidæ**. See p. 115.

Mussa Oken, Dana. See pp. 115-118, 128.

Mussa + *Symphyllia* + *Isophyllia* + *Mycetophyllia* + ? *Ulophyllia* Edw. & Haime, Hist. Corall., ii, 1857.

Cactus Corals.

Since printing the previous article, I have had occasion to study a new species of *Mussa*, described below, which is closely related, in most respects, to the typical species of *Isophyllia*, but yet it has the larger, exsert, distal septal teeth and the distally thickened septa characteristic of *Mussa*. See fig. 12.

In fact, it is truly intermediate between the two groups.

Consequently I am now led to reunite them, together with *Symphyllia*, *Mycetophyllia*, and *Ulophyllia*, in the old genus *Mussa*. But it may, nevertheless, be convenient to keep them in use as subordinate groups, equivalent to sub-genera, or sections, that are not clearly limited by structural characters, such as should characterize true genera.

On pages 115, 116 (note) I have already stated that this would probably have to be done eventually. See also my remarks, below, on the Brazilian species (*M. tenuisepta* and *M. Braziliensis*), which are also connecting species.

It is easy, also, to find in some calicles of typical *Isophyllia*, like *I. fragilis*, septa that have the distal teeth larger than the rest.

Sometimes this feature, in that species and others, may be found characteristic of many entire calicles. It is then, scarcely more than a variable specific character in some species.

In respect to the *Symphyllia* condition, I will add that I have one specimen of *M. (Isophyllia) fragilis*, from Bermuda, in which the six calicles terminate entirely distinct dichotomous branches, as in *M. Hartii*, var. *laxa*. The calicles are partly isolated, partly undergoing fission. There is no exotheca.

As to *Ulophyllia*, I am in some doubt, for I have been unable to study more than a few specimens of that group. Other species that have been figured appear to differ more from *Mussa* than those that I have seen, and possibly some of them may be generically distinct.

The Indo-Pacific species of *Mussa* (including *Symphyllia*, typical) differ as a whole from the West Indian species in having broader and more exsert septa; with larger and usually broader distal teeth, and usually in having stronger or more spiniform costal teeth. The columella is also apt to be more lamellose. But all these parts are variable and do not present any tangible generic characters for separating them from the West Indian group. These last present a wide range of variation in the size and character of the calicles and septa, and in their dentition.

***Mussa (Symphyllia) annectens* Ver., sp. nov.**

PLATE XXXV, FIGURES 1, 2.

Rose Coral. Cactus Coral. Tooth Coral (Bahamas). Figure 12.

Coral massive, either pedicelled or broadly attached, more or less hemispherical, up to 6 inches (150^{mm}) in diameter, with the walls of the corallites united, to their summits, by costæ and cellular exotheca, but nearly always showing a narrow groove along the summit. The proper walls are thin and solid. Calicles of moderate size and deep, mostly in short, separate, lobulate series, with two to four centers. Many of the compound calicles have a stellate or rosette-like form with three to six lobes, each of which has a calicinal center, which surround a larger central one. In other places the calicles run together in sinuous valleys, which are then about 12 to 15^{mm} wide from wall to wall, but between the edges of the septa only 7 to 10^{mm} wide. The largest calicles that are not dividing are usually about 18 to 20^{mm} across, rarely 25^{mm}; depth of calicle to top of wall, 9–12^{mm}. The septa are not very wide, but rather thick distally, and strongly exsert; their summits are often wider than the middle por-

tion, and rounded, but many are narrowed and angular or subacute ; all are terminated by two to four, more commonly three, strong, sharp, erect teeth, giving the coral a rough and spinose appearance. The inner edge is usually nearly perpendicular and thinner, and is divided into a variable number, usually six to eight, of sharp spiniform teeth, usually pointing strongly upward. These teeth of the inner edge are generally decidedly smaller, shorter, and thinner than the distal ones, but they are quite variable in size and form, and some of them are sometimes about as large and wide as those of the exsert portion, but not so thick. Sometimes they are all subequal, but in other places they are very unequal. See figure 12.

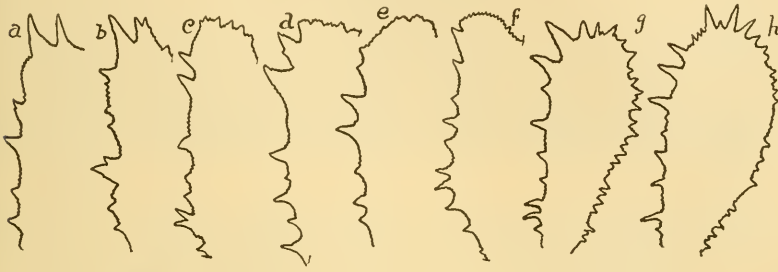


Figure 12.—*Mussa annectens* Ver. A series of outlines of the larger septa, from the type specimen, enlarged ; *a, b*, two septa with true *Mussa* dentition ; *c, d*, two septa with dentition of intermediate character ; *e, f*, two septa of the *Isophyllia* type ; *g, h*, two septa from the outer side of marginal calicles, to show the character of the costal spines. Drawn by A. H. Verrill.

In the type specimens the septa are rather openly arranged, and separated by interspaces exceeding their own thickness. But in one example they are thicker and more crowded. They are unequal in width and thickness, according to the three or four cycles that they represent, those of the last cycle being almost rudimentary. There are usually seven or eight larger ones to 10^{mm} in the type. The sides of the septa are sharply granulated. The columella is well developed, trabecular, and covered with rough, irregularly divergent spines.

The under side is strongly lobulated near the margin and naked for about 20 to 40^{mm} in the type, but much less in some others. The costæ are rather coarse, irregular, in some places having somewhat raised lamellæ, with sharply serrate edges ; in other places low and feebly toothed.

Hamilton Harbor, Bermuda, on the reefs.

This interesting species is represented by three large specimens, 4 to 6 inches in diameter, with numerous calicles. They were recently found in a lot of unsorted corals collected in Hamilton Harbor by Mr. A. Hyatt Verrill, March, 1901, and hitherto overlooked.

It is clearly a true *Mussa*, as contrasted with *Isophyllia*, for the distal, erect, exsert septal teeth are the stronger. The complete union of the walls by exotheca would place it in *Symphyllia*, if that group be recognized.

It is more nearly related to *M. (Symphyllia) rigida* Dana, of the West Indies, than to any other known species. But it has much larger calicles, and they are compound and much lobulated, and rarely astreiform, as in the latter. The walls, also, are much less solid. It also has a general resemblance to *M. (Isophyllia) multiflora*, but the latter has thinner and more numerous septa, which are toothed as in *Isophyllia*, and its calicles are smaller and more often isolated.

Mussa (Isophyllia) dipsacea (D.) Ver. See p. 118.

PLATE XVIII, FIGS. 2, 5; PL. XIX, FIGS. 2, 3; PL. XX, FIG. 2.

Rose Coral. Cactus Coral.

Occurs in the same places as the following; common.

Mussa (Isophyllia) fragilis (D.) Ver. See p. 121.

PLATE XVI, FIGS. 1, 2; PL. XVII, FIGS. 1-7; PL. XVIII, FIGS. 1, 6;
PL. XIX, FIGS. 1, 4, 5.

Rose Coral. Cactus Coral.

Outer and inner reefs and rocks, and on shallow flats, very common; Harrington Sd., common in 2-8 feet of water.

Mussa (Isophyllia) multiflora Ver. See p. 125.

PLATE XX, FIG. 1; PL. XXV, FIG. 1.

Outer reefs; Serpuline atolls; Hamilton Harbor, not common.

The numerous other species of *Isophyllia* and *Lithophyllia*, recorded by Quelch, are probably all varieties and young of *M. fragilis* and *M. dipsacea*.

Family **Agaricidæ**. See p. 139.

Agaricia fragilis Dana. See p. 142.

PLATE XXVI, FIGURES 1a-1d.

Hat Coral. Shade Coral.

Bermudas, on the reefs in shallow water; Castle Harbor; Harrington Sound, 0.5 to 3 fathoms, common; Florida and the West Indies, rather rare.

Siderastræa radians (Pallas) Ver. See p. 153.

Vaughan, Corals Porto Rican Waters, p. 309, pl. xv, pl. xvi, fig. 2, 1901.

PLATE XXX, FIGURE 1.

Star Coral.

Bermudas, common, both on the reefs and in shallow water in all bays and sounds; grassy flats of Long Bird Island at low tide and in pools, etc. Florida; everywhere in the West Indies and to Colon; abundant.

Siderastræa siderea (Ellis & Sol.) Blainv. See p. 151.

Vaughan, op. cit., p. 309, pl. xiv, figs. 1, 2, pl. xvi, fig. 1, 1901.

PLATE XXX, FIGURES 2, 3.

Star Coral.

Bermudas, much less common than the last. Florida Reefs and West Indies; Colon, etc.; common.

Family **Poritidæ** Gray, 1840. Dana, 1846. See p. 158.

Porites polymorpha Link. See p. 158.

Porites porites (*pars*=*forma clavaria*) Vaughan, op. cit., pp. 314-316, pl. xxix, pl. xxxi, fig. 2.

PLATE XXXI, FIGURES 3, 3a.

Bermudas, common on the reefs and also in the shallow bays, 0.5 to 3 fathoms; Harrington Sound. Florida and through the West Indies; abundant.

Porites astreoides Les. See p. 160.

Porites astreoides Vaughan, op. cit., p. 317, plates xxxii-xxxiv, 1901.

PLATE XXXI, FIGURES 4, 4a.

Common in shallow water and on the reefs, 0.5 to 4 fathoms. Florida and through the West Indies to Pernambuco, Brazil, abundant.

HYDROCORALLIA.

Family *Milleporidæ* Flem. (*pars*), 1828. Edw. and Haime (*pars*), *Hist. Corall.*, iii, p. 224, 1860.

Millepora alcicornis Linné.

Dana, *Zoöph.*, p. 543, 1846. Edw. & Haime, *Corall.*, iii, p. 228, 1860. Pourtalès, *Florida Reefs*, pl. xx, figs. 1-6, 1880, excellent. Quelch, *Voy. Chall.*, xvi, p. 190, 1886. Vaughan, *Corals Porto Rican Waters*, p. 318, plates xxxv-xxxviii.

Finger Coral. Sea Ginger. Ginger Coral.



Figure 13.—*Millepora alcicornis* L.
Tips of branches, $\frac{2}{3}$ natural size. After Sourel, in Agassiz.

Abundant everywhere on the Bermuda reefs and also on ledges and rocks near the shore, in 0.5 to 5 fathoms; Harrington Sound, 0.5 to 4 fathoms. Abundant on the Florida Reefs and throughout the West Indies to Colon. Abrolhos Reefs, Brazil, (var.)

Quelch recorded also *M. ramosa* Pallas (two specimens), and *M. Carthaginiensis* Duch. & Mich., as from the Bermudas. I did not find any specimens agreeing with either of these forms, which may be only growth-varieties of *alcicornis*.

The following species, which are not reef-corals, were recorded by Moseley as dredged by the Challenger about the Bermudas. See vol. ii, part 7, pp. 138-184, 1880:

? *Caryophyllia cylindracea* Reuss.; Moseley, p. 138.—435 fath.

Azohelia dumetosa Duch.; Moseley, p. 182.—435 fath.

Cladocora arbuscula Edw. & H.; Moseley, p. 184.—435 fath.

Bathyaectis symmetrica Moseley, p. 186, pl. xi, figs. 8-9a.—32 fath. and 1075 fath.

Deltoocyathus italicus Edw. & Haime; Moseley, p. 145, cuts.—1075 fath.

Caryophyllia communis Moseley, p. 135, pl. i, figs. 4-5a.—690 fath.

Madracis asperula Edw. & Haime ; Moseley, p. 182.—On South-west Bank, 30 fath. See p. 109, above.

Mr. G. Browne Goode, in a letter in 1877, mentions finding a small *Astrangia* at the Bermudas. The specimens have not been found in his collections. It may have been *Astrangia solitaria* (Les.) Ver., which is common in the West Indies.

2.—Characteristics of the West Indian Coral Fauna.

The coral fauna of the West Indian area is remarkably uniform from Florida and the Bahamas to the Lesser Antilles and the coast of Venezuela, and to Colon. The Florida reefs and keys, so far as known, lack a few species that are found in the Bahamas and further southward. But this may be due to the much greater difficulty in making collections on the outer reefs of Florida, as compared with those of the Bahamas. Still the list of Florida reef-corals published by Pourtalès (Mem. Mus. Comp. Zoöl., ii) includes nearly all the important West Indian species, though some that are abundant elsewhere seem to be rare on the Florida Reefs. Among the larger Bahama species, not yet known from Florida, are *Dendrogyra cylindrus*, *Stephanoconia intersepta*, *Solenastrea hyades*, *Plesiastrea Goodei*, *Mussa rigida*, *Agaricia crassa*. But it is probable that all these will eventually be discovered there.

The lists of species known from Colon and Cumana are probably very imperfect, as they represent only a small amount of collecting, but they include most of the ordinary West Indian reef-corals.

At Curacoa the coral fauna is known to be essentially the same as in the Bahamas. The same is true of St. Thomas and Guadaloupe.

The West Indian coral fauna is, however, totally distinct from that of Panama and the Indo-Pacific region. Not a single species is positively known to be common to the West Indies and either of those regions.*

With the coral fauna of Brazil there is a direct relationship. Apparently a few of the species are also closely related to, and perhaps identical with, those of the eastern Atlantic.*

* Quelch (Voy. Challenger, xvi, pp. 91, 99) records *Manicina areolata* from 10–20 fath., off Cape of Good Hope, and *Favia fragum* from the Azores, on the shores. He also records (pp. 181, 182) from the Cape Verde Islands, two of the nominal West Indian forms of *Porites* described by Duch. & Mich., but the latter are absolutely indeterminable without comparison of the types. His species may be quite different.

This is not surprising, for various West Indian mollusks and echinoderms, and some gorgonians, etc., are known to occur on the E. African coasts.

With the Mediterranean fauna there is little resemblance, but the genus *Cladocora* is found in both faunæ.

The West Indian coral-fauna is characterized by a few genera that are not known to occur in the Indo-Pacific fauna, and by others that are comparatively rare in that fauna. But there is no *family* of corals restricted to the West Indies.

Among the genera peculiar to the West Indies are *Colpophyllia*, *Dendrogyra*, *Meandrina*, rest. (= *Pectinia* auth.), *Eusmillia*, *Stephanocœnia*, and perhaps the subgenus *Isophyllia*.

Among the common genera that are comparatively rare in the Indo-Pacific, the following may be mentioned: *Agaricia*, *Siderastræa*, *Cladocora*, *Madracis*, *Oculina* (rest.), *Dichocœnia*, *Orbicella*.

But the West Indian reef-fauna is also characterized by the conspicuous absence of a large number of genera and even of some large *families* of corals that are abundant in the Indo-Pacific.

Among the families that are lacking are the *Turbinaridæ*, *Eupsamimidæ*, *Fungida** (with numerous genera), *Pocilloporidæ*.

Of the important Indo-Pacific *genera* that are lacking, the following are notable: *Turbinaria*, *Astræopora*, *Montipora*, *Alveopora*, † *Synaræa*, *Psammocora*, *Pavonia*, *Pachyseris*, *Fungia*, *Herpetolitha*, *Cryptobacia*, *Halomitra*, *Podobacia*, *Merulina*, *Hydnophora*, *Tridacophyllia*, *Echinopora*, *Mycedium* (restr.), *Utophyllia*, *Trachyphyllia*, *Galaxea*, *Euphyllia*, *Plerogyra*, *Favites* = *Prionastræa*, *Acanthastræa*, *Pocillopora*, *Stylophora* (true), *Seriatopora*, and many others.

The total absence of the slender-branched, corymbose and cæspitose species of *Acropora* (*Madrepora* auth.) is one of the most conspicuous differences between the West Indian and the Indo-Pacific reefs. Such species are exceedingly abundant and varied on the latter, and give to them some of their most striking characteristics. The absence of *Pocillopora*, which abounds on all the Indo-Pacific reefs, and even in the Panama fauna, is also a striking feature of the West Indian reefs. There are, however, a number of genera that are well developed and abundant in both of these great faunal areas. Among these are *Porites*, *Mæandra*, *Favia*, *Solenastræa*, *Mussa*, *Millipora*, and the stout-branched species of *Acropora*.

* A few small, simple representatives of this family, from deep water, have been described by Pourtalès.

† Species of *Alveopora* have been described as fossils in the later tertiary deposits of some of the islands, but none are known living in the West Indies.

The interesting relations between the West Indian and the Brazilian coral fauna will be discussed in the next chapter.

At present, it is impossible to make a satisfactory general catalogue of the West Indian corals. This is due mainly to the large number of forms badly determined and too imperfectly described by Duch. and Michelotti, especially those of the genera *Mussa* (*Isophyllia*), *Agaricia*, *Porites*, etc. All of these and others need careful revision, with large collections and comparisons of types.

3.—Characteristics of the Brazilian Coral Fauna.

The known Brazilian reef corals are but few in number, though the reefs have now been well explored, but they are of unusual interest, partly because they constitute a very special coral fauna, and partly because several of them present remarkably generalized or archaic characters, combining within a single species characters which ordinarily characterize two or more distinct genera.

This would seem to indicate that this fauna is a small surviving remnant of an ancient coral fauna that has mostly disappeared. Possibly this fauna may date back to the early Tertiary period. Certain of the still existing species may have been the ancestral species from which some of the modern West Indian reef-corals may have been derived, by evolution, under more tropical conditions.

Among those of special interest in this way, I may mention, especially, *Mussa Braziliensis* and *M. tenuisepta*, both of which present characters of *Mussa* (group *Symphyllia*), *Isophyllia*, and *Favia*, so that they might be placed about equally well in either of these three groups, while they also closely resemble *Acanthastræa*.

Mussa Hartii occurs in the form of a typical *Mussa*, with free dichotomous branches, and in the form of a *Symphyllia*, with abundant exotheca, uniting the corallites completely together. But all sorts of intermediate states also occur. Thus it serves to compel the union of these genera.

Mæandra conferta Ver., originally referred by me to *Favia*, is almost exactly intermediate between the two genera in all its characters, and therefore shows their close relations and common origin.

It is specifically allied to *F. gravida*, which lives with it, and also to *F. fragum* and *Mæandra Agassizii*, as well as *M. clivosa*, of the West Indies. Indeed these five species form a nearly continuous series of closely related forms, ranging from typical *Favia* to typical *Mæandra*.

On the other hand, *Favia leptophylla* Ver. closely resembles an *Orbicella*, and especially the Brazilian *Orbicella aperta* Ver., not only in external form and appearance, but especially in the internal structure, both of the endotheca and exotheca (see the figured sections, Plates xiii and xxxiii, from photographs). Indeed, they are so much alike that I have, at times, hesitated to keep them apart, even as separate species.

And yet the former increases mainly by median or submedian fission, as in *Favia*, while the latter increases mainly by extramural or exothecal budding, as in typical *Orbicella*. In *O. aperta*, however, fission occasionally occurs, while a few exothecal buds can be found on *Favia leptophylla*.

Thus these two forms serve to show the close relationship of two genera, which are typical of two groups, often considered as of subfamily or even family rank. I very much regret that I have been unable to study a large series of these forms, for such a series might even compel us to unite the two in one species, which might then be referred to either genus, about equally well.

Siderastraea stellata is, in several ways, intermediate between *S. radians* and *S. siderea*, the two West Indian species, though perhaps nearer to the former. It may well have been the ancestral form of both.

Meandrina (Pectinia) Braziliensis must be considered as a primitive or ancestral form of its genus, for it retains through life the simple lobulated condition of growth characteristic of the young of the much larger and more complex forms (*M. meandrites*, etc.) found in the West Indies.

The Brazilian *Agaricia*, so far as known, resembles the young of the West Indian *A. agaricites* much more than the adult.

Very few of the Brazilian reef corals are strictly identical with those of the West Indies. This is due, undoubtedly, to the vast volume of fresh water discharged by the Amazon River. This forms a barrier absolutely impassable to many forms of shallow-water marine animals, and to their free-swimming larval stages, when these live at the surface or at moderate depths. Those species living at the bottom, at considerable depths, would be less affected, for the fresh water would reach the bottom only at moderate depths, and near the coast.

But as the reef corals are all sensitive to brackish water, and all inhabit shallow water and have free-swimming, surface-dwelling larvæ, they naturally form one of the groups least able to pass such

a barrier as is produced by the Amazonian waters. Indeed, the wonder is that any of the species should ever have passed this barrier, except by human agency, unless they were in existence at a time when the South American continent was less elevated, and when the lower Amazonian valley may have been a great salt-water Bay.*

It is possible, of course, that some of the smaller and rarer incrusting forms, like the *Agaricia*, may have been carried from the West Indies to Brazil on the bottoms of vessels. If such vessels were kept well out at sea, away from the Amazonian waters, this might occur, for I have seen fine branching specimens of *Oculina*, six inches in height, as well as other corals, taken from the bottoms of vessels at the Bermudas. But the abundant and larger species, widely distributed on the coast, cannot be accounted for in any such way. In fact, the only ones to which such an explanation could possibly be supposed to apply, would be the *Agaricia*, *Porites astreoides*, var., and *Millepora alcicornis*. But the two latter are too abundant and too widely distributed to make such an explanation seem reasonable.

Since the course of the ocean currents along that coast is northward, any species common to the two faunæ is far more likely to have been carried northwards from Brazil to the West Indies by their agency, than in the opposite direction. Indeed, it would seem impossible for such species to migrate southward along the northern Brazilian coast.

Therefore the original home of those species found in both regions must have been the Brazilian coast.

Most of the Brazilian corals were first described by me in vol. i, part ii, of these Transactions, 1867, but they were not then figured. Prof. C. F. Hartt contributed to that paper notes on their habits and distribution.

The structure, extent, and distribution of the Brazilian coral reefs have been described by Prof. C. F. Hartt† and by Mr. R. Rathbun,‡ Prof. J. D. Dana, in his "Corals and Coral Islands," has made extracts from Prof. Hartt's descriptions (see pp. 140-142, and p. 55 of ed. iv, 1890), and on p. 113 has given a partial list of the corals.

* It has even been suggested that a direct marine connection between the Atlantic and Pacific Oceans, by the way of the Amazon Valley, may have existed in the Cretaceous and early Tertiary periods.

† Geology and Physical Geography of Brazil, 1879, pp. 187-214.

‡ Notes on the Coral Reefs of the Island of Itaparica, Bahia, and of Parahyba do Norte, Proc. Bost. Soc. Nat. Hist., xx, pp. 39-41, 1878; Brazilian Corals and Coral Reefs, Amer. Naturalist, xiii, pp. 539-551, 1879.

Many of the important West Indian genera of reef-corals are apparently absent from the Brazilian reefs. Among these are *Acropora* (*Madrepora* Lam.), *Colpophyllia*, *Dendrogyra*, *Dichocænia*, *Solenastrea*, *Oculina*, subgenus *Isophyllia*, etc.

The absence of large species of brain corals (*Mæandra* = *Meandrina* and *Diploria* anth.) is also a remarkable feature, for these and the several varieties of *Acropora muricata* are the most conspicuous and most abundant of the West Indian corals, and contribute more than any others to the growth of the reefs.

The Brazilian coral fauna is, however, far more nearly related to the West Indian fauna than to any other. It has no special connection with the Indo-Pacific fauna, nor with the Panamanian fauna. The only genera found common to Brazil and the Indo-Pacific region are the nearly cosmopolitan genera, *Porites*, *Favia*, *Mussa*, *Orbicella*, and *Millepora*. Of these, *Porites* alone occurs at Panama. But the species, even of these genera, are allied to the corresponding West Indian forms, and less so to those of the Indo-Pacific.

On the other hand, none of the characteristic Indo-Pacific genera and species occur on the Brazilian reefs. (See above, p. 184.)

Revised List of Brazilian Reef Corals.

MADREPORARIA.

Family *Mæandridæ* Ver. See p. 65.

Mæandra conferta Ver. See p. 84, and these Trans., i, p. 355.

PLATE XIII, FIGURE 6.

Abrolhos Reefs, types, (C. F. Hartt); Bahia and Fernando Noronha (Hartt); Mar Grande, Bahia (Rathbun); Pernambuco (Hartt, Rathbun). Cape Frio to Pernambuco, common in tide-pools (Hartt).

Favia gravida Ver. See p. 91, and these Trans., i, p. 354.

PLATE XIII, FIGURE 3.

Abrolhos Reefs, type, (C. F. Hartt); Pernambuco and Bahia (R. Rathbun); Cape Frio to Pernambuco, common in tide-pools (C. F. Hartt).

Favia leptophylla Ver. See p. 91, and these Trans., i, p. 353.

PLATE XIII, FIGURES 4, 5.

Abrolhos Reefs, type, (C. F. Hartt).

Family *Orbicellidæ*. See p. 93. Vaughan, p. 300.

Orbicella aperta Ver. See p. 103, and these Trans., i, p. 356.

PLATE XXXIII, FIGURES 1, 1a.

Abrolhos Reefs, type, (C. F. Hartt); Itaparica, Bay of Bahia (C. F. Hartt, R. Rathbun).

Orbicella Braziliانا Ver. See p. 101.

Off Barra Grande, in 30 fathoms, Challenger Exped. (Queleh).

Orbicella cavernosa, var. *hirta* Ver. See p. 103.

PLATE XXXIII, FIGURE 2, 2a.

This form, briefly described on p. 103, deserves further notice. Although it resembles *O. cavernosa* in appearance, it differs so much in details that it may hereafter be separated as a distinct species, when a series of specimens can be carefully compared. I have, unfortunately, only seen one specimen. This is an incrusting plate, 130^{mm} broad and 30 to 40^{mm} thick.

The mature corallites are pretty uniform in size, rather exsert, near together, nearly round, roughened by the slightly exsert, unequal, rudely serrulate, rounded tops of the septa, and strongly costate on the nearly vertical sides. The costæ are rather elevated, unequal in height, but nearly equal in thickness, not much thickened above, interlocking; their edges are roughly and lacerately serrulate, or hispid, the teeth being divided into small points; their sides are also roughly hispid with sharp granules, leaving narrow intercostal spaces. The calicles are wide and deep. The septa are about 40 to 48 in the larger calicles, those of the last cycle being quite narrow, but nearly as high as the others distally, and toothed in the same way. The 24 larger septa are subequal, rather narrow, rounded distally, their inner edge concave or perpendicular, so that the calicle is broad below, and often slight constricted above by the overarching of the upper part of the septa. The entire edge of the septa is roughly serrulate, but more so on the distal portion, and their surfaces are roughly granulated. At the base there is a rough, spine-like paliform tooth, directed inward to the columella, and often

blending with the processes of the latter. The columella is broad, flat, rudely trabecular, covered with rough, blunt, papilliform spines.

In sections, the exotheca is very cellular with several rows of arched dissepiments; the walls are thin and compact; the endotheca is formed by wide, thin, sloping dissepiments; septa trabecular and perforated near the columella.

Diameter of the larger calices, 7 to 8^{mm}; depth, 2–3^{mm}.

Bahia, Brazil, R. Rathbun, 1876.

Orbicella cavernosa, var. **compacta** (Rath. MSS.), Vaughan.

Vaughan, op. cit., p. 31, 1901.

According to Mr. Vaughan, Mr. Rathbun had considered this a distinct species, but Mr. Vaughan, himself, thinks it only a variety of *O. cavernosa*, "with dense walls between the corallites." I have not seen the specimens.



Figure 14.—*Meandrina Braziliensis*. A young specimen, No. 4557. Natural size.

Family **Eusmillidæ** Ver. See p. 113.

Meandrina Lam., 1801, *non* 1816. See p. 66.

Meandrina Braziliensis (Edw. & Haime) Vaughan.

Ctenophyllia Braziliensis Edw. & Haime, Monog., Ann. Sci. Nat., x, p. 279, pl. vi, fig. 7, 1849.

Pectinia Braziliensis Edw. & Haime, Pol. foss. palæoz., p. 57, 1851; Hist.

Corall., ii, p. 209, 1858. Verrill, these Trans., i, p. 353, 1867.

Meandrina Braziliensis Vaughan, op. cit., p. 20, 1901.

PLATE XXXIV, FIGURE 1.

This elegant species is pedicellate and usually oblong in form, with the secondary collines and valleys mostly transverse and simple. (See p. 186.) The valleys are deep; the septa are wide, rounded distally, exsert, and nearly entire.

According to Mr. R. Rathbun (op. cit., p. 542), it usually does not occur attached to the reefs, but on the mud-flats, in sheltered places, partially buried in the mud, and usually unattached when mature (at Bahia, etc.). But when young it is, even in such places, undoubtedly attached to small pieces of stone, or shells, as is the case with other similar corals (*Mwandra areolata*, etc.).

A young specimen from the Abrolhos Reefs, in the Yale Museum (No. 4537, coll. C. F. Hartt), was, however, firmly attached by a pedicel 23^{mm} long and 16^{mm} wide, and somewhat expanded at the edge of the attached base.*

This specimen (fig. 14, above) is 52^{mm} long, 33^{mm} wide, 32^{mm} high. The valleys are mostly 7 to 9^{mm} wide; the collines (and septa) are about 8 to 9^{mm} across, where simple.

Thus all the calicinal centers and grooves and their septa are much smaller and narrower than in the adult, which is in accordance with all young meandriform corals.

Its margins are deeply lobulated, with four lobes on one side and five on the other. The infoldings that form the collines are deep; three of the collines on each side have already subdivided distally into two or three short lobes, defining short valleys that start out from the median valley, which is as narrow as the lateral ones.

The septa are rather thin, alternately wider and very narrow, but the wider ones are alternately unequal, as if in three cycles. The larger ones are broadly rounded distally, little exsert, nearly perpendicular within the valleys. The distal third of their edges is

* In contrast with this specimen, I add a description of a young example of *M. meandrites*, of almost exactly the same size, from the Bahamas, collected by R. P. Whitfield, and now in the Amer. Mus. Nat. History. It was firmly attached by the central part of the base.

Length, 50^{mm}; breadth, about 18^{mm}; height, about 35^{mm}. It has six primary marginal folds or lobes, and about three small secondary ones, some just forming, and a little irregular.

The septa are somewhat exsert, entire, or nearly so; the edge is convexly rounded and narrowed distally. Small narrow ones alternate with the wider ones. Columella large, formed of small convoluted lamellæ and trabeculae, without any median continuous lamella. Collines narrow, double in most parts.

External wall with raised, unequal costæ, two or three small ones between the larger ones, and sparsely serrulate with small, rough denticles.

“Color of the animal, in life, emerald green” (Whitfield).

Another young specimen, from the same collection (No. 507), is a little larger. Length, 75^{mm}; breadth, 62^{mm}; thickness, 36^{mm}. This is already meandriform, with deep valleys and stouter collines. The columella is small, but coarsely lamellose, with irregular thickenings, but without a median lamella.

minutely and sharply serrulate, each denticle forming the end of a curved series of sharp granules on each side. These gradually fade out proximally.

The columella is formed by a continuous, median, lamelliform plate, and by thin, interrupted lamellæ on each side of it, formed by foliate extensions of the lower inner edge of the septa, which bend to one side and unite together more or less, and also join the central lamella at irregular intervals.

The exterior wall is covered with rows of small, rough, or lacerate, conical spinules that stand on slightly raised costæ. There is no epitheca. The exterior was covered with living tissue to the basal edge of the pedicel. The larger specimen, figured on plate xxxiv, fig. 1, was from Itaparica I., Bay of Bahia. No. 4543.

Abrolhos Reefs and Victoria (Hartt); Itaparica I., Bahia (Rathbun).

Family **Mussidæ** Ver. See p. 115.

Mussa Harttii Ver. See p. 128, and these Trans., i, pp. 357, 358, 1867.

PLATES XXII, XXIII, XXV, XXXIII.

Var. **laxa**, Ver. See p. 128.

PLATE XXIII, FIGURE 2.

Abrolhos Reefs, type, Victoria, Porto Seguro, and Pernambuco (Hartt); Bahia (R. Rathbun). Mostly in 3-6 feet of water (Hartt).

Var. **conferta** Ver. See p. 129.

PLATE XXIII, FIG. 1; PL. XXV, FIG. 3; PL. XXXIII, FIG. 3.

Abrolhos Reefs, type, (C. F. Hartt); Pernambuco, Victoria, Porto Seguro, Mar Grande, and Periperi, Bahia (C. F. Hartt, R. Rathbun).

Var. **intermedia** Ver. See p. 128.

PLATE XXII, FIGURE 2.

Pernambuco (Rathbun).

Var. **confertifolia** Ver. See p. 129.

PLATE XXII, FIGURE 1.

Pernambuco, type, (Derby and Wilmot), No. 4551.

Mussa (Symphyllia) Braziliensis Ver.

Acanthastrea Braziliensis Verrill, these Trans., i, p. 355, 1867.

PLATE XXI, FIG. 1; PL. XXXIII, FIG. 4.

This cannot properly be retained in *Acanthastræa*, for it increases by median and submedian fission. The calicles are very irregular, varying from circular to oblong-elliptical, hour-glass shaped, three-lobed to five-lobed, etc. They often have three or more centers. They are also very variable in size. Where the calicles are crowded the walls are completely united, thin and solid; in some other places they are united by cellular exotheca and costæ.

The mode of growth and forms of the calicles are like several species of *Mussa*, especially *M. hispida* V. and *M. rigida* D., to which it is evidently closely allied. From the former it differs chiefly in the smaller size of the calicles, the reduced columella, the fewer and less lacinate septa, and the thinner walls, solid or with little exotheca.

But the larger and somewhat paliform teeth at the base of the septa cause it to resemble some species of *Favia*, very decidedly. It might, in fact, be referred to that genus without hesitation by some writers, for it is in several ways an intermediate species. But it seems to lack true paliform lobes or teeth. It appears to be related more directly to *Mussa tenuisepta* V. and *M. Hartii*, which inhabit the same region. It may, then, be considered a *Favia*-like *Mussa*, with unusually small and well isolated calicles for a *Mussa*.

Abrolhos Reefs, type, No. 1467, Porto Seguro, Sta. Cruz, Bahia; Maceio, low tide to 15 feet or more, abundant (C. F. Hartt).

Mussa (Symphyllia) tenuisepta Ver., sp. nov. See p. 127.

PLATE XXI, FIGURE 3.

Coral massive, astreiform, with the corallites mostly isolated and united to the edges of the calicles by costæ and cellular exotheca, the division walls usually showing a superficial furrow at the surface. Proper calicinal walls very thin. Under side closely adherent to very near the edge in the types; the exterior costæ, where visible, are thin, elevated, and lacerately spinulose.

Calicles moderately large, diameter mostly 15 to 25^{mm}, average about 20^{mm}, rather shallow, rapidly narrowed to the bottom, irregular in form. Many of the smaller ones are rounded, but the larger ones are mostly lobulate, with two to four lobes, and many are undergoing median or submedian fission. A few small calicles seem to have arisen from exothecal buds.

The septa are thin, numerous, rather crowded, not very wide, little exsert, with their thin inner edges sloping and deeply laciniately

toothed; lateral surfaces sharply and finely spinulose. The teeth are often of nearly uniform size and length on the whole edge, but more frequently the upper ones are wider and thicker, while the lower ones are slender, sharp, mostly branched, thorny or lacerate, but often acute and simple. Very thin and narrow septa often alternate with the wider ones. Columella well developed, trabecular and roughly spinulose.

The larger specimen is about 112^{mm} broad and 45^{mm} thick.

Pernambuco, 1870, two types (C. F. Hartt), Nos. 4542 and 4543.

This species might be placed in the subgenus *Isophyllia* about as well as in *Symphyllia*, for in the smaller specimen the distal teeth are generally not larger than the proximal. But in the larger example the reverse is true, so that it is another intermediate form.

It is nearly allied to *M. hispidu* V. (see p. 127), but has more numerous and thinner septa. A larger series may eventually show that they are varieties of a single species.

Family **Astrangidæ** Ver. These Trans., i, p. 524, 1867.

Astrangia, sp.

Mr. R. Rathbun (op. cit., 1877, p. 542) mentioned the occurrence of an *Astrangia* on the Brazilian reefs, but I have not seen the specimens referred to. He stated that the corallites are widely separated, but "united by thin, creeping stolons."

According to Vaughan (Porto Rican Corals, p. 299), there are three species of *Astragidæ* on the Brazilian coast: An *Astrangia* similar to *A. solitaria* (Les.) Ver., 1864; a new species, *A. Rathbuni* Vaughan, MSS.; and *Phyllangia Americana* Edw. and Haime.

Family **Agaricidæ** Ver. See p. 139.

Agaricia agaricites (Linné) E. & Haime. See pp. 146, 149.

PLATE XXVI, FIG. 2; PL. XXVII, FIGS. 2, 2a, 7, 7a (typical form).

Var. **humilis** Ver., nov.

Agaricia agaricites? Verrill, these Trans., i, p. 352, 1867.

Coral small, encrusting, but often with a narrow, very thin, translucent free edge, which is delicately striate-costulate externally, the costulae being alternately larger and smaller and minutely granulated.

Caliceles small, deep, crowded, mostly in short, irregular, concentric or sinuous series of 3 to 12, in narrow, deep valleys, separated by narrow, acute collines, which often anastomose. In the young speci-

mens, 15 to 30^{mm} broad, the collines are less acute and pretty regularly concentric around a larger, regular, central, primary calicle.

The septa are mostly in three cycles, and of three different sizes; the number varies from 20 to 32. The primary and secondary septa are thickened, especially distally, but the primaries are wider and thicker proximally than the others; tertiaries are much narrower and thinner; all are finely and sharply granulated laterally, and a little exsert. They are not so much crowded as in typical *agaricites*, and are more unequal in size and thickness. The central pit is deep and narrow. Columella is small, solid, umbonate.

Diameter of ordinary calicles 1.5 to 2.5^{mm}; of central one, about 4^{mm}.

According to Prof. Hartt it never becomes more than two or three inches broad. Our largest specimen is 65^{mm} broad, partially covering a rather thickish frond of partially dead coral of the same kind, which appears to have been repeatedly nearly killed and then renewed by outgrowths. It shows no tendency to form upright crests or fronds, but one edge is free for a breadth of 30^{mm}, but of this only 4 to 6^{mm} was living.

The other specimens are young. The smallest is a simple primary corallite, 4^{mm} in diameter, closely sessile, even to the edges; it has four cycles of unequal septa. The next larger (on the same *Mussa*) is 15^{mm} broad, with a larger primary central calicle and two concentric circles around it, with some of the third circle on one side. This is also closely adherent and incrusting to the very edge, except at one place, where the edge is free for 2 to 3^{mm}. In this the inequality in thickness of the cycles of septa is very marked.

This form may prove to be a distinct species when a larger series can be studied, but with my small specimens the distinctive characters seem very slight, and may be largely due to immaturity, or to a dwarfed state, owing to unfavorable conditions of growth.

It agrees better with a young specimen from Key West, Florida (pl. xxvii, figs. 2, 2a, No. 103), than with any of the other West Indian forms that I have. But the latter has larger calicles; much higher and larger collines; thicker, closer, and less unequal septa; more finely and evenly striated exterior; and a less closely incrusting mode of growth. I have considered the latter a young stage of the typical *agaricites*.

The var. *pusilla*, from Colon, has decidedly smaller calicles and collines, and appears more like a depauperate variety of *agaricites*.

The entire group is a difficult one, and needs more study, with larger collections.

Maria Farinha, Pernambuco, No. 4522, type; and Abrolhos Reefs, No. 4538, type, Yale Mus. (C. F. Hartt). No. 4538 includes three young examples on *Mussa Harttii*.

Siderastræa stellata Ver. See p. 155, and these Trans., i, pp. 352, 353.

PLATE XXX, FIGURES 4, 5.

Abrolhos Reefs, type, (C. F. Hartt); Pernambuco, Mar Grande, Bahia (R. Rathbun). Common everywhere north of Cape Frio, on the reefs, in shallow water, and in tide-pools (C. F. Hartt).

Var. **conferta** Ver. See p. 155.

PLATE XXX, FIGURE 5.

Abrolhos Reefs, type, (C. F. Hartt); occurs with the last.

Family **Poritidæ**. See p. 158.

Porites Verrillii Rehb. See p. 161.

PLATE XXXI, FIGURE 5.

Abrolhos Reefs, type, and Porto Seguro (C. F. Hartt); Pernambuco? (Rathbun).

Porites Branneri Rath. See p. 162.

PLATE XXXI, FIGURES 6, 6a.

Parahyba do Norte and Pernambuco (R. Rathbun).

Porites astreoides Les. See p. 160.

PLATE XXXI, FIGS. 4, 4a (typical form).

Var. **Braziliensis** Ver., nov.

The specimens from Pernambuco are thick incrusting plates, 125 to 150^{mm} broad, with an uneven surface, much infested with barnacles. The coral is very porous. The calices are rather smaller than in the West Indian *astreoides*, and more crowded than usual in that form. They are mostly polygonal, separated by rather thin and high porous division walls, with a sharp crest, roughly denticulated by the tops of the septa, which are lacerately serrulate. Near the margins they are often less crowded, somewhat rounded, and separated by thicker division walls. A considerable number of major calices, with 24 septa, are scattered over the surface, and some are undergoing fission.

The septa are narrow, equal, and all join the wide columella, so as to leave a rather regular circle of small, deep, interseptal loculi or pits. The columella is unusually wide, nearly flat, generally without either a central pit or umbo.

Diameter of the calices mostly 1.5 to 2^{mm}.

Maria Farinha, Pernambuco (Hartt, 1870). No. 4540.

This coral is much more porous than *P. Verrillii*; the calices are less conspicuously stellate; the division walls are much narrower and more porous; the columella is larger, and not umbonate, as in that species.

HYDROZOA.

HYDROCORALLIA,

Family **Milleporidæ** Flem., *pars*, 1828. Edw. & Haime (*pars*).

Millepora nitida Ver. Pl. xxxvi D, fig. 1.

These Trans., i, p. 362, 1867.

Abrolhos Reefs and Porto Seguro, low-tide to 4 feet deep (C. F. Hartt).

Millepora Braziliensis Ver. Pl. xxxvi D, fig. 2.

These Trans., i, p. 363, 1867.

Pernambuco and Abrolhos (C. F. Hartt, R. Rathbun).

Millepora alaicornis (L.), var. *cellulosa* Ver.

These Trans., i, p. 363, 1867.

Pernambuco (C. F. Hartt), type; Rio Formosa; Parahyba do Norte.

Millepora alaicornis (L.), var. *digitata*? Esper.

Verrill, these Trans., i, p. 364, 1867.

Abrolhos, Cape Frio, Porto Seguro, Bahia, and Maceió (C. F. Hartt).

Millepora alaicornis (L.), var. *fenestrata* D. & Mich.

Verrill, these Trans., i, p. 364, 1867.

Abrolhos Reefs (C. F. Hartt).

I have not revised the several forms of *Millepora* recorded by me in 1867, though collections since received might cause some changes or additions, if carefully studied.

Family *Stylasteridæ* Gray.*Stylaster*, sp.

Pernambuco, on *Mussa Harttii* (R. Rathbun).

Recorded only by Rathbun, Amer. Nat., xiii, p. 542, 1879.

Many of the corals in the above list undoubtedly occur on all the principal groups of reefs, from the Roccas, north of Cape St. Roque, to the Abrolhos, but I have given only those particular localities from which I have seen specimens, or from which they have been recorded by Prof. Hartt or Mr. Rathbun.

The following species of corals, dredged by the Hassler Expedition off the coast of Brazil, in moderate depths, were described by Pourtalès (Mem. Mus. Comp. Zoöl., iv, 1874). None of them are reef-corals:

Flabellum Braziliense Pourt., p. 38, pl. vi, figs. 16, 17.

Off Brazil, 11° 49' S., 40 fathoms.

Sphenotrochus auritus Pourt., p. 37, pl. vi, figs. 14, 15.

Off Cape Frio, Brazil, 35 fath., and S. lat. 11° 49', 12–18 fathoms.

Bathycyathus maculatus Pourt., p. 34, pl. vi, figs. 5, 6.

Off the Abrolhos Is., 30 fathoms.

Thecocyathus cylindraceus ? Pourt.

Off Cape Frio, Brazil, 35 fathoms, dead.

Cladocora patriarca Pourt., p. 42, pl. vii, fig. 7.

Off Cape Frio, 35 fathoms.

Axohelia dumetosa D. & M. ? Pourt., pp. 40, 41, pl. viii, fig. 1.

Off Brazil, S. lat. 10° 49', 12 fath., (identity doubtful, t. Pourt.).

Madracis asperula E. & H.; Pourt., p. 41. See above, p. 109; also,

The Atlantic, i, p. 360, figure; and Vaughan, Porto Rico

Corals, p. 234, pl. i, fig. 4, pl. xvii, fig. 2.

Off Brazil, S. lat. 11° 49', 40 fathoms.

EXPLANATION OF PLATES X-XXXV.

The figures on these plates are reproduced from photographs made by Mr. A. Hyatt Verrill, of New Haven, who has taken unusual pains to bring out the finer details of structure.* The photographs necessarily lose many of the details by this process of engraving, but I believe they will show quite as much structure as many of the poorer photographs that are often reproduced by much more expensive processes, and certainly much more than can be shown by the best lithographic plates. Had the requisite funds been available, I should have preferred to have enlarged many of them considerably more, in order to show finer details.

PLATE X.

- Figure 1.—*Meandra labyrinthiformis* (Linné). Top view of a Bermuda specimen showing both single and double collines of various breadths. In several places it also shows the commencement of the formation of exothecal buds and calicles on the double collines. Natural size. Page 70.
- Figure 2.—The same. Part of a young Bermuda specimen with nearly all the collines simple (var. *truncata* Dana). About $\frac{2}{3}$ natural size. Page 72.
- Figure 3.—Part of a young Bermuda specimen with wide double collines (var. *Stokesii*). On several of the wider places exothecal buds were forming. About $\frac{2}{3}$ natural size. Page 72.
- Figure 4.—*Meandra cerebrum* (Ellis and Sol.) Ver. Vertical section of a Bermuda specimen. $\times 3$. Page 74.

PLATE XI.

- Figure 1.—*Meandra areolata*. Top view of a large Florida specimen, No. 1833c, with sinuous, meandriform valleys and *Diploria*-like collines; a, profile view of an attached *Favia fragum* (young). Slightly reduced ($\frac{1}{2}$). Page 81.
- Figure 2.—The same, Var. *confertifolia* Ver., nov. Side view of the type, No. 1833b, from Key West, Fla. Natural size. Page 83.

PLATE XII.

- Figure 1.—*Meandra areolata*, var. *laxifolia* Ver. Top view of the type from Florida. No. 1833a. About natural size ($1\frac{1}{2}$). Page 83.
- Figure 2.—The same. Var. *hispida*. (Type of *Manicina praeurupta* Dana, No. 4294.) Top view, slightly enlarged ($\times 1\frac{1}{3}$). Page 83.
- Figure 3.—The same. Variety with double collines and cellular exotheca. About natural size ($\frac{2}{3}$). Page 81.
- Figure 4.—*Meandra cerebrum*. Top view of a part of a typical Bermuda specimen. Natural size. Page 74.
- Figure 5.—*Meandra labyrinthiformis*, var. *Stokesii*. Portion of a Bermuda specimen showing the beginning of several exothecal buds, at a, b, c, d. About natural size ($1\frac{1}{2}$). Page 71.

* The reproductions have been made by The Gill Engraving Co., New York.

PLATE XIII.

- Figures 1, 2.—*Favia fragum*. Two varieties found together at Bermuda. $\times 1\frac{1}{2}$. Page 90.
- Figure 3.—*Favia gracida*. Type. Top view of a part of one of the original specimens, No. 1465. $\times 2$. Page 91.
- Figure 4.—*Favia leptophylla* Ver. Top view of a part of the type. No. 1517. $\times 2\frac{1}{5}$. Page 91.
- Figure 5.—The same specimen. Vertical section. $\times 2\frac{1}{5}$.
- Figure 6.—*Meandra conferta* Ver. Top view of part of one of the types. No. 1466. $\times 2$. Page 84.

PLATE XIV.

- Figures 1, 1a.—*Meandra Agassizii*. Top views of different parts of one Bahama specimen. No. 5615. 1, natural size; 1a, enlarged about $1\frac{1}{2}$. Page 81.
- Figure 2.—*Meandra clivosa*, var. *explanata* Ver., nov. Top view of a part next the margin of No. 1196. About natural size ($1\frac{1}{20}$). Page 79.
- Figure 3.—*Meandra spongiosa* (Dana). Top view of a part of the type, No. 4383. Natural size. Pages 69, 80.
- Figure 4.—*Meandra cerebrum*. Top view of the middle of a Bermuda specimen with acute narrow collines. Reduced to about $\frac{1}{3}$. Page 74.
- Figure 5.—The same. Portion of a Florida specimen, No. 1901, showing the formation of astreiform calicles (a, b) by exothecal budding. $\times 1\frac{1}{2}$. Page 75.
- Figure 6.—*Madracis decactis* (Ly.). End of a lobate branch, showing an exceptionally large calicle, with numerous septa, surrounded by those of ordinary size, but here crowded and without coenenchyma between them. $\times 4$. Page 108.

PLATE XV.

- Figure 1.—*Orbicella annularis*. Portion of upper surface of a Bermuda specimen. A, A calicle undergoing fission. Enlarged $1\frac{1}{2}$. Page 94.
- Figure 1a.—The same specimen. Natural size.
- Figure 2.—The same. Var. *stellulata* (Dana). Portion of Dana's type, with worn surface, No. 4266; a, a transverse section. $\times 2\frac{1}{2}$. Page 96.
- Figure 3.—*Orbicella hispidula* Ver., sp. nov. Portion of the surface of the type, No. 98. $\times 1\frac{1}{2}$. Page 100.
- Figure 3a.—The same specimen. $\times 2\frac{1}{2}$.
- Figure 3b.—The same specimen; vertical section. $\times 2\frac{1}{2}$.
- Figure 4.—*Orbicella excelsa* Dana. One of the distal lobes of one of the original types, No. 1729. $\times 1\frac{1}{2}$. Page 98.
- Figure 4a, 4b.—The same specimen. $\times 2\frac{1}{3}$.
- Figure 5.—*Solenastræa hyades* (D.). Side view of a specimen from St. Thomas. No. 1586b. $\times 1\frac{1}{2}$. Page 104.
- Figure 5a.—The same specimen. About natural size ($1\frac{1}{25}$).
- Figure 5b.—The same specimen. Group of calicles from the side, where not crowded. $\times 1\frac{1}{3}$.

PLATE XVI.

- Figure 1.—*Mussa (Isophyllia) fragilis* D. Side view of Dana's original type, No. 4298. Natural size. Page 121.
 Figure 2.—The same. A well-grown normal specimen, from the Bermudas. Natural size. Page 121.

PLATE XVII.

- Figures 1, 2.—*Mussa (Isophyllia) fragilis* Dana. Top and bottom views of a symmetrical young specimen, having five primary lobes or infoldings of the margin. About natural size. Page 124.
 Figure 3.—The same. A young specimen of about the same age, having 6 marginal folds, with the margin stellate below. About natural size. Page 124.
 Figure 4.—The same. A younger specimen with four marginal folds. About natural size.
 Figure 5.—The same. A large mature Bermuda specimen, with numerous calicles, many isolated, $\frac{1}{3}$ natural size. Page 121.
 Figure 6.—The same. A similar but smaller Bermuda specimen, reduced to $\frac{1}{3}$. Page 121.
 Figure 7.—The same. A specimen of the more common size and form, $\frac{1}{3}$ natural size. Page 121.

PLATE XVIII.

- Figure 1.—*Mussa (Isophyllia) fragilis* Dana. A symmetrical young specimen with six primary marginal infoldings. Natural size. Page 121.
 Figure 2.—*Mussa (Isophyllia) dipsacea* Dana. A normal, nearly regular Bermuda specimen of the ordinary size. Natural size. Page 118.
 Figure 3.—*Axohelia Schrammii* Pourt. Part of a branch of No. 5662. $\times 2\frac{1}{2}$. Page 110.
 Figure 4.—The same. Part of a branch. No. 5662. $\times 2$. Page 110.
 Figure 5.—*Mussa (Isophyllia) dipsacea* Dana. Part of the calicles of a large Bermuda specimen, to show character of dentition. Natural size.
 Figure 6.—*Mussa (Isophyllia) fragilis* Dana. Part of the under side, to show character of the costæ and of the epitheca (e). About natural size.

PLATE XIX.

- Figure 1.—*Mussa (Isophyllia) fragilis* Dana. A young Bermuda specimen with double, partly separate walls, much like the type, but more regular in form. About natural size. Page 123.
 Figure 2.—*Mussa (Isophyllia) dipsacea* Dana. A Bermuda specimen with the calicles mostly isolated and the walls only partly united. Natural size. Page 120.
 Figure 3.—The same. A young specimen with three primary infoldings, just developing. Enlarged about $1\frac{1}{10}$. Page 118.
 Figure 4.—*Mussa (Isophyllia) fragilis* (?). A young five-lobed example, with the infoldings appearing earlier than usual in this species, and therefore resembling *M. multiflora*, to which it may belong. Natural size. Page 121.

- Figure 5.—The same (?). A young, simple, undivided example, probably of *M. fragilis*, in the *Scolymia* or *Lithophyllia* stage. $\times 1\frac{1}{2}$. Page 124.
- Figure 6.—*Mussa (Isophyllia) fragilis* (Dana). A young, typical Bermuda specimen. $\times 1\frac{1}{2}$.
- Figure 7.—*Meandra cerebrum*. Oblique view of a few collines to show dentition of septa. From same specimen as fig. 5, pl. xiv. An exothecal calicle is shown at *b*. About natural size.

PLATE XX.

- Figure 1.—*Mussa (Isophyllia) dipsacea* Dana. A Bermuda specimen with unusually large and shallow calicles. Side view. About $\frac{9}{10}$ natural size. Page 120.
- Figure 2.—*Mussa (Isophyllia) multiflora* Ver., sp. nov. The best type. Natural size. Page 125.

PLATE XXI.

- Figure 1.—*Mussa (Symphyllia) Braziliensis* Ver. Part of the upper surface of the type. No. 1467. Natural size. Page 192.
- Figures 2, 2a.—*Mussa (Symphyllia) hispida* Ver., sp. nov. Portions of the upper surface, No. 4287. $\times 1\frac{1}{2}$. Page 127.
- Figure 2b.—The same specimen. Transverse section. $\times 1\frac{3}{8}$.
- Figure 2c.—The same specimen. Vertical section. $\times 2\frac{1}{2}$.
- Figure 3.—*Mussa (Symphyllia) tenuisepta* Ver., sp. nov. Part of the surface of the type. No. 4542. About $1\frac{3}{8}$ natural size. Page 193.

PLATE XXII.

- Figure 1.—*Mussa Harttii*, var. *confertifolia* Ver., nov., with corallites partly free. Type, No. 4544. About natural size. Page 129.
- Figure 2.—*Mussa Harttii*, var. *intermedia* Ver., nov., with corallites partly united proximally. About natural size. Page 128.

PLATE XXIII.

- Figure 1.—*Mussa Harttii* Ver., var. *conferta* Ver., nov. One of the types. No. 4514. From Bahia. About natural size. $\times 1\frac{1}{5}$. Page 128.
- Figure 2.—The same. Var. *laxa* Ver., nov. Type. No. 1468. Natural size. Page 128.

PLATE XXIV.

- Figure 1.—*Calogyra formosa* Ver., sp. and gen. nov. Type.* Upper side. About natural size ($\frac{9}{10}$). Page 86.
- Figure 2.—The same specimen. Under side. $\frac{9}{10}$.

* Mr. R. P. Whitfield is quite positive that this specimen came from the Bahamas.

PLATE XXV.

- Figure 1.—*Mussa (Isophyllia) multiflora* Ver., sp. nov. A young specimen (No. 4009). Natural size. Page 126.
- Figure 2.—*Mussa (Symphyllia) rigida* (Dana). Type of Dana. No. 4297. Transverse section. $\times 2$. Page 127.
- Figure 3.—The same. A fresh Bahama specimen, in Amer. Mus. Nat. Hist. Natural size. Page 128.
- Figure 4.—*Mussa Harttii*, var. *conferta* Ver. Vertical section of type. $\times 2$. Page 128.
- Figure 5.—*Favia Whitfieldi* Ver., sp. nov. Type, in Amer. Mus. Nat. Hist. No. 543. Natural size. Page 132.

PLATE XXVI.

- Figures 1a, 1b.—*Agaricia fragilis* Dana, from Bermuda. Upper and under sides of two symmetrical young specimens of ordinary size and form. Reduced to $\frac{3}{8}$. Page 142.
- Figure 1c.—The same. Upper side of a specimen with two primary calices, perhaps due to the early coalescence of two young specimens. Page 142.
- Figure 1d.—The same. Side view of two small specimens. All the above reduced to about $\frac{3}{8}$ natural size. Page 142.
- Figure 2.—*Agaricia agaricites*, var. *agaricites*. Part of the surface of a large frondose specimen. No. 5671 (= fig. 7, pl. xxvii). From the Bahamas. $\times 3$. Page 146.
- Figure 3.—The same. Var. *Dance* E. and H. Part of the surface of a frond from a large Bahama specimen (= fig. 6, pl. xxvii). $\times 3$. Page 147.

PLATE XXVII.

- Figure 1.—*Agaricia agaricites*, var. *gibbosa* D. Part of Dana's type from Barbados. No. 1860. Side view of a terminal lobe. Natural size. Page 148.
- Figure 1a.—The same specimen. Calices, $\times 1\frac{1}{2}$.
- Figure 2.—*Agaricia agaricites*, var. *agaricites*, young. About half of a small incrusting Florida specimen. No. 103. Natural size. Page 147.
- Figure 2a.—The same specimen. Calices, $\times 1\frac{1}{2}$.
- Figure 3.—*Agaricia agaricites*, var. *pusilla* V., nov. Part of the type. From Colon. No. 1487. Natural size. Page 148.
- Figure 3a.—The same specimen. Part of upper side. $\times 1\frac{1}{2}$.
- Figure 4.—*Agaricia purpurea* Les., var. *faveolata* V., nov. Upper surface of one of the types. No. 1201. From Colon. $\times 1\frac{1}{2}$. Page 149.
- Figure 4a.—The same specimen. Vertical section. $\times 1\frac{1}{2}$.
- Figure 5.—*Agaricia agaricites*, var. *Dance* E. and H. Part of Dana's type. No. 4301. $\times 1\frac{1}{2}$. Page 147.
- Figure 6.—The same variety. Part of a large frond from the Bahamas. $\times 1\frac{1}{2}$.
- Figure 6a.—The same specimen. No. 5672. A group of calices, $\times 5$.
- Figure 7.—*Agaricia agaricites*, var. *agaricites*. Part of a frond from a large, frondose, Bahama specimen. No. 5671. $\times 1\frac{1}{2}$. Page 147.
- Figure 7a.—The same specimen. Calices, $\times 5$.
- Figures 8, 8a.—*Asteroseris planulata* (Dana) Ver. Small portions of Dana's type. No. 4309. $\times 3$. A transverse section is shown at b. Page 156.

PLATE XXVIII.

- Figure 1.—*Agaricia nobilis* Ver., nov. Type No. 850, from Turks I. Reduced to $\frac{2}{3}$. Page 150.
 Figure 2.—The same specimen. Part of upper surface. $\times 1\frac{1}{6}$.

PLATE XXIX.

- Figures 1, 1a, 1b.—*Mycedium explanatum* Ver., nov. Parts of upper side of type, No. 6173. $\times 1\frac{1}{10}$. Page 136.
 Figure 1c.—The same specimen. Vertical section. $\times 1\frac{3}{5}$.
 Figure 1d.—The same specimen. Under side, near margin. Natural size.
 Figures 2, 2a, 2b.—*Mycedium tenuicostatum* Ver., nov. Parts of upper side of type, No. 6174. $\times 1\frac{1}{10}$. Page 137.
 Figure 2c.—The same specimen. Vertical section. $\times 1\frac{3}{5}$.
 Figure 2d.—The same specimen. Under side. Natural size.
 Figure 3, 3a.—*Echinopora elegans* Ver., nov. Parts of the upper side of the type, No. 6180. $\times 2\frac{1}{2}$. Page 138.
 Figure 4.—*Echinopora concinna* Ver., nov. Part of upper side of the type, No. 6182. $\times 2\frac{1}{2}$. Page 139.
 Figure 5.—*Podobacia dispar* Ver., nov. Part of the upper side of the type, No. 6178, towards the margin. $\times 1\frac{3}{4}$. Page 136.
 Figure 5a.—The same specimen. Under side. Natural size.

PLATE XXX.

- Figure 1.—*Siderastraea radians*. Group of calicles, from a Florida specimen. No. 1901. $\times 2\frac{1}{4}$. Page 153.
 Figure 2.—*Siderastraea siderea*. Group of calicles from a West Indian specimen. No. 1838. $\times 2\frac{1}{4}$. Page 151.
 Figure 3.—*S. siderea*, var. *nitida* Ver., nov. Group of calicles from the type. No. 1028, from Colon. $\times 2\frac{1}{4}$. Page 152.
 Figure 4.—*S. stellata* Ver. Group of calicles from one of the types, No. 1464, from Brazil. $\times 2\frac{1}{4}$. Page 155.
 Figure 5.—*S. stellata*, var. *conferta* Ver. Group of calicles from one of the types, No. 1464a, from Brazil. $\times 2\frac{1}{4}$. Page 155.
 Figure 6.—*Agaricia crassa* Ver. Groups of calicles from the type, No. 514, Am. Mus., from near Nassau. $\times 2$. Page 145.

PLATE XXXI.

- Figures 1, 1a.—*Plesiastrea Goodei* Ver. Groups of calicles from the Bermuda type. No. 6628. $\times 5$. Page 106.
 Figure 2.—*Cyphastrea nodulosa* Ver. Side view of the type. No. 542, Amer. Mus., and No. 6625, Yale Mus. From near Nassau, N. P. $\times 1\frac{1}{2}$. Page 107.
 Figures 2a, 2b.—The same specimen. Groups of calicles, $\times 4$.
 Figures 3, 3a.—*Porites polymorpha* Link. Groups of calicles from a Bermuda specimen. $\times 4$. Page 158.
 Figures 4, 4a.—*Porites astreoides* Les. Groups of calicles from a Bermuda specimen. $\times 4$. Page 160.

Figure 5.—*Porites Verrilli* Rehb. Group of calicles from the type of Verrill, No. 4539. From the Abrolhos Reefs. $\times 4$. Page 161.

Figures 6, 6a.—*Porites Braueri* Rath. Groups of calicles from a Pernambuco specimen. No. 4552. $\times 4$. Page 162.

PLATE XXXII.

Figure 1.—*Acropora muricata*, var. *surculo-palmata* Ver. Top view of a West Indian specimen. No. 6621, having a cluster of var. *prolifera* growing up from a frond of var. *palmata*. Reduced to about $\frac{1}{3}$. Page 165.

Figure 2.—*Oculina varicosa* Les. Branch of a Bermuda specimen, showing prominent corallites on one side and low circumvallate ones on the other side at x, x, x. Natural size. Page 173.

Figure 3.—The same. Part of a branch with more swollen corallites. $\times \frac{1}{4}$.

Figure 4.—The same. Var. *conigera* Ver., nov. Part of the type. From Bermuda. No. 4495. $\times 1\frac{1}{3}$. Page 175.

Figure 5.—*O. Valenciennesi* ? Part of a branch of a Bermuda specimen with low circumvallate corallites. No. 1311. $\times 1\frac{1}{3}$. Page 176.

PLATE XXXIII.

Figure 1.—*Orbicella aperta* Ver. Group of calicles from the type. No. 1518. From the Abrolhos Reefs. $\times 2$. Page 103.

Figure 1a.—The same specimen. Vertical section. $\times 2$.

Figure 2.—*Orbicella cavernosa*, var. *hirta* Ver. Calicles of the type, No. 4517 from Brazil, 1876. $\times 1\frac{2}{3}$. Page 189.

Figure 3.—*Mussa Hartlii*, var. *conferta*, growing out from a branch of var. *laxa*. No. 4545. From Brazil. About natural size ($1\frac{1}{8}$). Page 128.

Figure 4.—*Mussa (Symphyllia) Braziliensis* Ver. Group of calicles from the type. No. 1467. About natural size. Page 192.

PLATE XXXIV.

Figure 1.—*Meandrina Braziliensis* (E. and H.) Vaughan. A mature specimen from Bahia. No. 4543. About natural size ($\frac{1}{16}$). Page 190.

Figure 2.—*Agaricia crassa* Ver., sp. nov. Side view of one of the types. From Nassau, N. P., No. 514, Amer. Mus. About natural size. Page 145.

PLATE XXXV.

Figure 1.—*Mussa annectens* Ver., sp. nov. Part of one of the types. From Bermuda. $\times 1\frac{3}{4}$. Page 178.

Figure 2.—The same specimen. Natural size.

[Cuts in the text, Nos. 3, 8, 9, 10, 13; and 4, 5, 6 of Article II, were loaned by the publishers of Webster's International Dictionary. The others are original.]

ADDENDA.

Since this article was put in type I have corresponded with Dr. T. W. Vaughan, in regard to various debated cases in the nomenclature of the West Indian Reef Corals, concerning which we did not agree, as stated above in Article III. See also note, p. 169.

He has recently authorized me to state that he now agrees with my determinations in the following cases:—

Meandra versus *Platygyra*. P. 66–68.

He accepts the former name, as restricted by me (p. 66), instead of *Platygyra*, and also agrees with me as to the necessity of uniting to it *Diploria*, *Manicina* (auth.), and *Cecloria*. (See p. 67.)

Acropora versus *Isopora*. P. 164, 208.

He accepts the name *Acropora* for this genus, as restricted (p. 164) instead of *Isopora*. He also agrees with me as to the restriction of *Madrepora* to the type of *M. oculata*, = *Amphihelia* and *Lophohelia*. See pp. 110–113.

Madracis versus *Axohelia*. P. 109.

He accepts the former, as having priority.

Orbicella annularis versus *O. acropora*. P. 94, 95.

He agrees with me as to the propriety of using the former name.

In respect to the restriction of *Meandrina* to the type of *M. meandrites* = *Pectinia* auth. we were already in accord (p. 66). Also in the use of *Favites* for *Prionastrea* (p. 92); and in the union of all known West Indian forms of *Acropora* under the name *muricata* (p. 165). On some other minor points we no longer differ.

But he does not, at present, agree with me in the use of *Meandra cerebrum* in place of *M. viridis*, on the ground that he does not consider the description of Ellis and Solander sufficient for the identification of the species. (See pp. 74, 77.)

Nor does he agree with me as to the use of *Porites polymorpha* (p. 158), instead of *P. porites* or *P. clavaria*. He believes that Ellis and Solander practically restricted *porites* to the type of *clavaria*. If their treatment of the species can be considered as such a restriction, then the name properly should hold for this species. But I have not hitherto considered that Ellis and Solander intended to separate the West Indian form from others, but that they merely described the form that they had from the West Indies as an example of the species. This point is a debatable one.

Mr. Vaughan's family name *Favidae* is equivalent to my *Meandridae* (p. 65), and has priority. His use of the family name *Orbicellidae* also has priority over my identical use of it (p. 93).

V.—NOTES ON CORALS OF THE GENUS ACROPORA (MADREPORA LAM.) WITH NEW DESCRIPTIONS AND FIGURES OF TYPES, AND OF SEVERAL NEW SPECIES.

BY A. E. VERRILL.

MANY changes in the nomenclature of this great and difficult genus have recently been made, especially in the extensive descriptive catalogue by Brook. But in consequence of the new determinations of many of the species by him, and of his redescrptions of a number of the types of Ehrenberg, Edw. and Haime, Quelch, and others, it has become very desirable to compare the types of Dana and other American writers with his new descriptions.

It is certain that there is still great confusion among writers on corals as to the character and limits of many of the species of this genus, and especially as to the application of the names given by Lamarck, Ehrenberg, and other early writers to some of the species.

Such Lamarckian names as *luxa*, *abrotanoides*, *corymbosa*, and others have each been applied to a dozen or more species, by as many different writers.

This is due partly to the total lack of figures of many of the older types, and partly to the very short and imperfect descriptions. Brook has done great service by redescrbing in detail many of these original types, in the museums of Berlin, Paris, and the British Museum. But if he could have figured them, his work would have been of much greater value.

Now that photographs of corals can be so easily and cheaply reproduced, it is to be hoped that all the extant types will soon be illustrated.

At this time, owing to the lack of funds for the purpose, I am able to give figures of only a few of the types in our museum, but I hope that more work of this kind can be done at no distant time.

In this article I have undertaken to redescrbe only a few selected out of the whole number of Dana's types that are in the Yale Museum,* selecting those in respect to which European writers have made the most mistakes, and those which Dana did not figure. I

* The principal set of Dana's types is in the U. S. Nat. Museum. Those have been enumerated by Mr. R. Rathbun, Proc. U. S. Nat. Mus., x, 1887. But he did not redescrbe them.

have also given additional descriptions of several of my own types, described in 1864–68, and on the type of *A. tubigera* (Horn, 1860) I have added descriptions of several new species.

A number of these types are here figured from enlarged photographs, made by Mr. A. Hyatt Verrill.

Acropora Oken (restr.). Type, *A. muricata*.

Madrepora (*pars*) Lam., Syst. Anim., p. 371, 1801 (*non* Linné, ed. x). Lam., Hist. Anim. s. Vert., ii, p. 277, 1816. Dana, Zoöph., p. 435, 1846. Edw. and Haime, Hist. Corall., iii, p. 132, 1860 (*non* Ehr.).

Acropora (*pars*) Oken, Lehr. Naturg., p. 66, 1815 (type, 3d species=*A. muricata*).

Madrepora Brook (with ten subgenera), Cat. Mad. Brit. Mus., i, p. 22, 1893.

Isopora Vaughan, Fossil Corals Curacoa, etc., p. 68, 1901. Stony Corals Porto Rican Waters, Bull. U. S. Fish Comm. for 1900, ii, p. 312, 1901.*

On pages 110–113 and 164, I have given reasons for displacing *Madrepora* as the name of this genus, and for the substitution of *Acropora* Oken.

In brief they are these:

- 1st. No recognized species of this genus was included in *Madrepora* by Linné, in his Syst. Nat., ed. x.
- 2d. *M. muricata* (auth.), which originally included all the known species of *Acropora*, was put under *Millepora* in the ed. x, though placed in *Madrepora* in ed. xii, as also by Pallas. Therefore it cannot properly be taken as the type of *Madrepora* if the ed. x is to be used as the starting point of the binomial system.
- 3d. Lamarck, in 1801, gave only two species as examples of *Madrepora*, viz: *M. muricata* and *M. porites*. The latter was made the type of the genus *Porites* by Link, in 1807, otherwise it might have been adopted for the type of *Madrepora*.
- 4th. Oken, in 1815, proposed the genus *Acropora*, including three species, of which the third was *A. muricata*. This can be adopted as its true type, because the second had already been placed in *Porites* by Link, 1807; and the first was placed in *Pocillopora* by Lamarck, in 1816. This leaves the name *Acropora* clearly available for the great genus of which *A. muricata* is the type.

The genus *Acropora* (restr.) is characterized by the presence of at least two forms of corallites. In all branched forms there is a sym-

* Mr. Vaughan has recently authorized me to state that he now accepts the name *Acropora* for this genus, instead of *Isopora*. See p. 206.

metrical and usually larger axial corallite at the end of each branch (sometimes more than one), which produces radial or lateral buds around its base. These buds mostly develop into a symmetrical, often one-sided or labiate radial corallites in which the zooids may have longer directive tentacles and wider directive septa.

More or less of the radial corallites become larger and symmetrical and eventually may become the axial corallites of new branches or branchlets.

Other radial corallites, without prominent lips, often occur on the larger branches, or on their under sides, wholly immersed in the cœnenchyma.

Most, if not all, of the species when young form incrusting groups or plates. In this stage new corallites are formed around the margins from exothecal buds. Massive or unbranched species sometimes have scattered axial corallites, scarcely more prominent than the others.

The porous cœnenchyma is usually scanty in the smaller branches, but often becomes abundant in the basal mass and larger branches.

The septa are usually 12, in two cycles, those of the second cycle being narrow and thin, and often rudimentary or entirely lacking. The directive septa are usually wider than the others, and often unequal. Sometimes all the septa are nearly abortive.

In several species a few larger or giant calices occur, with 24 septa.

The surface of the cœnenchyma varies much in character and often furnishes useful specific characters, but it is liable to vary on different parts of a single specimen, according to age and other conditions. It is commonly porous or pitted, and more or less thickly covered with minute rough or sharp spinules or granules.

The walls of the corallites may be regularly costulate, or else covered with granules, either in rows or densely grouped. These differences afford useful specific characters, but are liable to vary.

Brook (Cat. Mad., 1893) recognized 220 species. Probably many of these will be united when larger series can be compared. Probably Brook has attached too much importance to variations in modes of growth.

I have studied about 120 species, most of which seem valid, including those described by Dana, a number of the types of Edw. and Haime, and many others from China, the East Indies, Ceylon, Red Sea, etc. But of many of these I have not seen good series.

The types of most of Dana's species collected by the U. S. Expl. Exped. are in the U. S. National Museum. The first series of the duplicates of that collection was early given to Professor Dana for

the Museum of Yale University. These I found in the original packages, with Dana's labels, when I took charge of them in 1864.

A second series of duplicates was selected from the collections in the National Museum (then in the Smithsonian Inst.) by me in 1860, under the direction of Professor S. F. Baird, for the Museum of Comparative Zoölogy.

The types of Dana's species received from other sources are mostly in the Museum of Yale University. The most important of these came from Point Pedro, Ceylon, collected in 1843, by the Rev. George H. Apthorp, who was a missionary there, 1833-1844. His letters relating to this valuable collection are still preserved in the museum.* Some of the specimens recorded by Dana as from "Singapore" probably were from this collection, but others were correctly recorded as from Ceylon:—e. g. *M. effusa*, *M. plantaginea*, *M. efflorescens*. The locality-labels of some of the Ceylon specimens were lost before Dana studied them.

The types of my own species, from the U. S. North Pacific Expl. Exped., are in the Nat. Mus., but duplicates or fragments of most of them are also in the Museum of Yale University. Other species described by me in 1864-1866 are in the Museum of Comparative Zoölogy and Yale Museum. The species studied by me from the Red Sea were mostly in the Ward collection, afterwards purchased by the Field Columbian Museum of Chicago, but duplicates or fragments of many of them are also in the Yale Museum.

All the West Indian forms seem to be mere growth-varieties of one polymorphic species. See *A. muricata* and varieties, pp. 165-168.

* The Rev. George H. Apthorp, of the American Ceylon Mission, was born May 31st, 1798, at Quincy, Mass.; died at Oodoopitty, Ceylon, June 8th, 1844. He graduated at Yale College in 1829, and at Princeton Theol. Seminary in 1832. Sailed for Ceylon July 1833, arriving there in Oct. 1833.

He was a very devout man and a devoted missionary, laboring, apparently, in a very barren and unpromising field, under many and great disadvantages.

The collection of corals was made at Point Pedro, about 7 miles from Varany, where he was then stationed with his wife, who aided in obtaining and bleaching the corals, and also in making a collection of shells sent with them.

In his letters of 1843, to Prof. Benj. Silliman, Sr., he mentions some of the difficulties encountered, both in obtaining and also in packing the corals, for no suitable packing materials could be had, except the cast-off garments of the girls in the mission school. His specimens arrived in good condition, however.

He also states that no other corals had ever been sent away from that locality. Some of the species sent by him are still very rare in collections, as for example, *Pocillopora grandis* D.

Notes on the Distribution and Subdivisions of Acropora.

The following list contains most of the species that I have personally studied, with their principal recorded localities. It is probable that most of the East Indian species have a very wide distribution, though at present recorded from only a few localities, or perhaps from only one. Many species are known to range from Singapore to Tahiti or the Fiji Is., or even to the Great Barrier Reef, and to the Red Sea. Probably many others will be found to have as great a range, when more fully collected.

This wide distribution, and even a greater one, is well known to occur, also, in the case of numerous mollusks, echinoderms, etc., characteristic of the Indo-Pacific fauna.

But it is probable that local variations, especially in growth-forms, will occur in the same coral when found in widely separated localities, as is the case in other groups. Probably many of these growth-variations have been described as distinct species, but without a large series of specimens it is not possible to determine this, in most cases. The variations of *A. muricata* in the West Indies should serve as a caution against overestimating the importance of mere forms of growth in corals of this genus and others.

Many mollusks and echinoderms of the East Indian fauna range to Australia, Africa, and even to the Hawaiian Islands. But I have never seen an authentic specimen of *Acropora* from the Hawaiian Islands. Local collectors assert that the genus does not occur there. But great quantities of corals, etc., are brought from the Polynesian Islands to Honolulu by the missionary vessels and sold there as curiosities.

Many corals, seen in collections, labelled as from the Hawaiian Islands, have been obtained in this way, but are natives of the Caroline Islands, Ebon Island, the Kingsmills Islands, etc. This is especially the case with ornamental species, like *Stylaster elegans* V., *Distichopora nitida*, etc.

Probably this was the case with the several species of *Acropora*, recorded from the Hawaiian Islands by Brook. Their occurrence there certainly needs confirmation, for in the large authentic collections of corals that I have studied from those islands no *Acropora* has occurred.

Specimens of corals are brought to Singapore from long distances by the natives, for sale, and thus may be recorded from there erroneously.

Similarly, species of this genus have been recorded from St. Helena, the White Sea, etc., where they probably do not live.

Though some of the ten "subgenera" of Brook are useful divisions, for diagnostic purposes, others are not of any practical value, and often serve more to mislead than to help the student. This remark applies particularly to those based on slight differences in the mode of growth or branching, and on small variations in the size or prominence of the terminal or axial corallites. One part of a single specimen will often go in one such "subgenus," while another part will go in another.

The forms of the radial corallites; the texture of the cœnenchyma; and the presence or absence of distinct costæ, would give more constant characters for the differentiation of sections of the genus.

For this reason much enlarged photographic figures of the calicles and cœnenchyma are of the greatest value in illustrating species of this genus. Drawings seldom give the complex texture satisfactorily. Young specimens of all the profusely branched species appear totally unlike the mature forms, and are, therefore, apt to be erroneously determined.

List of Species of Acropora examined.

I have arranged the species alphabetically, for greater convenience of reference.

An asterisk prefixed, indicates that the species is in the Museum of Yale University.

Authorities for names and localities are often much abbreviated: B.=Brook; D.=Dana; E. and H.=Edw. and Haime; Kl.=Klunzinger; Q.=Quelch; R.=Rehberg; St.=Studer; V.=Verrill.

**Acropora abrotanoïdes* (Lam., non Dana, see *polymorpha*).
Brook, op. cit., p. 56, 1893.

Singapore (B.); Polynesia; Tahiti (B.); Great Barrier Reef (B.).

**A. acervata* (Dana). Brook, p. 147. See notes, below.

Singapore (D., V.).

**A. aculeus* (Dana). Brook, p. 104.

Fiji (D.); Philippines? (Quelch).

**A. acuminata* (Ver.) Brook, p. 38. See notes, below.

Kingsmills Is. (Ver.).

**A. alliomorpha* (Brook, p. 87).

Singapore (B.).

**A. amblyclados* (Brook, p. 140).

Singapore, Indian O., and Australia (B.).

**A. appressa* (Ehr., D., not *appressa*, as in Edw. and H.) Brook, p. 85. See notes, below.

Singapore and Ceylon (D., V.).

Loc. of type unknown.

- **A. Arabica* (E. and H.) Brook, p. 66.
Red Sea (E. and H.); Seychelles (B.).
- **A. arbuscula* (D.) Brook, p. 40. See notes, below.
Singapore (D., V., B.); East Indies; Sulu Sea (B.); Great Barrier Reef (B.).
- **A. arcuata* (Brook, p. 102, pl. xii).
Samoa (Br.); Fiji ? (V.).
- **A. armata* (Brook, p. 100; non *M. spicifera*, Var., D., pl. 33, figs. 4, 4a, young). Brook, p. 100. See *A. cytherella* and *A. turbinata* in notes, below.
Singapore; Tahiti (B.); Fiji ?; Diego Garcia (B.). Perhaps not distinct from *turbinata*.
- A. aspera* (D.) Brook, p. 62.
Fiji (D.); Philippines (Q.); Great Barrier Reef (B.); New Hanover (B.).
- **A. assimilis* (Brook, p. 85, pl. xx, fig. A.=*M. appressa* D., non Ehr., t. Brook). See notes, below.
Singapore (D., V.); Ceylon (V.); Amboina (Q.).
- **A. austera* (D.) Brook, p. 56. See notes, below.
Singapore (B.); Philippines ? (Q.).
- **A. brachiata* (D.) Brook, p. 43.
E. Indies; Sulu Sea (D.); Fiji, Sumatra, etc. (B.).
- A. calamaria* (Brook, p. 154, pl. xxiii, A, B.).
Rodriguez (B., type).
- A. Brueggemanni* (Brook, p. 145, pl. xxiv, xxxv)=*M. laxa* Brug., non Lam.
Singapore (type, B., V.); Torres St. and G. Barrier Reef (B.).
- **A. canaliculata* (Klz.) Brook, p. 151.
Red Sea (Kl.); G. Barrier Reef (B.).
- **A. carduus* (D.) Brook, p. 178.
Fiji (Q.); New Britain (B.); Mauritius (B.); ? Australia (B.).
- **A. cerealis* (D.) Brook, p. 91.
Sooloo Sea (D.); Singapore (B.); Amboina (B.); Ternate (B.); Samoa, Fiji, and Tongatabu (B.); Great Barrier Reef (B.); Mauritius and Seychelles (B.).
- A. clathrata* (Brook, p. 49, pl. v, vi).
Mauritius (B.).
- A. concinna* (Brook, p. 165, pl. xvii).
Mauritius, type, and Amirante Is. (B.).
- A. conferta* (Q.) Brook, p. 108.
Fiji (Q.); Tongatabu, Torres St., Amirante Is., and Great Barrier Reef (B.).

- **A. confraga* (Q.) Brook, p. 182.
Fiji (Q.); Malacca (B.); Pelew I. (V.).
- **A. conigera* (D.) Brook, p. 34.
Singapore (D., V.).
- **A. convexa* (D.) Brook, p. 118.
Singapore (D., V.); Cebu I. and Ceylon (V.); Tongatabu and Gr. Barrier Reef (B.).
- **A. corymbosa* (Lam., non Dana) Brook, p. 97. See *sureulosa*.
Indian O.; Red Sea (Kl., B.); Rodriguez (B.); Zanzibar ? (V.);
China (B.); Tahiti (B.); Great Barrier Reef (B.); Fiji (B.);
Ramesvarum (B.); Tizard Bank (B.).
- A. cribripora* (D.) Brook, p. 123.
Fiji (D.); Tongatabu and Gr. Barrier Reef (B.).
- **Aeropora cucullata* Ver., sp. nov. See notes, below.
Indo-Pacific (V.).
- A. cuneata* (D.) Brook, p. 134.
Fiji (D., Q., B.); Great Barrier Reef (B.).
- **A. cuspidata* (D.) Brook, p. 124.
Tahiti (D.); Pouapé (B.).
- **A. cyclopea* (D.; not *cycloptera*, as in E. and H.) Brook, *pars*, p. 33.
Wakes I., Pacific O. (D., V.). Not West Indian, as in Brook.
- **A. cytherea* (D.) Brook, p. 99.
Tahiti (D., V.); Singapore (D., B.); Solomon Is. (B.); Ceylon
(B.); Mauritius (B.); Red Sea (Kl., B.); Diego Garcia (B.).
- **Aeropora cythereella* Ver., sp. nov. (= *M. spicifera* D., var.).
See notes, below.
Tahiti (D.).
- **A. Danae* (E. and H., Ver., = *M. deformis* D., non Mich.) Brook,
p. 57.
Tahiti (D.).
- **A. diffusa* (Ver.) Brook, p. 80. See notes, below.
Kingsmills Is. (V.); Banda (Q., B.); E. Indies (B.).
- **A. digitifera* (D.) Brook, p. 75. See notes, below.
E. Indies (D., V.); Madagascar (B.); Gr. Barrier Reef (B.).
- **A. dissimilis* Ver. sp. nov. (= *M. echidnea* D., non Ehr.). See
notes below.
E. Indies and Sulu Sea (D.).
- **A. divaricata* (D.) Brook, p. 64.
Fiji (D.); Seychelles (B.); Gr. Barrier Reef (B.); Amirante Is.
(B.).
- **A. echinata* (D.) Brook, p. 184.
Fiji (D.); Sulu Sea (B.); Liu Kiu Is. (B.); Samoa (B.); Australia
(B.); ? Hawaii (B.), probably imported.

- **A. efflorescens* (D.) Brook, p. 35.
Ceylon (D., V., type in Yale Mus.); Fiji (D.); Singapore (B.).
- **A. effusa* (D.) Brook, p. 76 (*non* Quelch, t. Brook). See notes, below.
Ceylon (D., V., type in Yale Mus.); Great Barrier Reef (B.).
- **A. Ehrenbergii* (E. and H. = *scandens* (Kl., t. Brook) Brook, p. 48.
See notes, below.
Red Sea (E. and H., B., V.); Persian Gulf (B.); Indian O. (B.).
- **A. erythraea* (Kl.) Brook, p. 157.
Red Sea (Kl.); Mauritius and Maldive Is. (B.); Great Barrier Reef (B.).
- A. exigua* (D.) Brook, p. 125.
Fiji (D.); New Hebrides and Solomon Is. (B.).
- A. exilis* (Brook, p. 172, pl. x, C, D).
G. Barrier Reef (B., type); China Sea and Arafura Sea (B.).
- **A. florida* (D.) Brook, p. 53.
Fiji (D.); Tongatabu, Malacca, and Louisade Is. (B.).
- **A. formosa* (D.) Brook, p. 43.
Fiji (D.); E. Indies (V.); Sumatra, Torres St., Sulu Sea, New Ireland (B.).
- **A. Forskalii* (Ehr., Kl.) Brook, p. 70.
Red Sea (Ehr., K., V.); Persian Gulf (B.).
- **Acropora fraterna* Ver., sp. nov. (= *M. plantaginea*, pars, Br.).
See notes, below.
Tahiti (D.).
- **A. gemmifera* (Brook, p. 142, pl. xxi, near *A. fruticosa* Br.
Fiji, Torres St., Arafura Sea, and G. Barrier Reef, type, (B.).
- **A. globiceps* (D.) Brook, p. 152.
Tahiti (D.).
- **A. gracilis* (D.) Brook, p. 32.
Sulu Sea (D.); Fiji, Amboina, and Ceylon (B.).
- A. grandis* (Brook, p. 42, pl. i, f. A, B).
G. Barrier Reef (B.).
- **A. gravida* (D.) Brook, p. 59.
Singapore (D., V.); Fiji and G. Barrier Reef (B.).
- A. Huimei* (E. and H.) Brook, p. 77 (*non arbuscula* Ver.).
Red Sea (E. and H., B., V.); Ceylon, Mauritius, Maldives, Singapore, and Fiji (B.).
- **A. hebes* (D.) Brook, p. 128.
Fiji (D., V., B.); Malacca, Torres St., and G. Barrier Reef (B.).
- A. Hemprichii* (Ehr., Kl.) Brook, p. 173.
Red Sea (Ehr., K., V., B); Ceylon, Solomon Is., and G. Barrier Reef (B.).

- **A. horrida* (D.) Brook, p. 188.
Fiji (D., V.); ? Arafura Sea (B.).
- A. humilis* (D.) Brook, p. 145.
Fiji (D., B.); G. Barrier Reef (B.).
- **A. hyacinthus* (D.) Brook, p. 107.
Fiji (D., V., B.); Tizard Bank and G. Barrier Reef (B.).
- A. hydra* (Brook, p. 181, = *M. longicyathus* Ort., non E. and H., t. Brook).
Singapore (V.).
- **A. implicata* (D.) Brook, p. 172.
Fiji (D.).
- **A. indurata* Ver., sp. nov. See notes, below.
Australia (V.).
- A. (Isopora) labrosa* (D., Stud.). See *A. palifera*.
Sulu Sea (D.).
- **A. laxa* (Lam., non Ehr.) Brook, p. 46, from type.
Seychelles, Rodriguez, Macclesfield Bank, and G. Barrier Reef (B.).
- **A. longicyathus* (E. and H., non Ort.; non *prolixa* V.) Brook, p. 187, from type.
New Guinea (B.); Palau I. (V.).
- **A. Luzonica* Ver., sp. nov. See notes, below.
Luzon, near Manilla (V.), type in Yale Mus.
- **A. microphthalmia* (Ver.) Brook, *pars*, p. 168. See *A. parvistella* V., and notes, below.
Loo Choo Is. (V.), type in Yale Mus.
- **A. millepora* (Ehr., D., non D., t. Brook). Brook, p. 116. See notes below.
Singapore (D., V., B.); Ceylon (D., V., B.); Gr. Barrier Reef (B.).
- **A. muricata* (L.), Oken. Brook, pp. 23-30. See pp. 166-169.
- *Var. *cervicornis* (Lam.).
- *Var. *prolifera* (Lam.).
- *Var. *flabello-prolifera* (Ver., p. 167).
- *Var. *palmato-prolifera* (Ver., p. 167).
- *Var. *surculo-palmata* (Ver., p. 167).
- *Var. *cornuta* (D. and M.).
- *Var. *flabellum* (Lam.).
- *Var. *palmata* (Lam.).
- *Var. *perampla* (Horn) V., p. 168, = *M. alces* auth., ? non Dana.
- *Var. *infundibulum* (Ver., p. 168).
- Var. *columnaris* (Ver., p. 168).
- *Var. *clivosa* (V. = *cyclopea* Br., non Dana).
Florida and the West Indies, to Colon and Cumana.

- **A. nasuta* (D.) Brook, p. 73. See notes, below.
Tahiti (D., V., B.); Fiji (B.).
- **Aeropora neglecta* Ver., sp. nov. See notes, below.
Fiji (Dana).
- **A. nobilis* (D.) Brook, p. 135. See notes, below.
Singapore (D., V.); Ceylon (V.); Java (B.).
- *Var. *secunda* (D., Ver. from type). ? Brook (*pars*) p. 30.
Singapore (D., V.); Ceylon (B.).
- A. ocellata* (Klz.) Brook, p. 148.
Red Sea (Kl., V.); Ceylon (B.).
- **A. pachycyathus* Ver., sp. nov. See notes, below.
Locality unknown, Indo-Pacific (V.).
- A. Pacijica* (Brook, p. 39).
Samoa I. (type), and Tizard Bank (B.).
- **Aeropora paniculata* Ver., sp. nov. See notes, below.
Fiji or Tahiti (V.).
- A. parvistella* (Ver. 1864 = ? *M. microphthalma* B., non Ver.),
Brook, p. 197. See notes, below.
Singapore (V.).
- **A. paxilligera* (D., non Q.) Brook, (*pars*) p. 74.
Tahiti (D., V., B.); Fiji and Mergui Arch. (B.).
- A. Pharaonis* (E. and H.) Brook, p. 58 = *microcyathus* Kl.
Red Sea (E. and H., B., Kl., V.); Indian O. and Keeling I. (B.).
- A. plantaginea* (Lam., non D., t. Brook). Brook, p. 156.
Tahiti; Samoa, Tongatabu, and Ceylon (B.).
- A. pocillifera* (Lam., D.) Brook, p. 61, descr. from Lam., type.
Tongatabu (Lam., B.); Tahiti (Q., B.); Fiji (B.); New Hebrides,
and G. Barrier Reef (B.).
- **A. polymorpha* (Brook), p. 169 = *M. abrotanoides* D., non Lam.).
See notes, below.
Fiji? (D.); Malacca (B.).
- **A. proluxa* (Ver. non = *longicyathus*, as in Brook, p. 187. See
notes, below, and figure.
Ousima (V.).
- **A. prostrata* (D., non Q.) Brook, p. 119.
Sulu Sea (D.); ? Fiji (D., B.); ? G. Barrier Reef (B.).
- **A. pumila* (Ver.) Brook, p. 166. See notes, below, and figure.
Bonin Is. (V.).
- A. (Isopora) palifera* (Lam., Brook from type, non D.) Brook, p.
131 = *M. labrosa* D., t. Brook.
Sulu Sea (D., B.); China Sea, Solomon Is., Diego Garcia, New
Guinea, Tizard Bank, Queensland, and G. Barrier Reef (B.).

- **A. pyramidalis* (Klz.) Brook, p. 150.
Red Sea (Kl., V., B.); Mauritius, Mergui Arch., Pelew Is., Caroline Is., China Sea, and G. Barrier Reef (B.).
- **A. ramiculosa* (D., non Q., nec Ortm.).
Fiji (D.).
- **A. retusa* (D.) Brook, p. 77.
Fiji (D., B.); Tahiti (B.).
- A. robusta* (D.) Brook, p. 42.
Fiji (D., B.).
- A. rosacea* (Esp., Stud., Q.) Brook, p. 84. See *dissimilis*, and notes, below.
Ternate and Samboangan (Q., B.).
- **A. rosaria* (D.) Brook, p. 179.
Fiji (D.); Tahiti; Samoa, Louisade Arch., Caroline Is., Tongatabu, and G. Barrier Reef (B.).
- **A. Samoensis* (Brook, p. 143).
Samoa (B., V.).
- **A. scandens* (var. of *Ehrenbergii*, t. Brook, p. 49). See notes, below.
Red Sea (Kl., V.).
- **A. secale* (Stud., non Q.) Brook, *pars*, p. 87, = *M. plantaginea* *pars*, D., non Lam. See notes, below.
Ceylon (D., V.); Singapore? (B.); ? China and Tizard Bank (B.).
- **A. secaloides* Ver., sp. nov. See notes, below.
Singapore (D., V.).
- **A. secunda* (D., non Brook). See under *A. nobilis*, var., and notes, below.
Singapore (D., V.).
- **A. (Isopora) securis* (D., non Q., t. B.) Brook, p. 133.
E. Indies? (D.); Solomon Is. and Amirante Is. (B.).
- **A. seriata* (Ehr., D.) Brook, p. 149 = *pallida* and *pyramidalis* (*pars*) Klz., t. Brook.
Red Sea (Ehr., Kl., B.); Mauritius, Mergui Arch., Ceylon, and G. Barrier Reef (B.).
- **A. Solanderi* (Def.).
Tertiary of France.
- A. spectabilis* Brook, op. cit., p. 141, pl. xviii, fig. B.
Locality of type unknown (B.).
- **A. spicifera* (D.) Brook, p. 92 = *microclados*, *pars*, Ehr., Stud.
Singapore (D., V., B.); Fiji (D., B.); Tahiti (D., V.); Ceylon (D., V., B.); Tizard Bank, China Sea, Gulf of Aden, Mergui Arch., Tongatabu, New Ireland, New Guinea, New Caledonia, and Solomon Is. (B.).

- **A. squamosa* (Brook, p. 120, pl. xx, fig. B.). See notes, below.
Singapore (B., V.); G. Barrier Reef (B., type).
- A. squarrosa* (Ehr.) Brook, p. 65.
Red Sea (E., Kl., B., V.); Pelew I., Ponapé, Tahiti, and Australia (B.).
- **A. stellulata* Ver., sp. nov. See notes, below.
Zanzibar (V.).
- **A. striata* (Ver.) Brook, p. 178. See notes, below.
Ousima? (V.).
- **A. subulata* (D.).
Singapore (D., V., B.); New Guinea (B.).
- **A. subtilis* (Klz.) Brook, p. 68.
Red Sea (Kl., V., B.); Solomon Is. (B.).
- **A. surculosa* (D.) Brook, p. 104. See notes, below.
Fiji (D., B.); Singapore (D., V., B.); Mergui Arch., and G. Barrier Reef (B.).
- **M. symmetrica* (Brook, p. 94, pl. xv). See notes, below.
Mauritius (B., type); Zanzibar (V.).
- **A. tenuis* (D.) Brook, p. 83.
Locality of type unknown (D.); Samboangan and G. Barrier Reef (B.).
- A. teres* (Ver.) Brook, p. 198.
Ousima (V.).
- **A. tortuosa* (D.) Brook, p. 71.
Fiji (D.); Caroline Is. (B.).
- **A. tubigera* (Horn, *non* Quelch, *nee* Brook, p. 79). See notes, below.
Singapore (V.). Type examined.
- **A. tubicinaria* (D.) Brook, p. 139.
Fiji (D.); Tahiti (V.).
- **A. tubulosa* (Ehr.) Brook, p. 175.
Red Sea (Ehr., Klz.); New Guinea, Carolina Is., and Malacca (B.).
- **A. turbinata* Var.? See *A. surculosa*, and notes, below.
Tahiti (D., type in Yale Mus.).
- **A. tumida* (Ver.) Brook, p. 163. See notes, below.
Hong Kong (V.); China (B.).
- A. turgida* (Ver.) Brook, p. 198.
Loo Choo Is. (V.).
- **Acropora urceolifera* Ver., sp. nov. (= *M. corymbosa* D., *non* Lam.).
E. Indies (D.).

A. valida (D.) Brook, p. 168.

Fiji (D., B); Tongatabu, Torres St., Mergui Arch., and Singapore (B.).

**A. variabilis* (Kl.) Brook, p. 161=*coalescens* Ort., t. Br.

Red Sea (Kl., V.); Ceylon, Macclesfield Bank, Samoa, Tongatabu, and G. Barrier Reef (B.).

**A. virgata* (D.) Brook, p. 40.

Fiji (D., B.); Tahiti (B.); New Hanover, Amboina, and Tongatabu (B.).

**A. Wardii* Ver., sp. nov. See notes, below.

Indo-Pacific (V.).

The localities of numerous specimens of species included in the above list, that I have studied, were doubtful or unknown, many of the specimens having been bought from dealers. In such cases I have omitted the doubtful localities, adding only those that seemed to be authentic.

Probably many of the localities given by others, and quoted here, are not altogether reliable, for the same reasons.

Another source of error lies in the various modes of cleaning and bleaching the specimens. Chemicals are sometimes used that injure the delicate parts. Long exposure to the weather, as in bleaching them, always destroys or changes the delicate septa, margins of the calicles, and especially the fine spinules of the surface.

Acropora acervata (Dana) Ver. See p. 212.

Madrepora acervata Dana, Zoöph., p. 460, pl. xxxiv, fig. 4, 1846. Brook, Cat. Madreporarian Corals British Mus., i, p. 147, 1893.

?*Madrepora amblyclados* Brook, op. cit., p. 140.

PLATE XXXVI. FIGURE 17. PLATE XXXVI B. FIGURE 8.

Brook assumed, without due evidence, that my (1864) determination of Dana's species was incorrect and that I had a distinct species in view. However, I had Dana's types in my hands for comparison, and still have some branches that he specially described, for the details.

Brook merely quotes Dana's description and records no additional specimens. This indicates that he had not identified the species, although it is a common one at Singapore. Doubtless he has it under some other name or names in his catalogue.

Brook was, however, probably correct in stating that Dana's species is not the same as *M. plantaginea* Lam., as described by him

from a specimen supposed to be one of Lamarek's types. But it was probably included under that heterogeneous species by Lamarek and by Edw. and Haime.

This species forms broad convex clumps of rather stout, upright, more or less divided, obtuse branches, with a large, swollen axial corallite. The clumps arise from a broad, short basal mass; the outer and under ones are curved and spread out nearly horizontally in the larger specimens, and they often become flattened, irregular, and more or less coalescent, but they may be much coalescent on one side of a clump and entirely free on the other. In young specimens the outer branches are less spreading, or more upright, and do not coalesce. The central branches of the upper side are mostly 60 to 70^{mm} long, often forked at the base, and may give off two or more small divergent, ascending branches from the middle portion, or distally. The calicles of the horizontal branches and bases of the upright ones are mostly immersed, but rather large and conspicuous, with a very distinct star of six primary septa, the directives larger. Our largest specimen (No. 6118, from Singapore) is a foot in diameter (300^{mm}), and half as high. I have seen others considerably larger, from Singapore.

The axial corallites are large (4^{mm}), very short, obtuse, with very thick, openly porous walls, and a rather small calicle (1^{mm}), which has a distinct star of 12 septa, the directives wider. The lateral calicles are various in size and form. The larger ones are large and thick, tubular, strongly ascending, but not much appressed, with the distal margin obliquely truncate, so that the margin of the calicle is very oblique.

The outer side of these calicles is much thickened and rounded at the outer lip, so that the corallites often appear slightly scaphoid; in some cases they are somewhat appressed, but usually the inner lip is fairly well developed, though much shorter and thinner than the outer. The star is very distinct, usually with 12 septa; the six primaries are wide, the directives broader; those of the second cycle are very narrow and thin, often absent. The exterior wall of these corallites is porous and densely echinulate-costate, the small spinules being arranged in costal lines.

Among the larger corallites are many others that are equally wide, but much shorter, more divergent, the calicles opening more outward, but with a similar thick outer lip and star. Lower down many are verruciform and a few small ones are immersed.

The cœnenchyma of the branches is firm, but somewhat porous,

and covered with sharp or blunt rough spinules, which are not very fine nor very closely arranged; in some places it becomes reticulate-porous.

Singapore (D.; V., type). Several perfect specimens are in the Museum of Yale University (coll. Capt. Putnam and others) from Singapore. I have studied others, from the same sources, in the Mus. of Comp. Zoölogy; the Peabody Inst., Salem, Mass.; the Field Columbian Museum, etc. Nos. 1777, 6118, Yale Mus.

In mode of growth and general appearance this species resembles *A. Studeri* (Br.); *A. diversa* (Br.); *A. bullata* (Br.); and *A. fruticosa* (Br.), but in the details of the corallites it does not appear to agree very well with either of these.

Acropora appressa (Ehr.?) Dana. See p. 212.

Madrepora appressa Dana, Zoöph., p. 457, pl. xxxi, fig. 8; pl. xxxiv, fig. 5, (? non Ehr., t. Brook).

Madrepora assinitis Brook, op. cit., p. 85, pl. xx, fig. A.

Madrepora alliomorpha Brook, op. cit., p. 87.

?*Madrepora appressa* Ehr., redescribed by Brook from type, op. cit., p. 87.

PLATE XXXVI D. FIGURE 4. PLATE XXXVI E. FIGURE 4.

Fragments of the type of Dana are in the Yale Museum. No. 2029. Also numerous excellent specimens, of various ages, from Singapore, which agree perfectly with the type. Nos. 1, 3, 5, 6, 8, 11, 1371, 1383, 5541.

When young (up to 100 to 150^{mm} broad), this species does not have the branches of the under side coalescent, or else they are only slightly so. In this stage of growth the branches form a rounded convex clump of much divided branches, arising from a stout basal mass, the outer ones spreading and proliferous. Small branchlets are also given off on the under side and soon begin to be appressed and flattened, losing their prominent calices. Gradually, as they become more flattened and crowded, they begin to coalesce, openly at first, but eventually, in large specimens, they may form a nearly continuous plate, with few irregular openings through it, toward the margins, as described by Dana.

The immersed calices of the under side are few, scattered, small (0.5^{mm}), but distinctly stellate, usually with 12 septa, the secondaries narrow.

The fragments from Dana's types apparently came from two specimens. They have the following characters:

The axial corallites are small (1.5 to 2^{mm}), and about 1–2.5^{mm} exsert; walls not swollen, calice with 12 septa. The radial coral-

lites are mostly strongly appressed and imbricated, seldom arranged serially, but rather in quincunx. The more distal ones are somewhat spreading, mostly compressed, tubo-nariform, the larger ones 4–5^{mm} long, 1.5^{mm} broad, with the aperture very oblique and elliptical; the inner lip may be wanting, or short and thin; the outer lip is elongated, a little thickened, either obtusely rounded or narrowed, usually a little incurved, both laterally and distally. The radial corallites, a little lower down, gradually become more appressed, with the outer lip narrower and more pointed, and the inner lip abortive. The wall of the distal corallites is strongly grooved and costulate, with sharp-edged and finely echinulate costulae; those lower down have less prominent costulae, and larger, rough or sharp granules in series; the lower lip is perforate between the costulae. Toward the base of the branchlets the corallites become much shorter, closely appressed, but still tubular, with nearly round calicles. On the larger basal branches there are many immersed calicles, with a very distinct 12-rayed star, and many others with a slightly raised border. These calicles are very distinctly stellate with six wide and six narrow septa, and are 0.75 to 0.8^{mm} in diameter.

All the radial calicles have six strong primary septa, the directives wider, and six narrow secondary ones.

The cœnenchyma is firm, but porous, and roughly echinulate, with rather large, sharp granules, often in series.

The specimens from Singapore agree well with the types in the size and form of the branches and corallites, but the walls of the corallites often lack the costulae and are densely covered with fine sharp granules, which may be in series; but in most cases the distal and less appressed corallites are more or less costulate, even when those below are evenly echinulate. In some of these specimens the outer lip of the larger radial corallites is thicker and more convex, so that the form is slightly scaphoid.

But in the large series of specimens examined, there are all intermediate states and many other variations.

Hence I am led to doubt the distinctness of *A. appressa* (Ehr.); *A. assimilis* (Br.); and *A. alliomorpha* (Brook), all of which are certainly much alike.

Brook, himself, refers Dana's *appressa* to his *assimilis*, but the general figure of the latter (from a photograph) shows some differences. The most notable is the very evident arrangement of the corallites in vertical series, which I have not observed to any marked extent in the Singapore specimens. The type photographed by him

is from Macelesfield Bank. To me it seems much like *M. alliomorpha* Brook.

The true *appressa* Ehr. has been redescribed by Brook from the type in the Berlin Museum. It has not been figured. It seems to agree pretty closely with Dana's species in most respects, but has larger axial and radial corallites than I have observed in the latter. According to Brook the larger radial ones are up to 8^{mm} long and 2^{mm} thick; the axial 2–2.5^{mm} in diameter. I can find no other marked difference, and possibly this is not beyond the limits of variation in this species, for many others are known to vary more than this in the size of the corallites. The upright branches are shorter than in Dana's type (one inch long, t. Ehr.; 4–6^{cm}, t. Brook).

Brook also states that the wall is "dense and echinulate, not striate." I have shown above that this character is variable in Dana's form. According to Brook the radial corallites are mostly "hooked labellate, with a thick, blunt, and frequently incurved apex." The larger size of the axial corallites (t. Ehr.) formerly led me to suppose that it might be identical with *M. acervata* Dana, but the measurements given by Brook would seem to contradict this, unless the type be undeveloped in this respect; but Ehrenberg states that it is nine inches in diameter.

The distinctions between *assimilis* and *alliomorpha* seem to me very slight and at most only varietal. See also *A. dissimilis*, below.

Acropora arbuscula (Dana) Ver. See p. 213.

Madrepora arbuscula Dana, Zoöph., p. 474, pl. xl, fig. 2, 1846. Brook, op. cit., p. 40.

? *M. laxa* Lam., Brook, p. 46.

This species, in a large series from Singapore, shows much variation. There are two branches of Dana's type from the Sulu Sea, in the Yale Museum (Nos. 2005, 4165) besides a good series from Singapore.

The type differs a little from most of the latter in having the radial corallites rather shorter and more squarrose, with the walls more porous and more distinctly costulate. But these characters vary in this species.

In the type the radial corallites of the upper side of the branch are rather crowded, subequal, short (about 2–3^{mm} long and 2^{mm} broad), tubular, with lower wall a little thicker, obliquely truncate, and with the aperture terminal and a little oblique, owing to the thinner and shorter inner lip. The outer lip is distinctly thickened, rounded, but

not incurved. The wall is covered with elevated thin costulae, which become echinulate lower down, and on the degenerate corallites of the lower side of the branch.

The cœnecyema is porous-reticulate, or vermiculate-pitted, and sparingly granulated.

The Singapore specimens are variously arborescently branched, with rather few divisions, most of the branches not over 16–20^{mm} thick. The corallites are often few and degenerate on the under side, but generally they are crowded and rather long on the upper side.

The radial corallites stand at various angles, even on different branches of one specimen. Most commonly they are ascending and stand at 45° to 60°, but they may stand at 90°. They are commonly nearly terete, tubular, a little tapered, truncate, with the aperture terminal and often only slightly or not at all oblique, but in other cases decidedly oblique, as in the type. The larger ones are often 4–5^{mm} in length and 2.5^{mm} wide at base. Between these there are usually many short, verruciform, or subconic corallites.

All the calicles are very distinctly stellate, usually with 12 septa, the primaries well developed, with wider directives; the secondaries thin and narrow. The outer wall is generally distinctly thickened, and the outer lip a little prominent and rounded, but not incurved. Externally the wall of most of the calicles is densely covered with minute granulations, generally in longitudinal lines, but sometimes uniformly arranged, giving the surface a smoothish appearance. On the younger calicles distinct costulae are often present, but they are seldom so distinct as in the type.

The cœnecyema is also generally very finely and closely echinulogranulate, like the corallites, but in many parts it becomes pitted, as in the type.

Some specimens occur in which the corallites of the larger branches and proximal parts of the smaller ones are short-conical or verruciform, with crowded, swollen bases, unequal in size, and in contact, with small, terminal, stellate calicles, 0.5^{mm} in diameter. But on the distal parts of the branches corallites of the ordinary form occur.

This variety has the cœnecyema and corallites densely echinulogranulate. It seems to grade into the ordinary varieties, though the small size of the calicles is a striking character.

At first sight the Singapore variety looks like a distinct species, owing to the fine, dense granulation of the surface, and the longer and more tapered corallites. But some of the specimens have

branches showing almost exactly the structure of the type, though other branches may be as usual. Therefore I conclude that the difference is at most only a local variation.

M. laxa Lam., as described from the type by Brook, seems to differ very little from the Singapore variety of this species, and it may, perhaps, be identical. It has not been figured.

Acropora austera (D.) Ver. See p. 213.

Madrepora austera Dana, Zoöph., p. 478. Brook, p. 56.

PLATE XXXVI. FIGURE 10.

PLATE XXXVI B. FIGURE 1.

Branches of Dana's type are in the Yale Museum. These show that the axial corallites have thick reticulate walls and 12 wide, thin septa, the 6 primaries nearly meeting. No. 4190.

The radial corallites also have 12 septa, the secondaries narrow.

The walls of the larger corallites are very porous and costulate, but the costulae are thin and spinulose, and more or less interrupted by the larger pores between them; toward the margin, the walls are often reticulate or fenestrate, owing to the large pores. But the smaller radial corallites often have the walls strongly and roughly echinulate, without costulae.

The surface of the cænenchyma is openly porous or reticulate, and very scabrous, with coarse and irregular spinules.

I have seen no specimens, except Dana's type. Brook, apparently, had no specimens of it, unless he put them under some other species, as is not improbable. He refers to it, doubtfully, some worn fragments only.

Acropora dissimilis Ver., sp. nov.

Madrepora echidnaea Dana, Zoöph., p. 458, pl. xxxi, fig. 9, pl. xxxv, fig. 3, 1846, non Lam., Ehr., Stud.

Madrepora rosacea Studer (*pars*). Brook, op. cit., p. 84, (*non M. rosacea*, as on pl. xv, nec *rosacea* Esper, p. 115).

PLATE XXXVI. FIGURE 9.

PLATE XXXVI A. FIGURE 9.

Studer was undoubtedly correct in stating that the *A. echidnaea* (Lam., and of Ehr.) was a very distinct species from Dana's, but he was wrong in uniting the latter with Esper's *M. rosacea*, which has very exsert radial corallites.

Dana's species is closely allied to *cerealis*, *appressa*, and *assimilis*.

It has unequal, tubular, loosely arranged, distal radial corallites; the longer ones but little appressed, and with oblique margins; the calicles open inward and upward.

It has slender, acute, elongated, proliferous branches, with rather small axial corallites, about 3^{mm} in diameter and 1 or 2^{mm} exsert, with porous walls and a small, 12-rayed calicle.

The radial corallites are loosely, irregularly arranged, and very unequal in length. On the distal 25–40^{mm} there are many, longer, ascending, tubular corallites, somewhat incurved, not appressed, with the aperture oblique. The larger of these, which are free distally and bear one to several small basal buds, may be 6 to 8^{mm} long and 1.75–2^{mm} in diameter; some of them give rise to small ascending proliferous branches.

Between these are other tubular and tubo-nariform radial calicles that are about as large, but not so long, attached for nearly the whole length, but not appressed, or only slightly so, with the aperture oblique, round or slightly elliptical, and directed upward, and without a free inner lip. Part of these are somewhat compressed, with the outer wall thickened and convex; others are nearly round and straight, but all have the outer lip thickened, prominent, obtuse, sometimes slightly incurved, sometimes straight.

The corallites are about 3–5^{mm} long and 1.75^{mm} in diameter. Others mixed with these are one-half shorter, with the aperture less oblique. The wall of the distal corallites is echino-costulate; that of the more proximal ones is densely echino-granulate, usually with the granules in series.

On the proximal half of the branches many of the corallites are immersed or have only short appressed lips; on the larger branches they are nearly all immersed, with small stellate calicles.

The radial calicles all have about 12 narrow, unequal septa, the directives a little wider. The cœnenchyma is uneven, pitted, and roughly granulated.

This species is related to *M. alliomorpha* and *M. assimilis* Brook, = *M. appressa* Dana, but seems to be distinguishable on account of its much longer and very unequal radial corallites, which are not so much appressed.

In the length of the radial corallites it is more like the typical *appressa* of Ehr., but that is said to have the corallites strongly appressed and not striate.

As it cannot properly be referred to *A. rosacea* (Esper), I propose to give it, for the present at least, a new name (*A. dissimilis*). Future comparisons with the types may lead to the union of this and several of the allied forms. The union of this and *appressa* (Dana) was suggested by me in 1864, but at present the tendency

seems to be to separate the allied forms of this group, rather than to unite them. Still I think it not unlikely that a larger series of specimens would compel us to unite them in one species.

Acropora diffusa Ver. See p. 214.

Madrepora diffusa Verrill, Bull. Mus. Comp. Zoöl., i, p. 41, 1864. Quelch, op. cit., p. 161. Brook, op. cit., p. 80.

PLATE XXXVI C. FIGURE 2. PLATE XXXVI F. FIGURE 16.

The larger radial corallites in this species are prominent, compressed, nariform, standing at about 45° to 60° , not at all appressed. The outer lip is thickened, a little incurved and considerably longer than the thin inner lip. The free part of the inner wall is short but evident, thin. The aperture is oblique and elliptical. Six very narrow primary septa are visible; the directives are a little wider than the others. The walls are firm but porous and roughly echinulate; the sharp granules are often in costal lines, but usually no distinct costulae are visible, unless on very young corallites.

The axial corallites are a little exsert and scarcely larger than the radial, with a small calice (0.75 to 1^{mm}). The primary septa are well developed, but thin.

Kingsmills Is., cotypes. No. 1808.

Acropora digitifera (Dana) Ver. See p. 214.

Madrepora digitifera Dana, Zoöph., p. 454, 1846. Brook, op. cit., p. 75, 1893.

PLATE XXXVI. FIGURE 12. PLATE XXXVI B. FIGURE 3.

Several branches of the type-specimen are in the Yale Museum (No. 430). These were, in part, used by Dana in describing the details of the calices. The longer branches are 50–65^{mm} long, and 10–13^{mm} in diameter at base, somewhat curved and compressed, proliferous, with small normal branchlets on the distal third.

Near the base the calices are small and many of them are wholly immersed, deep, with 12 very narrow septa; others are larger, with a squarrose, short, thick, spout-like lower lip; the upper lip is abortive, or nearly so.

The most fully formed, radial calices (2 to 2.2^{mm} in diameter) are on the distal half of the branches; these are large, strongly squarrose, or stand nearly at right angles to the branch. They are spout-shape, rather prominent, with the lower lip thick, expanded, well rounded, and not at all contracted; the upper lip is short and thin. They have a distinct star of 12 septa, all of which are narrow except

the two directives. The outer wall is covered with numerous, very thin costulae.

The more distal corallites are a little more ascending, but the lower lip is slightly excurved and expanded, so that the calices are conspicuous. Some smaller immersed calices (0.3^{mm} in diameter) are found between the labiate ones nearly to the tips of the branches.

The axial corallites are moderately large (2.5 to 3^{mm}), with thick walls, and only a little exsert. The axial calicle is small (1^{mm}), with 12 subequal, thin, but not narrow, septa.

The cœnenchyma of the branches is rather dense, with few small pores, and its surface is covered with rather coarse, rough or sharp spinules, not crowded, and mostly arranged in longitudinal series, or often united into irregular costulae or small tabulae.

The origin of the type is unknown, but is doubtless Indo-Pacific.

Acropora effusa (Dana) Ver. See p. 215.

Madrepora effusa Dana, Zoöph., p. 455, 1846. Brook, p. 76 (non Quelch).

PLATE XXXVI. FIGURES 16, 16a. PLATE XXXVI B. FIGURES 7, 7a.

Dana's unique type of this species from Ceylon (coll. Rev. Geo. H. Apthorp) is in the Museum of Yale University.

It is a regular corymbose clump, with a slightly convex surface, 10 by 14 inches ($250 \times 350^{\text{mm}}$) across, and 5 inches (125^{mm}) high. The upper surface is covered with upright branches 25 to 40^{mm} long, arising from a solid basal mass of cœnenchyma, covered above with immersed stellate calices. The base is broadly incrusting, about 250^{mm} across, and free marginally only for a slight distance, except on one side, where the free part is 75 to 100^{mm} wide. It here forms a nearly solid plate of coalesced branches, with a few submarginal openings, without free branchlets, but covered thickly with exsert, conoidal, verrucose, and tubular corallites, $1-3^{\text{mm}}$ long, with porous, echinulate walls and 6-rayed, stellate calices, the directives wider. There are few immersed calices beneath. The cœnenchyma of the outside base is very porous.

The marginal branches are nearly horizontal at base, and coalescent; submarginal ones are curved upward distally; those nearer the middle are straight, upright, partly simple and partly forked, or more or less proliferous; they are rather stout and tapered, 10 to 15^{mm} thick at base, subacute, with a moderately large, but not swollen, axial corallite, $2.5-3.5^{\text{mm}}$ in diameter, and $1-3^{\text{mm}}$ exsert, with rather thick, openly porous, costulate walls.

Many of the proliferous branches bear rather numerous, large, tubular corallites, mostly with a few small basal buds, some of them thus forming the axial corallites of incipient branchlets, 8 to 12^{mm} long. The gemmiferous corallites are much like the axial, regular tubular, with the calicle terminal, and the walls rather thick and costulate. Septa 12, all narrow, the directives a little wider.

Radial corallites of various sizes intermixed. The larger ones are tubular, round or slightly compressed, many of them tubo-nariform; many are dimidiate or spout-shaped; others have the aperture subterminal and oblique. The outer lip is usually prominent, a little thickened, and often slightly incurved, but in others the lip is shorter and straight; many have the inner lip short, or abortive, but in others it is well developed and thin. The smaller intermixed corallites have the same forms but some are short verruciform, others labellate; immersed ones are few, except at the base.

The walls are reticulate-porous and regularly costulate or echinocostulate on the distal corallites, but often evenly and sharply granulated on those of the lower portion of the branches. The basal corallites are mostly short, verruciform, with the calicle terminal. Septa in nearly all cases are 12, but narrow; those of the first cycle are fairly well formed; those of the second are very narrow, sometimes rudimentary; directives are rather wider than others.

The longer tubo-nariform calicles are about 3 to 4^{mm} broad and 2^{mm} in diameter; many of these are gemmiferous at base.

Point Pedro, Ceylon, coll. Rev. G. H. Apthorp, 1843. No. 3063.

This species, in its form and mode of growth, resembles *A. Studeri* (Br.), but the latter forms more regularly corymbose clumps, with shorter and more conical branches, and its corallites seem to be more divaricate and more labiate. *A. baodactyla* (Br.), pl. xiii, also has a similar form, but the corallites are quite different. It is closely allied to *A. secale* (type from Ceylon).

***Acropora indurata* Ver., sp. nov.**

PLATE XXXVI. FIGURE 19.

PLATE XXXVI C. FIGURE 6.

PLATE XXXVI F. FIGURE 12.

Coral dense and heavy, sparingly branched, with short, stout branches, somewhat as in *A. robusta* Dana. Branches often 25^{mm} or more in diameter, subconic, or gradually tapered, obtuse.

Axial corallites short, scarcely larger than the radial ones and not much different in form; 3–3.5^{mm} in diameter, 1 to 2^{mm} exsert; walls

moderately thick and lips rounded ; calicle small (about 1^{mm}), with 12 septa distinct.

Radial corallites irregularly arranged, crowded and exsert on the upper side ; loosely arranged below, and less exsert ; on the smaller branches more regular and ascending, nearly adnate, but not appressed. On the larger branch they stand at angles varying from 30° to 60° , and sometimes form oblique rows. They are verruciform, conoidal, or tubo-conoidal, with thickened walls and swollen base ; summit usually obliquely truncated, with the small calicle opening upward ; but sometimes it looks downward, or sideways, and often it is terminal.

Length of the larger radial corallites, mostly 3 to 4^{mm} ; diameter at base, about 3^{mm} ; calicles, 0.75 to 0.80^{mm} .

The distal end of the radial corallites is usually free for 1 to 3^{mm} , with the inner lip well formed, but some are entirely adnate, with no free inner lip. No immersed calicles occur on this specimen.

The radial corallites are strongly stellate ; the six primary septa are well developed, but narrow, thick next the wall, subequal ; the secondaries are much smaller, but distinct. The whole surface is uniformly and densely covered with fine rough granules.

The type is a single stout branch, 100^{mm} long, with one side branch 20^{mm} long. No. 6155, Mus. Yale Univ. Australia (coll. Ward). The rest of the specimen, on which I made my notes several years ago, may now be in the Field Columbian Museum, Chicago.

This species is remarkable for the unusual density of its ctenenchyma, and for its conoidal radial corallites.

***Acropora Luzonica* Ver., sp. nov.**

PLATE XXXVI C. FIGURE 4.

PLATE XXXVI F. FIGURE 9.

Coral arborescent, distantly, loosely, and irregularly branched, with the branches often forked, mostly ascending, but some are widely divergent and often crooked. The terminal branchlets taper gradually to rather slender tips. Principal branches are mostly 12 to 15^{mm} in diameter at base ; terminal ones are 6 to 10^{mm} thick at base, and up to 60 to 75^{mm} long. Their tips are subacute, truncate, with the axial corallite 2 to 3^{mm} in diameter and 1 to 3^{mm} exsert, walls are not very thick, reticulate-porous, and strongly costulate.

The radial corallites are mostly entirely or nearly immersed, on all the larger branches ; some of them have slightly raised, thin margins ; others have the lower lip a little prominent ; their calicles

are rather large (1 to 1.25^{mm}), and regularly stellate, with six well-developed primary septa and six narrow ones; the directives nearly meet in the center.

On the more distal parts, and especially on the terminal branches, the margins of the calicles become more elevated, especially on the lower side, forming thin lower lips that stand out often nearly at right angles, but unevenly so, thus giving the surface a rough and irregular appearance.

Those near the ends of the branches are often tubular, but entirely adnate, with the large, terminal, round calicles opening upward; the inner lip being thin and very short or adherent, while the thin outer lip is tubular and truncate. A little lower down the inner lip is suppressed and the outer lip is shorter and often half-tubular or dimidiate, but the calicles are nearly round and often open rather outward, so that they are conspicuous in a side view. They are rather crowded and unequal in size, the larger ones being about 1.25^{mm} in diameter. All the larger ones have 12 septa, but the septa may all be rather narrow, except the directives, which are usually well developed.

The walls are always thin, compact, and strongly costulate. The cœnenchyma is firm but porous, irregularly pitted, and covered with rather loosely arranged, small, rough granules.

Manilla Bay, Luzon. The type is in the Mus. Yale Univ. (No. 1809, orig. number 198), received from the Museum of Comp. Zoölogy, where there were formerly many specimens.

This species belongs to the subgenus *Eumadrepora* of Brook. It is, perhaps, more nearly allied to *Acropora pulchra*, var. *stricta* Brook, than to any other form described by him, but the latter has smaller and more tubular corallites, and the surface is "closely reticulate."

***Acropora microphthalma* Ver.** See p. 216.

Madrepora microphthalma Verrill, Comm. Essex Inst., vi, pp. 83, 102, [49, 68,] 1869. Brook (*pars*), p. 168.

PLATE XXXVI C. FIGURE 1.

PLATE XXXVI F. FIGURE 15.

The specimens referred to this species by Brook (p. 169) appear to be quite distinct. They are "laxly arborescent; branches elongate, 2^{cm} thick; scarcely tapering," and have much larger radial corallites, which are "dilated, tubular," with the inner part of the wall "often incomplete or absent."

None of these characters apply to my original type, which is in the Yale Museum (No. 774). This is a very much branched, small, arborescent coral, with the branches small (larger ones about 10^{mm}), strongly divaricate, and very proliferous, especially distally. Many of the smaller branchlets stand nearly at right angles to the branches; others at 45° or less.

The axial corallites are small (1.75 to 2^{mm}), not swollen, a little exsert, slightly tapered, with the wall porous and finely echinulate, rarely echino-costulate.

The radial corallites are very unequal in size and form, but all are small. The larger ones (1.5–2^{mm}) are nearly regularly tubular, a little tapered distally, obtuse at the end (about 3^{mm} long), with the calicle small and only slightly, if at all, oblique, and about 0.5 to 0.6^{mm} broad, with thickened walls. The six septa nearly meet in the center; rudimentary ones of the second cycle are often present, but minute. These larger corallites mostly diverge at an angle of 45° or more, except distally.

Between the larger ones are many smaller subconical or verruciform corallites, standing at various angles, with the terminal calicles only 0.3 to 0.4^{mm} in diameter, while others, like small, rounded verrucae, have calicles of only 0.2^{mm} diameter, but yet show six septa.

The corallites and cœnenchyma are densely covered with minute sharp granules, and show but few pores.

The type of *A. microphthalmia* was from the Loo Choo Islands.

The specimens described by Brook were from Korea, Torres St., and Ramesvaren. They may, perhaps, belong to *A. parvistella* (Ver., 1864).

Acropora nobilis (Dana) Ver. See p. 217.

Madrepora nobilis Dana, Zoöph., p. 481, pl. vi. fig. 3, 1846. × *M. secunda*, var., p. 481, pl. xi, fig. 4. Verrill, Bull. Mus. Comp. Zoöl., i, p. 40, 1864.

A good Ceylon specimen (No. 454) of this species, which was used by Dana in his description, is in the Yale Museum, and also a branch of his East Indian (Singapore) type. Also, one of his types of *M. secunda*, from Singapore (No. 2014).

In addition to these, there are numerous good specimens of this species from Singapore (coll. Capt. W. H. A. Putnam and others). I have also seen large series in other museums.

The Ceylon specimen is a low clump of short, stout branches, up to 25–30^{mm} in diameter, arising from a large basal mass. The branches divide rapidly and irregularly, so that the undivided termi-

nal branches are mostly only 25 to 50^{mm} long, and taper rapidly. They stand at various angles; some are almost squarrose.

Most specimens grow taller (up to 2 feet high=600^{mm}) and branch more arborescently, with longer and more distant branches, variable in size. This was the case with Dana's Singapore type.

But the characters of the corallites are generally pretty constant in all. The axial corallites are nearly always large and swollen, with thick, porous walls; their diameter is commonly 4 to 5^{mm}, but varies from 3 to 6^{mm} on a single specimen; their calicles are about 2^{mm} broad; the naked, exsert portion may be 2-3^{mm} in length.

The radial corallites are various in size and form on one branch. The larger ones, in typical *nobilis*, are dimidiate-cylindrical or spout-like, scarcely at all compressed, with the lower lip thick and rounded, rather long, porous, often slightly expanded, frequently a little incurved, but distally on the branches more spreading and often a little excurved, though the greater number are nearly straight on the outer side; they stand at angles of 50° to 90°, but more generally at 60° to 70°. The inner lip is usually short and thin. The larger ones are usually about 2-2.5^{mm} broad and 2 to 4^{mm} long.

Their septa are very distinctly stellate, with six rather wide primary septa, the directives wider, and six narrow ones of the second cycle. The axial corallites have 12 distinct septa, rarely 24.

The walls of the axial and radial corallites are strongly costulate, with pores between the costulae; the lower lip of the radial corallites is fenestrate-porous distally. The coenenchyma is very porous and pitted, and roughly granulated.

Between the larger radial corallites there are many small labellate or dimidiate ones, with the outer lip either long or short, straight or incurved, and also a few that are nearly or quite immersed.

Var. *secunda* Ver., 1864.

Madrepora secunda Dana, op. cit., p. 487, pl. xl, fig. 4.

One of Dana's types of this form, in the Yale Museum, forms a loosely, arborescently branched clump, about 10 inches high (250^{mm}), with the main branches rather long and divergent, about 15 to 18^{mm} in diameter, branching freely distally, with evenly tapered branches.

In its form and mode of branching it does not differ from many typical specimens of *nobilis*, but the main branches are more slender than usual.

The terminal or axial corallites are thick and swollen, porous, and costulate, formed exactly as in *nobilis*, though they average rather

smaller, but several of the branches have them as large as is usual in typical *nobilis*; they vary from 3 to 5^{mm}, the average being about 3.5 to 4^{mm}.

The structures of the coenenchyma and walls are as in *nobilis*.

The lateral corallites are rather smaller than usual in that form, and they are mostly distinctly compressed, and have the outer lip less thickened, and more often incurved, so that many of the corallites are slightly boat-shaped, and the calicles elliptical; but they are cut away on the upper side and have the short inner lip as in *nobilis*.

Moreover, on some branches of the type, the calicles are not more compressed than often occurs on typical *nobilis*. This character varies in this species, as in many others, and may be due to more or less crowding of the buds.

This more compressed and more beaked form of the radial calicles is, however, the only tangible character for separating this form, even as a variety.

The second condition, due to the partial suppression of the corallites on the under sides of some branches, is an accident of growth that may occur in any species. The smaller size of the branches is not even of varietal importance.

Brook not only considers *secunda* a good species, but he puts it in a different group,* far removed from *nobilis*, though he refers to my uniting these forms in 1864. Probably Brook had a different species, from Australia,† which he described under the name of *secunda*; but he also quotes Dana's description.

My conclusion in regard to this point, in 1864, was based on a direct comparison of Dana's types of both forms, with a fine series of *nobilis* in the Mus. of Comp. Zoölogy. Although I have studied larger collections since then, I have seen no reason to change my opinion.

* Brook puts *secunda* in his 1st subgenus, *Eumadrepora*, on p. 30; *nobilis* in his 6th subgenus, *Tylopora*, on p. 135. This is mainly an account of the slight difference in the size of the axial corallites.

† Brook's Australian specimen is said to have the radial calicles rather distant, much compressed, thin-walled, tubo-nariform or dimidiate, 3-4.5^{mm} long, 1.2-1.6^{mm} broad; the walls striato-reticulate, not echinulate, unless at base. Most of these characters do not apply to Dana's *secunda*, especially the thin-walled, elongated, nariform corallites, nor would Dana's species go in the subgenus *Eumadrepora*, as defined.

Hence I believe it a distinct species with a superficial resemblance to *secunda* and would propose to call it *secundella*, sp. nov. The types are from Port Denison and Bandin Is., Australia (coll. Kent).

Even in 1864, I had devoted over three years to the continuous study of reef-corals, including all of Dana's types, so that I was then very familiar with all his species, and not more likely to err than now, in comparing types.

A. canalis Queleh, sp. (op. cit., p. 150, pl. ix, fig. 2), from the Philippines, is a very closely allied species, and perhaps will not prove to be distinct, when a series from that locality can be studied.

Brook refers the latter (with *nobilis*) to his subgenus *Tylopora*, on account of the large, thick-walled axial corallites. This character is as variable as others, and I think that Brook has given it too much importance in many cases, thus widely separating species that are closely allied, and perhaps, in some instances, widely separating forms that are mere varieties of a single species, as in the case of *secunda* and *nobilis*. To me this species seems to be more nearly allied to typical *Eumadrepora*.

***Acropora pachycyathus* Ver., sp. nov.**

PLATE XXXVI. FIGURE 20. PLATE XXXVI C. FIGURE 5.

PLATE XXXVI F. FIGURE 6.

Coral probably cæspitose, perhaps corymbose. Branches divergent, stout, 20-25^{mm} in diameter, often irregularly proliferous; the terminal branchlets short, tapered, obtuse.

Axial corallites large and swollen, (4-5^{mm} in diameter), with thick, rounded, porous walls and a rather large, deep calice, 2^{mm} in diameter. They are about 2-4^{mm} exsert.

Radial corallites large, thick, unequal in size, ascending, laterally sessile, very irregularly arranged, often aggregated into uneven and prominent clusters. The larger ones are mostly tubular, or conic-tubular, with stout, enlarged bases and thick, swollen, incurved summits; their small calices open obliquely inward, so as not to be visible in a side view. But with these are some that are more regularly tubular, truncate at the blunt ends, with the calice round and terminal; some of these may carry basal buds and eventually become axial corallites. They are from 3 to 5^{mm} long and 3 to 3.5^{mm} in diameter. They are mostly attached for the whole length of the inner side, but not appressed. The inner lip is usually very short or absent, but may be fairly well developed. The aperture is very small (0.6 to 1^{mm}) and often is almost concealed by the very thick, rounded outer lip, which usually curves inward very strongly. On the distal part of the branchlets they are more regular in form and

arrangement, with the end truncate and the nearly round calicle opening upward.

Among the larger radial calicles are many that are smaller, shorter, conoidal or verruciform, with a very small terminal calicle, often less than 0.5^{mm} in diameter. No entirely immersed calicles occur on these branches.

Septa of the axial corallites 12, those of the 1st cycle well developed, the others narrower. In the radial corallites six are wide and six very narrow, but distinct.

Surface of walls and cœnenchyma everywhere rather coarsely and roughly echinulate; the granules on the distal corallites usually thorny or lacerate, not crowded, often in costal lines, but no costulae are visible. The cœnenchyma is dense.

The type (No. 6141) is a single branch with four principal divisions and several small, distal, divergent branchlets.

Locality unknown (coll. Ward). Perhaps the rest of the specimen may be in the Field Columbian Museum.

This species is remarkable for the large, very thick-walled, closely adherent radial calicles, having the small apertures mostly concealed in a side view, by the very swollen, incurved outer lip.

It belongs to the group *Tylostoma*, in Brook's system, on account of the large and swollen axial corallites, but it does not have much resemblance to any other species of that group. Perhaps, in general appearance, it is more like *A. gonagra* than any other species.

***Acropora prolixa* Ver.** See p. 217.

Madrepora prolixa Ver., Communications Essex Inst., Salem, vol. v, p. 22, 1866. Brook, op. cit., p. 187.

PLATE XXXVI. FIGURES 3, 3a. PLATE XXXVI A. FIGURES 3, 3a.

PLATE XXXVI F. FIGURE 14.

Mr. Brook (p. 187) referred this species doubtfully to his *M. longicyathus* (E. & H.), which he redescribed from the type.

Our species does not agree with his description, nor with an authentic fragment of the type of Edw. & Haime, sent to the Mus. of Comp. Zoölogy, by Prof. Milne-Edwards himself, and with which I had compared my type, in 1864, as then stated.*

* Mr. Brook, in numerous instances, ignored the fact that I have had constant access to the types of Dana and others and that my determinations of species were made by comparison with types. Thus he often arrived at different and erroneous results. Had he kept this fact in mind, and given it due weight, he might have avoided several errors.

I will add the following details from one of my types :

The cœnenchyma is very finely and evenly echinulated, and almost without visible pores.

The radial corallites are mostly short, verruciform, but some are long, tubular, tapering from a thickened base; there are also many small immersed calicles. The radial calicles are all small, but they mostly have 12 septa, those of the second cycle being very narrow; those of the first cycle meet below, as seen in sections.

Wall of the axial calicles is thickened and rounded at the margin; the sides are without costæ. In sections the wall is thick and nearly solid, and the cœnenchyma is dense.

Ousima. No. 1686.

It is nearer *A. procumbens* (Br., p. 188, pl. xxviii) than to *longicyathus*. It also resembles, in a general way, *A. subglabra* (Br.), and *A. Rayneri* (Br.).

Acropora stellulata Ver., sp. nov.

PLATE XXXVI C. FIGURE 3.

PLATE XXXVI F. FIGURE 10.

Coral arborescent, loosely and sparingly branched, with long slowly and regularly tapered, terete branches, which often diverge at an angle of 50° to 60° . The larger branches are 12 to 14^{mm} in diameter, or more; the undivided distal ones may be 70 to 100^{mm} long, and 10^{mm} in diameter, 70^{mm} from the end.

The axial corallites are of moderate size (2 to 2.5^{mm}), cylindrical, a little exsert, with somewhat thickened porous, strongly costulate walls, bearing small buds close to the end; the costulæ are regular, thin, and high.

The radial corallites are small, tubular, squarrose, short and standing nearly at right angles on the larger branches, but becoming longer and slightly ascending more distally. The larger ones on the distal half of the terminal branches are longer than broad (about 1^{mm} broad and 2^{mm} high), slightly or not at all compressed, not tapered, obliquely truncate, with the outer lip rounded, a little thickened, and slightly incurved; the inner lip thin. Their walls are porous, sometimes reticulate-porous, and strongly costulate, with thin, high costulæ. Between these are scattered many smaller, short, tubular corallites, mostly squarrose and with reticulate walls.

On the larger branches the corallites are of more uniform size and length, very squarrose, short tubular or sub-verruciform, not so high as broad (diameter about 1^{mm}), with the calicle terminal and about 0.5 broad. Wholly immersed corallites seldom appear, except a few on the under side of a single injured branch.

Six septa are well developed and form a regular star in all the calicles, the directives being wider. In many calicles six very narrow septa of the second cycle are visible.

The cœnenchyma is dense and rather closely covered with rather sharp rough granules, often united into linear or irregular groups, and also more or less covering the walls of the corallites on the larger branches.

Zanzibar, Mus. Yale Univ., type, No. 435. Received from Boston Soc. Nat. History, as a duplicate.

This species somewhat resembles *A. virgata* (D.), the type of which (No. 2001) I have compared with this. *A. virgata* has the larger radial corallites stouter, more ascending, more compressed, obliquely truncated, with a very short inner lip, and more strongly costulate and echinulate walls. The corallites of the larger branches are larger, less squarrose, more prominent. Its cœnenchyma is more strongly and more roughly spinulose.

Acropora tubigera (Horn). See p. 219.

Madrepora tubigera Horn, Proc. Acad. Nat. Sci., Philad., 1860, p. 435 (*non* Quelch, *nec* Brook).

PLATE XXXVI. FIGURES 1, 2-2b. PLATE XXXVI A. FIGURES 1, 2, 2a, 2b.
PLATE XXXVI F. FIGURE 8.

Horn's type, in the Mus. Phil. Acad. of Science, was carefully examined by me, many years ago, and described in my notes. Several fine specimens now in the Museum of Yale University and Mus. Comp. Zoölogy, from Singapore, were identified by me, at that time (1863), by direct comparison with the type.

It is a common Singapore species. Many specimens were brought from there about 1860 to 1863, by Capt. W. H. A. Putnam, during several voyages to that port. These are now in the Museum of Comp. Zoölogy; the Peabody Inst., Salem, Mass.; and the Yale Museum. Altogether I have seen about 20 specimens of it.

It forms somewhat irregular rounded or one-sided, much branched, convex clumps, up to 12 to 15 inches (300-375^{mm}) across, and 4 to 8 inches (100-200^{mm}) or more in height, with the proliferous terminal, upright branchlets rather slender, tapered, subacute, and usually terminated by a slender exsert axial corallite.

The texture of the coral is firm, dense, almost translucent, with few pores, and the surface of the cœnenchyma is generally vermiculated or irregularly pitted, sometimes costulate, and rough with more or less numerous spinulose granules.

The main branches spread out radially from the stout, one-sided or subcentral base, and branch dichotomously; the outer branches lie nearly in one plane, but usually do not coalesce to any considerable extent.

The under side is covered with short irregular branchlets, directed outwardly, and somewhat appressed, each having one or several long divergent, often crooked and tapered tubular axial corallites, up to 10 to 15^{mm} long, and 2 to 2.5^{mm} in diameter. Many of these tubular corallites stand separately, or in clusters of 2 or 3, without any radial corallites upon them; but most bear at least a few small, appressed radial corallites, and many terminate the small, irregular branchlets.

The immersed corallites of the under side are scattered, not very small, and have a conspicuous star.

The cœnenchyma beneath is very firm and dense, translucent, and with a strongly vermiculated, rough surface, in many places sharply granulated.

The ascending branches and branchlets of the upper side are much subdivided dichotomously, the divisions forming acute angles; those toward the margins are often very proliferous. The smaller simple branches are from 5 to 8^{mm} in diameter, and up to 20–25^{mm} long; usually evenly tapered and acute.

The axial corallites are slender (1.7 to 2^{mm} thick), cylindrical, and usually considerably exsert (up to 4–6^{mm}, rarely 10^{mm}); the wall is moderately thick and very strong, though perforate, not swollen at the margin; its exterior is covered with regular and rather thin costulae, between which there are rows of pores, in the grooves.

The radial corallites are rather large, especially on the larger branches, where they are nearly immersed; the distal radial calicles are about as large as the axial, or even larger. The distal radial corallites are short and rather openly tubular, with the summit very obliquely truncate, so that the inner lip is abortive, or nearly so; the outer lip is large, thin, often fenestrate, frequently a little narrowed and incurved at the tip, but often flaring somewhat. These corallites stand at angles of 30 to 45°, and are not appressed; they are about 2.75 to 3^{mm} long, and about 2.5^{mm} broad. The wall is thin, porous distally, and covered with regular, sharply defined costae.

The calicles are all distinctly stellate; the radial ones have six strong primary septa, the directives widest, and usually six very narrow secondary ones. The axial corallites have six wide and subequal septa, usually with six very narrow ones of the second cycle.

On the proximal part of the branches some of the corallites are

low, verruciform, and broad at base; others are immersed, not crowded, separated by coarsely and roughly echinulate and irregularly pitted, dense cœnenchyma; the calicles are large and their 12 septa are distinct and nearly equal.

Singapore (coll. Capt. Putnam). Nos. 1370, *a, b, c, d*, etc., No. 1483, fragment of type.

***Acropora Bandensis* Ver., nom. nov.**

Madrepora tubigera Quelch, op. cit., p. 161. Brook, p. 79, (*non* Horn).

Probably the specimens described by Quelch and by Brook, from Banda, as *M. tubigera* were not of this species, for they say that it has a very porous cœnenchyma ("extremely porous," Brook), while in the type and in all our Singapore specimens it is remarkable for its density and hardness.

Brook also states that in the radial calicles the septa of the second cycle are "usually not noticeable," which is contrary to the condition in this species. The axial corallites are also said to be labellate or nariform. Therefore I propose to designate the Banda form as *A. Bandensis*, with the diagnosis as given by Brook.

***Acropora tumida* Verrill.**

Madrepora tumida Verrill, Synopsis Polyps and Corals North Pacific Expl. Exp., Comm. Essex Inst., v, p. 21, 1866. Brook, op. cit., p. 163.

PLATE XXXVI. FIGURES 11-11*b*. PLATE XXXVI B. FIGURES 2, 2*a*, 2*b*.
PLATE XXXVI F. FIGURE 3.

This species is easily recognized by the evenness of the under surface of the partially coalesced branches, with very small immersed calicles, and by the short, swollen, thick-lipped corallites of the upper surface of the larger branches.

On the distal parts of the upright branchlets the tumid character of the radial corallites is not so marked, and they are directed more upward, or may become somewhat appressed, but they are thick at the base, and taper to the summit, with the end rather squarely truncated and the terminal calicle opening upward.

The walls are echinulo-costulate, or sharply echinulate, with the acute granules arranged in lines, and with very few pores. There are six well developed septa, and often four to six rudimentary ones.

The axial corallite is a little exsert, rather stout (2.5 to 3^{mm}) with thick walls and a small calicle with six subequal primary septa and six small secondary ones. The calicle is not larger than that of the radial corallites (about 1^{mm}).

A fragment of the original type, from near Hong Kong, is in the Yale Museum, No. 886. The rest is in the U. S. Nat. Mus.

A. glauca (Brook) is evidently closely related to this species, and very likely may be identical with it.

Acropora turbinata (Dana) Ver.

Madrepora surculosa, var. *turbinata* Dana, Zoöph., p. 446, pl. xxxii, fig. 5, 1846. Brook, op. cit., p. 200, 1893.

Madrepora turbinata Verrill, Bull. Mus. Comp. Zoöl., i, p. 42, 1864.

? *Madrepora armata* Brook, 1892; Brook, Catal., p. 100, pl. x, figs. A. B.

PLATE XXXVI. FIGURE 6. PLATE XXXVI A. FIGURE 6.
PLATE XXXVI F. FIGURE 2.

The type of this form, which Dana considered a marked variety of *surculosa*, is in the Museum of Yale University, No. 2017.

It appears to be a species quite distinct from Dana's type of *M. surculosa*, from the Fiji Islands, fragments of which are also in the Yale Museum, No. 4181.

This coral forms a somewhat turbinate corymbose, nearly flat clump, consisting of stout, divergent, ascending primary branches, arising from an incrusting base and rarely coalescent. The exterior surfaces of the outer branches, from the base up, are covered with numerous, small, irregular, divergent, proliferous branches, not at all appressed, which give the under side a rough, ragged appearance. These mostly vary in length from 10 to 40^{mm}, the upper ones longer; the proliferous ones may bear branchlets 5–12^{mm} long and 4–6^{mm} in diameter, with slender exsert axial corallites, 1.5 to 3.5^{mm} long, and tubular, truncate, or labiate-tubular radial corallites, with the aperture either terminal or oblique. On the lower branches are numerous immersed corallites, about 1^{mm} in diameter, with rudimentary or abortive septa, as in *surculosa*.

The upper side is covered with rather slender, neatly tapered, acute, forked or proliferous upright branchlets, their divisions rising at an acute angle, and nearly parallel, as is well shown in Dana's general figure of this specimen. Some of them bear 6 to 10 divisions. The larger branchlets are 35 to 50^{mm} long, often 8 to 10^{mm} thick at base, when simple or nearly so; those toward the margins are compressed and stouter.

Axial corallites are rather small and slender, about 2^{mm} in diameter and 1–2^{mm} exsert; walls thin, reticulate-porous, strongly costulate; septa six, narrow, the directives usually a little wider.

Radial corallites small, prominent, regularly arranged, not crowded, strongly divergent, mostly at angles of 60° to 70° , openly tubular, with the aperture oblique and looking upward, not compressed, nor appressed, inner lip adnate or abortive; outer lip prominent, narrowed distally, concave, slightly or not at all incurved, very thin, fragile, reticulate-porous, regularly costulate, with thin costulae. Calicles relatively large and open; septa nearly all abortive or rudimentary; sometimes the directives alone are visible and very narrow.

Below the middle of the branchlets and on the basal branches are numerous immersed calicles, 0.75 to 1^{mm} in diameter, with rudimentary or abortive septa.

Cænenchyma very openly porous and pitted, or vermiculate, and sometimes lamellose at the surface.

Tahiti, J. D. Dana (coll. U. S. Expl. Exped.). Yale Mus., No. 2017.

This species is closely allied to *A. surculosa* (typical), and apparently to *A. corymbosa*, as restricted by Brook. Compared with a branch of Dana's type of *surculosa* from the Fiji Islands (Yale Mus., No. 4181), the latter has much more compact cænenchyma, echinulate in series at the surface; the radial corallites are shorter with a broader, more dimidiate, and flatter outer lip, which is also firmer, much less porous, and more truncate, with more strongly costulate walls; the calicles are still more widely open, but have the same sort of rudimentary septa. The rather large, open, immersed calicles are also essentially the same, with rudimentary or abortive septa, but they are perhaps a little larger ($1-1.20^{\text{mm}}$).

Perhaps, with a large series, we might be obliged to reunite the two forms, but with the specimens that I have hitherto seen they seem to be as distinct as many of the recognized species of corymbose *Acropora*. Should we unite these species, it would probably be necessary to unite with them, also, *M. corymbosa* (Brook), *M. cytherea* Dana, *M. symmetrica* Brook, and others of the same group, in which the radial and immersed calicles are not stellate, but have only rudimentary septa. See below under *A. symmetrica*, p. 254, and *cythereella*, p. 253.

I cannot perceive any appreciable specific differences between this species and *A. armata* (Brook), as described and figured by Brook (see below, p. 252), and think that they should probably be united.

Acropora secale (Stud.) Ver. See p. 218.

Madrepora plantaginea Dana, Zoöph., p. 459. 1846 (*non* Lam.).

Madrepora secale Studer, Reise Corv. Gazelle, Monatsb. Kongl. Preuss. Akad. Wissens., Berlin, 1879, p. 530 (*non* Brook, p. 88, 1889).

Madrepora Ceylonica Ortmann + *M. remota* Ort. + *M. valida* Ort. + *M. secale* Ort., Zoöl. Jehr., 1889, iv, pp. 506, 510, pl. xiii, fig. 6; pl. xli, fig. 3.

M. Ceylonica Brook, op. cit., p. 162.

PLATE XXXVI. FIGURES 14, 14a.

PLATE XXXVI B. FIGURES 5, 5a.

The large specimen from Ceylon, described by Dana, which is distinct from his Singapore specimens, is in the Yale Museum (coll. G. H. Apthorp). This is a crescent-shaped corymbose clump, attached by a large, one-sided pedicel. It is about 2 feet long and 1 foot broad, with the upper surface a little convex, the length of the upright branches decreasing from 75–85^{mm} in the middle to 25 to 40^{mm} near the border, while the under side is inclined upward. The main branches are completely coalesced, so that the under side is a nearly even, thick plate, without any projections and with scarcely any openings, except close to the margin, where the branches are reticulately joined; the immersed calicles of the under side are scattered, small, six-rayed.

The upright branches of the upper side are rather stout (mostly 10 to 15^{mm}), obtuse, somewhat angular, sparingly proliferous, except the marginal ones. They are rather close, mostly separated by intervals of 12 to 20^{mm}.

The axial corallites are rather thick and swollen, rounded, little exsert, with a small calicle and thick, porous walls; diameter, about 3–3.5^{mm}; calicle, about 1^{mm}. The calicle has 12 thin, narrow, subequal septa; wall closely and finely echino-granulate, in series.

The radial corallites are very unequal in size and form. The larger ones, which are mostly on the distal part of the branches, and within 25–35^{mm} of the tip, are large, tubular, a little tapered, with thick walls, rounded at tip, and with a small terminal calicle. Many of these have a few small, radial calicles on their basal portion, and are then like incipient branches. They are 3–6^{mm} exsert; diameter about 2.5–3^{mm}.

Between these, with some nearly or quite immersed calicles, are also many short (1–2.5^{mm}), thick, ascending or appressed, tubular corallites, with the outer lip thick, rounded, and often a little incurved, and the calicle oblique and slightly elliptical; the inner lip is short and thin, or often abortive. Wall densely and finely granulated, with sharp granules arranged in costal striæ.

Some of the radial corallites are longer (2-3^{mm}), with the outer surface convex, or boat-shaped, and the calicle opening obliquely inward. The radial corallites have six narrow primary septa, the directives rather wider when the calicle is elliptical; often 4 to 6 rudimentary septa of the second cycle are also visible.

Point Pedro, Ceylon, 1843 (Rev'd Geo. H. Apthorp), No. 3063. (See note, p. 210.)

This is the type-specimen on which Dana based his description of *M. plantaginea*. It, therefore, becomes also the type of *M. secale* Studer. Studer's *M. secale* was simply a new name for Dana's *plantaginea*. He gave no description. According to Brook (p. 88), Studer's specimens in the Berlin Museum include more than one species. He gave Singapore as the locality of his specimens. Therefore he probably had in mind an East Indian form, rather than the one from Ceylon. However that may be, Dana's type, from Ceylon, in the Yale Museum, was the one that he described.

The species described as *M. Ceylonica* by Ortmann, and by Brook, with the other related forms described by Ortmann, from Ceylon, appear to be varieties and different stages of growth of this species.

The specimens described by Brook, as *M. secale*, are probably a different species, and more like *A. appressa* (Dana).

In mode of growth this species resembles *A. leptocyathus* (Br.), and also *A. Guppyi* (Br.). It may prove to be only a variety of *A. effusa* (Dana), to which it is very closely related.

The specimens from Singapore, mentioned but not described by Dana, are quite distinct, with smaller upright branches; those of the lower side not forming a plate; axial corallites smaller; radial corallites short and swollen. One of these types is in the Yale Mus. (No. 2033). It is not *M. secale* of Brook. I have described it below under the name of *A. secaloides*.

Acropora secaloides Ver., sp. nov.

Madrepora plantaginea (pars) Dana, Zoöph., p. 459, (non Lam., t. Brook).

Madrepora secale (pars) anth., (non Studer).

PLATE XXXVI. FIGURES 15, 15a. PLATE XXXVI B. FIGURES 6, 6a.

One of the specimens that Dana named *M. plantaginea*, now in the Yale Museum, is quite distinct from the Ceylon specimen, on which his description was evidently based, and which has thus become the type of *A. secale* (Studer), see p. 244. The specimen referred to is from Singapore and apparently belongs to a species

that has not yet received a distinctive name, hence I propose to call it *A. secaloides*.

It is a flat-topped corymbose clump, about 18x15 inches across (450x375^{mm}), and five inches (125^{mm}) thick. It arises from a stout, short, pedicellate base. The nearly horizontal primary branches coalesce into a nearly solid plate subcentrally, but farther out there are many irregular openings, and numerous flattened, obtuse, appressed branchlets, with only a few small, immersed calicles, the surface in general appearing rather smooth, as if covered with plaster of Paris.

The upper side is covered with nearly upright, moderately stout dichotomous branches, mostly 12–18^{mm} in diameter at base. Those of the central parts are 75 to 100^{mm} long. They may fork two or three times; most often they divide near the base into two or three ascending branches, and these again divide into 2 to 8 terminal branchlets, 25 to 50^{mm} long. Some of them may be proliferous near the tip; they are mostly 8 to 10^{mm} in diameter, little tapered, obtuse.

The axial corallites are of moderate size, 2.5–3.5^{mm}, usually about 3^{mm} in diameter, and 1–2^{mm} exsert, with the walls rather thick, compact, and finely, evenly echinulate-granulate, not at all costulate; calicle small, with 12 unequal septa.

The larger radial corallites are short, divergent, with very thick, prominent, rounded outer lip, not appressed; inner lip usually wholly adnate; calicles, rather small, .07–.08^{mm}, conspicuously stellate, opening upward, little visible in a side view; primary septa well developed, secondaries narrower, but very distinct. Walls thick, compact, very evenly and finely echinulate-granulate, like the cœnenchyma.

Between the larger radial corallites there are many smaller ones, often verruciform, with short lips, and some wholly immersed. On the proximal third of the branches most of the calicles are immersed, but stellate with 12 septa. Cœnenchyma rather compact, everywhere evenly echinulate-granulate.

Singapore, U. S. Expl. Exped., No. 2033, Yale Mus.

Probably this species has been included under *A. secale* by several writers. Indeed, it is quite probable that Studer himself so included it, for he refers to specimens of the latter from Singapore, but he did not describe them. It does not appear to agree with *A. secale* (Brook), *non* Stud., which has more appressed corallites, but it may be that it varies in this respect.

In general appearance this has some resemblance to *A. calamaria* (Br.), but the primary branches of the latter do not coalesce into a basal disk, at least in the type, and its branchlets are more obtuse, shorter and thicker, and the corallites do not agree very closely.

Acropora fraterna Ver., sp. nov.

PLATE XXXVI. FIGURE 18.

PLATE XXXVI B. FIGURE 9.

One of the specimens in the Yale Museum labelled as *M. paxilligera* by Dana, differs specifically from another type-specimen, which agrees well with his description and figure.

This coral forms a large, flat-topped, turbinate clump, covered above with stout, conoidal, subacute branches; below, it arises from a stout, compact pedicel, 6 to 7 inches (150 to 175^{mm}) in diameter, rapidly widening upward. It is formed by large, obliquely ascending, primary branches, which are almost completely coalesced into a thick mass, with only a few submarginal openings, and covered beneath with numerous, rather large (1.10 to 1.30^{mm}), stellate, immersed calices, but without any projecting branchlets nor prominent corallites.

The upper marginal branches are stout, very obliquely divergent, and digitate, more or less coalesced proximally. The upright branches of the central portions are not crowded, elongate-conical, 35 to 50^{mm} long, 15 to 25^{mm} in diameter at base, regularly tapered, subacute.

The axial corallites are rather large, mostly 3 to 3.5^{mm} in diameter; 1 to 2^{mm} exsert, with moderately thick, very porous walls, strongly costulated externally; septa usually 12, narrow.

The radial corallites are very unequal; the larger distal ones are 2-3^{mm} exsert, about 1.5-2^{mm} in diameter, tubular, scarcely compressed, obliquely truncated or labellate, with a dimidiate lower lip, which is not thickened nor incurved, or but slightly so; inner lip usually pretty well developed, free, but thin, often entirely adnate; outer walls strongly costulate, with rows of large pores between the costulae. Septa usually 12, the six primaries rather narrow; the others almost rudimentary.

Between the larger radial corallites there are many crowded smaller ones, 0.5 to 1.25^{mm} in diameter, short-tubular, rather exsert, with thin, costulate walls, and an open terminal aperture, which may be more or less oblique. The larger corallites stand out rather

prominently and are sometimes squarrose, but in other cases form an angle of about 68° – 75° . The cœnenchyma is loosely porous, or reticulate-porons. Immersed calicles become numerous on and between the bases of the branches.

Tahiti, U. S. Expl. Expd. No. 2032.

The *A. gemmifera* (Br.) grows in much the same form as this species, so far as the upper side is concerned, but it does not seem to form a solid basal disk, and its short, conical, lateral branchlets do not occur in this species. The corallites are quite different in form.

***Acropora Wardii* Ver., sp. nov.**

PLATE XXXVI. FIGURE 13. PLATE XXXVI B. FIGURE 4. PLATE XXXVI F. FIGURE 4.

Coral a flat-topped, corymbose clump, arising from a large, thick, short base, 150 to 250^{mm} broad. The larger specimens are 18 to 20 inches across (450 to 500^{mm}), and 100 to 125^{mm} high. The lower side of the disk is composed of firmly coalesced, nearly horizontal, primary branches, united into a large, thick, continuous plate, except near the margin, where it becomes lobate; most of the under side is covered with epitheca, to within 50 to 70^{mm} of the margin, where the cœnenchyma is at first compact, nearly even, and finely granulated, but nearer to the margin it bears slightly elevated corallites, becoming more prominent close to the margin.

The upper surface is evenly and rather closely covered with short, stout, often crowded and subangular, bluntly tapered, upright branches, the submarginal ones becoming oblique, and those at the edge short, nearly horizontal, often coalesced. The central ones are mostly 35 to 40^{mm} high, and 15 to 20^{mm} thick at base; they are mostly separated by intervals of 6 to 10^{mm}. The cœnenchyma between their bases is covered with immersed calicles.

The axial corallites are of moderate size, often not much larger than the radial ones, diameter 2.5 to 3^{mm}, 0.5 to 1^{mm} exsert, with a porous thickened wall, strongly costulate externally; calicle small, about 0.75^{mm}, with 12 narrow septa.

Radial corallites short, mostly 1.5 to 2^{mm}, numerous, much crowded, with a dimidiate or auricular lower lip, which is only a little thickened and is strongly costulate externally, with small pores between the costulae. The larger distal corallites are about 1.5 to 1.7^{mm} thick, often short, dimidiate-tubular, scarcely, if at all, compressed, with the upper side cut away obliquely, so that the

aperture is wide-open, and looks upward and outward, and is visible in a side view. The inner lip is often free for a short distance, but usually wholly adnate. Lower down the corallites rapidly become shorter and the lower lip becomes a thin crescent-shaped margin, and at the base many calicles are wholly immersed.

The septa are all narrow, except the directives; the six secondaries are often present, but very narrow; in other cases abortive. Cœnenchyma openly reticulate-porous.

East Indies or Polynesia? (coll. H. A. Ward), Yale Museum, No. 6151. Also in Field Columbian Museum.

In form of coral and mode of growth, this species resembles *A. Guppyi* (Brook), as figured by Brook, but the latter has stouter branches with much larger axial corallites, and the walls of the latter are not costulate.

It has some resemblance to *A. conigera* (D), but the branches are larger and more obtuse; the calicles are shorter, more crowded, and less labrate; the walls are more regularly costulate and fenestrate; and the cœnenchyma is finer and not so rough.

Several specimens were in the Ward collection several years ago (Nos. 6118, 6120, 6151), from which the above description was made. That collection was afterwards sold to the Field Columbian Museum. A few fragments of No. 6151 are in the Museum of Yale University.

Acropora polymorpha (Brook) Ver.

Madrepora polymorpha Brook, Ann. and Mag. Nat. Hist., viii, p. 466, 1891.
Catal. Mad. Brit. Mus., p. 169, 1893.

Madrepora abrotanoides Dana, Zoöph., p. 477, pl. xli, fig. 1, 1846 (*nōn* Lam.).

Several branches from specimens labeled as *M. abrotanoides* by Dana are in the Yale Mus. (No. 4202). A careful study of these shows that they belong to two distinct species.

That which is most fully represented is the species figured by Dana. One of our specimens appears to be the figured branch. It agrees with Brooks' description of his *M. polymorpha*.

It has unequal, compressed-nariform, thick-walled, prominent, divergent radial corallites, with the small, elliptical, stellate calicles looking obliquely upward; outer lip thick, rounded, and prominent; inner lip usually free for some distance. External surface of wall is densely and finely echinulo-granulate, not costulate.

Between the larger corallites are many small tubular or verruciform corallites with a small terminal or subterminal calicle. The cœnenchyma is compact and finely granulated.

Acropora neglecta Ver., sp. nov.

PLATE XXXVI. FIGURE 21. PLATE XXXVI E. FIGURE 7.
 PLATE XXXVI F. FIGURE 5.

The other species, mixed with the last, which I have been unable to identify, is represented only by a single terminal branch, 13^{mm} in diameter, with a few short, divaricate branchlets, three arising at one point in one case. It was evidently arborescently branched.

Axial corallites about 2.5^{mm} in diameter, and 3^{mm} exsert, with strongly costulate wall, and 12 very distinct subequal septa, the directives wider.

Radial corallites are tapered, tubular, or conoidal, ascending, not compressed, obliquely truncate, with the round stellate calicle looking upward and somewhat outward; outer lip a little prominent, not much thickened, narrowed, and incurved; inner lip thin, usually free for a short distance, but often entirely adnate. Outer wall strongly costulate, with the costulae rather coarsely echinulate, and with small pores in rows between the costulae.

Septa 12, unequal, but all narrow, the directives a little wider. There are but few small calicles between the larger, and none immersed.

The larger corallites are openly arranged, much fewer than in *polymorpha*, and very different in the conoidal form and strongly costulate exterior. The cœnenchyma is irregularly and strongly pitted and roughly echinulate, in series. This is a true *Eumadrepora* (Brook).

Probably this specimen was from Singapore, or that region. U. S. Expl. Exped., 1846. No. 6126, Yale Mus.

Acropora pumila Ver.

Madrepora pumila Verrill, Comm. Essex Inst., v; p. 23, 1866. Brook, p. 166.

PLATE XXXVI. FIGURE 5. PLATE XXXVI A. FIGURE 5.
 PLATE XXXVI D. FIGURE 9.

In addition to the original description, which is pretty complete, the following points are noted. The calicles, both axial and radial, are unusually small, mostly not over 0.5^{mm}, and some on the lower branchlets are immersed and still smaller, but the immersed calicles are scattered and inconspicuous. On the lower branchlets the axial corallites are often so thickened that the calicle becomes very small, or almost obsolete. Some of the calicles, both radial and axial, have 12 septa; the primaries are all rather narrow and subequal; the secondaries very narrow.

Many of the lateral corallites are verruciform or low conoidal, with a wide thick base.

The cœnenchyma and walls are nearly uniformly covered with close, rough, not very minute granules.

Bonin Islands, U. S. North Pacific Expl. Exp. Yale Mus., No. 1687.

Acropora striata Ver.

Madrepora striata Ver., Comm. Essex Inst., v, p. 24, 1866. Brook, p. 178.

PLATE XXXVI. FIGURES 4, 4a. PLATE XXXVI A. FIGURES 4, 4a.

PLATE XXXVI F. FIGURE 7.

This species is notable on account of the large size of the calices and the thin, flaring lips of the tubular corallites, which have regularly costulate, thin walls.

The axial and gemmiferous radial corallites are either exsert-tubular or somewhat trumpet-shaped, many being distinctly widened distally and 2-2.5^{mm} in diameter, with the wide, round calice about 1.5^{mm}; they are often 4-5^{mm} long, with thin, flaring, porous edges.

The normal radial corallites are mostly openly tubular, about 3^{mm} long, with the summit obliquely truncated and the inner lip nearly or quite adnate, but not at all appressed nor compressed. The outer lip is thin, but firm, usually somewhat excurved, so that the calice is widely open (1.5^{mm}) and looks outward and upward. The corallites mostly stand out pretty strongly, at angles of 50° to 70°.

The septa are unusually well developed in the radial corallites; the six primaries nearly or quite meet in the center, rather deep down in the calices; the directives generally unite: the secondaries are narrow, but usually distinct.

The cœnenchyma is firm, somewhat translucent, but with the surface irregularly pitted and sharply echinulo-granulate.

It is a handsome, shrubby or arborescently branched species, not very closely allied to any other that I have seen, except *A. tubigera*, with which it has several points in common.

Ousima, U. S. N. Pacific Expl. Exped. Yale Mus., No. 1688.

Acropora urceolifera Ver., sp. nov.

Madrepora corymbosa Dana, Zoöph., p. 456, 1846 (non Lam.).

PLATE XXXVI D. FIGURE 3. PLATE XXXVI E. FIGURE 6.

PLATE XXXVI F. FIGURE 13.

It is remarkable that no recent writer seems to have had in hand the species described by Dana as *corymbosa*. A part of the original type is in the Yale Mus., No. 4187, labelled in Dana's handwriting.

It agrees well with his description. I have never met with any other example of the same species. It is easily recognizable on account of its peculiar, more or less urceolate radial corallites, which have thin walls, often constricted below the aperture.

It is very unlike the type of *corymbosa* described by Brook, which is nearly allied to *A. spicifera*, *A. cytherea*, and *A. surculosa*. Dana states that this species is caespitose, but our fragment is insufficient to determine the form of growth. It is a single nearly straight branch, 50^{mm} long and 10 in diameter, with four divergent branchlets arising from one side, as if it were a proliferous submarginal branch from the upper side of a corymbose or caespitose clump. The branches are tapered, obtuse.

Axial corallites are rather large and prominent, 3.5^{mm} in diameter and 2–3^{mm} exsert, with thick, porous, closely echinulate walls and funnel-shaped calicles, about 1.5^{mm} in diameter.

Radial corallites are thin-walled, and unequal in size and form. The larger ones are rather large and prominent, 3^{mm} long and 2–2.5 in diameter, standing mostly at angles of 45° to 60°, and sometimes in vertical rows. They are tubular, mostly somewhat swollen in the middle and rather suddenly narrowed or constricted just below the orifice, so as to give them an urceolate form; but many are scarcely, if at all, swollen, and have the outer lip incurved, and often slightly beaked, or with the edge lacerate.

The aperture is round, oblique, and looks upward and inward. The corallites are not at all appressed, and the inner lip is usually free for some distance. The walls are thin, but firm, not costulate, but thickly covered with rather strong, sharp, rough spinules, sometimes arranged in costal rows.

Between the larger corallites are many that are small, short-tubular, or verruciform, with the calicle terminal and the lips lacerate.

Septa distinct, but all narrow; the secondaries often rudimentary or abortive.

The cœnenchyma is firm, irregularly pitted, thickly covered with sharp spinules.

Precise locality unknown, E. Indies or Indian Ocean (Dana).

This species differs from all others known to me in the swollen and urceolate form of the radial corallites, with their spinulose walls.

A. neglecta Ver. approaches it, in this respect, more nearly than any other species.

Acropora armata Ver.

Madrepora armata Brook, op. cit., Ann. and Mag. N. Hist., x, p. 452, 1892.
Catal. Mad., p. 100, pl. x, figs. A, B, 1893 (?=*A. turbinata* Ver.).

Mr. Brook considered the coral figured by Dana as variety of his *spicifera* (p. 443, pl. 31, figs. 6-6c, pl. 33, figs. 4-4b) identical with his *armata*.

This does not seem to be the case.

The type of Dana's variety is in the Museum of Yale Univ., No. 2007. It differs in the details of the corallites and cœnenchyma, though it grows in similar form. It also resembles *A. turbinata* in its mode of growth, but it has much smaller calicles than the latter, the walls and cœnenchyma are much less porous, and the outer lip is narrower and more ascending.

A. turbinata agrees, therefore, very closely with *A. armata* and is probably identical with it, for the latter has the same spreading radial corallites and very porous and fragile lower lip as *turbinata*. But Dana's variety has an ascending or almost appressed outer lip, which is compact and strong, though thin, and the corallites and calicles are decidedly smaller. I propose to call the latter *A. cytherella*.

Acropora cytherella Ver., sp. nov.

Madrepora spicifera (var.) Dana, Zoöph., p. 443, pl. xxxi, figs. 6-6c, pl. xxxiii, figs. 4-4b.

PLATE XXXVI. FIGURE 7. PLATE XXXVI A. FIGURE 7.
PLATE XXXVI F. FIGURE 1.

The coral is vase-shape or salver form, from a stout pedicel, and the under surface of the coalesced branches is covered with divergent calicles and dwarfed branchlets in the type, as figured by Dana.

The branches of the upper side are slender and very proliferous distally, mostly 25 to 35^{mm} long. The axial corallites are about 2^{mm} in diameter and 2-3^{mm} exsert, cylindrical, with firm, finely and regularly costulate walls.

Radial corallites dimidiate-tubular, elongate, 2-3^{mm}, strongly ascending, not truly appressed; outer lip long, thin, but not fragile, half-round, with the aperture very oblique; inner lip thin, often free to some extent, but mostly adnate; wall finely and regularly costulate with a few very small pores in the grooves. Cœnenchyma irregularly and roughly pitted, and spinulose, rather firm.

Calicles small, 0.5 to 0.8^{mm}. Septa distinct, but narrow, in the axial corallites, usually 6, sometimes 12; all nearly abortive in the radial calicles.

Fiji Is., U. S. Expl. Exped., No. 2007.

This is not identical with *A. armata*, as supposed by Brook. See remarks under the latter, above.

It is closely allied to *A. surculosa* and *A. cytherea*, but has much smaller corallites and calicles than either of those species, and differs in other ways.

In the very numerous, small and slender upright branchlets this species resembles *A. arcuata* (Br.), to which it appears to be nearly allied.

Acropora symmetrica (Brook) Ver.

Madrepora symmetrica Brook, p. 94, pl. xv, 1893.

!=*Madrepora corymbosa* (pars, Lam.). Restricted by Brook, p. 97.

?=*Madrepora surculosa* Dana, var., p. 445.

PLATE XXXVI. FIGURE 8.

PLATE XXXVI A. FIGURE 8.

A large specimen from Zanzibar, in the Yale Mus., seems to agree closely with Brook's type, as described and figured, but is rather more proliferous beneath and has somewhat longer upright superior branchlets.

Our specimen is a broad, flat-topped corymbose coral, with a stout pedicel, nearer to one side. It measures about 16x18 inches, or 400x450^{mm}, across the top.

The free part of the disk, beneath, on the widest side, is 12 inches, or 300^{mm}. Diameter of pedicel, 3.5 inches, or 88^{mm}. The disk is composed of intricately coalesced branches, with numerous rounded openings, 12-30^{mm} or more in diameter. The under side is covered with an abundance of short, irregular branchlets, more or less appressed toward the margins, giving it a rough appearance. They spread nearly at right angles on and near the pedicel, and are covered like the cœnenchyma with large immersed calicles and others that are short and appressed.

The upper side is thickly covered with rather slender, acute, furcate and proliferous branches, upright in the middle and curved outward and upward toward the margins, so as to rise to about one general level. Many of them are 70 to 80^{mm} long, with the branchlets mostly 25 to 50^{mm} long, and mostly about 6 to 8^{mm} in diameter, but often with shorter distal ones, 5-10^{mm} long. They are mostly separated by spaces of 10 to 20^{mm} at tips.

The axial corallites are slender, about 1.3 to 1.5^{mm} in diameter, and 1 to 3^{mm} exsert. They have a rather thin but firm, costulate wall; septa usually only six, and all narrow.

The normal distal radial corallites are ascending and loosely imbricated distally, round, dimidiate-tubular, with an elongated, straight, slightly incurved, or a little flaring, hollow lower lip, which is sometimes very slightly thickened; its edge is obtuse and denticulate; wall strongly costulate with rows of pores in the grooves; inner lip thin, mostly adnate.

The calicles are rather large, about 1^{mm} in diameter, round or nearly so, and look upward and slightly outward.

Lower down, the lower lip rapidly becomes shorter and mostly disappears on the bases of the branchlets and on the larger branches, where open immersed calicles are numerous and conspicuous; they are usually at least 1^{mm} in diameter.

Septa in all the radial calicles are nearly all abortive or rudimentary; often two very narrow directives are alone present; in other cases 4 or more additional rudimentary ones can be seen with a lens, especially in the immersed calicles.

Cænenchyma is roughly and irregularly reticulately pitted and vermiculate, and with rough echinulations in series.

Zanzibar. No. 79. Exchange, from Peabody Inst., Salem. Branches of other specimens, with longer branchlets, from Mozambique, are in the collection.

Although this specimen appears to be identical with *A. symmetrica*, I have described it pretty fully, to show its probable identity with *A. surculosa* Dana.

I have compared it directly with Dana's original types of the latter in the Yale Museum, and can find no tangible differences between it and No. 4178, from Tahiti, and others, in the details of the corallites. The walls, lips, calicles, and septa are identical, except that the calicles of the Tahiti specimen may be in part a trifle smaller, and the branchlets that I have at hand are also a little smaller, but they do not differ so much as do those from contiguous parts of our specimen.

The somewhat greater length of the upright branches of the upper side and the abundance of imperfect proliferous branchlets on the lower side, are the only noticeable differences.

These are both very variable characters in corymbose corals of this group. Therefore I believe that the two forms should be united.

The above description may be considered as essentially a description of *A. surculosa*, as to the details of the corallites, calicles, and cænenchyma.

It is certain that several of the forms admitted as "species" by Brook in this group are very closely related, and perhaps are mere local or growth-varieties of one species. The *A. corymbosa* (Lam.) as restricted and described by Brook, from the type, with its several varieties, belongs to this series, and bears the earliest name.

It seems to me probable that a careful study of a good series of specimens would compel us to unite *A. surculosa*, *A. turbinata*, *A. armata*, and *A. symmetrica* as varieties of *A. corymbosa*. It may also become necessary to unite with these *A. cytherea* and *A. cythereella*, as somewhat more marked varieties.

All these forms are essentially alike in form and mode of growth; in the structure of the corallites; and especially in the rudimentary condition of the septa. All have an abundance of rather large, open, immersed calicles on the larger branches.

Brook puts all these forms in section C of his subgenus *Poly-stachys*, but he puts *surculosa* in subsection *c*, and the rest in subsection *a*. I can see no grounds whatever for this distinction; moreover these forms do not, as a rule, conform with the characters given by him for his section C.

Some of the forms referred to *corymbosa* by Klunzinger (as his fig. 1, pl. iv, and fig. 2, pl. 1) seem to me very different from the *corymbosa* of Brook (after Lam.), although admitted by Brook, without question, in his synonymy.

As photographed by Klz., the radial corallites are spreading and have a decidedly thickened outer lip, while Brook states the outer lip is "half-tubular or labellate" and "very fragile." Moreover the Red Sea form is represented as having much larger and stouter branches than the type.

This stout-branched Red Sea form, with thickened walls and stout lip to the corallites, seems to me a distinct species. I have examined several specimens of this sort, from the Red Sea, but have not seen a good series.

For the same reason, I have not thought it desirable, at this time, to formally unite all the forms, mentioned above, as varieties under *A. corymbosa*, for of some of them I have seen only single examples. Far better series are doubtless to be seen in the British Museum and probably, also, in the large collections of South Pacific corals recently added to the Mus. Comp. Zoölogy by Mr. A. Agassiz, but which I have not yet seen.

The *M. corymbosa* of Dana is a very different species. See *A. urceolifera*, p. 251.

Acropora millepora (Ehr.), and var. **squamosa** (Brook).

Madrepora millepora Brook, op. cit., p. 116, 1893. Dana, Zoöph., v. 446, pl. xxxiii, fig. 2, 1846.

Madrepora squamosa Brook, Ann. and Mag. N. H., x, p. 463, 1892; op. cit., p. 120, pl. xx, fig. B.

Brook has redescribed the type of Ehrenberg. He considered it distinct from the *M. millepora* of Dana, and described, as a new species (*A. squamosa*), the form that he identified with Dana's. To me, the differences mentioned seem trivial and not of specific value.

In either case, Dana apparently had both forms in view when he described his *M. millepora*. Portions of the types of his species of that name are in the Yale Museum, and also a good series of specimens of this species received from Singapore (coll. Capt. W. H. A. Putnam).

Several of the latter agree with the *A. squamosa* (Brook), but I cannot distinguish them as more than a slightly marked variety of *A. millepora*.

I think it probable, also, that *A. subulata* is only a longer-branched variety of *A. convexa*.

Acropora nasuta (Dana) Ver.

Madrepora nasuta Dana, Zoöph., p. 453, pl. xxxiv, fig. 2, 1846.

Madrepora nasuta and var. *crassilabia* Brook, op. cit., pp. 73, 74, 1893.

One of Dana's types is in the Museum of Yale University (No. 2026, and 4187, branches), as well as other similar specimens from different sources. It is the form described as var. *crassilabia* by Brook.

This type forms a rounded, convex, thick clump of divergent branches and branchlets, which show no tendency to coalesce or form a basal disk. The marginal branches are divergent, stout, and shorter than the others. In these respects it agrees with Dana's figure, but not with the larger specimen that he described.

The radial corallites are prominent, compressed, and truly nariform, as well described by Dana. The lower lip is elongated, narrowed, incurved, and decidedly thickened, as in the type of *crassilabia*. The edge of the lip is usually lacerate and rough. The walls are finely echino-costulate. The calicles are elliptical, with 12 septa, more conspicuous in the immersed calicles of the bases of the branches. Tahiti (Dana).

Acropora cucullata Ver., sp. nov.

PLATE XXXVI D. FIGURES 8, 8a. PLATE XXXVI E. FIGURE 1.

The coral forms a broad, flat-topped, corymbose clump, covered with rather long, moderately stout, upright, dichotomous, and more or less proliferous branches, those toward the margin arching outward at the base; on the under side usually with numerous divergent, abortive branchlets.

The upright branches are mostly 8 to 10^{mm} in diameter, and 35 to 50^{mm} or more long, round, or subangular when crowded, little tapered to near the ends, which are rapidly narrowed and a little obtuse.

Axial corallites moderately thick, about 2.5^{mm}, scarcely exsert; wall thick, porous, rounded, costulate, with many pores between the costulae.

Radial corallites unequal; the larger normal ones are large, prominent, about 2.5–3^{mm} long, 2–2.5^{mm} broad, divergent at angles of 45°–70°, a little compressed, arched-nariform or cucullate, with the wall thickened and convex on the middle of the outer side, and the thick, obtuse outer lip arched and incurved, so as to produce a hooded form on many of the larger corallites. The edge of the lip is thin and lacerate. Between these are many smaller, short, open tubular or subnariform corallites, with thin lacerate lips, and also many that are immersed, with wide, deep calices, 1–1.10^{mm} in diameter.

The septa are all narrow, and part of them are often rudimentary. In the larger radial corallites the directives are more distinct, but ten other subequal narrow septa are usually visible. In the immersed calices they are mostly obsolete, or nearly so, except the directives, which may meet in the middle, in some cases. But many calices occur in which all six primary septa are well developed, deep down in the calice; others occur with 12 distinct, equal septa, at the edge.

Many of the upright branches also bear more or less numerous gemmiferous corallites, rather longer and larger than the normal radial ones, about 4^{mm} long and 2.5^{mm} broad. These are also at first cucullate with a thick, arched outer lip, and bear 1–4 small, arched corallites; some may later become more evenly tubular, like the axial corallites. All the corallites have finely costulate walls.

Immersed corallites are abundant on the primary branches; less numerous beneath. The cœnenchyma is porous, with numerous, elongated pits, and roughly echinulate.

Indo-Pacific (coll. Ward), No. 6130, Yale Museum. Also Field Columbian Museum. This species is somewhat allied to *A. nosuta*, but is different, not only in growth, but the corallites are more arched and incurved; the walls are more finely costulate and not so rough; the septa are less developed; and the texture more porous.

In mode of growth and form of branches it resembles *A. Kentii* (Br.) and *A. obscura* (Br.), but neither of those species have the peculiar form and structure of radial corallites seen in this.

***Acropora paniculata* Ver., sp. nov.**

PLATE XXXVI D. FIGURES 7, 10, 10a.

PLATE XXXVI E. FIGURE 5.

Coral much branched, forming small dense clumps, 150 to 200^{mm} high and broad, in which the principal branches, which are 12 to 15^{mm} in diameter at base, are repeatedly forked; branches proliferous on all sides, with slender ascending or somewhat excurved branchlets of different lengths, thus producing panicle-like groups of branchlets. The terminal branchlets may be 20 to 40^{mm} long, and 3 to 5^{mm} in diameter, tapered, acute, often bearing 1-3 long, exsert, tubular corallites, besides the axial one.

The axial corallite is slender and exsert, about 1.5^{mm} wide and 3 to 5^{mm} long, with a thin strongly costulate wall and a regular 12-rayed calicle.

The exsert, tubular, lateral gemmiferous calicles may be 6 to 8^{mm} long and 1.5^{mm} in diameter, with 1-3 small basal buds, and costulate wall; the calicle is round and terminal, as in the axial one, with 12 distinct septa; some of them are slightly larger or clavate distally.

The normal radial corallites are prominent, ascending, elongate-tubular, obliquely truncate, nearly as large as the axial ones, with round calicles; the more distal ones usually have the inner lip free for some distance and the end only slightly obliquely truncated, with thin, porous, but firm, costulate walls; those lower down have the inner lip adnate, or nearly so, and the aperture more oblique, with the lower lip a little prolonged, and sometimes a little thickened; some of them are slightly wider distally; all are strongly costulate.

On the bases of the branches they become short-tubular, or verruciform, and many are entirely immersed; these have calicles about 1^{mm} in diameter, with 12 narrow septa.

The cœnenchyma is firm, sparingly porous, irregularly pitted, sparsely covered with minute, sharp granules.

Fiji Islands (?) or Tahiti, Yale Museum (coll. Mrs. Mills), No. 3810.

This species has some resemblance to *A. tubigera*, but the form of the radial corallites is different and it lacks the numerous long, tubular, clustered, exsert corallites of the outer branches. The texture of the cœnenchyma is also different and less compact. The mode of branching is similar, and both have similar costulate walls and stellate calicles.

It also has some resemblance to *A. delicatula* (Br., pl. xxviii), but the latter is more suffruticose, with more profuse and more slender branchlets. The tubular corallites are longer and more numerous.

***Acropora acuminata* Ver.**

Madrepora acuminata Ver., Bull. Mus. Comp. Zoöl., i, p. 40, 1864. Brook, op. cit, p. 38, 1893.

PLATE XXXVI D. FIGURE 5. PLATE XXXVI E. FIGURE 2.
PLATE XXXVI F. FIGURE 11.

This arborescent species branches much like some specimens of *A. muricata*, var. *cervicornis*. The long branches are apt to arise several near together and diverge widely, tapering very gradually. The larger branches are about 20 to 30^{mm} in diameter and 150 to 250^{mm} long.

The axial corallites are of moderate size, not swollen. The normal radial corallites are mostly of one form but unequal in size, widely divergent, mostly standing at angles of 60° to 80°, sometimes 90°. They are mostly rather large, 2 to 2.2^{mm} in diameter, and about the same in length, or 2 to 2.75^{mm}, with rather open, nearly round calicles, 1 to 1.2^{mm} in diameter, looking outward and upward.

The corallites are regularly short tubular, with the end very obliquely truncated or dimidiate and often slightly enlarged, rarely a little compressed. Outer lip a little thickened, often slightly incurved, obtusely rounded; inner lip thin, the free part not half as long as the outer lip. Wall firm, strongly costulate, with small pores in the grooves. Between the large corallites there are many small ones of similar form, but with the calicle less oblique and lips thinner.

On the large branches there are also, in some cases, many longer, spreading, gemmiferous, tubular corallites, with the calicle more nearly or quite terminal. The larger of these are nearly like the true axial corallites in form, about 3-4^{mm} long, and 2.25-2.75^{mm} in diameter; they mostly bear only 1-4 very small basal calicles. The walls are roughly and strongly costulate.

Septa very narrow in all the calicles: usually there are six narrow primaries, the directives a trifle wider; sometimes a few rudimentary secondaries are also present.

Cænenchyma irregularly and roughly pitted, or vermiculate and echinulate.

Kingsmills Islands (coll. A. Garrett). Received from the Mus. Comp. Zoöl. No. 1007.

The above description is from one of the original types. In general appearance and mode of growth it considerably resembles *A. grandis* (Brook) and *A. intermedia* (Brook), as figured by Brook (op. cit., pl. i), but the corallites of both these are quite different, being small and with a more nearly terminal aperture than in our species.

Acropora Ehrenbergii (E. and Haime) var. **scandens**?

? *Madrepora Ehrenbergii* Edw. and Haime, Hist. Corall., iii, p. 143.

? *Madrepora scandens* Klunz., Corall. Rothen Meeres, ii, p. 26, pl. ii, fig. 6, pl. iv, fig. 3, pl. ix, fig. 21. Brook, p. 48.

PLATE XXXVI D. FIGURE 6. PLATE XXXVI E. FIGURE 3.

A large and fine specimen, apparently of this species, but not agreeing very closely with the descriptions, was studied by me. It was formerly in the Ward collection.

It consists of a very large, one-sided, irregularly reticulated corallum, about three feet (900^{mm}) broad and two feet (600^{mm}) high. It arises obliquely from a stout pedicel. The main branches, which are 25-62^{mm} in diameter, diverge and rapidly subdivide into smaller branches, which are very proliferous, the branches being arranged somewhat in one plane. The distal small branches rise up very obliquely and have tapering tips; many small, short, proliferous branches, with similar tips are scattered over the upper side of the frond. On the under side the branches coalesce into an open reticulum, with large, unequal and very irregular meshes, 75 to 100^{mm} long and 25 to 38^{mm} wide.

The larger basal branches bear divaricate, conical branchlets, 10 to 20^{mm} long, 5 to 10^{mm} thick, and others 50^{mm} or more long, and 12 to 15^{mm} thick, which are proliferous and bear smaller divaricate, conical branchlets, 5 to 12^{mm} long. These small, conical branchlets have a large, conical axial corallite, often 5 to 12^{mm} long and 3 to 5^{mm} in diameter at base. They are covered with round, short-tubular, obliquely truncate corallites standing at about 45°, with a round, open calicle; outer lip thickened, obtuse.

Septa 12, all narrow, the directives a little wider. On the larger branches are scattered rather large, open calices, about 1^{mm} in diameter. Some of the calices have a long acuminate outer lip.

Cœnenchyma firm, rough, irregularly and roughly pitted, and rudely echinulate.

On the upper branches the larger radial corallites are divaricate, tubular, obliquely truncate, with the calices opening outward, and with a short, thick, rounded outer lip.

Red Sea ? (coll. Ward), probably now in the Field Columbian Museum. Fragments are in the Yale Museum. No. 6139.

EXPLANATION OF PLATES XXXVI-XXXVI F.

PLATE XXXVI.

[All the figures on this plate are natural size.]

- Figure 1.—*Acropora tubigera* Horn. Branchlet from the original type. P. 239. No. 1483.
- Figure 2.—The same. Upright branch from a Singapore specimen. No. 1370.
- Figures 2a, 2b.—The same specimen. Proliferous tubular corallites and branchlets from the outer and lower sides.
- Figures 3, 3a.—*Acropora protixa* Ver. Branchlets from the type. No. 1686. P. 237.
- Figures 4, 4a.—*Acropora striata* Ver. Branchlets from the type. No. 1688. P. 251.
- Figure 5.—*Acropora pumila* Ver. Branchlet from the type. No. 1687. P. 250.
- Figure 6.—*Acropora turbinata* (Dana). Proliferous upright branch from the type. No. 2017. P. 242.
- Figure 7.—*Acropora cytherella* Ver., sp. nov. An upright branchlet from the type. No. 2007. P. 253.
- Figure 8.—*Acropora symmetrica* (Br.). An upright branchlet from a Zanzibar specimen. No. 79. P. 254.
- Figure 9.—*Acropora dissimilis* Ver., sp. nov. A terminal branchlet from the type. No. 4341. P. 226.
- Figure 10.—*Acropora austera* (Dana). A terminal branchlet from the type. No. 4190. P. 226.
- Figures 11, 11a, 11b.—*Acropora tumida* Ver. Branchlets from the type. No. 886. P. 241.
- Figure 12.—*Acropora digitifera* (Dana). A terminal branch from the type. No. 430. P. 228.
- Figure 13.—*Acropora Wardii* Ver., sp. nov. An upright branchlet from the type. No. 6151. P. 248.
- Figure 14.—*Acropora secale* (Stud.). Distal part of an upright branchlet of the type. Ceylon. No. 3063. P. 244.

- Figures 15, 15a.—*Acropora secatoides* Ver., sp. nov. Distal and middle portions of two upright branchlets of the type. No. 2033. P. 245.
- Figures 16, 16a.—*Acropora effusa* (Dana). Two upright branchlets from the type. No. 3063. P. 229.
- Figure 17.—*Acropora acervata* (Dana). An upright branchlet from the type. No. 4185. P. 220.
- Figure 18.—*Acropora fraternata* Ver., sp. nov. Distal part of an upright branchlet from the type. No. 2032. P. 247.
- Figure 19.—*Acropora indurata* Ver., sp. nov. Branch from the type. No. 6155. P. 230.
- Figure 20.—*Acropora pachygyathus* Ver., sp. nov. Branches from the type. No. 6141. P. 236.
- Figure 21.—*Acropora neglecta* Ver., sp. nov. A terminal branch of the type. No. 6126. P. 250.
- Figure 22.—*Acropora appressa* (Ehr., Dana). Branchlet. $\frac{1}{2}$. P. 222.

PLATE XXXVI A.

[All the figures on this plate are enlarged about two diameters.]

- Figure 1.—*Acropora tubigera* (Horn). A branchlet from an outer upright branch of the type. No. 1483. P. 239.
- Figure 2.—The same. Distal part of an upright branch from a Singapore specimen. No. 1370. $\times 2$.
- Figures 2a, 2b.—The same specimen. Proliferous branchlets from the lower side of a lateral branch. $\times 2$.
- Figures 3, 3a.—*Acropora prolifera* Ver. Branches from the type. No. 1686. $\times 2$. P. 237.
- Figures 4, 4a.—*Acropora striata* Ver. Branches from the type. No. 1688. $\times 2$. P. 251.
- Figure 5.—*Acropora pumila* Ver. A branchlet from the type. No. 1687. $\times 2$. P. 250.
- Figure 6.—*Acropora turbinata* (Dana). A proliferous upright branch from the type. No. 2017. $\times 2$. P. 242.
- Figure 7.—*Acropora cytherella* Ver. A proliferous upright branch from the type. No. 2007. $\times 2$. P. 253.
- Figure 8.—*Acropora symmetrica* (Brook). An upright branch from No. 79. $\times 2$. P. 254.
- Figure 9.—*Acropora dissimilis* Ver. (= *M. echidnea* D.) A terminal branch of the type. No. 4341. $\times 2$. P. 226.

PLATE XXXVI B.

[All the figures on this plate are enlarged about two diameters.]

- Figure 1.—*Acropora austera* (Dana). A terminal branchlet from the type. No. 4190. P. 226.
- Figures 2, 2a, 2b.—*Acropora tumida* Ver. Portions of the type. No. 886. $\times 2$. P. 241.
- Figure 3.—*Acropora digitifera* (Dana). A branch from the type. No. 430. $\times 2$. P. 228.

- Figure 4.—*Acropora Wardii* Ver. An upright branchlet from the type. No. 6151. $\times 2$. P. 248.
- Figure 5.—*Acropora secale* Stud. The distal part of upright branches from the type of Dana. No. 3063. $\times 2$. P. 244.
- Figures 6, 6a.—*Acropora secaloides* Ver. Distal and middle portions of two upright branches of the type. No. 2033. $\times 2$. P. 245.
- Figures 7, 7a.—*Acropora effusa* (Dana). Two upright branches of the type. No. 3063. $\times 2$. P. 229.
- Figure 8.—*Acropora acervata* Dana. An upright branch of the type. No. 4185. $\times 2$. P. 220.
- Figure 9.—*Acropora fraterna* Ver. Distal part of an upright branch of the type. No. 2032. $\times 2$. P. 247.
- Figure 10.—*Acropora appressa* (Dana). Branchlet. $\times 2$. P. 222.

PLATE XXXVI C.

[All figures on this plate are enlarged about two diameters.]

- Figure 1.—*Acropora microphthalma* Ver. A small branch from the type. No. 774. $\times 2$. P. 232.
- Figure 2.—*Acropora diffusa* Ver. Portion of one of the types. No. 1808. $\times 2$. P. 228.
- Figure 3.—*Acropora stellulata* Ver., sp. nov. Part of a branch of the type. No. 435. $\times 2$. P. 238.
- Figure 4.—*Acropora Luzonica* Ver., sp. nov. Portion of a branch of the type. No. 1809. $\times 1\frac{1}{2}$. P. 231.
- Figure 5.—*Acropora pachygyathus* Ver., sp. nov. A branch of the type. No. 6141. $\times 1\frac{1}{2}$. P. 236.
- Figure 6.—*Acropora indurata* Ver., sp. nov. A branch of the type. No. 6155. $\times 1\frac{1}{2}$. P. 230.

PLATE XXXVI D.

[All the figures on this plate are natural size, except 1a, 2a, 9, 10, 10a, 11.]

- Figure 1.—*Millepora nitida* Ver. Part of one of the types. No. 1458. $\frac{1}{2}$. P. 197.
- Figure 1a.—The same specimen. Surface. $\times 5$.
- Figure 2.—*Millepora Braziliensis* Ver. Part of a branch of one of the types. No. 1461. $\frac{1}{2}$. P. 197.
- Figure 2a.—The same specimen. Portion of the surface. $\times 5$.
- Figure 3.—*Acropora urecolifera* Ver., sp. nov. Branch of the type. No. 4187. $\frac{1}{2}$. P. 251.
- Figure 4.—*Acropora appressa* Ehr. Branches from Dana's type. No. 2029. $\frac{1}{2}$. P. 220.
- Figure 5.—*Acropora acuminata* Ver. Part of one of the types. No. 1007. $\frac{1}{2}$. P. 260.
- Figure 6.—*Acropora Ehvenbergii*, var. *scandens*? Klz. Branch from No. 6139. $\frac{1}{2}$. P. 261.
- Figure 7.—*Acropora paniculata* Ver., sp. nov. One of the outer branches of the type. No. 3810. $\frac{1}{2}$. P. 259.

- Figure 8.—*Acropora cucullata* Ver., sp. nov. Two curved upright branches from near the margin of the type, 8a. A marginal branch from the under side. No. 6130. $\frac{1}{4}$. P. 258.
- Figure 9.—*Acropora pumila* Ver. A branchlet from the type. No. 1687. $\times 2\frac{1}{2}$. P. 250.
- Figures 10, 10a.—*Acropora paniculata* Ver., sp. nov. Portions of branchlets from the type. No. 3810. $\times 2\frac{7}{8}$. P. 259.
- Figure 11.—*Acropora effusa* (Dana). Part of a branchlet of the type. No. 3063. $\times 2\frac{5}{8}$. P. 229.

PLATE XXXVI E.

- Figure 1.—*Acropora cucullata* Ver., sp. nov. Two ascending branchlets of upper side of type. No. 6130. $\times 2$. P. 258.
- Figure 2.—*Acropora acuminata* Ver. Part of a branch of type. No. 1007. $\times 2$. P. 260.
- Figure 3.—*Acropora Ehrenbergii*, var. *scaudens?* (Klz.). Branch of No. 6139. $\times 1\frac{1}{3}$. P. 261.
- Figure 4.—*Acropora appressa* (Ehr.). Branches of Dana's type. No. 2029. $\times 1\frac{2}{3}$. P. 222.
- Figure 5.—*Acropora paniculata* Ver., sp. nov. Terminal branchlet of the type. No. 3810. $\times 1\frac{9}{10}$. P. 259.
- Figure 6.—*Acropora urceolifera* Ver., sp. nov. Branch of the type. No. 4187. $\times 1\frac{5}{8}$. P. 251.
- Figure 7.—*Acropora neglecta* Ver., sp. nov. Distal part of branch of the type. No. 6126. $\times 1\frac{5}{8}$. P. 250.

PLATE XXXVI F.

- Figure 1.—*Acropora cytherella* Ver., sp. nov. Branchlets of type. No. 2007. $\times 2\frac{2}{3}$. P. 253.
- Figure 2.—*Acropora turbinata* (Dana). Branchlets of the type. No. 2017. $\times 2\frac{2}{3}$. P. 242.
- Figure 3.—*Acropora tumida* Ver. Branchlet of type. No. 886. $\times 2\frac{2}{3}$. P. 241.
- Figure 4.—*Acropora Wardii* Ver., sp. nov. Part of tip of upright superior branchlet of type. No. 6151. $\times 2\frac{2}{3}$. P. 248.
- Figure 5.—*Acropora neglecta* Ver., sp. nov. Part of branch of type with small lateral branchlet. No. 6126. $\times 2\frac{3}{4}$. P. 250.
- Figure 6.—*Acropora pachycyathus* Ver., sp. nov. Portion of type. No. 6141. $\times 2\frac{3}{4}$. P. 236.
- Figure 7.—*Acropora striata* Ver. Part of a branch of the type. No. 1686. $\times 2\frac{2}{3}$. P. 251.
- Figure 8.—*Acropora tubigera* (Horn). Branchlets of a typical specimen. No. 1370. $\times 2\frac{2}{3}$. P. 239.
- Figure 9.—*Acropora Luzonica* Ver., sp. nov. Portion of a branch of the type. No. 1809. $\times 2\frac{2}{3}$. P. 231.
- Figure 10.—*Acropora stellulata* Ver., sp. nov. Portion of a branch of the type. No. 435. $\times 3$. P. 238.

- Figure 11.—*Acropora acuminata* Ver. Portion of a branch of a cotype. No. 1007. $\times 3$. P. 260.
- Figure 12.—*Acropora indurata* Ver., sp. nov. Small branchlet of the type. No. 6155. $\times 2\frac{3}{4}$. P. 230.
- Figure 13.—*Acropora urecolifera* Ver., sp. nov. Tip of branch of the type. No. 4187. $\times 2\frac{3}{4}$. P. 251.
- Figure 14.—*Acropora prolifica* Ver. Branchlet of the type. No. 1686. $\times 2\frac{2}{5}$. P. 237.
- Figure 15.—*Acropora microphthalma* Ver. Branch of the type. No. 774. $\times 3$. P. 232.
- Figure 16.—*Acropora diffusa* Ver. Portion of a branch of a cotype. No. 1808. $\times 3$. P. 228.

ADDENDA.

Acropora effusa (Dana), see p. 229, and *A. secale* (Stud.), see p. 244.

Under these species I mentioned that they are closely allied, as shown by the types.

A later comparison of the types, with reference to their relationship, shows that, judging from these two specimens, they cannot properly be united, although they agree in mode of growth and some other characters.

The corallites show very evident differences without transitional forms. The axial corallites of *secale* are distinctly larger, throughout, than in *effusa*, and have thicker walls. The radial corallites are larger, more unequal, and more prominent; the larger ones are more tubular, with thicker walls, and a more nearly terminal calicle. In *effusa* they are more obliquely truncated with a shorter inner lip and more oblique calicle.

Of course, a large series might serve to fill the gap between them, but for the present they seem as distinct as most of the related species. The types are both from Point Pedro, Ceylon.

ERRATA.

Page 184, line 6 from bottom, for *Millipora* read *Millepora*.

Page 222, line 19, add PL. XXXVI. FIG. 22; and PL. XXXVI B. FIG. 10.

Page 229, line 17, add PL. XXXVI D. FIG. 11.

Page 244, line 8, omit FIG. 5a and 14a.

VI.—SOME SPIDERS AND MITES FROM THE BERMUDA ISLANDS.
BY NATHAN BANKS.

THE following pages contain a list of some spiders and mites collected in the Bermudas by Prof. A. E. Verrill and some of his assistants. Most of them were gathered the past spring, 1901.*

Several of the spiders are immature, so that they cannot be fully determined. Three of the spiders are described as new. There are twenty-eight spiders in the list, which is more than twice as large as any previous list. They are distributed in sixteen families; the Theridiidae, with six species, leads in point of numbers; eleven families are represented by but one species.

John Blackwall recorded six species of spiders from the Bermudas in 1868.† They are as follows:

1. *Loxosceles rufescens* Lucas. +
2. *Epeira gracilipes* Blackw. +
3. *Thomisus pallens* Blackw. +
4. *Salticus diversus* Blackw.
5. *Heteropoda venatoria* Linn.
6. *Filistata depressa* Koch.

His *Epeira gracilipes*, which was originally described from Rio Janeiro, is probably the common *Epeira theisii* Walek. The *Filistata depressa* is the same as *F. hibernalis* Hentz; while his *Salticus diversus* is a synonym of *Plexippus paykulli* Aud. and Sav.

In 1889, Dr. George Marx reported on the spiders collected in the Bermudas by Prof. Angelo Heilprin.‡

He had twelve species, as follows:

1. *Uloborus zosis* Walek.
2. *Nephila clavipes* Koch.
3. *Cyclosa caudata* Hentz.
4. *Epeira labyrinthica* Hentz. +
5. *Theridium tepidariorum* Koch.

* These collections were made in April and May, 1898, and from March 10th to May 9, 1901. Probably many other species could be found in summer and autumn.—A. E. V.

† Notice of several species of Spiders supposed to be new or little known to Arachnologists. Ann. Mag. Nat. Hist. (4), ii, 1868, pp. 403-410.

‡ A contribution to the knowledge of the spider fauna of the Bermuda Islands, Proc. Acad. Nat. Sci., Philad., 1889, pp. 98-101, one plate. Heilprin's collection was made in midsummer. Prof. Verrill's in the spring. This may account for part of the difference.

6. *Argyrodes nephilæ* Tacz. +
7. *Pholcus tipuloides* Koch.
8. *Dysdera crocata* Koch.
9. *Plexippus paykulli* Aud.
10. *Tapinattus melanognathus* Lucas.
11. *Heteropoda venatoria* Linn.
12. *Lycosa atlantica* Marx.

Although in the present list there are many more species than in these two together, there are five species in these lists (indicated by +) which do not appear in the collections of Prof. Verrill. Adding these to the present list, we have a total of 33 spiders known from the Bermudas.

Three of Blackwall's list he considered new; the other three do not show anything as to the affinities of the fauna. Of Dr. Marx's twelve species, ten are found in the Southern United States, but most of these are widely distributed in the neotropical region. The present list will not uphold this affinity to the mainland, but indicates a relationship with the West Indian fauna.

Although Blackwall described three new species in his list, Dr. Marx one in his, and the writer three in this list, it is quite improbable that any of the species are peculiar to the islands; two of those here described are known to me from Hayti, and elsewhere in the West Indies.

FILISTATIDÆ.

Filistata hibernalis Hentz. Large Brown Spider.

Filistata hibernalis Hentz, Journ. Bost. Soc. Nat. Hist., iv, 227, pl. vii, fig. 6, 1842.

Several specimens; a male from Walsingham, May 5; one specimen from Tucker's Island, 3 May, under stones. Known from the Southern United States, Mexico, Central America, and the West Indies. Nos. 2321, 2322, 2324, 2331-33.

SCYTODIDÆ.

Scytodes longipes Lucas.

Scytodes longipes Lucas, Ann. Soc. Ent. France, 1845, p. 71, pl. i, fig. 1.

Three specimens; a male from mouth of Tucker's Island cave, 3 May. Known from northern South America, Central America, and West Indies. Two specimens collected by Mr. T. G. Goslin in summer. Nos. 2319, 2343, 2360, 2408.

Scytodes fusca Walekenaer.

Scytodes fusca Walck., Aptères, i. p. 272, 1837.

One specimen from the entrance of Tucker's Island cave, 3 May. Distribution like that of the preceding species. Nos. 2355.

DYSDERIDÆ.

Dysdera crocata Koch.

Dysdera crocata Koch, Die Arach., v, p. 81, pl. clxvi, figs. 392, 393, 394, 1839.

Several specimens, one from Walsingham, 3 May, common under stones. Occurs in Europe and the Eastern United States. Nos. 2308, 2347.

OONOPIDÆ.

Oönops bermudensis, sp. nov.

Cephalothorax, mandibles, sternum and legs pale yellow, the femora paler on bases, eyes on black spots; abdomen pale gray. Cephalothorax clothed with scattered black hair; central eyes short

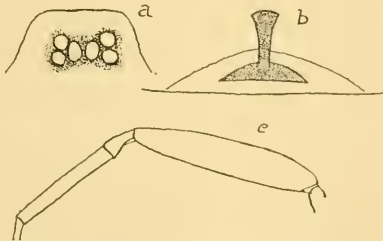


Figure 1.—*Oönops bermudensis*; a, eyes; b, epigynum; c, hind leg.

elliptical, touching; lateral eyes round, equal, their point of touching opposite the middle of the central eyes; the eye-area plainly broader than long. Legs with black hair and reddish spines, quite long and slender, hind femora thickened and reaching the posterior third of the abdomen. Palpi with many short stout spines and a pair of longer spines under the bases of the tibia and tarsus. Abdomen once and two-thirds longer than broad; epigynum shows a transverse crescentic mark and from the middle in front is a clavate extension.

Length, 2^{mm}. No. 2340.

One specimen from the Bermudas, without more definite locality.

DRASSIDÆ.

Callilepis, sp.

One immature specimen of a dark-colored species, from mouth of Tucker's Island cave, 3 May. No. 2356.

CLUBIONIDÆ.

Corinna, sp.

Several immature specimens from Hungry Bay, April. No. 2334.

Hypsinotus, sp.

An immature specimen, very close to, and perhaps identical with *H. pumilis* Keys., from Porto Rico. No. 2309.

Anyphæna Verrilli, sp. nov.

Cephalothorax pale yellowish, darker in front, the clypeus and mandibles red-brown; sternum yellowish; legs pale, more red-brown on metatarsi and tarsi, especially of the anterior pairs. Abdomen above and below pale, above with many rows of darker hairs. The cephalothorax is rather short and broad; the A. M. E.



Figure 2.—*Anyphæna Verrilli*, epigynum.

scarcely diameter apart, rather closer to the equal A. S. E.; P. M. E. somewhat larger, nearly twice their diameter apart and about as far from the nearly equal P. S. E. Posterior eye-row strongly procurved, longer than the anterior eye-row. Mandibles rather large and hairy, but not porrect nor divergent, a little longer than the patella of leg I. Legs of moderate length, and quite densely spined. Ventral furrow about three-fourths the distance from the spinnerets to the lung-slits; abdomen about twice as long as broad, truncate at base.

Length ♀, 8.5mm.

One specimen from Walsingham, 3 May, 1901. I have also seen specimens from parts of the West Indies. No. 2346.

Eutichurus insulanus, sp. nov.

Cephalothorax dull brownish yellow, eyes on black spots; mandibles red-brown; sternum brownish yellow; legs pale greenish; abdomen pale gray, rather darker above than below, blackish around the spinnerets, the latter pale. The cephalothorax is rather

low and quite broad in front. The mandibles are large and gibbous above at base, plainly divergent, in front with many small granules from each of which arises a bristle. Posterior eye-row straight, a little longer than the anterior; all eyes sub-equal. A. M. E. less than their diameter apart, and as close to the equal A. S. E.; P. M. E. once and one-half their diameter apart, about diameter from the equal P. S. E.



Figure 3.—*Eutichurus insulanus*; epigynum.

Legs moderately long, very hairy, with a few weak spines; two pairs under the tibiae and metatarsi I and II; tibiae III and IV below with one spine near base, one near middle, and a pair at tip, these metatarsi with three pairs below. Abdomen about once and three-fourths as long as broad, broadest behind the middle, rounded at base and tip, convex above; the superior spinnerets long, two-jointed, the apical joint tapering and as long as the basal; epigynum shows two oblique, elliptical openings, some distance apart.

Length ♀, 5.5^{mm}. No. 2362.

One female from the Bermudas (without more definite locality) collected by W. G. Van Name, in May. It occurs also in Hayti.

DICTYNIDÆ.

Dictyna, sp.

One young specimen, without particular locality. No. 2367.

AGALENIDÆ.

Tegenaria derhami Scopoli.

Araneus derhami Scop., Entom. Carnioli., p. 400, 1763.

Tegenaria derhami Emerton, Trans. Conn. Acad., viii, p. 29, pl. vii, figs. 6, 6c; 1890.

Several specimens; one from Walsingham, 3 May; another preyed upon by *Plexippus paykulli*, 20 April. It is a cosmopolitan spider. Nos. 2326, 2327.

PHOLCIDÆ.

Pholcus tipuloides Koch.

Pholcus tipuloides Koch, Die Arachn. Australiens, p. 281, 1871.

Pholcus tipuloides Marx, Proc. Phil. Acad. Nat. Sci., 1889, p. 99, pl. iv, fig. 5.

Several specimens, some from Tucker's Island cave, 3 May. (It occurred at and within the entrance of the cave in considerable numbers.—A. E. V.). A cosmopolitan species. Nos. 2315, 2316, 2320, 2361, 2409.

THERIDIIDÆ.

***Theridium tepidariorum* Koch.**

Theridium tepidariorum Koch, Die Arach., viii, p. 75, figs. 647, 648, 1841.

Theridium tepidariorum Emer., Trans. Conn. Acad., vi, p. 13, pl. ii, fig. 1, 1882.

Four specimens collected by Mr. T. G. Goslin in summer. Nos. 2401, 2407. It is found in houses throughout the civilized world.

***Theridium studiosum* Hentz.**

Theridium studiosum Hentz, Journ. Bost. Soc. Nat. Hist., vi, p. 274, pl. ix, fig. 5, 1850.

Two females from Walsingham, 3 May. Occurs in the Southern States, and Mexico. No. 2349.

***Theridium rufipes* Lucas.**

Theridium rufipes Lucas, Explor. de l'Algérie, Arachn., p. 263, pl. xvi, fig. 5, 1847.

One specimen, male, from mouth of Tucker's Island cave, 3 May. A common cosmotropical spider. No. 2354.

***Lathrodectus geometricus* Koch.**

Lathrodectus geometricus Koch, Die Arachn., viii, p. 117, pl. cclxxxiv, fig. 684, 1841.

Several examples; a pair from Paynters' Vale, 28 April; two females have their egg-cocoons. Known from South America, and the West Indies. Nos. 2323, 2352, 2353, 2363.

***Bathyphantes*, sp.**

Two specimens, both immature; the sternum and venter are black, the dorsum of abdomen dark gray with a black herring-bone mark, legs pale, cephalothorax yellowish. No. 2338.

***Erigone*, sp.**

One female, immature, abdomen and sternum black, mandibles rather prominent and diverging. No. 2335.

ULOBORIDÆ.

Uloborus geniculatus Olivier.

Araneus geniculatus Oliv., Ency. Meth., ii, p. 214, 1789.

Uloborus zosis Walck., Aptères, ii, p. 231, 1842.

Uloborus zosis Marx, Proc. Acad. Nat. Sci. Philad., 1889, pl. iv, fig. 1.

Several specimens received from Mr. T. G. Goslin, collected in summer. Nos. 2404, 2406. A widely distributed, cosmotropical spider.

EPEIRIDÆ.

Cyclosa caudata Hentz.

Epeira caudata Hentz, Journ. Bost. Soc. Nat. Hist., vi, p. 23, pl. iii, figs. 14, 14a, 14b, 1850.

Cyclosa conica Emerton, Trans. Conn. Acad., vi, p. 321, pl. xxxiv, fig. 3, 1884.

Various specimens, several from Walsingham woods, 3 May, on trees; two from Tucker's Island, 3 May. Distributed over the United States and Mexico. Nos. 2339, 2350, 2358.

Argyropeira hortorum Hentz. Silver Spider.

Epeira hortorum Hentz, Journ. Bost. Soc. Nat. Hist., v, p. 477, pl. xxxi, fig. 19, 1847.

Argyropeira hortorum Emerton, Trans. Conn. Acad., vi, p. 332, pl. xxxvii, figs. 29-32, 1884.

Three adults from Walsingham woods, 3 May, on trees; several young specimens. Occurs in the eastern United States, Mexico, and the West Indies. No. 2330.

Nephila clavipes Fabricius. Silk Spider.

Aranea clavipes Fabr., Entom. Syst., ii, p. 420, 1775.

Nephila clavipes Koch, Die Arachn., v, p. 31, pl. clii, fig. 355, 1839.

Several adults taken by Mr. T. G. Goslin, last summer. The largest has an expanse of 5.5 inches. This is the typical form, as is shown by Mr. F. O. P. Cambridge in a recent paper on spiders from the Bahama Islands (Ann. Mag. Nat. Hist., April, 1901, pp. 322-332).

Occurs along the South Atlantic coast, and the regions adjacent to the Caribbean Sea.

(The adults are found only in late summer and autumn. It is mentioned by the earliest settlers, 1610-1615.—A. E. V.) Nos. 2314, young; 2399, adult.

SPARASSIDÆ.

Heteropoda venatoria Linn. Great House Spider.

Aranea venatoria Linn., Syst. Nat., Ed. x, p. 1037, 1758.

Ocypte murina Koch, Die Arach., xii, p. 36, pl. cecev, fig. 978, 1845.

Several specimens, one very young. A common cosmopolitan spider, occurring in the extreme southern portions of the United States. (Found in outhouses and sometimes in dwellings. The largest are 4.50 inches across the outstretched legs. It is a very active running spider.—A. E. V.) Nos. 2305, 2306, 2317, 2342.

LYCOSIDÆ.

Lycosa atlantica Marx.

Lycosa atlantica Marx, Proc. Acad. Nat. Sci., Philad., 1889, p. 100, pl. iv, fig. 4.

Several specimens; one from Hungry Bay, April, under stones; another from the mouth of Tucker's Island cave, May 3. It is very possibly the same as *Lycosa fusca* Keys., described from Cuba in 1877. Nos. 2307, 2325, 2357, 2405.

OXYOPIDÆ.

Oxyopes salticus Hentz.

Oxyopes salticus Hentz, Jour. Bost. Soc. Nat. Hist., v, p. 196, pl. xvi, fig. 10, 1845.

Two immature specimens. Occurs from the southern United States to Brazil. No. 2345.

ATTIDÆ.

Wala vernalis Peckham. Jumping Spider.

Anoka vernalis Peck., Proc. Zoöl. Soc. London, 1893, p. 701.

Anoka vernalis Peck., Occ. Pap. Nat. Hist. Soc. Wis., vol. ii, no. 2, pl. xiii, fig. 3, 1894.

One female collected by Mr. T. G. Goslin in summer. No. 2410. Described from Jamaica, but now known from many parts of the West Indies.

Tapinattus melanognathus Lucas. Jumping Spider.

Salticus melanognathus Lucas, Hist. Nat. d'Iles Canar., ii, p. 29, 1839.

Menemerus melanognathus Marx, Proc. Acad. Nat. Sci., Philad., 1889, p. 99, pl. iv, fig. 3.

One specimen. A cosmotropical spider, found in Florida and California. No. 2313.

Plexippus paykulli Aud. and Sav. Larger Jumping Spider.

Attus paykulli A. and S., Descrip. de l'Égypte, xxii, p. 172, 1827.

Menemerus paykulli Marx, Proc. Acad. Nat. Sci., Philad., 1889, p. 99, pl. ii, fig. 2.

A number of specimens; one feeding on a *Tegenaria derhami*, 20 April. A very common cosmotropical spider, not rare in the southern United States. Nos. 2310-12, 2359, 2402.

ACARINA.

Actineda agilis Banks. Mite.

Actineda agilis Bks., Trans. Amer. Entom. Soc., 1894, p. 211.

Two specimens, one from Castle Island, under stones, 24 April. Previously known only from the eastern United States. No. 2379.

Rhyncholophus, sp. Mite.

Two specimens of a small, undescribed species. No. 2380.

Holostaspis, sp.

Two specimens and one young, probably of the same species. The American forms of this genus have not been studied. No. 2381.

VII.—THE MARINE AND TERRESTRIAL ISOPODS OF THE BERMUDAS,
WITH DESCRIPTIONS OF NEW GENERA AND SPECIES.

BY HARRIET RICHARDSON.

[Collaborator, Smithsonian Institution.]

1. *The Marine Isopods of the Bermudas, with descriptions of thirteen New Species and three New Genera.*

There is almost no literature relating to the Marine Isopods of the Bermudas.

In 1891 Ives* described and figured a new species of *Cymodocea* from the Bermudas (*C. bermudensis*), which has since been referred to the genus *Dynamene*.

Several species of wide-spread distribution have been recorded from the Bermudas, as for example, *Idotea marina* (Linnæus), specimens of which are in the Smithsonian Institution. It was taken in abundance by the Yale party in 1901, in Hamilton Harbor.

Spence Bate† mentions, without any description, a species of *Bopyrus* from the Bermudas, parasitic on *Latreutes ensiferus* (Milne-Edwards), which is without doubt, identical with *Bopyroides latreuticola* Gissler, found on the same host at Beaufort, North Carolina.

The material for the present paper is the result of three expeditions to the Bermudas; one in 1876-7, when Prof. George Brown Goode collected a number of Isopods; one in 1898, undertaken by Prof. A. E. Verrill and party; and another in the spring of 1901, by Prof. A. E. Verrill and Mr. A. H. Verrill.

These collections contain both known and unknown species. Among the known species are to be mentioned specimens of *Dynamene bermudensis* Ives, and *Idotea marina* (Linnæus), already recorded from the Bermudas.

Also specimens of *Corallana quadricornis* Hansen, *Alcirona krebsii* Hansen, *Nerocila acuminata* Schiædte and Meinert, *Dynamene perforata* Moore, and *Cilicæa caudata* (Say), common to West

* Proc. Philad. Acad. Nat. Sci., 1891, p. 194.

† Report of the Scientific Results of the Exp. Voyage of H. M. S. Challenger, xxiv. p. 582, 1888.

Indian waters ; *Tanais cavolinii* Milne-Edwards, *Leptochelia rapax* Harger, and *Leptochelia dubia* (Krøyer), the first and last named of wide distribution, and all three common to the Northeast coast of America. These species have not been previously recorded from the Bermudas.

The thirteen new species herein described are representatives of the following families : *Apseudidae*, *Anthuridae*, *Cirolanidae*, *Sphaeromidae*, and *Janiridae*. Three are the types of new genera.

CHELIFERA or TANAIIOIDEA.

Family Tanaidæ.

Tanais cavolinii Milne-Edwards.

Tanais cavolinii Milne-Edwards, in Andouin and Milne-Edwards, Précis d'Entomologie, i, pl. xxix, fig. 1, 1828 ; Hist. Nat. des Crust., iii, p. 141, pl. xxxi, fig. 6, 1840.

Tanais tomentosus Krøyer, Naturhist. Tidsskr., iv, p. 183, 1842 ; *ibid.* (2) ii, p. 412, 1847 ; Voy. en Scand., Crust., pl. xxvii, figs. 2a-q, 1849. Lilljeborg, Öfvers. Vet.-Akad. Förh., Årg., viii, p. 23, 1851. Meinert, Crust. Isop. Amph. Dec. Danaïæ, p. 86, 1877.

Crossurus vittatus Rathke, Fauna Norwegens, p. 39, pl. 1, figs. 1-7, 1843.

Tanais hirticaudatus Bate, Rep. Brit. Assoc., 1860, p. 224, 1861.

Tanais vittatus Lilljeborg, Bidrag Känn. Crust. Tanaid, p. 29, 1865. Bate and Westwood, Brit. Sess. Crust., ii, p. 125, 1866. Stebbing, Trans. Devon. Assoc., 1874, p. 7, and 1879, p. 6 ; Ann. Mag. Nat. Hist., (4) xvii, p. 78, 1876. Verrill, Am. Jour. Sci. (3), x, p. 38, 1875. Harger, Proc. U. S. Nat. Mus., ii, p. 162, 1879 ; Rep. U. S. Fish Comm., pt. 6, p. 418-419, pl. xiii, figs. 81-82, 1880.

Tanais tomentosus G. O. Sars, Crust. of Norway, ii, pt. i, ii, p. 12, pl. v, 1896.

Tanais Cavolinii Dollfus, Bull. Soc. Zoöl. de France, xxi, p. 207, 1897 ; Mém. de la Soc. Zoöl. de France, xi, p. 35, 1898. Norman, Ann. Mag. Nat. Hist. (7), iii, pp. 332-333, 1899. (See Norman for synonymy and full reference.)

Hab. Castle Harbor, Bermudas, in dead coral, collected by A. E. Verrill and party.

Also found at Noank, Conn. ; Long Island Sound ; Greenland ; west coast of Norway ; British Isles ; West France ; Azores. Depth, 1-6 ft. (Verrill).

Leptocheilia dubia (Krøyer).

Tunais dubius Krøyer, Naturh. Tidssk., iv, p. 178, pl. ii, figs. 20-22, 1842-3.

Paratanais algicola Harger, Am. Jour. Sci. and Art, xv, p. 377, 1878.

Leptocheilia algicola Harger, Report U. S. Fish Com., pt. 6, p. 421, 1880.

Leptocheilia dubia G. O. Sars, Archiv for Math. og Naturvid., p. 26, 1880; and p. 317, pl. x, xi, 1886.

Leptocheilia algicola Dollfus, Mém. de la Soc. Zool. de France. xi, p. 44, 1898.

Leptocheilia dubia Norman, Ann. Mag. Nat. Hist. (7), iii, p. 334, 1899.

?*Leptocheilia incerta* Moore, Report U. S. Fish Com., ii, p. 165-166, 1901.

There are two males and a small number of females in the collection. The males and females agree with the original description and figures of *L. dubia* (Krøyer), the inner branch of the uropoda in both sexes consisting of five joints.*

There are also two specimens in the collection, both females, which have the inner branch of the uropoda two-jointed. Although this may be a new species of *Leptocheilia*, I do not feel warranted with such scanty material, and with no males, to describe a new species of this genus.

Hab. Castle Harbor, Bermudas, collected by A. E. Verrill and party, in 1898. Also Jersey; Birterbny Bay, Ireland; Falmouth Harbor; Valentia, Ireland; Mediterranean; Atlantic coast from Brittany to Senegal and Teneriffe; Northeast coast of N. America; Brazil.

Leptocheilia rapax Harger.

Leptocheilia rapax Harger, Proc. U. S. Nat. Museum, ii, p. 163, 1879. Report U. S. Fish Comm., pt. vi, p. 424, pl. xiii, figs. 89, 90, 1880.

Hab. Bermudas, collected by W. G. Van Name, May, 1901.

Also found at Annisquam, Mass., in 3 feet of water, on muddy bottom.

* There is no character of specific importance to separate *L. algicola* Harger from *L. dubia* (Krøyer) the males and females of *L. dubia* in the collection from the Bermudas agreeing with Harger's specimens as figured and described, with the exception that the Bermudian specimens have five joints to the inner branch of the uropoda instead of six. Stebbing has pointed out (Ann. Mag. Nat. Hist. (6) xvii, p. 158-159, 1896) that there is some variation in the number of joints in several species of *Leptocheilia*, and *L. Edwardsii*, which Krøyer figures and describes as having seven joints to the inner branch, is now recognized as a synonymy of *L. savignyi*, which is figured and described by the same author as having six joints. It is not improbable, as Stebbing has suggested, that *L. savignyi* and *L. dubia* are identical.

Family **Apseudidæ.****Apseudes triangulata** Richardson, sp. nov.

PLATE XXXVII. FIGURES 1-5.

Body narrow, elongated, surface smooth.

Head with frontal margin produced at the middle in a rostrum like a spear point, whose sides near the base are excavated below the lateral expansion of the rostrum. On either side of the excavation thus formed the margin is acutely produced in a small anterior process. Lateral to this process is the ocular process, which is produced anteriorly about the same distance. The eyes are distinct and black and occupy almost the whole surface of the ocular lobe.

The first pair of antennæ have the first joint of the peduncle long, the inner lateral margin of which is armed with three long spines and one small one; the outer margin, with one large spine near the apex. The second joint is one-third the length of the first joint and is unarmed. The third joint is one-half as long as the second joint. The flagellum is composed of about fourteen joints; the secondary appendage of about seven joints. The peduncle of the second pair of antennæ extends to the end of the first joint of the peduncle of the first pair, and has an exopod developed at the base of the third joint. The flagellum is composed of about ten joints, and extends about half the length of the flagellum of the first pair of antennæ. There is a prominent spine on the epistoma.

The first free segment of the thorax is shortest, the two following ones being longer, the next two the longest, and the last but little longer than the first. The first segment is as wide as the head, the others decrease in width gradually. The antero-lateral margins of all the segments except the first are produced into one acute process, of the fourth and fifth free segments into two acute processes. The last segment bears a ventral spine.

The abdominal segments gradually decrease in width backwards. The sixth or terminal segment is produced on either side near the base into two acute processes. Beyond the last process the segment widens slightly for the attachment of the uropoda, and ends posteriorly in a triangular process. The uropoda are very long, the inner branch being half the length of the body, and composed of about twenty-five joints. The outer branch is composed of seven joints.

First gnathopods with the upper distal margin of the propodus, finely serrate and armed with a tooth near the articulation of the

dactylus. Second gnathopods have the merus armed with one spine at its distal extremity on the posterior margin, and one on the anterior margin; the carpus armed with two spines on its posterior and one on the anterior margin at the distal extremity; the margin of the propodus armed with three spines on the posterior margin, and one large spine and one small one at the distal extremity on the anterior margin. The dactylus is serrate on its inner margin. Exopods are present on both first and second gnathopods. The other legs are beset with spines.

The specimen is a female and has a large marsupium filled with eggs, extending the length of the first four free segments of the thorax.

Only one individual was collected by A. E. Verrill and party, in Harrington Sound, Bermudas.

Type specimen in Peabody Museum, Yale University. Cat. No. 3192.

Apeudes propinquus Richardson, sp. nov.

PLATE XXXVII. FIGURES 6-9.

Body narrow, elongated, surface smooth.

Head with frontal margin produced in the middle in a long, acute, deflected process, from base of which on both sides there is an abrupt lateral expansion, the margin forming an outward curve which extends to the base of the ocular lobe and then proceeds straight to the lateral margin of the head. Ocular lobe produced in an acute process. Eyes large, black, occupying the whole of the ocular lobe.

First pair of antennæ with first joint of peduncle long, and armed on inner lateral margin with two large spines and one small one near the base, and on distal end of outer margin with one large spine. Second joint less than one-third the length of first joint and unarmed. Third joint one-half as long as second joint. Flagellum composed of sixteen joints. Secondary appendage composed of eight joints. Second pair of antennæ with an exopod at base of third joint of peduncle; flagellum composed of ten joints. There is a conspicuous spine on the epistoma.

First two free segments of the thorax about equal in length, the three following ones longer, increasing in length, the last segment a little longer than the first two. The antero-lateral margins of all the segments are acutely produced, those of the fourth and fifth free

segments have two antero-lateral angulations. There is an anteriorly directed curved spine on the ventral surface of the first free segment. On the ventral surface of the second segment there is a straight spine directed posteriorly. The third, fourth, and fifth segments bear each a ventral curved spine directed anteriorly. The sixth segment has on the ventral surface a large, stout process.

The lateral margins of all the first five abdominal segments are drawn out in acute processes.

The terminal segment has two lateral angulations above the attachment of the uropoda. The posterior margin is triangulate. The inner branch of the uropoda is very long, equal in length to half the body, and is composed of thirty-four joints. The outer branch consists of eleven joints.

The first gnathopods have a tooth on the distal margin of the propodus near the articulation of the dactylus. There is a conspicuous spine on the posterior margin of the basis.

The second gnathopods have one spine at the distal end of the merus on the anterior margin; one spine at the distal end of the carpus on the anterior margin and two spines on the posterior margins of the same joint; four spines on the posterior margin of the propodus and two on the anterior margin at the distal extremity; the dactylus is serrate along the inner margin. Exopods are present on both first and second gnathopods. The other legs are beset with spines.

A few specimens, both males and females, were collected by A. E. Verrill and party at Bailey Bay and Castle Harbor, Bermudas, in 1898.

Type specimen from the Bermudas in Peabody Museum, Yale University. Cat. No. 3194.

This species is very closely related to *Apsuedes intermedius* Hansen* but differs in the following points.

1.—The first joint of the peduncle of the first pair of antennæ is armed with three spines on the inner margin, and one spine on the outer margin at the distal end. In *A. intermedius*, this joint is unarmed.

2.—In the increased number of joints in the flagella of both pairs of antennæ, there being sixteen joints in the flagellum of the first pair of antennæ, eight in the secondary appendage, and ten in the flagellum of the second pair of antennæ, while in Dr. Hansen's spe-

* Isopoden, Cumaceen, und Stomatopoden der Plankton-Expedition, p. 49-50, pl. v, fig. 10-10b, pl. vi, fig. 1, 1895.

cies the flagellum of the first pair of antennæ is composed of seven joints, the secondary appendage of three joints, and the flagellum of the second pair of antennæ of four joints.

3.—In the much greater length of the uropoda, the inner branch of which in *A. propinquus* is half the length of the body and composed of thirty-four joints, the outer branch consisting of eleven joints, while in *A. intermedius* the outer branch has only four joints, and the inner branch is only twice the length of the terminal abdominal segment and is composed of only fifteen joints.

Parapseudes goodei Richardson, sp. nov.

PLATE XXXVII. FIGURES 10-14.

Surface of body smooth; color light yellow.

Head but slightly narrowed anteriorly. Eyes with large, brown ocelli and placed on ocular processes, articulated to the head. Frontal margin with a rostrum projecting between the basal joints of the first pair of antennæ. The base of the rostrum is constricted, the anterior margin broadly rounded.

The first pair of antennæ have the peduncle short, the first joint twice as long as the second, the third half as long as the second, all three with margins smooth, unarmed, but fringed with long hairs. The flagellum consists of seven joints; the secondary appendage of four joints. The second pair of antennæ extend only to the end of the peduncle of the first pair; the flagellum contains five joints; a scale is articulated to the peduncle.

The first, second and third free thoracic segments are about equal in length, the following three being longer than the first three, and sub-equal. The first and second segments have a small epimeral lobe on the antero-lateral margin. The third segment has a small lobe about the center of the lateral margin. The lobes of the three following segments are situated post-laterally.

The abdomen is very short; all the segments together not equaling in length the last two thoracic segments. The first five segments have the margins produced at the sides, with deep lateral incisions between the segments.

The terminal segment is triangulate posteriorly with the apex acute. The uropoda are quite half the length of the body; the inner branch consisting of about twenty-five joints, the outer and smaller branch consisting of six joints. There are but four pairs of pleopoda.

The first pair of legs of the female are much more slender than those of the male. In the male there is a deep excavation on the distal margin of the propodus near the articulation of the dactylus, while in the female this excavation is comparatively small. In the male there is a spine within this excavation and one on the dactylus, both situated at the articulation of the dactylus and the propodus. Exopods are present on both pairs of gnathopods. All the other legs are very spinulose.

A few specimens (types) were collected by A. E. Verrill and party in 1898, at Castle Harbor, Bermudas, and one specimen was collected by G. Brown Goode at the Bermudas in 1876-7.

Type in Peabody Museum, Yale University. Cat. No. 3222.

This species has a close resemblance to *Parapseudes latifrons* (Grübe),* but differs in the following characters: in *P. goodei* the first pair of gnathopods are more robust; the propodus has a deep excavation near the articulation of the dactylus, within which is a large spine. There is also a spine on the dactylus.

The rostrum is constricted at the base in *P. goodei*, while in *P. latifrons* the line is unbroken from the apex of the rostrum to the lateral margin of the head.

The secondary appendage of the flagellum of the first antennæ is composed of four joints in *P. goodei* while in *P. latifrons* this appendage is composed of seven joints. The flagellum of the second pair of antennæ consists of five joints in *P. goodei*, while in Grübe's species it consists of eight joints.

FLABELLIFERA or CYMOTHOIDEA.

Family Anthuridæ.

Paranthura infundibulata Richardson, sp. nov.

PLATE XXXVIII. FIGURES 15-20.

♂. Body narrow, elongate; color yellow, with markings of black.

Head with antero-lateral angles prominent, between which the frontal margin is excavate for the reception of the antennæ, the middle being produced in a conspicuous median point. The eyes are situated in the antero-lateral prolongations.

* *Rhoëa latifrons* Grübe, Die Insel Lussin und ihre Meeresfauna, p. 75, 1864.

Parapseudes latifrons G. O. Sars, Archiv for Math. og Naturvidenskab, Vol. xi, p. 304, pl. viii, 1886.

The first pair of antennæ have the basal joint long, oblong in shape, the other two joints of the peduncle being short and about equal in length; the flagellum consists of nine joints.

The second pair of antennæ have the second joint of the peduncle very long, slightly exceeding in length the first and second peduncular joints of the first pair of antennæ. The second antennæ are geniculate at the articulation of the second and third joints. The other three joints, following the second, are of nearly equal length. The flagellum consists of a single tapering joint, furnished with hairs.

The first three thoracic segments are about equal in length, elongate, the first two having their posterior angles rounded. The fourth, fifth and sixth segments are equal in length, and one-third shorter than the first three. The seventh segment is about half as long as the preceding one, and has the posterior angles produced downwards.

The segments of the abdomen are distinct, and very short, all five anterior to the terminal segment being no longer than half the length of the seventh thoracic segment. The terminal segment is long and narrow, of the same width throughout its length, except at the apex, where the lateral margins are abruptly drawn out into processes, which curve upwards, giving a funnel-shaped appearance to the posterior end of the segment, which is very concave. The posterior margin is truncate and coarsely denticulate.

The inner branches of the uropoda do not quite reach the extremity of the terminal abdominal segment. The basal joint is about half the length of the terminal abdominal segment. The inner branch is extremely concave, with its entire margin denticulate, its ventral surface having a longitudinal carina. The outer and superior branch is long and narrow, quadrangular and somewhat narrowed posteriorly, and from the middle slightly curving upward, coarsely denticulate on its inner lateral and posterior margin, the teeth being rather widely separated. The branches of the uropoda and the terminal abdominal segment are fringed with hairs.

The first, second and third pairs of legs are sub-cheliform. The second and third pairs have the propodus similar in shape to the first pair, but more slender and armed on their posterior margin with seven or eight large conspicuous spines. The other legs are longer and more slender, and armed with four spines on the anterior margin of both the carpus and the propodus.

A number of specimens, all males, were collected by George Brown Goode in 1876-7, at the Bermudas.

Type specimens in Peabody Museum, Yale University. Cat. No. 3207.

Paranthura verrillii Richardson, sp. nov.

PLATE XXXVIII. FIGURES 21-22.

Body narrow, elongate. Color dark brown, with scattered black dots.

Head with lateral angulations prominent, rounded, between which the front is excavate on either side of a small median point. Eyes large, situated in the lateral angulations.

First pair of antennæ have the first joint of the peduncle oblong, the other two shorter and about equal in length, flagellum six to seven jointed. The second pair of antennæ have a five-jointed peduncle, (the first joint being short and indistinct,) of which the second and fifth joints are longest, the flagellum being consolidated into a single, flattened, tapering joint, furnished with hairs.

The first five thoracic segments are of equal length. The sixth is somewhat shorter than any of the others, and the seventh is half as long as the sixth.

The abdominal segments are distinct, the first five taken together being no longer than the seventh thoracic segment. The terminal abdominal segment is long and narrow, rectangular in shape, with margins entire. The basal joint of the uropoda is half as long as the terminal segment of the abdomen; the inner branch is rectangular, coarsely denticulate, and reaches the apex of the telson. The outer superior branch is narrow, elongate, rectangular, with margins coarsely denticulate, the teeth being close together.

The branches of the uropoda and the terminal abdominal segment are fringed with long hairs.

The first three pairs of legs are sub-chelate. The second and third pairs have the posterior margin of the propodus armed with spines, as in the preceding species. In the following four pairs of legs the anterior margin of the propodus is armed with four spines.

A single female was collected by A. E. Verrill and party in 1898, at the Bermudas. Depth, 1-2 feet.

Type specimen in Peabody Museum, Yale University. Cat. No. 3186.

Colanthura Richardson, gen nov.

Body narrow, elongate. First pair of antennæ composed of four joints, the last joint being the flagellar joint. Second pair of antennæ composed of five joints, the terminal joint fringed with hairs.

The first six segments of the thorax large, the seventh very short, abruptly narrower than the sixth, not as wide as the abdominal segments and devoid of legs.

The first three pairs of legs are sub-chelate, the three following pairs ambulatory.

The abdominal segments are well defined and distinct from one another. The terminal abdominal segment is rounded, entire. The inner branch of the uropoda is likewise rounded; the outer and superior branch arches over the telson.

This genus agrees with both *Hyssura* Norman and Stebbing and *Cruregans* Chilton in the absence of the seventh pair of legs, but differs from the first named in the structure of the antennæ, both pairs of antennæ in *Hyssura* having multi-articulate flagella; in the structure of the outer branch of the uropoda, which in *Hyssura* does not arch over the telson; and in the structure of the mouth parts. *Colanthura* differs from *Cruregans* in the presence of eyes, which are wanting in *Cruregans*, and in the structure of the outer branch of the uropoda, the outer branch in *Cruregans* being very narrow and not arching over the squamiform telson, while in *Colanthura* the outer branch is broad and arches over the rounded terminal segment. The structure of the mouth parts is the same as found in the genera *Paranthura*, *Calathura* and *Cruregans*.

Colanthura tenuis Richardson, sp. nov.

PLATE XXXVIII. FIGURES 23-28.

Body narrow, elongate; surface smooth; color light yellow. Head with a prominent median process extending between the first pair of antennæ. Antero-lateral angles prominent, produced, reaching the distal end of the first joint of the peduncle of the first pair of antennæ. Eyes large, conspicuous.

First pair of antennæ consist of four joints, the terminal or flagellar joint being fringed with long hairs. The second pair of antennæ are composed of five joints, the terminal joint being fringed with hairs.

The first three thoracic segments are about equal in length. The fourth and fifth segments are each much longer than any of the

three preceding segments, and are about alike in size. The sixth segment is short, not quite as long as any one of the first three segments. The seventh is very short, being one-third the length of the sixth segment, and in both specimens examined is devoid of legs.

The segments of the abdomen are distinct, the first five together not being as long as the sixth thoracic segment. The last thoracic segment is abruptly narrower than the sixth, and is likewise somewhat narrower than the abdominal segments.

The terminal segment of the body is linguiform, the posterior margin evenly rounded and smooth. The inner branch of the uropoda is likewise rounded posteriorly with a smooth margin. The outer and superior branch arches over the telson. Both branches, as well as the terminal abdominal segment, are fringed with hairs.

The first pair of legs are cheliform, the propodus unarmed. The second and third pairs are also cheliform, but smaller, with the propodus armed on the posterior margin with five spines. The three following pairs of legs are ambulatory in character. The seventh pair are wanting.

Two specimens were collected by A. E. Verrill and party at the Bermudas in 1898. Both specimens are adult females, the marsupium in one being very large and extending the entire length of the thorax, from the second segment.

Type specimen in Peabody Museum, Yale University. Cat. No. 3252.

Anthelura affinis Richardson, sp. nov.

PLATE XXXVIII. FIGURES 29-32.

Body narrow, elongate. Head with small median point. Eyes distinct, situated in antero-lateral angulations.

Antennae of both pairs with flagella consisting of several joints, and fringed with long hairs at the tip. Maxillipeds consist of five joints.

First three thoracic segments about equal in length. Three following segments somewhat longer, and sub-equal. Seventh segment fully half the length of preceding segment.

All the segments of the abdomen distinctly defined. Terminal segment narrowly linguiform, roundly triangulate at the apex and with smooth margins.

Outer superior branch of uropoda long, oval, reaching quite to the extremity of the terminal abdominal segment, and arching over the telson. Inner branch with posterior margin widely rounded and

extending beyond telson. Both branches have the margins smooth, entire.

First gnathopods with small hand. Dactylus short. Free inner margin of propodus furnished with hairs. Second gnathopods and first pereopods similar in shape to, but smaller in size than, first pair of gnathopods. The free inner margin of the propodus is beset with two spines, the carpus with one spine. The remaining pereopods have a single spine at the distal margin of the propodus and two spines on the carpus.

One specimen, a female, was collected by A. E. Verrill at the Bermudas in 1901.

Type in Peabody Museum of Yale University. Cat. No. 3349.

This species differs from *A. elongata* Norman, in the shape of the outer branch of the uropoda, in the length of both branches, as compared with the terminal abdominal segment, and in the fact that the margins of the outer branch in our species are smooth and not crenulate, as in *A. elongata*.

Family Cirolanidæ.

Colopisthus Richardson, gen. nov.

Head transversely elongated. Eyes situated in the middle of the lateral margins at the extreme edge and elevated knob-like above the surface.

Both pairs of antennæ short; second pair reach the posterior margin of the first thoracic segment.

First five abdominal segments consolidated into one short segment. Terminal segment strongly keeled in the median longitudinal line.

Colopisthus parvus, Richardson, sp. nov.

PLATE XXXVIII. FIGURES 33-36.

Head transversely elliptical, the anterior and posterior margins rounded. The eyes are situated in the middle of the lateral margins at the extreme edge, and are elevated above the surface of the head like knobs. The head is concave between the eyes.

The first pair of antennæ are short, not much longer than the width of the head, and reach the end of the last peduncular joint of the second pair of antennæ; the flagellum contains three joints.

The second pair of antennæ are also short, extending to the posterior margin of the first thoracic segment; flagellum consists of seven joints.

The first thoracic segment is longest. The others are sub-equal with well defined epimera.

The first five abdominal segments are all coalesced into one segment. The terminal segment is triangular and strongly keeled along the median longitudinal line.

The inner branches of the uropoda extend beyond the tip of the terminal segment, are broadly oval and fringed with hairs. The outer branches are narrowly oval, about half as wide as the inner branches, and shorter.

Color light yellow, with numerous black dots.

About seven specimens were collected by A. E. Verrill and party at Bailey Bay, Bermudas, in 1898. Found at low water in corallines. Others were collected in 1901 at Waterloo, on Castle Harbor, Bermudas.

Type specimen from the Bermudas in Peabody Museum, Yale University. Cat. No. 3179.

Family **Corallanidæ.**

Corallana quadricornis Hansen.

Corallana quadricornis Hansen, Vidensk. Selsk. Skr. (6), natur. og math. Afd., v, p. 382, pl. vii, fig. 2, 1890.

Hab. Bermudas, at the Flatts; at Long Bird Island in the cavities of a massive, black keratose sponge, living on the grassy sand-flats at low tide; Castle Harbor, in the same sponge. Also St. Thomas, West Indies.

Family **Alcironidæ.**

Alcirona krebsii Hansen.

Alcirona krebsii Hansen, Vidensk. Selsk. Skr. (6), natur. og math. Afd., v, pp. 391-393, pl. viii, figs. 1-19, 1890.

PLATE XXXVIII. FIGURES 38a, 38b.

Hab. Castle Harbor, Bermudas, in the cavities of living bathing sponges and in dead coral. Two specimens (No. 33, 34) were taken from the fins of a Hamlet Grouper, in May;* St. Thomas, West Indies.

* The colors of these, in life, were as follows: Ground color, pale flesh-color; head and tail, yellowish brown; seven transverse, irregular bands of yellowish brown, those of the middle of the body with two points projecting forward, so as to show a tendency to form two dorsal lines of brown. A. E. V.

Family **Cymothoidæ.**

Nerocila acuminata Schiødt and Meinert.

Nerocila acuminata Schiødt and Meinert, Naturhist. Tidsskr., xiii, pp. 48-50, pl. iii, figs. 5-6, 1881-83.

Hab. Bermudas, collected by George Brown Goode in 1876-7. Also recorded from Beloxi, Miss.; St. Anna, Mexico; Fort Macon, North Carolina.

Family **Sphæromidæ.**

Cilicæa caudata (Say).

Nesca caudata Say, Jour. Phil. Acad., i, p. 482, 1818. Milne-Edwards, Hist. Nat. des Crustacés, iii, p. 219, 1840.

Cymodocea caudata Ives, Proc. Phil. Acad. Nat. Sci., p. 188, pl. vi, figs. 11-14, 1891.

Cilicæa caudata Richardson, Proc. U. S. Nat. Museum, xxiii, p. 536, 1901.

Hab. Bermudas, at Harrington Sound, Castle Harbor, and the Flatts. Also Egg Harbor, N. J.; Beaufort, N. C.; No Name Key, Fla.; between Salt Pond Key and Stock Island; Key West, Fla.; Sugarloaf Key, Fla.; N. W. end St. Martin's Reef, Fla.; Sarasota Bay, Fla.; off Progreso, Yucatan.

Found on the surface; also at the depth of 1 to 12 feet.

Dynamene bermudensis (Ives).

Cymodocea bermudensis Ives, Proc. Phil. Acad. Nat. Sci., p. 194, pl. vi, figs. 15, 16, 1891.

Hab. Bermudas. Also Punta Rassa, Fla.; Cedar Keys, Fla.; Key West, Fla.; No Name Key, Fla.; Sarasota Bay, Fla.; Beaufort, N. C.

Dynamene perforata Moore.

Dynamene perforata Moore, Report U. S. Fish Com., ii, pp. 173-174, pl. x, figs. 9-19, 1901.

PLATE XXXIX. FIGURE 39.

Head broader than long; eyes situated post-laterally. First pair of antennæ with the first two peduncular joints large, the second half as long as the first; the third joint long and slender, twice as long as second joint; flagellum consists of seven joints. The first two peduncular joints of the second pair of antennæ are of equal length; the following three of equal length and longer than the first two; the flagellum consists of about seven joints, and extends to the posterior margin of the third thoracic segment.

The thoracic segments are of equal length, with the exception of the first, which is slightly longer. The seventh segment is produced

backwards in two rounded lobes, one on either side of the median line, and close together.

The first abdominal segment has two suture lines at either side, indicative of coalesced segments. The terminal segment is very convex at the base, and has four small tubercles, forming a square on the convexity. Its apex has a heart-shaped opening, formed by the prolongation of the lateral margins, which prolongations meet anteriorly, and are divergent posteriorly, so that a triangular excavation is formed on the posterior end of the segment immediately below the heart-shaped opening.

The two branches of the uropoda are similar in shape and size. They are large, very much expanded, rounded posteriorly, with margins distinctly crenulate or denticulate, and extend some distance beyond the tip of the terminal abdominal segment.

The color is brown, with markings of black. Surface smooth, with the exception of the abdomen, which is very granular.

A number of specimens (13) were collected by George Brown Goode in 1876-7, at the Bermudas.

Several specimens differ from the specimen described in not having the 7th thoracic segment produced in lobes, and are without the four small tubercles at base of terminal segment. Several differ in having the uropoda not longer than the terminal segment.

The females do not have the heart-shaped opening in the terminal segment.

Specimens described are in Peabody Museum, Yale University. Cat. No. 3204.

The above species was described and figured as new, but the manuscript had not been sent to print when Mr. Moore's Report on the Porto Rican Isopoda was published, in which he described *Dynamene perforata*.

It was thought best to publish the author's description and figures, for although in the text Mr. Moore mentions the fact that the uropoda are serrate or crenulate, he does not show this in his drawings. The figures published here bring out this point.

Sphæroma crenulatum Richardson, sp. nov.

PLATE XXXIX. FIGURE 40.

Surface of body smooth. Color, light brown, with markings of black.

Head rounded in front with small median point, on either side of which is small excavation. Eyes situated post-laterally.

First pair of antennæ with the first joint of the peduncle long ; second joint half as long as first ; third joint equal in length to first ; flagellum of five joints reaches the post-lateral margin of the head.

Second pair of antennæ extend to the middle of the first thoracic segment.

Thoracic segments subequal. Lateral margins straight. Epimera distinctly separated from segments.

First abdominal segment long, a little longer than any of the thoracic segments, with two suture lines. Terminal segment very convex, surface smooth, posterior margin widely rounded. Uropoda not extending beyond tip of terminal segment. Inner branch somewhat pointed at its extremity, margin smooth. Outer branch widely rounded and crenulate on the posterior edge.

Legs similar, all ambulatory, with small curved dactyli.

A number of specimens were collected at the Bermudas in 1876-7, by George Brown Goode.

Type in Peabody Museum, Yale University. Cat. No. 3250.

VALVIFERA.

Family Idoteidæ.

Idotea marina (Linnæus).

Oniscus marinus Linnæus, Fanna Suecica, p. 500, 1761 ; Syst. Nat. (ed. xii), p. 1060, 1766.

Oniscus tridens Scopoli, Entom. Carniolica, p. 415, 1763.

Oniscus balticus Pallas, Spic. Zoöl. (9), p. 67, pl. iv, fig. 6, 1772.

Stenosoma irrorata Say, Journ. Acad. Nat. Sci. Philad., i, p. 423, 1818.

Idotea tricuspudata Desmarest, Dict. des Sci. Nat., xxviii, p. 373, pl. xlvi, fig. 11, 1823.

Idotea irrorata Milne-Edwards, Hist. Nat. Cr., iii, p. 132, 1840. Verrill and Smith, Invert. Vineyard Id., pp. 22, 275, pl. v, fig. 23, from Report U. S. Comm. Fish and Fisheries, i, pp. 316, 569, 1873. Harger, Rep. U. S. Fish Comm., pt. 6, p. 343, pl. v, fig. 24-26, 1880.

Idotea marina Miers, Journ. Linn. Soc. Lond., xvi, p. 25-31, 1883. (See Miers for synonymy.)

Hab. Bermudas, at the Flatts Inlet, collected by A. E. Verrill and party. Also British Isles ; Kattegat ; Baltic ; Dutch coast ; coast of France ; Mediterranean ; Black and Caspian Seas ; Atlantic coast of North America, from Nova Scotia and the Gulf of St. Lawrence to North Carolina. South America at Desterro and Rio Janeiro, Brazil ; New Zealand ; Red Sea ; Java.

ASELLOTA or ASELLOIDEA.Family **Janiridæ.****Carpias** Richardson, gen. nov.

Head without rostrum ; frontal margin straight. Both pairs of antennæ multi-articulate ; the second pair much longer than the body, and with a scale-like appendage articulated to the peduncle. Uropoda long, much longer than abdomen.

The first pair of legs in the male are prehensile and remarkably long, being one and two-thirds times the length of the body ; are greatly enlarged distally, forming a broad club-like hand armed with triangular processes, to which is articulated a moveable finger, the propodus, likewise armed with triangular processes.

The ambulatory legs are simple, biunguiculate, and are of normal structure.

Carpias bermudensis Richardson, sp. nov.

PLATE XXXIX. FIGURES 42-45.

PLATE XL. FIGURE 41.

Surface of body smooth. Color yellow, with odd shaped markings of black.

Head narrower than first thoracic segment, with lateral margins rounded, entire. Frontal margin straight, antero-lateral angles not produced, rounded. Eyes large, with many ocelli, and situated on the lateral margins of the head.

The first pair of antennæ have the basal segment of the peduncle enlarged, the next two segments successively narrower, all about equal in length ; the flagellum is multi-articulate, composed of about fourteen joints. The second pair of antennæ have a scale-like appendage outside of the third joint ; the fourth and fifth joints are long, the fifth a little longer than the fourth ; the flagellum is much longer than the body, and is composed of about one hundred joints.

The first thoracic segment is wider than the head ; the lateral margins are straight, entire. The second and third segments have the lateral margins excavate, the anterior and posterior angles produced, with the epimeron situated in the excavation. The fourth segment has the anterior angle produced, the epimeron being situated in the excavation of the entire posterior part of the segment. The fifth, sixth and seventh segments have the lateral margins entire, the epimeron showing at the posterior part of the segment.

The terminal segment of the body is about as broad as long, the entire margin smooth, with a small rounded lobe between the basal joints of the uropoda.

The uropoda are very long, much longer than the abdominal segment. The basal joint is about two-thirds the length of the abdominal segment, and is narrower at the base than at the apex. The two branches are of nearly equal length, the outer one being slightly shorter, and are longer than the basal joint.

The first pair of legs in the male are remarkably long, being one and two-thirds times the length of the body, and are prehensile. The basis is as long as the width of the first thoracic segment, and has the distal end very much enlarged and inflated. The ischium is not more than half the length of the basis. The merus is a little longer than the basis, and is enlarged at its distal end. The carpus is very much elongated, is longer than the ischium, is greatly enlarged distally, and has its upper distal margin armed with three large triangularly-shaped processes. The propodus has the inner surface armed with two long, sharp triangular processes, its distal end being widely expanded and rounded on the inner surface. The dactylus is biunguiculate.

The other legs are of normal structure, ambulatory in character, and biunguiculate. In the female the first pair of legs are similar in structure and size to the other legs.

A number of individuals were collected by George Brown Goode at the Bermudas.

Type specimens in Peabody Museum, Yale University. Cat. No. 3203.

Stenetrium stebbingi Richardson, sp. nov.

PLATE XXXIX. FIGURES 46-49.

Body long, narrow, depressed. Color light yellow, with markings of black.

Head narrowed posteriorly, widening anteriorly; the antero-lateral angles produced into narrow acute processes, curving slightly inward; the anterior margin is produced in a rostrum, which is truncated, on either side of which is a triangular process. Eyes obliquely situated on the anterior portion of the head.

First pair of antennæ are placed between the two triangular processes and the rostrum; the first peduncular joint is large, broad, the two following joints narrow; the flagellum is composed of nine

joints and reaches a little beyond the middle of the fourth peduncular joint of the second pair of antennæ.

The second pair of antennæ have the first three joints short, the third joint being provided with an exopod, the fourth and fifth joints long and of equal length; the flagellum is multi-articulate.

The first thoracic segment has the lateral margins straight, the anterior angles acutely produced forwards. The lateral margins of the second, third and fourth segment are also straight, with the epimera evident about the middle.

The fifth and sixth segments have the posterior half of the lateral margin rounded, the epimera evident below. The seventh segment has the lateral margin acutely produced posteriorly, the epimera evident on the posterior margin of the segment within the processes. The thoracic segments are all widely separated from each other by deep lateral incisions.

The terminal segment of the body has the lateral margin produced backwards in two small spines, between which the posterior margin is widely rounded. The uropoda are double branched, the branches being nearly equal in length and about as long as the basal joint.

The first pair of legs are subchelate. In the male the carpus is postero-distally produced in a markedly long process, which extends half the length of the propodus, its entire margin being fringed with long hairs. The propodus is elongate, its lower two-thirds being fringed with long hairs on the posterior margin, the upper third or distal margin being provided with three large spines, the inner one being bifurcate; the dactylus is long and also fringed with hairs upon its inner margin, and extends half its length beyond the last digital spine, almost touching the carpal process. The ischium is antero-distally produced in a short process.

The other legs are simple, biunguiculate.

In the female the carpus of the first pair of legs is not produced in as long a process as in the male. The propodus is shorter than in the male, more triangular in shape, denticulate on its distal margin, with a long, acute, digital spine. The dactylus does not extend beyond the digital spine. The ischium is antero-distally produced in a process fringed with hairs.

A number of individuals were taken by A. E. Verrill and party at Bailey Bay, Bermudas, in corallines, at low water, and at Harrington Sound, in 1898. Other specimens were collected at the Bermudas in 1876-7 by G. B. Goode.

Type specimens from Harrington Sound in Peabody Museum, Yale University. Cat. No. 3209.

Janira minuta Richardson, sp. nov.

PLATE XXXIX. FIGURES 50-52.

Surface of body smooth. Color light yellow, almost white, spotted with black.

Head with frontal margin straight; eyes large, conspicuous, oblong, and situated at the lateral margin. First pair of antennæ with the three peduncular joints equal in length, the first one, however, being very much the broadest, the second a little stouter than the third; flagellum multi-articulate, composed of about ten or eleven joints. The second pair of antennæ have a scale outside the third joint of the peduncle; flagellum multi-articulate, much longer than the body. Thoracic segments subequal in length. First segment with the lateral margin entire, epimeron not evident from a dorsal view. Second and third segments with margins entire, straight, epimera evident about the middle of the segments. Fourth segment with the posterior half of the lateral margin slightly excavate, the epimeron evident in the excavation. The last three segments with the lateral margins entire, the epimera evident as small lobes at the post-lateral angles.

The terminal segment is about as broad as long, rounded posteriorly with a median lobe between the peduncular joints of the uropoda. The uropoda extend much beyond the terminal segment, being longer than that segment. The outer branch is somewhat shorter than the inner branch; both branches are longer than the peduncle, and are fringed with long hairs.

In the female the first pair of legs are prehensile; the others are simple walking legs, with binnguiculate dactyli. In the male, however, the first pair of legs are modified, though prehensile. The carpal joint is very much enlarged and is produced on the inside, at its outer distal end, in a long, acute process, between which and the articulation of the propodus are two long acute processes about half as long as the outer process. The propodus is similar to that of the female; the dactylus is binnguiculate.

A number of specimens, both males and females, were collected by A. E. Verrill and party in 1898, at Castle Harbor, Bermudas.

Type specimens in Peabody Museum, Yale University. Cat. Nos. 3194 and 3261.

Jæropsis rathbunæ Richardson, sp. nov.

PLATE XL. FIGURES 53, 54, 55a, 55b, 55c.

Body elongate, depressed, segments loosely articulated; surface smooth; color uniformly light, almost white.

Head with a median excavation, on either side of which the frontal margin is produced into angulations. On either side of these angulations is another excavation, on the outside of which are lateral angulations. A rounded lobe is placed in the median excavation. The eyes are small and are situated near the lateral margins about half way between the anterior and posterior margins. The first pair of antennæ consist of five joints, the two first joints being large, the three following ones small, the last fringed with hairs. The second pair of antennæ have a rudimentary flagellum, consisting of five or six joints; the peduncle has the third and fifth joints long and oval in shape, the fourth joint somewhat triangular.

The thoracic segments are loosely articulated. The lateral margins are straight, with no indication of epimera.

The terminal segment of the body is rounded in outline, the posterior margin excavated at the insertion of the uropoda, which do not extend beyond the edge of the segment, thus preserving the oval outline. Between the uropoda there is an acute median projection.

The legs are all simple, with biunguiculate dactyli.

One specimen was collected by A. E. Verrill and party at the Bermudas, and another by G. B. Goode, from the same locality.

Type specimens in Peabody Museum, Yale University. Cat. No. 3251.

Six species of this genus have been heretofore described: *Jæropsis lobata* Kähler, *Jæropsis marionis* Beddard, *Jæropsis neo-zealandica* Chilton, *Jæropsis lobata* Richardson, *Jæropsis Dollfusi* Norman, and *Jæropsis curvicornis* (Nicolet).* The present species adds another to the above list. It is named in honor of Miss Mary J. Rathbun.

* *Jæra curvicornis* Nicolet, in Gay's Hist. de Chile, iii, p. 263, Zoöl. Atlas, Crust., No. 3, fig. 10, 1849. This species should be referred to the genus *Jæropsis*.

EPICARIDEA or BOPYROIDEA.

Family Bopyridæ.

Bopyroides latreuticola Gissler.

Bopyroides latreuticola Gissler, Am. Nat., xvi, pp. 591-594, 1882.

Bopyrus, sp. ?, Spence Bate, Report of the Scientific Results of the Exploring Voyage of H. M. S. Challenger, xxiv, p. 582, 1888.

Bopyroides latreuticola Richardson, Proc. U. S. Nat. Museum, 1901, p. 579.

Hab. Bermudas, parasitic on *Latreutes ensiferus* (Milne-Edwards), (Spence Bate); Beaufort, North Carolina, parasitic on *Latreutes ensiferus* (Milne-Edwards).

A *Bopyrid* parasitic on *Clibanarius tricolor* was collected by G. Brown Goode at the Bermudas in 1876-7.

2.—*The Terrestrial Isopoda of the Bermudas, with a Description of a New Genus of Armadillididae.*

Dollfus, in his report on the terrestrial isopoda of the Challenger Expedition,* recorded from the Bermudas a number of well-known forms common to other localities. In his list were included *Tylos niveus* Budde-Lund, *Porcellio levis* Latreille, *Metoponorthus seafasciatus* Budde-Lund, *Armadillidium vulgare* (Latreille), and *Ligia exotica* Roux.

In addition to these forms, the collection made by Prof. A. E. Verrill and parties at the Bermudas, in 1898 and 1901, also contains the following described forms common to other localities: *Tylos Latreilli* Audouin and Savigny, *Metoponorthus pruinosus* (Brandt), and *Aconiscus ellipticus* Harger.

Only three new species, one of which is also the type of a new genus, are described herein.

*Bull. Soc. d'Études Scientifiques de Paris, xii, p. 1-8, 1890.

ONISCOIDEA.

Family Tylides.

Tylos Latreilli Audouin and Savigny.

PLATE XL. FIGURE 56.

Tylos armadillo Latreille, Cuvier Règne animal, ed. 2, iv, p. 142, 1829. Guérin, Iconogr. Crust., p. 35, pl. xxxvi, fig. 4.

Tylos Latreilli Audouin and Savigny, Descript. de l'Égypte, p. 285-87, pl. xiii, fig. 1, 1827. Milne-Edwards, Hist. Crust., iii, p. 188, 1840; Règne anim. Crust., pl. lxx, bis., f. 2. Lucas, Expl. d'Alg., i, p. 73, 1849. Heller, Verh. zool.-bot. Ver., Wien, xvi, p. 732, 1866. Miers, Proc. Zool. Soc. Lond., p. 674, 1877. Budde-Lund, Crust. Isop. Terrestria, p. 273, 274, 1885. (See Budde-Lund for synonymy.)

Tylos armadillo Dollfus, *Mém. Soc. Zool. de France, p. 550, 1896.

Body elliptical in outline, very convex, and able to be contracted into a ball. Surface smooth or minutely granular and setigerous. Color yellow or light brown, marked with black spots.

Head with front not marginate; lateral angulations produced into lobes, which are truncate. Epistome forming a triangular shield, advancing some distance beyond the surface of the head. Eyes situated post-laterally. External antennæ, with a five-jointed peduncle and a flagellum consisting of four joints, extends to the posterior margin of the second thoracic segment.

The seven thoracic segments are subequal. The epimera of the first segment are represented by a thickening of the lateral edge, which is incised or cleft posteriorly. The epimera of all the other segments are dorsally separated by distinct suture lines.

The first two abdominal segments have their lateral margins covered by the seventh thoracic segment. The three following segments complete the elliptical outline of the body, their lateral margins forming a line curving inwards towards the terminal segment. The last abdominal segment is quadrangular in outline, its post-lateral angles rounded, and extends a little distance beyond the epimera of the preceding segment. The uropoda are transformed into opercular valves. At the posterior end of each large lamellar valve is a small setose joint. The third, fourth and fifth abdominal segments have

* In the Bull. Soc. d'Études Scientifiques de Paris, xiith year, pl. i, fig. 4, 1890. Dollfus gives figures of *Tylos nireus* Budde-Lund and *Tylos Latreilli* Audouin and Savigny.

plates on the ventral side extending from the margin inwards in the form of lamellæ, those of the fifth segment being longest and largest, but not meeting in the median line, being a little distance apart.

The legs are simple, ambulatory.

Three specimens were collected by Mr. J. M. Jones at the Bermudas, and about twenty more by Prof. A. E. Verrill and party at the same locality in 1898. Others were collected in 1901 at Long Bird Is., Bermudas.

Tylos niveus Budde-Lund.

Tylos niveus Budde-Lund, Crust. Isop. Terr., p. 278, 1885. Dollfus, Bull. Soc. d'Études Scientifiques de Paris, xiith year, p. 8, pl. i, fig. 4a, 1890.

Hab. Bermudas (Dollfus). Also Key West (Budde-Lund).

Family **Oniscidæ.**

Porcellio lævis Latr.

Porcellio lævis Latreille, Hist. Nat. des Crust. and Insectes, vii, p. 46, 1804.

Porcellio degeerii Andouin and Savigny, Descript. de l'Égypte, p. 289, pl. xiii, fig. 5.

Porcellio cucereus Brandt, Bull. Soc. Imp. d. Moscou, vi, p. 177, 1833.

Porcellio syriacus Brandt, Bull. Soc. Imp. d. Moscou, vi, p. 178, 1833.

Porcellio musculus Brandt, Bull. Soc. Imp. d. Moscou, vi, 1833.

Porcellio cinerascens Brandt, Bull. Soc. Imp. d. Moscou, vi, p. 178, 1833.

Porcellio dubius Brandt, Bull. Soc. Imp. d. Moscou, vi, p. 178, 1833.

Porcellio poeyi Guérin, Comptes Rendus, p. 132, 1837.

Porcellio urbicus Koch, Deutsch. Crust., p. 36.

Porcellio flavipes Koch, Berichtig, etc., p. 206, pl. 8, fig. 97.

Porcellio cubensis Saussure, Mém. Soc. phys., Genève, xiv, p. 477, pl. v, fig. 35, 1858.

Porcellio sumichrasti Saussure, Mém. Soc. phys., Genève, xiv, p. 478, pl. v, fig. 36, 1858.

Porcellio cotille Saussure, Mém. Soc. phys., Genève, xiv, p. 478, pl. v, fig. 37, 1858.

Porcellio aztecus Saussure, Mém. Soc. phys., Genève, xiv, p. 479, pl. v, fig. 38, 1858.

Porcellio mexicanus Saussure, Mém. Soc. phys., Genève, xiv, p. 479, pl. v, fig. 39, 40, 1858.

Porcellio lævis Budde-Lund, Crust. Isop. Terrestria, p. 138-141, 1883. (See Budde-Lund for synonymy and full reference.)

Porcellio lævis Dollfus, Bull. Soc. d'Études Scient. de Paris, xiith year, p. 4, 1890.

Habitat, Bermudas, collected by George Brown Goode. Bermudas (Dollfus). Distribution world-wide.

Porcellio parvicornis Richardson, sp. nov.

PLATE XL. FIGURE 57.

Body ovate, surface marked with minute granulations. Color yellow, with markings of light brown.

Head with median lobe small, widely rounded. Lateral lobes small, rounded. Eyes distinct, and situated on lateral lobes of head. Exterior antennæ short, about one-third the length of the body: flagellum two-jointed, first joint very much shorter than second joint, about one third shorter.

Thoracic segments subequal, with the exception of the first, which is a little longer than any of the others.

First two abdominal segments with lateral parts hidden by the preceding thoracic segment. Three following segments with lateral parts expanded, the margins continuing the oval outlines of the body. Terminal segment triangular, with sides somewhat incurved and rounded at the apex. Basal joint of uropoda reaching a little more than half the length of the last abdominal segment. Inner branch extends a short distance beyond the terminal segment of the body; outer branch extends but very little beyond inner branch.

One specimen was collected by A. E. Verrill at the Bermudas in 1901.

Type specimen in Peabody Museum, Yale University. Cat. No. 3353.

Metoponorthus sexfasciatus Budde-Lund.

Metoponorthus sexfasciatus Budde-Lund, Crust. Isop. Terrestria, pp. 167-168, 1885. Dollfus, Bull. Soc. d'Études Scientifiques de Paris, xiith year, p. 4, 1890.

Hab. Bermudas (Dollfus). Also Mediterranean and Canaries, Madeira, Azores, Spain, France, Algeria.

Metoponorthus pruinus (Brandt).

Porcellio pruinus Brandt, Consp. Monogr. Crust. Isop. terrestr., p. 19, fig. 21, 1833.

Porcellio maculicornis Koch, Deutschlands Crustacéen, p. 34, 1840. Stuxberg, Ofversigt af Vetensk. Akad. Forhandl., No. 2, p. 55, 1875.

Metoponorthus pruinus Budde-Lund, Crust. Isop. Terrestria, pp. 169, 170, 1885. Sars, Crust. of Norway, ii, pts. ix-x, p. 184, pl. lxxx, fig. 2, pts. xi, xii, p. 185, 1898. (See Budde-Lund for synonymy and full reference.)

Habitat, Bermudas at Harrington Sound, collected by Prof. Rankin, of Princeton; and at Walsingham, Castle Island, and Tucker's

Island Cave, collected by A. E. Verrill, 1901. Also Europe, North America, South America, North Africa, Sumatra, Madagascar.

Leptotrichus granulatus Richardson, sp. nov.

PLATE XL. FIGURE 58.

Body roughly and minutely granulated. Color light reddish or yellowish brown, with markings of dark brown in patches on each segment, forming four longitudinal rows, the two median rows not extending anteriorly beyond the third segment of the thorax in one specimen, and in the other being almost obsolete.

The head is produced in front in a prominent rounded median lobe, and at the sides in large rounded lateral lobes. The eyes are small, but distinct, and are placed at the base of the lateral lobes. The external antennæ are very short, not reaching the anterior angle of the first thoracic segment. The fourth joint of the peduncle is not longer than the third; the flagellum is composed of two joints, the first of which is about half the length of the second.

The thoracic segments are subequal in length, the lateral parts broadly expanded.

The first two abdominal segments have the lateral parts undeveloped. The third, fourth and fifth segments are broadly expanded laterally, the outer margins forming a continuous and unbroken line with the margins of the thoracic segments. The terminal segment of the abdomen extends but a distance of half its length beyond the epimera of the preceding segment; its surface is smooth. The basal joint of the uropoda attains half the length of the terminal segment. The inner branch reaches the apex of the last segment. The outer branch extends half its length beyond this.

Two specimens were collected by A. E. Verrill and party at the Bermudas in 1898. They were found in dead coral at Castle Harbor.

Type in Peabody Museum, Yale University. Cat. No. 3333.

This species cannot be identified with any of the described species of the genus: *L. panzerii* (Audouin and Savigny), *L. tauricus* Budde-Lund, *L. squamatus* Budde-Lund, and *L.* lentus* (Budde-Lund), although it seems more closely related to the last named than to any of the former.

* See Dollfus, Mém. Soc. Zoöl. de France, pp. 542-543, 1896.

Family **Armadillididæ.****Armadillidium vulgare** (Latreille).

Armadillo vulgaris Latreille, Hist. Crust., vii, p. 48, 1804; Gen. Crust., i, p. 71, 1806. Leach, Edinb. Encycl., vii, p. 406. Lamarck, Hist. Nat. an. s. vert., v, p. 152, 1818.

Armadillo pilularis Say, Crust. United States, Journ. Acad. Nat. Sci., Philad., p. 432, 1818.

Armadillidium vulgare Budde-Lund, Crust. Isopoda Terrestria, pp. 66-68, 1885. Dollfus, Bull. Soc. d'Études Scient. de Paris, xiiith year, p. 4, 1890. Sars, Crust. of Norway, ii, pts. ix-x, pl. 80, pts. xi-xii, p. 189-190, 1898.

Hab. Bermudas, collected by G. B. Goode in 1876-7; and by A. E. Verrill, in 1901, at Tucker's Island; Bermudas (Dollfus). Common in all parts of Europe and neighboring regions of Asia and Africa; North America.

Uropodias Richardson, gen. nov.

Head with the front produced in a prominent rounded lobe. Eyes small, obscure. External antennæ, with a flagellum of two joints, the second joint the smaller of the two.

First six thoracic segments with the lateral parts lamellarly expanded. Seventh segment as long as the six preceding segments, but with the lateral parts undeveloped, and not wider than the first two abdominal segments, which likewise have the lateral parts or epimeral plates undeveloped. Abdomen not narrower than thorax, the lateral parts of the third, fourth and fifth segments being expanded and continuing the regular outline of the body. The abdominal segments equal in length and half as long as the thoracic segments. Terminal segment quadrangular in shape, the posterior margin produced in a median rounded lobe. The outer branch of the uropoda is large, broad, flattened, with rounded margins; the inner branch is smaller and narrower, and rounded posteriorly.

There are only six pairs of legs, the appendages of the last thoracic segment being wanting.

Uropodias bermudensis Richardson, sp. nov.

PLATE XL. FIGURES 59, 60.

Body very convex, able to be contracted into a ball. Surface smooth. Color uniformly light brown.

Head large, produced in front in a prominent rounded projection. Eyes very small, obscure, and situated about the middle of the lateral margin. The external antennæ, with a flagellum of two joints, extend to the middle of the first thoracic segment, and are geniculate at the articulation of the third and fourth joints.

The thoracic segments are subequal in length. The seventh segment is abruptly narrower than the preceding six, and not wider than the first two abdominal segments. The seventh thoracic and the first and second abdominal segments have the lateral parts or epimeral plates undeveloped. The first six thoracic and the third, fourth and fifth abdominal segments have the lateral parts lamellarly expanded, so that the regular outline of the body is preserved, the third abdominal segment not being narrower than the six thoracic, whose lateral portions extend down laterally beyond the seventh thoracic and the first and second abdominal.

The terminal abdominal segment is quadrangular, with the posterior margin produced in a median rounded lobe. The uropoda extend but a short distance beyond the epimeral plates of the fifth abdominal segment. The outer branch is broad, flattened and round; the inner branch is smaller and narrower, and posteriorly rounded.

There are but six pairs of legs, those of the seventh thoracic segment being wanting.

A few specimens were collected by A. E. Verrill and party at the Bermudas in 1898, and at Castle Island in 1901, under stones, in dry places.

Type in the Peabody Museum, Yale University. Cat. No. 3224.

Family *Trichonisaïdæ*.

Actoniscus ellipticus Harger.

Actoniscus ellipticus Harger, Am. Jour. Sci. (3), xv, p. 373, 1878; Proc. U. S. Nat. Mus., ii, p. 157, 1879; Report U. S. Fish Comm., pt. vi, p. 309, pl. i, fig. 3, 1880.

Hab. Bermudas, collected by G. B. Goode, 1876-7 (one specimen of a brown and yellow mottled color); and near Hungry Bay, Bermudas, near salt water under decayed sea-weed and stones, collected by A. E. Verrill in 1901. Savin Rock, near New Haven; Stony Creek, Long Island Sound.

Family Ligiidæ.

Ligia baudiniana Milne-Edwards.

Ligia baudiniana Milne-Edwards, Hist. des Crust., iii, pp. 155-156, 1840.

? *Ligia baudiana* Spence Bate, Ann. Mag. Nat. Hist. (4), i, pp. 443, 446, 1868.

? *Ligia baudiniana* Saussure, Mém. Soc. phys. Genève, xiv, p. 476, 1858.

Ligia exotica Dollfus, Bull. Soc. d'Études Scientifiques de Paris, xiith year, p. 7, 1890.

Ligia exotica hirtitarsis Dollfus, Bull. Soc. d'Études Scientifiques de Paris, xiith year, p. 7, 1890.

Ligia baudiana Ives, Proc. Acad. Nat. Sci. Phila., pp. 185, 186, pl. vi, fig. 2, 1891.

Ligia baudiniana Richardson, Proc. United States Nat. Museum, xxiii, p. 574, 575, 1901.

Ligia gracilis Moore, Report U. S. Fish Comm., ii, pp. 161-176, pl. 7-11, 1901.

PLATE XL. FIGURE 61.

Hab. Bermudas, collected by George Brown Goode in 1876-77, and by A. E. Verrill and party in 1898 and 1901; Bermudas, collected by J. M. Jones; Bermudas (Dollfus); San Juan d'Ulloa, Mexico (Milne-Edwards); Yucatan (Ives); Rio Janeiro (Spence Bate); Cuba (Saussure.)

"At the Bermudas the *Ligia* occurs in great abundance on the ledges and cliffs along all the shores. It runs with surprising activity and quickly seeks refuge in the cracks and crevices of the ledges, so that it is not easy to capture without injury.

Its dark, bluish-gray color is not particularly protective here, unless in the night, owing to the light color of most of the rocks, but on darker rocks it would be decidedly protective." A. E. V.

It is doubtful if the specimens found at Cayenne by Miers* and identified by him as *Ligia baudiniana* really were that species. I am inclined to think they should be referred to *Ligia exotica*. In his description of them, Miers states that the antennæ are very long, reaching in one specimen to the extremity of the body, and in the other specimen not quite, but almost to the extremity. The first was probably the male and the other the female of *L. exotica*. There has been much difference of opinion in regard to these two species, *Ligia baudiniana* and *Ligia exotica*, the former being considered by Budde-Lund† and Dollfus‡ as a synonym of the latter, although Dollfus states of the specimens found at the Bermudas, and

* Proc. Zool. Soc. Lond., p. 670, 1877.

† Crust. Isop. Terrestria, p. 267, 1885.

‡ Bull. Soc. d'Études Scientifiques de Paris, xiith year, p. 7, 1890.

which he identified as *L. exotica*, that they differed from the specimens of *L. exotica* in his collection from Senegal in the thickness of the tarsus, which was furnished with long, stiff hairs in the males. However, he did not consider this a specific character; it could only be sufficient to distinguish a variety, for which he proposed the name *hirtitarsis*. His specimens should undoubtedly be referred to *Ligia baudiniana*, the characters of which, as a distinct species, near, perhaps, but not identical with *Ligia exotica*, I shall endeavor to point out.

A comparison of male specimens of *Ligia baudiniana* and *Ligia exotica* show the following points of difference:

First, in the size and formation of the body, *Ligia baudiniana* being the smaller species, with the body more compact than in *L. exotica*, which has the segments very loosely articulated.

Second, in the length of the antennæ, which in *L. baudiniana* do not extend beyond the last segment of the thorax (which character is constant, being true of all the specimens examined), while in *L. exotica* the antennæ reach the extremity of the body in all the specimens examined.

Third, in the length of the peduncle of the antennæ, which in *L. baudiniana* extend to the posterior margin of the second thoracic segment, the last two joints being shorter than in *L. exotica*, the peduncle of whose antennæ reach the posterior margin of the third thoracic segment.

Fourth, in the character of the first pair of legs in the two species, those of *L. exotica* (plate xl, figs. 62*a*, 62*b*), having the propodus furnished near the apex with a conspicuous process, oval and produced, the carpus and merus not being fringed with a thick row of long stiff hairs, while those of *L. baudiniana* (fig. 61) have the propodus simple, unarmed and without a conspicuous process, the carpus and merus being fringed along the entire posterior margin with a row of long stiff hairs.

Fifth in the shape of the terminal segment of the body, the angle in the middle of the posterior margin being more acutely produced in *L. exotica* than in *L. baudiniana*, and the lateral angulations being also much more produced. In the color of the two forms, *L. baudiniana* being much lighter in color, the color extending to the margins of the segments, while in *L. exotica* there is a colorless border on the lateral and posterior edges of all the segments.

In the females of the two species the first pair of legs are simple. The antennæ are shorter than in the males, and the peduncle of the

antennæ is also shorter. In the female of *L. exotica* the antennæ do not quite reach the extremity of the body; in the female of *L. baudiniana* they do not quite reach the extremity of the thorax. In the female of *L. exotica* the peduncle of the antennæ extends only to the posterior margin of the second thoracic segment; in the female of *L. baudiniana* the peduncle of the antennæ does not extend beyond the posterior margin of the first thoracic segment.

The species recently described by Mr. Moore* as *Ligia gracilis*, found at Porto Rico, is identical with *Ligia baudiniana*. The type specimens of *Ligia gracilis*, which have been placed in the U. S. Nat. Museum, have been carefully examined by Mr. Moore and myself since the publication of his paper, and exhibit the same characters found in *Ligia baudiniana*. The leg of the first pair, figured by Mr. Moore, is the leg of the female, which does not present the row of stiff hairs on the carpus and merus, as found in the male.

Although Mr. Moore did not investigate the differences existing between *L. exotica* and *L. baudiniana*, and was misled by such eminent authorities as Dollfus and Budde-Lund,† who consider the latter species a synonym of the former, yet he regarded his specimens, when compared with specimens of *L. exotica*, as specifically distinct. Although *Ligia gracilis* cannot be considered new, yet the fact that Mr. Moore considered his specimens specifically different from *L. exotica*, and his identification of them later with *L. baudiniana* give additional weight to the view that *Ligia baudiniana* is distinct from *Ligia exotica*.

* Report U. S. Fish Commission, ii, pp. 161-176, pl. 7-11, 1901.

† It is very doubtful if Budde-Lund ever had specimens of *L. baudiniana*. He places *L. baudiniana* in the synonymy of *L. exotica*, with a question mark.

EXPLANATION OF PLATES.

PLATE XXXVII.

- Figure 1.—*Apseudes triangulata* R., sp. nov. Head. $\times 35$.
 Figure 2.—The same. Segments of thorax and abdomen. $\times 19\frac{1}{2}$.
 Figure 3.—The same. Segments of abdomen and part of uropods. $\times 35$.
 Figure 4.—The same. First gnathopod. $\times 35$.
 Figure 5.—The same. Second gnathopod. $\times 35$.
 Figure 6.—*Apseudes propinquus* R., sp. nov. Head. $\times 35$.
 Figure 7.—The same. Segments of thorax and abdomen. $19\frac{1}{2}$.
 Figure 8.—The same. Last four segments and part of uropods. $\times 35$.
 Figure 9.—The same. First gnathopod. $\times 35$.
 Figure 10.—*Parapseudes goodei* R., sp. nov. Head and first thoracic segment. $\times 35$.
 Figure 11.—The same. General figure. $\times 19\frac{1}{2}$.
 Figure 12.—The same. Abdomen with uropods and last thoracic segment. $\times 35$.
 Figure 13.—The same. First gnathopod of female. $\times 35$.
 Figure 14.—The same. First gnathopod of male. $\times 35$.

PLATE XXXVIII.

- Figures 15a, 15b.—*Paranthura infundibulata* R., sp. nov. Mandible and maxillipeds. $\times 33$.
 Figure 16a.—The same. Antenna of first pair. $\times 33$.
 Figure 16b.—The same. Antenna of second pair. $\times 33$.
 Figure 17.—The same. Last four thoracic segments and abdomen. $\times 11\frac{2}{3}$.
 Figure 18.—The same. Lateral view of abdomen. $\times 11\frac{2}{3}$.
 Figure 19.—The same. First gnathopod. $\times 32\frac{1}{2}$.
 Figure 20.—The same. Second gnathopod. $\times 32\frac{1}{2}$.
 Figure 21a.—*Paranthura verrillii* R., sp. nov. Antenna of first pair. $\times 32\frac{1}{2}$.
 Figure 21b.—The same. Antenna of second pair. $\times 32\frac{1}{2}$.
 Figure 22.—The same. Last two thoracic segments and abdomen. $\times 11\frac{2}{3}$.
 Figure 23.—*Colanthura tenuis* R., sp. nov. Head and antennæ. $\times 62$.
 Figure 24.—The same. General figure. $\times 18\frac{2}{3}$.
 Figure 25.—The same. Abdomen and last two thoracic segments. $\times 62$.
 Figure 26.—The same. Lateral view of uropoda. $\times 62$.
 Figure 27.—The same. First pair of legs. $\times 62$.
 Figure 28.—The same. Second pair of legs. $\times 62$.
 Figure 29.—*Anthelura affinis* R., sp. nov. General figure. $\times 32\frac{1}{2}$.
 Figure 30.—The same. First gnathopod. $\times 62$.
 Figure 31.—The same. Second gnathopod. $\times 62$.
 Figure 32.—The same. Sixth periopod. $\times 62$.
 Figure 33.—*Colopisthus parvus* R., sp. nov. General figure. $11\frac{2}{3}$.
 Figure 34.—The same. Head and first two thoracic segments. $\times 18\frac{2}{3}$.
 Figure 35.—The same. First maxilla. $32\frac{1}{2}$.
 Figure 36.—The same. Second maxilla. $32\frac{1}{2}$.
 Figure 37.—The same. Maxilliped. $\times 32\frac{1}{2}$.
 Figure 38a.—*Alcirona krebsii* Hansen. First maxilla. $\times 32\frac{1}{2}$.
 Figure 38b.—The same. Maxilliped. $\times 32\frac{1}{2}$.

PLATE XXXIX.

- Figure 39.—*Dynamene perforata* Moore. Last two thoracic segments and abdomen. $\times 17\frac{1}{4}$.
- Figure 40.—*Sphaeroma circulatum* R., sp. nov. General figure. $\times 17\frac{1}{4}$.
- Figure 41.—See plate xl.
- Figure 42.—*Carpis bermudensis* R., sp. nov. Mandible. $\times 58$.
- Figure 42a.—The same. Maxilliped. $\times 58$.
- Figure 42b.—The same. First maxilla. $\times 58$.
- Figure 42c.—The same. Second maxilla. $\times 58$.
- Figure 43.—The same. Male operculum. $\times 58$.
- Figure 44.—The same. Female operculum. $\times 58$.
- Figure 45.—The same. First leg of male. $\times 30\frac{3}{4}$.
- Figure 46.—*Stenotrium stebbingi* R., sp. nov. Head and first thoracic segments. $\times 30\frac{3}{4}$.
- Figure 47.—The same. Terminal segment of body and uropoda. $\times 30\frac{3}{4}$.
- Figure 48.—The same. First leg of male. $\times 30\frac{3}{4}$.
- Figure 49.—The same. First leg of female. $\times 30\frac{3}{4}$.
- Figure 50.—*Janira minuta* R., sp. nov. Terminal segment and uropoda. $\times 58$.
- Figure 51.—The same. Leg of first pair of female. $\times 58$.
- Figure 52.—The same. Leg of first pair of male. $\times 58$.

PLATE XL.

- Figure 41.—*Carpis bermudensis* R., sp. nov. General figure. $\times 18\frac{2}{5}$.
- Figure 53.—*Javropsis rathbunæ* R., sp. nov. Head and first thoracic segment. $\times 32\frac{4}{5}$.
- Figure 54.—The same. Terminal segment and uropoda. $\times 32\frac{4}{5}$.
- Figure 55a.—The same. Mandible. $32\frac{4}{5}$.
- Figure 55b.—The same. Mandible. $32\frac{4}{5}$.
- Figure 55c.—The same. Maxilliped. $32\frac{4}{5}$.
- Figure 56.—*Tylos armadillo* Latreille. Operculum.
- Figure 57.—*Porcellio parvicornis* R., sp. nov. General figure.
- Figure 58.—*Leptotrichus granulatus* R., sp. nov. General figure. $\times 11\frac{3}{5}$.
- Figure 59.—*Uropodias bermudensis* R., sp. nov. Head and first thoracic segment. $\times 62$.
- Figure 60.—The same. Abdominal segments and last two thoracic segments. $\times 62$.
- Figure 61.—*Ligia baudiniana* Milne-Edwards. First leg of male. $\times 11\frac{3}{5}$.
- Figure 62a.—*Ligia exotica* Dollfus. First leg. $\times 11\frac{3}{5}$.
- Figure 62b.—The same. Terminal joints. $\times 11\frac{3}{5}$.

VIII.—THE RECONSTRUCTION OF A CRETACEOUS DINOSAUR, *CLAOSAU-
SAURUS ANNETENS* MARSH. BY CHARLES E. BEECHER.
(With Plates XLI to XLV.)

Introduction.—The completion of the mounting of the skeleton of a large dinosaur is a matter of considerable moment to any museum, as well as of some general scientific interest. Although the subject lies wholly outside the particular field of research of the writer, it still seems desirable to present, even imperfectly, some description of a specimen which is in many ways unique, and by chance is the first dinosaurian skeleton to be mounted in America.

In most kinds of construction the concrete result is usually found to differ in many particulars from the ideal or mental picture as expressed in language or by an artist. This being a general statement of fact, one would naturally expect some discrepancy between the pictured restoration of the skeleton of an extinct animal and the skeleton itself when actually put together and mounted.

The limitations of paleontologic work require that in order to give a general conception of an animal, this must be represented by a drawing or model in which the missing parts are restored according to the best knowledge and inference on the part of the investigator. The more complete the material studied, the more satisfactory and accurate the restoration is likely to become. An illustration of this fact will appear later on.

Even when approximately entire skeletons of fossil vertebrates are discovered, the bones are usually found displaced, and their nature and position are determined principally by comparative studies on other better known animals supposed to be related or to have analogous features. In the study of a group of vertebrate animals that is wholly extinct and has left no direct descendants, the difficulties of attempting to make a restoration of any particular type are considerably increased. This applies either to a drawing or to the mounting of the skeleton in a manner which shall be rendered true to nature, by placing all the bones in their proper position and giving the skeleton a posture it may have had during life. It has therefore come about that *the positive information conveyed by the finding of a foot or of any other portion of a skeleton, with the bones in a sequential position in the rock, is of far greater anatomical value than any number of expert opinions.*

In 1891, the Yale University Museum received the skeleton of a herbivorous dinosaur from the Laramie beds of the Cretaceous in Converse County, Wyoming. The specimen is one of the many treasures in the Marsh collection, and was obtained in the field by Mr. J. B. Hatcher and party. This skeleton and another apparently belonging to the same species were made the basis of the pictorial restoration of *Claosaurus annectens*, as published by the late Professor Marsh.⁶ On account of the completeness of the material, and especially because many of the more important bones were in their true position in the rock, the writer decided to direct the preparation of the specimen as a museum exhibit. Most of the work of mounting has been performed in an admirable manner by Mr. Hugh Gibb, preparator in the Geological Department, and to his skill is due the elegance of the finish and the solid strength of the specimen.

The animal lay on its side in the rock and was somewhat laterally compressed. The preservation was such that the left side was in much better condition than the right. It was therefore decided to mount the skeleton in high relief on a slab consisting in part of the original sandstone matrix. The amount of relief shows all four limbs, those on the left side being entirely free. The left side of the entire vertebral column is exposed and the head shows the front, back, top, bottom, and left side, the right only being concealed.

Owing to the shattered condition of the left femur (making it impracticable to free it from the matrix) and to its being in the rock in its true position with respect to the pelvis, the pose of the animal was determined in large measure by this bone. It is directed forward at such an angle as to demand a running position for bipedal locomotion. An attempt has been made to carry out this idea of rapid motion and to make all parts of the skeleton contribute to the completeness and realism of the general effect. In order to do this there must be the proper balance and the true swing of the living animal.

It is intended, therefore, that this huge specimen, as now mounted, should convey to the observer the impression of the rapid rush of a Mesozoic brute. The head is thrown up and turned outward. The jaws are slightly separated. The fore arms are balancing the sway of the shoulders. The left hind leg is at the end of the forward stride and bears the entire weight of the animal. The right foot has completed a step and has just left the ground preparatory to the forward swing. The ponderous and powerful tail is lifted free and doubly curved so as to balance the weight and compensate for the

swaying of the body and legs. The whole expression is one of action and the spectator with little effort may endow this creature with many of its living attributes.

In seeking to secure a life-like pose for *Claosaurus*, considerable assistance was afforded by photographs of existing animals in motion, especially several illustrating bipedal locomotion among living lizards. One of these is here introduced for comparison (figure 1).³

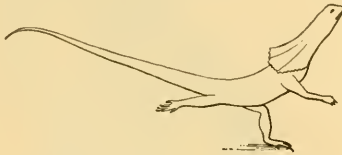


FIGURE 1.—Running lizard, illustrating bipedal locomotion. From photograph of living *Chlamydosaurus*, by W. Saville Kent.

Synonymy.—It is not within the province or purpose of this paper to enter into any analyses or discussions of generic synonymy, though the proper reference of the animal here described is somewhat uncertain. The type species of *Claosaurus* (*C. agilis* Marsh⁵) was obtained from the Niobrara of Kansas, and is possibly generically distinct from the species afterward described from the Laramie as *Claosaurus annectens*, by Professor Marsh.⁷ Neither is it feasible at present to bring evidence that *Thespesius occidentalis* of Leidy⁴ does not include the Laramie type. The fragmentary remains upon which *Thespesius* was based consisted only of several vertebrae and a phalangeal bone. These portions seem to have very little diagnostic value within the group. Therefore the relationships of these forms, as well as questions of priority, must be left for future careful comparisons, and for the present it seems best to accept the name *Claosaurus annectens* for this species.

Restorations of Ornithopoda.—Several restorations of various members of the Ornithopoda have been already made, including the genera *Iguanodon*, *Hadrosaurus*, *Claosaurus*, *Hypsilophodon*, *Laosaurus*, and *Camptosaurus*. The last three in the list have been restored only by means of drawings.

Hadrosaurus was modelled by Waterhouse Hawkins to represent both the skeleton and the animal in the flesh. Owing to the extremely fragmentary remains upon which this restoration was based it was necessarily very faulty and has long since ceased to have any value or interest except as a historical attempt. A figure

of it is here introduced (figure 2). With somewhat greater success

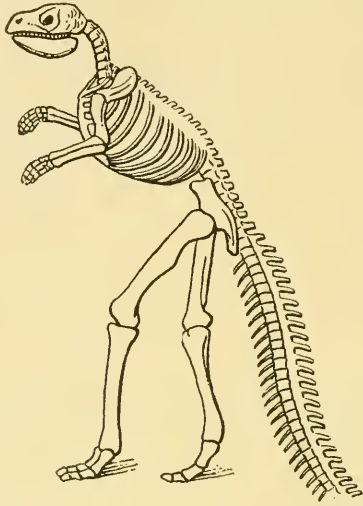


FIGURE 2.—Restoration of *Hadrosaurus*. After Hawkins.

Hawkins also restored the *Iguanodon*, from material in the English museums. The later discovery of a number of quite complete skeletons of this genus in Belgium, and their careful analysis by Dollo,¹ led to a subsequent successful restoration in a superb manner by De Pauw (figure 3).

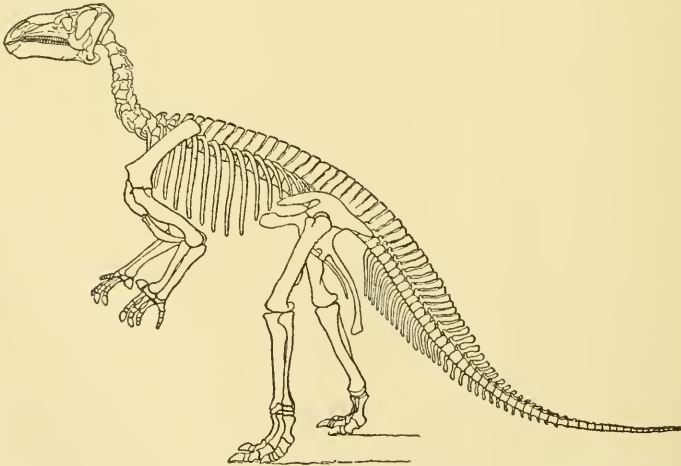


FIGURE 3.—Restoration of *Iguanodon bernissartensis*; one-eightieth natural size. After Dollo.

The Pose of Claosaurus.—The entire skeleton of *Claosaurus*, as already mentioned, was given in a drawing published by Professor Marsh. This drawing is here reproduced (figure 4), since it differs

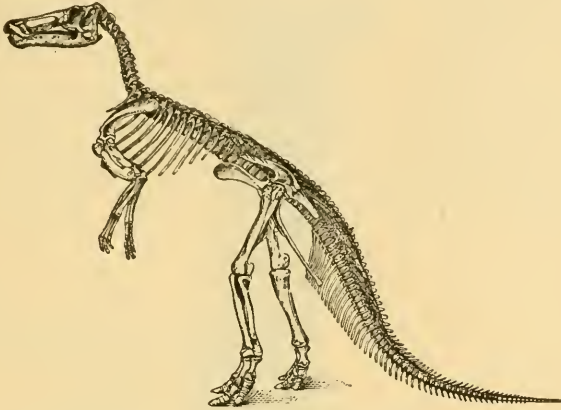


FIGURE 4.—Restoration of *Claosaurus annectens*; one-eightieth natural size. After Marsh.

in some important details from the skeleton now mounted (Plates XLI–XLV). It represents the animal as standing nearly on the ends of the toes, with the tail resting on the ground and with pendent fore limbs.

In the mounted specimen, for reasons previously stated, the animal was placed in a running position. Moreover, since there is an obvious analogy between the habits and posture of *Iguanodon* and *Claosaurus*, and the footprints of the former show no marks of a dragging tail, the latter was mounted with the tail raised to balance the weight of the animal. Further, this is the position assumed by modern lizards employing bipedal locomotion (figure 1). In *Claosaurus* the ischia are closely united at their distal ends, and it would have been impossible for the chevrons to pass between them as shown in figure 4. Without doubt the animal could have sat down or dropped the tail to the ground. The mounted skeleton shows that there were really four instead of two post-sacral vertebræ without chevrons, and that the first chevrons were short and very oblique so as entirely to clear the ends of the ischia (Plate XLIII).

The present restoration represents the animal as touching nearly the whole length of the toes to the ground (figure 5). This position was adopted because of the fact that all the bird-like dinosaurian footprints show the imprint of nearly the full length of the phalanges.

The attitude of the fore limbs depends largely upon the placing of the scapula. In Professor Marsh's illustration the scapula is represented at about sixty degrees inclination to the vertebral column.



FIGURE 5.—*Claosaurus annectens* Marsh; left hind foot, with tibia and fibula: one-tenth natural size.

The same position was previously adopted in the mounting of *Iguanodon* (figure 3), and in both cases it results in throwing the fore limbs down so that they would lose much of their value as

organs of prehension. The present mounted specimen of *Claosaurus* shows the left scapula lying on the ribs nearly parallel to the direction of the vertebræ (Plate XLIV, figure 1). The reason for this is, primarily, that the bone is placed where it was *found* in the rock in connection with the body, and as so much of the remaining portions of the skeleton was in a normal position, it seemed safe to assume that the scapula, also, was in its true place. It is likewise of the greatest significance that, in the specimen of *Iguanodon* figured by Dupont,² the position of the scapula as it was lying in the rock is precisely identical and not as subsequently placed in the mounted specimen (see figures 3, 6). It is quite possible that the present

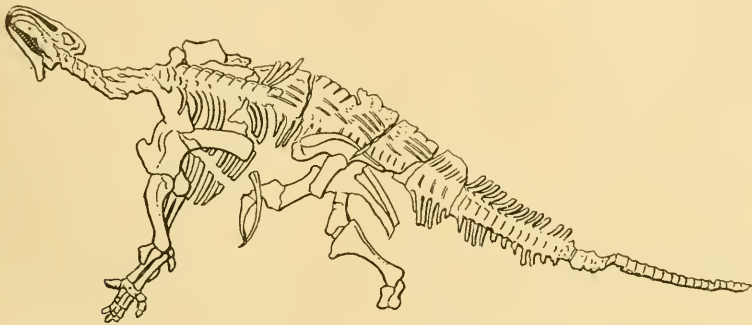


FIGURE 6.—Skeleton of *Iguanodon* in position in the rock. After Dupont.

scapula belongs higher up, though still retaining its parallel position, but the actual location does not involve any question of judgment, since the bone is where found. The scapulæ in most birds (compare skeleton of Penguin) are almost parallel to the vertebral axis, and a similar position among the Ornithopoda would not be unexpected.

The structure of the pollex in *Claosaurus* shows that it was probably opposable to the other digits and functioned as a true thumb. This with the slender form of the whole manus indicates that the fore limbs were properly organs of prehension. To be thus used to the greatest advantage, the position of the scapulæ parallel with the axis would be an obvious structural benefit.

There are a number of minor anatomical differences between the actual specimen and its original pictorial representation which could be discussed, but those here mentioned are believed to be the more important ones. These discrepancies have arisen largely from the difficulty in construing the whole or parts of a skeleton before the actual articulation of the bones is attempted.

Condition of the Skeleton and Amount of Restoration. (See Plate XLV.)—The head and neck have been left in the original matrix, with the exception of the five posterior cervicals, which were separated in order to form the curve joining the trunk. As found, the head was bent under the body and the cervicals turned ninety degrees from the median plane. This accounts for the fact that the neural spines are directed outward.

The series of dorsal vertebræ is complete. The spines of the posterior dorsals are restored. With the exception of the second, the ribs from the first to the seventh were modelled from those on the right side, while those remaining on the left side are well preserved and in the matrix. They are somewhat bent by pressure, but it was thought best to leave them as originally found, especially as the impression of the blade of the scapula was preserved. The right scapula of this individual is complete, but it was necessary to restore the left one and to substitute the anterior half of the scapula of another individual. The coracoid is modelled from another specimen. The sternal bone is complete and belongs to this skeleton. Both humeri, radii, and ulnæ were preserved, as well as the metacarpals of both fore feet. The carpal bones were modelled after Professor Marsh's drawing. About half the phalangeal bones were preserved, and the missing ones have been modelled.

The sacrum and pelvic region were quite complete and are still in the rock, the only restoration necessary being the spines of the sacral vertebræ and part of the posterior portion of the ilium, which were modelled from another specimen. The left pubis and ischium were essentially entire.

The outside of the left femur was considerably exfoliated and shattered and has been restored, though the main part of it is in its original position in the rock. The end of the right femur is also partially restored.

The remaining bones of both hind legs and both feet were all in proper sequence in the rock, the only missing bone being the terminal phalanx of the middle toe of the left foot. This was supplied by a cast of the same bone in the right foot.

A considerable portion of the tail was wanting, though fortunately the proximal third was nearly perfect and in a natural position, with the chevrons attached. The middle and distal portions were represented by a number of detached vertebræ, and with the information furnished by an entire tail of another specimen it has been possible to restore this member in a satisfactory manner.

The ossified tendons were mostly weathered away or very much broken and no attempt to restore them has been made. A small group is preserved over the spines of the first five caudal vertebrae.

From the foregoing somewhat detailed statement of the actual and restored portions of this skeleton it is at once evident that for a fossil vertebrate it is unusually complete. The most important parts, as the pelvic region, the hind limbs, most of the bones of the fore limbs, and the head and neck, were not only well preserved but were in their true sequence and largely in their normal position.

Method of Mounting.—The skeleton of *Claosaurus* is mounted on a slab consisting in part of the natural stone and in part of a rock surface manufactured from ground and disintegrated Laramie sandstone. The slab measures twenty-six feet ten inches, in length, by fourteen feet two inches, in height; and has a base two feet two inches wide, extending out from the lower edge, and upon which the feet rest. This method of mounting fossil skeletons has been employed with great success in the American Museum of Natural History, New York, and is especially well adapted for skeletons that are somewhat compressed or are more or less imperfect on one side. The present specimen is very much larger than anything heretofore attempted, and the result shows that slab mounts can be practically employed with success for animals of considerable size.

For convenience in handling and to provide for the future possibility of moving this specimen, it was mounted in four sections, which may be detached by simply breaking the thin artificial rock crust and removing the bolts holding them together. Each section rests upon a truck supported on strong casters. This construction is of course entirely concealed by the casing and framing of the finished mount.

The sections were made of timbers measuring three by four inches in section, with vertical and horizontal cross pieces at regular intervals. The horizontal base was attached by means of heavy double angle-irons. On these frames the pieces of rock carrying the bones, together with the separate bones, were securely fastened and the intervening spaces covered with wire netting of one-half inch mesh. Over this netting was spread a thin layer of plaster of Paris, and lastly a still thinner layer of ground Laramie sandstone mixed with plaster of Paris and gum Senegal. Before the artificial rock covering was thoroughly hardened the surface was tool-dressed, thus giving it the same appearance as the surface of the real rock where it was chiseled away to expose the bones. The left fore and

hind limbs are entirely free from the slab and are supported by irons in the usual way. They are mounted so that they can be readily detached and taken apart for purposes of study. The original rock connections of all the bones have been preserved and there can be no controversy over their primary order and sequence.

Dimensions.—The entire length of the animal measured along the spinal column is twenty-nine feet three inches (8.79^m), and the height of the head above the base is a little over thirteen feet (4^m). From the shoulder to the base is ten feet (3.08^m), while the hind limbs are about nine and a half feet long (2.89^m). The tail measures thirteen feet seven inches, in length (4.17^m).

Measurements of the Skull.

Total length.....	102 ^{cm}
Greatest vertical diameter.....	42 ^{cm}
Length in front of teeth.....	38 ^{cm}

Measurements of the Lower Jaw.

Greatest length of ramus to articulation.....	78 ^{cm}
Greatest depth of ramus through dentition.....	16 ^{cm}

Measurements of Shoulder Girdle and Fore Limbs.

Scapula, length.....	86 ^{cm}
Scapula, greatest width of blade.....	86 ^{cm}
Scapula, least width of blade.....	19 ^{cm}
Coracoid, length.....	27 ^{cm}
Humerus, length.....	59 ^{cm}
Humerus, diameter of distal end.....	13 ^{cm}
Humerus, least diameter.....	8 ^{cm}
Radius, length.....	55 ^{cm}
Radius, diameter of proximal end.....	8 ^{cm}
Radius, diameter of distal end.....	7 ^{cm}
Radius, least diameter.....	4 ^{cm}
Ulna, length.....	60 ^{cm}
Ulna, diameter of proximal end.....	12 ^{cm}
Ulna, diameter of distal end.....	10 ^{cm}
Ulna, least diameter.....	5 ^{cm}
Metacarpal I, length.....	11 ^{cm}
Metacarpal II, length.....	25.5 ^{cm}
Metacarpal III, length.....	27 ^{cm}
Sternal bone, length.....	42 ^{cm}
Sternal bone, width.....	26 ^{cm}

Measurements of the Pelvic Arch.

Greatest length	184 ^{cm}
Diameter of acetabulum	26 ^{cm}
Ilium, length	115 ^{cm}
Pubis, length in front of acetabulum	60 ^{cm}
Ischium, length posterior to acetabulum	115 ^{cm}

Measurements of the Hind Limbs.

Whole length	289 ^{cm}
Femur, length	106 ^{cm}
Femur, least diameter of shaft	16 ^{cm}
Tibia, length	95 ^{cm}
Tibia, diameter of proximal end	29 ^{cm}
Tibia, diameter of distal end	26 ^{cm}
Tibia, least diameter of shaft	10 ^{cm}
Fibula, length	92 ^{cm}
Fibula, diameter of proximal end	14 ^{cm}
Fibula, diameter of distal end	12 ^{cm}
Fibula, least diameter of shaft	5 ^{cm}
Metatarsal I, length	26 ^{cm}
Metatarsal I, diameter of proximal end	18 ^{cm}
Metatarsal I, diameter of distal end	15 ^{cm}
Metatarsal II, length	36 ^{cm}
Metatarsal II, diameter of proximal end	17 ^{cm}
Metatarsal II, diameter of distal end	13 ^{cm}
Metatarsal III, length	28 ^{cm}
Metatarsal III, diameter of proximal end	13 ^{cm}
Metatarsal III, diameter of distal end	9 ^{cm}
Phalanx of I, length of proximal	14 ^{cm}
Phalanx of I, diameter of proximal	10 ^{cm}
Phalanx of I, length of median	6 ^{cm}
Phalanx of I, diameter of median	7 ^{cm}
Phalanx of I, length of ungual	9 ^{cm}
Phalanx of I, diameter of ungual	9 ^{cm}
Phalanx of II, length of proximal	12 ^{cm}
Phalanx of II, diameter of proximal	10.5 ^{cm}
Phalanx of II, length of second	5 ^{cm}
Phalanx of II, diameter of second	11 ^{cm}
Phalanx of II, length of third	4 ^{cm}
Phalanx of II, diameter of third	9.5 ^{cm}
Phalanx of II, length of ungual	10 ^{cm}
Phalanx of II, diameter of ungual	11 ^{cm}
Phalanx of III, length of proximal	12 ^{cm}
Phalanx of III, diameter of proximal	9 ^{cm}
Phalanx of III, length of second	3.5 ^{cm}
Phalanx of III, diameter of second	8 ^{cm}

Phalanx of III, length of third.....	3.5 ^{cm}
Phalanx of III, diameter of third.....	7 ^{cm}
Phalanx of III, length of fourth.....	3 ^{cm}
Phalanx of III, diameter of fourth.....	6.5 ^{cm}
Phalanx of III, length of ungual.....	9 ^{cm}
Phalanx of III, diameter of ungual.....	8 ^{cm}

Measurements of the Tail.

Length.....	417 ^{cm}
Width at 8th chevron.....	68 ^{cm}
Diameter of centrum in 3d caudal.....	8 ^{cm}
Diameter of centrum in 30th caudal.....	7 ^{cm}
Diameter of centrum in 45th caudal.....	3.5 ^{cm}
Diameter of centrum in 60th caudal.....	3 ^{cm}

Measurements of Ribs.

Length of first rib.....	43 ^{cm}
Length of second rib.....	80 ^{cm}
Length of third rib.....	100 ^{cm}
Length of fourth rib.....	110 ^{cm}
Length of fifth rib.....	117.5 ^{cm}
Length of sixth rib.....	125 ^{cm}
Length of seventh rib.....	125 ^{cm}
Length of eighth rib.....	122.5 ^{cm}
Length of ninth rib.....	112.5 ^{cm}
Length of tenth rib.....	97.5 ^{cm}
Length of eleventh rib.....	83.5 ^{cm}
Length of twelfth rib.....	77.5 ^{cm}
Length of thirteenth rib.....	55 ^{cm}
Length of fourteenth rib.....	42.5 ^{cm}
Length of fifteenth rib.....	32.5 ^{cm}
Length of sixteenth rib.....	30 ^{cm}
Length of seventeenth rib.....	27.5 ^{cm}

The Right Scapula (Plate XLIV, figure 1).—The right scapula is well preserved and shows one very interesting feature. Near the lower edge of the blade is an elongate elliptical hole, 8^{cm} in length, with smooth edges, indicating that the animal received a severe injury during life and completely recovered from it before death. It is, of course, idle to speculate on the character of this accident, yet the presence in the same beds of numerous remains of the armored and horned *Triceratops* suggests that there may have been an encounter between this *Claosaurus* and one of the individuals of the Ceratopsidae. The injury to the scapula is just such a one as could be made by a thrust of one of the horns of *Triceratops*.

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EXPLANATIONS OF PLATES.

PLATE XLI.

Claosaurus annectens Marsh.

Side view of mounted specimen ; one-fortieth natural size.

Owing to the impossibility of properly lighting the specimen for photographic purposes, it has been necessary to paint out the background and shadows in the negative. Therefore this illustration merely gives a projection, and does not show the high relief of the specimen.

PLATE XLII.

Claosaurus annectens Marsh.

Oblique side view. As in the preceding plate, it was necessary to paint out the background, with the consequent loss of actual relief.

PLATE XLIII.

Claosaurus annectens Marsh.

Pelvis and hind limbs, with proximal portion of tail ; one-eighteenth natural size.

This illustration shows the detail of mounting and the finish of the slab. Plates XLI and XLII should show the same characters of rock surface and the same degree of relief.

PLATE XLIV.

Claosaurus annectens Marsh.

FIGURE 1.—Right scapula ; showing elliptical perforation of blade due to an injury received during life ; two-fifteenths natural size.

FIGURE 2.—Anterior portion of skeleton ; showing the fore limbs, shoulder girdle, neck, and skull ; one-nineteenth natural size.

PLATE XLV.

Claosaurus annectens Marsh.

Line drawing ; showing real and restored parts.

Original bones are represented by line shading.

Bones partially restored are represented by dotted line shading.

Bones wholly restored are represented in outline.

IX.—THE ASCIDIANS OF THE BERMUDA ISLANDS.
BY WILLARD G. VAN NAME, PH.D.

IN preparing the account of the Bermuda ascidians which is presented in the following pages, the writer has hoped that it would not be of local interest only. The waters about these islands are remarkably rich in animals of this class, including many new species and several new genera, and the Tunicata of the part of the world in which the Bermuda Islands are situated are only slightly known.

The species which have been described from the Atlantic coast of North America are for the most part northern forms, from the British Provinces and the New England States. Concerning those of the Southern States but little is recorded. A large number of species of Simple Ascidians from the West Indies and the adjacent parts of tropical America have been described in the works of Heller (4, 5), Traustedt (16), and Sluiter (15), though these writers had only preserved, and often very insufficient, material as a basis for their descriptions and figures. Only one of these writers (Sluiter) describes any Compound Ascidians from this region, and he describes only a very few.

Our knowledge in regard to the Tunicata of the Bermuda Islands themselves was until very recently confined to the six species obtained there by the Challenger Expedition, and described by Herdman (6) in the reports of that voyage.

In the spring of 1898, Prof. A. E. Verrill, of Yale University, and a party of students under his direction, made a general collection of the invertebrates of the Bermuda Islands, and among them a considerable number of ascidians were obtained, though particular attention was not directed to this class of animals. But few Simple Ascidians were comprised in this collection. Most of these were described by Prof. Verrill in these Transactions (Vol. x, 1900), as well as one new Compound Ascidian. He also mentioned four genera of the latter which had not been previously recorded from there, though he did not describe or identify the species.

Prof. Verrill has turned over to the writer the entire collection of Tunicata obtained by that expedition, and this paper is in part the result of a study of those specimens. In the spring of 1901, Prof. Verrill and Mr. A. Hyatt Verrill made another trip to Bermuda and obtained an even larger collection of Tunicata than in 1898, and the

writer himself spent some time during the months of April and May of that year at Bermuda, part of the time in company with Prof. Verrill, and has consequently been able to collect and study nearly all the species in a living state and in their natural surroundings. The writer has also examined some specimens obtained by Prof. G. Brown Goode in the years 1876 and 1877, though there proved to be no forms among them which were not also obtained by the Yale parties.

The fauna of the Bermuda Islands is exceedingly rich in Compound Ascidians, not only in the number of species, but in individuals also, many of the forms being very abundant and generally distributed about the islands. There may be other localities of no greater extent where an equal variety of species and abundance of individuals may be found, but there are probably few places where all the generally recognized families of this group are so fully represented. A very large proportion of the more important genera of the Compound Ascidians are also present, and a study of the Bermuda forms comes very near to giving a complete and comprehensive idea of this group of animals.

With the Simple Ascidians the case is different. The genera and species are few, and though some of the species are common, none are conspicuously abundant. One large and important family, the Molgulidæ, does not appear to be represented at all.

No examples of the free-swimming Tunicata, the Pyrosomidæ, Thaliacea, and Larvacea were obtained, but no collecting of a kind likely to result in finding them was attempted, owing to lack of time. Unquestionably representatives of all these groups occur in the vicinity of the islands and will be found when sought for.

The following are the Bermuda Tunicata described by Herdman in the Challenger Reports :—

<i>Symplegma viride.</i>	<i>Ecteinascidia turbinata.</i>
<i>Didemnum (?) inerme.</i>	<i>Clavelina oblonga.</i>
<i>Botrylloides nigrum.</i>	<i>Ascidia nigra</i> Savigny, (= <i>A. atra</i> Lesueur).

All but the last of these were new species. With the exception of *Symplegma viride* and perhaps *Didemnum (?) inerme* they are represented in the Yale collections.

Didemnum inerme is a form described by Herdman from a single small specimen in such a poor state of preservation that nothing could be made out in respect to the structure of the zooids, and he is

consequently uncertain in regard to the genus and even of the family in which it should be placed. Considering the difficulty of recognizing most species of Compound Ascidians even when an abundance of well preserved material is at hand, the practice of describing new species from such wretched specimens need not be commented on. The writer does not believe that the animal in question is a *Didemnum*. It may or may not be identical with one of the forms described in this paper, but the description does not warrant devoting time and space to conjectures concerning it.

The following are the additions to this list made in Prof. Verrill's paper (17) above alluded to:

<i>Styela partita</i> (Stimpson).	<i>Microcosmus miniatus</i> .
<i>Styela canopoides</i> Heller.	<i>Polycarpa multiphiata</i> .
<i>Halocynthia rubrilabia</i> .	<i>Diazona picta</i> .
<i>Halocynthia riiseana</i> (Traustedt).	

Of these, four were new species. All save the last named are Simple Ascidians. Prof. Verrill also mentions the occurrence of the following genera, *Leptoclinum*, *Distaplia*, *Distoma* and *Amaroucium*, though naming no species.

One of these, *Styela canopoides* Heller, is, I think, included on insufficient evidence, while the Bermuda representatives of two of the others, *Styela partita* (Stimpson) and *Halocynthia riiseana* (Traustedt) differ sufficiently from the types to be considered as new subspecies.

Omitting *Styela canopoides* and the doubtful *Didemnum inerme*, there remain a total of eleven species recorded from the islands. Of these six are Simple and five Compound Ascidians, according to the classification I have adopted in this paper, in which the Clavelinidæ and Perophoridæ are regarded as Compound Ascidians. Only one of these, *Symplegma* (unfortunately the most interesting of them), is wanting from the Yale collections.

This is no inconsiderable number if the small geographical area under consideration is taken into account, yet a study of the collections made in 1898 and 1901 enables me to increase it to no less than 38 species, one of which is represented by at least six well-marked varieties and another by three, in addition to the type. As these varieties differ sufficiently to constitute species if intermediate forms did not occur, we have 46 as the total number of kinds of tunicates known to occur at Bermuda. They are distributed as follows in 23 genera (4 new) and 9 families.

COMPOUND ASCIDIANS.

Clavelinidæ.

- Clavelina* (*Stereoclairella*) *oblonga* Herdman.
Rhodozonia picta (Verrill).

Perophoridæ.

- Perophora viridis* Verrill.
Ecteinascidia turbinata Herdman.

Distomidæ.

- Distoma capsulatum*, n. sp.
Distoma convexum, n. sp.
Distoma obscuratum, n. sp.
Distoma olivaceum, n. sp.
Distoma clarum, n. sp.
Cystodytes draschii Herdman.
Cystodytes violaceus, n. sp.
Distaplia bermudensis, n. sp.

Polyclinidæ.

- Amaroucium bermudæ*, n. sp.
Amaroucium exile, n. sp.

Didemnidæ.

- Didemnum solidum*, n. sp.
Didemnum savignii Herdman.
Didemnum atrocantum, n. sp.
Didemnum porites, n. sp.
Didemnum lucidum, n. sp.
Didemnum orbiculatum, n. sp.
Leptoclinium speciosum Herdman, represented at Bermuda by six new subspecies: *bermudense*, *pageti*, *hamiltoni*, *harringtonense*, *acutilobatum*, and *somersi*.
Polysyncrator amethystrum, n. sp.
Diplosoma macdonaldi Herdman.
Diplosoma lacteum, n. sp.
Diplosoma atropunctatum, n. sp.
Diplosomoides fragile, n. sp.
Echinoclinium verrilli, n. sp.

Botryllidæ.

Botrylloides nigrum Herdman, represented by three new subspecies: *concolor*, *planum*, and *sarcinum* in addition to the typical form.

Symplegma viride Herdman.

Polystyelidæ.

Michaelsenia tincta, n. sp.

Diandrocarpa botrylloidsis, n. sp.

SIMPLE ASCIDIANS.**Halocynthiidæ.**

Polycarpa obtecta Traustedt.

Styela partita (Stimpson) var., *bermudensis*, nov.

Halocynthia rubrilabia Verrill.

Halocynthia riiseana (Traustedt) var., *munita*, nov.

Microcosmus miniatus Verrill.

Asciididæ.

Ascidia atra Lesueur.

Ascidia curvata Traustedt.

The writer does not believe that this list by any means exhausts the number of forms really found there. The collections were made during the spring months. Collecting at other seasons would probably result in finding new species and larger and better specimens of many of those which are here described. Moreover, different methods of collecting might further increase the number.

A few words in defense of the somewhat appalling number of new species (21) are probably called for. The writer believes that our knowledge of certain families, notably the Didemnidæ, Halocynthiidæ, and Botryllidæ, has been retarded rather than advanced by the practice of many authors of describing as a new species nearly every faded and shrunken specimen that comes into their hands, because it cannot be made to agree perfectly with descriptions of other authors, made in many cases from similarly poor and scanty material. Such specimens had far better be left undescribed, unless they present characters so marked, that there is not likely to be much difficulty in identifying the form again, and characters of

such a nature that it is reasonably certain that they are not merely individual peculiarities of the specimen.

Minute and careful description cannot make up for insufficiency of material. Indeed it often decreases rather than increases the possibility of positively recognizing the species again if the individual peculiarities of the specimen be described as specific characters, and if no indication is given in regard to the directions in which individual variation (which is vastly greater in the ascidians than most writers give credit for) may be expected to manifest itself.

In the case of some Bermuda forms, the amount of material available has not been as great as could be desired, yet in nearly all cases I have had several specimens collected at different times and places. In two cases only have I ventured to describe a species on the strength of a single colony (*Didemnum solidum* and *Diptosoma atropunctatum*), and these only where there were well-marked specific characters, and when I had examined the specimen in a living state. In fact, there are only two or three of the forms which I have not myself collected and studied in a fresh condition.

The almost total neglect of the Compound Ascidians of this part of the world by previous collectors and investigators sufficiently explains, I think, the large number of new species in that group.

Methods of Collecting.

Most of the species may be found attached to stones along the shores of the bays and harbors, at low water. They grow chiefly on the under sides of stones of sufficient size to resist the movement of the waves and currents to which they are exposed. In such situations, as well as in narrow crevices in the rocks, they are safe from the attacks of the fishes and larger animals of other kinds which would otherwise destroy them.

The limestone rock, of which the islands are composed, contains numerous caverns to which the sea water has access through narrow passages where there is always a current of water when the tide is rising and falling. About the mouths of these passages (as at Waterloo, on Castle Harbor) are the best collecting places, not only for ascidians but for many other forms of invertebrates as well, as the constant currents of water carry an abundant supply of the minute organisms on which they feed. In such places it is not uncommon to find five or six different species of ascidians attached to the under side of the same stone. Sometimes several forms of Compound Ascidians may be found attached to an individual of one of the larger Simple Ascidians (Fig. 130).

A few species are seldom to be found along the shore, but grow chiefly on the corals, sponges, gorgonians, etc., on the reefs or in water deep enough to escape the effect of the waves and tides. These were obtained in collecting the corals and gorgonians by diving or by means of the nippers, attached to a long pole, which are used for that purpose.

Rhodozона picta (Verrill), *Distoma olivaceum*, *Cystodytes draschii* Herdman, *Distaplia bermudensis*, *Amaroucium bermudæ*, *A. exile*, and *Botrylloides nigrum* var. *concolor* are among the forms which are partial to such situations.

As far as I know, no ascidians are to be found on the white shell sand which covers large areas of the bottom in the sounds and harbors about the islands. So rough and rocky is the bottom in most other places that but little dredging was done, and this did not add any new forms to the list of tunicates.

It is possible that in the vicinity of the outer reefs there may be bottoms where a dredge can be used to advantage, and would probably disclose the existence of other species, particularly of the Polyclinidæ, which are partial to deeper water and are but poorly represented in our collections. Moreover, owing to the strong winds and rough water prevailing during the spring season (when all the collections were made), no collecting was done on the outer reefs. As many forms of invertebrates occur there which are seldom found on the reefs near shore, there are probably other kinds of ascidians there also.

NOTE.—The names of places, given as the localities where the specimens were found, are those of places about the Bermuda Islands, unless otherwise stated.

Methods of Preservation and Study.

Most of the specimens were preserved in formalin of from 2 to 4 per cent. This preserves the form and to some extent the color of the specimens better than any other method, but for anatomical study alcoholic specimens are usually better, though more contracted.

The specimens were studied microscopically by dissecting out the zooids or parts and staining and clearing in glycerine; also by means of paraffin sections of the zooids, or of the colonies, or parts of the same. Generally the specimens must first be decalcified. Owing to the absence of silicious sand at Bermuda, no trouble was met with in cutting the sections.

New Genera.

Diazona picta Verrill requires a new genus, which I have termed *Rhodozona*. It is in many respects intermediate between *Diazona* and *Clavelina*. In the general shape of the colony it is not unlike *Stereoclavella australis* Herdman (8) from Australia, but only the anterior portions of the zooids project from the common test, and the colony has the beautifully transparent and gelatinous character of a *Diazona*. The branchial sac resembles *Clavelina* in the absence of internal longitudinal bars, but the strong longitudinal muscle bands along each side of the dorsal lamina, and the many transverse muscle bands in the mantle are very different from any species of that genus with which I am familiar.

The genus *Echinoclinum* is also an intermediate form, serving to unite more closely the genera *Didemnum* and *Diplosoma*, and furnishes an additional argument for uniting the Didemnidæ and Diplosomidæ in one family. In its zooids and in the gelatinous nature of the colony, it resembles the last named genus or family. The large cavities present in the test in that genus are however wanting, and the large tetrahedral spicules, though peculiar in their shape and arrangement, are more suggestive of the former genus.

The two new genera of the Polystyelidæ, *Michaelsonia* and *Diandrocarpa*, appear to be connecting forms linking that family with the Halocynthiidæ and Botryllidæ respectively. In the latter genus one or more of the forms included by Michaelson (12) in his genus *Gyandrocarpa* may also be placed, though the Bermuda form approaches the genus *Botryllus* more closely in the general character and pigmentation of the colony than any of the other species.

Classification.

The classification employed is based upon that of Herdman, but with a number of modifications, such as separating the Perophoridæ from the Clavelinidæ, and uniting the Diplosomidæ with the Didemnidæ, as many writers have done. Moreover, I include the Clavelinidæ and Perophoridæ among the Compound Ascidians, because they are compound. They reproduce by budding and form colonies, and are by no means so closely related to the Simple Ascidians as some of the Polystyelidæ are, though Herdman includes these among the Compound Ascidians.

I have made free use of Herdman's diagnoses of families and genera, as given in his Revised Classification (7), with many changes and omissions, and wish to acknowledge my obligations to that author.

Before proceeding to the description of the species, I wish to express my thanks to Prof. A. E. Verrill for the use of his material and for much valuable advice and assistance. I am also indebted to Prof. H. C. Bumpus and Prof. H. M. Smith, of the United States Fish Commission, for the opportunity of working at the Fish Commission laboratory at Wood's Hole, where a portion of this work was done, and also to Prof. S. I. Smith and Dr. W. R. Coe of Yale University, and Mr. T. Goodwin Gosling of Hamilton, Bermuda.

WILLARD G. VAN NAME.

New Haven, Conn., December, 1901.

Descriptions of Species.

ASCIDIÆ COMPOSITÆ.

Fixed ascidiæ which reproduce by gemmation, forming colonies the individuals of which remain united together by stolons or by being more or less completely buried in the common test. This group is usually regarded as a sub-order.

Family **CLAVELINIDÆ** Forbes, 1853.

Body attached by the posterior end or more or less entirely buried in a creeping basal stolon or common stolonial mass, from which the young zooids form by gemmation. Test usually gelatinous, apertures simple, or (rarely) lobed.

Branchial sac not folded, with or without longitudinal bars.

Dorsal lamina represented by or provided with languets.

Alimentary canal extending beyond the thorax to form a distinct abdomen.

Reproductive organs in or beside the intestinal loop.

Genus **Claveiina** Savigny, 1816.

Zooids oblong or club-shaped, nearly independent, each enveloped in its own test and connected by stolons arising from the posterior end.

Apertures not lobed. Mantle muscles mainly longitudinal.

Branchial sac with straight stigmata, with no internal longitudinal bars or papillæ, but with horizontal membranes.

The Bermuda species of this genus belongs in Herdman's sub-genus *Stereoclavelina*, which differs from the typical *Clavelina* in having the stolons united in a basal thickening or mass of test.

Clavelina (Stereoclavella) oblonga Herdman.

Clavelina oblonga Herdman, Prelim. Rep. Proc. Roy. Soc. Edin., 1879-80, p. 724.

Clavelina oblonga Herdman, Report Voy. Challenger, Zoöl., vol. vi. pt. xvii, p. 246, plate xxxv, figs. 6-10.

Stereoclavella oblonga Herdman, Trans. Biol. Soc. Liverpool, vol. v, pp. 160-161, also Jour. Linn. Soc. Zoöl., vol. xxiii, p. 603.

PLATE XLVI. FIGURE 1.

PLATE XLVII. FIGURE 7.

PLATE LXII. FIGURE 130a.

Individual animals club-shaped, the anterior end rounded, the body tapering gradually into the very short stalk. The colony consists of a number of such individuals quite closely grouped together, united by the expanded bases of the stalks.

The total length of the largest individuals (including the short stalk) is about 30^{mm}. Removed from the test the zoöid ordinarily measures less than half this length, but large ones fully expanded measure about 20^{mm} in length.

The test is thick but perfectly transparent and colorless; the lower part may be slightly incrustated with fine sand. It is gelatinous in consistency, firmer near the base. The zoöids themselves are nearly colorless. The stomach and intestine in life are brownish. There are often spots of very pure opaque white on the thorax, and always about the edges of the orifices.

The musculature of the mantle consists of a rather small number of slender bands, most distinct on the thorax. Beneath there are very delicate transverse muscles placed close together. These form an almost continuous but very thin layer about the thorax, but the longitudinal muscles are much the stronger and the animals contract greatly in length in preservation. The thorax contracts more than the abdomen. In life when the animal is expanded the branchial sac is fully half the length of the body.

There are 15 or more rows of stigmata, and sometimes 50 in a row. The stigmata begin close beside the dorsal lamina.

According to Herdman, the dorsal languets are short, conical and tentacular, and separated by about their own length. The tentacles are short and stout, about 20 in number, of two sizes placed alternately. The dorsal tubercle is small and irregularly oval.

In all the specimens obtained the reproductive organs were small, but a large number of embryos in various stages were contained in the atrial cavities of some of the zoöids.

This is a common species. It was obtained both in 1898 and 1901, also by Prof. Goode, as well as by the Challenger Expedition. The writer has collected it in Castle Harbor and on the north shore of Coney Island, where a number of colonies were found under stones a little below low water mark.

Genus **Rhodozona**, n. gen.

An examination of *Diazona picta* Verrill (17) shows that it differs so materially from the type of *Diazona* that it must be made the type of a new genus, having characters intermediate between *Diazona* and *Distoma* or *Clavelina*.

It differs from the former genus in having the colony divided up into a large number of small lobes, in the absence of internal longitudinal bars from the branchial sac, and in having no lobes to the apertures. It has a smooth-walled stomach, except for a single longitudinal ridge on the inner surface.

Rhodozona picta (Verrill).

Diazona picta Verrill, Trans. Connecticut Academy, vol. x, pt. 2, pl. lxx, fig. 8, 1900.

PLATE XLVI. FIGURE 3. PLATE XLVII. FIGURE 5.
PLATE LX. FIGURE 122.

“Forms large gelatinous colonies, consisting of a massive main stem from which arise more or less numerous lobes, each lobe often containing 12 to 20 zoöids, which, in expansion, are much exsert above the common mass, the free portion being slender and three or four times as high as broad. Apertures, when expanded, on short terminal tubes, the oral one larger and higher than the atrial.

“General color usually translucent pinkish white; the oral aperture surrounded by a band of bright carmine-red, edged on both sides with flake-white; a stripe of the same carmine color extends from the oral band down the ventral side of each zoöid.

“Height of the larger colonies, 125 to 160^{mm}; breadth about the same; height of free part of zoöids, in life, 15 to 20^{mm}; their diameter, 5 to 6^{mm}; diameter of oral tube, about 2^{mm}.” (Verrill 17.)

The test is gelatinous and transparent and of similar character to that of *Diazona*. In young colonies and in newly developing lobes of larger colonies, where the zoöids are still small, they do not project above the surface of the lobe. Such specimens may, however, be readily identified by the color and the great numbers of anasto-

mosing vessels with enlarged ends, which occur in the lower parts of the colonies. These vessels arise from the posterior ends of the zooids.

The largest zooids measure, in the preserved condition, about 22^{mm}, or slightly more, in length when removed from the test. In formalin they are of a pale flesh-color. The white contents of the intestine show plainly from the outside.

The mantle is provided with a varying number of rather narrow longitudinal muscle-bands. Beneath these bands there are still narrower transverse bands of different sizes, which are spaced rather far apart, so as to form with the longitudinal muscles square or oblong meshes often of considerable regularity. (Fig. 5.) On the abdomen, the musculature becomes weak and inconspicuous. The siphons have delicate longitudinal and sphincter muscles. The apertures are not lobed, but in contraction their edges become thrown into folds which may easily be mistaken for lobes.

There are fifteen or more rows of stigmata in the branchial sac, each with a great number of short but narrow and closely placed stigmata. The transverse vessels are muscular and have very wide membranes attached along their inner sides. These membranes unite with each other and with the rather long tapering dorsal languets at the dorsal lamina. The dorsal lamina itself is rather broad, and has a thick muscle-band along each side.

There are about a dozen tentacles placed rather far apart and forming a single circle in which large and small ones alternate, but in addition to these there are numerous much smaller ones inserted farther forward and apparently forming more than one circle. In this it resembles the genus *Distoma*. There are no atrial tentacles.

The stomach is smooth-walled and elongated. It is provided with a single internal ridge running longitudinally, and a similar ridge may be traced along a large part of the intestine.

The reproductive glands are poorly developed in the specimens in the collection. The ovary is elongated and situated in the loop of the intestine, and in most cases contains numerous small eggs, but no large eggs or embryos were found. There is a well developed oviduct.

“Harrington Sound and Castle Harbor, just below low-tide, usually attached to gorgoniae or bryozoa” (Verrill). One or two large colonies, and many small ones, were collected in 1898; but in 1901 only a few small ones were found. It appears to grow chiefly on the gorgonian *Muricea muricata*.

Family **PEROPHORIDÆ** Giard.

Distinguished from the Clavelinidæ chiefly by the absence of an abdomen.

Branchial sac with from four to many rows of stigmata, either plain or with papillæ or longitudinal bars. The dorsal lamina may be a continuous membrane, but languets are usually present.

The stomach and intestine lie on the left side of the branchial sac. Reproductive organs in the intestinal loop.

Genus **Perophora** (Lister, 1834), Wiegman, 1835.

Body short and wide, the branchial sac with but four rows of long, narrow stigmata. Both apertures lobed.

Branchial sac with papillæ (which are often branched) on the transverse vessels, but no internal longitudinal bars. Dorsal lamina with languets.

Perophora viridis Verrill.

Perophora viridis Verrill, American Jour. Science, ser. iii, vol. ii, p. 359, 1871; also Rep. of Comm. Fish and Fisheries, (Invertebrate animals of Vineyard Sound, etc.), p. 702, 1871-72; also Webster's International Dictionary, pp. 1365, 2004 (figures).

See also Lefevre, Budding in *Perophora*, Jour. of Morphology, 1898.

PLATE XLVII. FIGURE 8.

"Colonies composed of nearly sessile individuals about 2.5^{mm} to 3^{mm} high, connected by slender stolons, and thickly covering the surfaces over which they creep. Test compressed; seen from the side, scarcely higher than broad, oval, elliptical or sub-circular, often one sided or distorted, with a short pedicle or subsessile at base. Branchial orifice large, terminal; anal lateral or subterminal, both a little prominent, with about 16 angular lobes, alternately larger and smaller. Test transparent; mantle beautifully reticulated with bright yellowish green; intestine yellow." (Verrill.)

There are a dozen or more tentacles of two sizes placed alternately. The horizontal bars of the branchial sac bear one papilla for every two stigmata except near the ends. Testis usually consisting of several separate glands.

Specimens of *Perophora* from Bermuda do not appear to differ in internal structure from this well known species of the New England coast. The colonies collected were all small, with but few individuals, and these were lighter colored and rather more transparent

than the average of a large number of specimens collected at Wood's Hole, Massachusetts. They were rather yellower in color during life and appear to be somewhat less compressed laterally, though this may be partly due to the fact that the zooids are in no case crowded together, the colonies being loose and straggling.

The writer collected specimens in May, 1901, under stones at various points, including Waterloo, on Castle Harbor, Coney, and Long Bird Islands, Somerset Island, and Hungry Bay. It is widely distributed, but at that season of the year, at least, it is not very abundant or conspicuous.

Genus **Ecteinascidia** Herdman, 1880.

Body elongated, usually tapering posteriorly, sometimes with a short peduncle; but not divided into thorax and abdomen. Test thin and membranaceous, containing no blood vessels.

Mantle thin, musculature consisting of transverse bands.

Branchial sac with internal longitudinal bars which are not papillated.

Dorsal lamina usually represented by a series of tentacular languets.

Viscera placed on the left side of the branchial sac.

Ecteinascidia turbinata Herdman.

Ecteinascidia turbinata Herdman, Prelim. Rep., Proc. Roy. Soc. Edin., p. 724, 1879-80.

Ecteinascidia turbinata Herdman, Report Voy. Challenger, part xvii, p. 243, pl. xxxvi, figs. 1-6.

See also Lefevre, Budding in *Ecteinascidia*, Anat. Anzeiger, vol. xiii, 1897.

PLATE XLVII. FIGURES 4 and 6. PLATE LIX. FIGURE 116.

Prof. Verrill (17) states that he found this species in 1898. There were, however, no specimens among the ascidians he brought home.

In 1901 the writer found what he considers to be immature specimens of this species, but no adults.

The following is condensed from Herdman's description of the adult:

Shape of each individual elongated, the anterior three-fourths almost cylindrical, the posterior part tapering rapidly to a short, slender stalk. Apertures sessile and minute, both at the right side of the anterior end. They are not lobed.

Length of body 30^{mm}, breadth near the anterior end 10^{mm}. Test thin and membranaceous, transparent. Internal longitudinal bars of

branchial sac narrow and borne on stout connecting ducts. No horizontal membranes present. The meshes between the internal longitudinal bars contain two or three stigmata. On each side of the dorsal lamina (which consists of a row of narrow tentacular languets) there are no internal longitudinal bars for a space of about ten stigmata, but there is a papilla on each transverse vessel at about half this distance.

Tentacles simple and filiform. They are of three lengths placed regularly. Dorsal tubercle elongated and tapering posteriorly. Its aperture is anterior, and the horns are coiled.

Genital glands in the intestinal loop. Ovary alongside and curved parallel to the intestine. Testis in the concavity of the ovary.

The young individuals obtained by the writer do not exceed 6^{mm} in length. Most of them are smaller. The test and mantle are very transparent and the latter contains branching vessels similar to those in *Perophora*.

In life the color is a pale greenish yellow, due to corpuscles of that color in the vessels of the branchial sac and mantle. It becomes brown in preservation.

The body and branchial sac are much shorter than in the adult; none have over 18 or 20 rows of stigmata. There are two sizes of tentacles. The apertures appear lobed, but these may merely be folds produced by contraction of the strong sphincter muscles.

None of the individuals had reproductive organs developed.

The type specimen of this species was obtained by the Challenger Expedition at Bermuda in shallow water. Herdman also states that there are several colonies in the Liverpool Free Public Museum from Alexandria Harbor (3 to 5 fathoms). It also occurs at Jamaica (Lefevre 9).

The young specimens collected at Bermuda by the writer were mostly found under stones along the shores of Castle Harbor and at Coney Island, during the month of May.

Family **DISTOMIDÆ** Giard, 1872.

Colony generally thick and massive, sometimes pedunculated. Systems often wanting. Zooids usually completely imbedded in the common test.

Zooids having the body divided into two distinct regions,—thorax and abdomen. From the posterior part of the latter vascular processes usually extend into the test, and upon these the buds form.

Branchial sac without internal longitudinal bars or folds. Dorsal lamina in the form of a series of languets.

Reproductive organs in or on one side of the intestinal loop. Testes consisting of a number of separate pyriform glands. Vas deferens not spirally coiled.

This family is none too well separated from the Clavelinidæ. On the other hand the adult zoöids of this family much resemble those of the Didemnidæ, but the last named family has an entirely different method of budding and is in reality only distantly related.

Genus **Distoma** Savigny, 1816.

Colony generally thick and fleshy. Systems sometimes present. More often both orifices of the zoöids open independently on the surface and the zoöids are irregularly placed. No calcareous spicules.

Branchial orifice normally six-lobed. Atrial orifice also with six lobes and placed at the end of a distinct tubular siphon.

Tentacles often very numerous; in more than one circle.

Stomach globular. Intestinal loop more or less twisted.

Reproductive organs on the left side of the abdomen, which is separated from the thorax by a more or less elongated and narrow peduncle. No incubatory pouch is present, though the embryos develop under the mantle of the parent.

The stomach is smooth-walled in the Bermuda forms.

The zoöids in this genus are quite elongated, but the mantle is strongly muscular, and in preserved specimens they are apt to be so contracted as to give little idea of their natural shape. This must be taken into account in identifying specimens of these animals.

For the purposes of illustrating this paper, individuals were selected which were not much contracted.

Analytical Table of Bermuda species of Distoma, based on the character of the colony.

A.—Incrusting, but thick. Surface uneven, usually slightly raised over the positions of the zoöids. Test firm, colorless but rendered more or less opaque by included sand and shell fragments, which are usually most numerous immediately about the zoöids, forming a sort of capsule. Zoöids large, not pigmented. *D. capsulatum.*

B.—Massive, rounded, attached by most of lower surface. Upper surface smooth and shining. Test soft and gelatinous, with brown or dusky pigment, yet more or less transparent. Much sand included in lower portions of colony. Zoöids rather large with more or less rich brown pigment. *D. convexum.*

C.—Flattened and incrusting but rather thick. Test firm, color greenish black, entirely opaque. Surface smooth. Zoöids rather large, with much black pigment. *D. obscuratum*.

D.—More or less completely divided into heads raised on short peduncles (small colonies consisting of a single head). Color some shade of greenish yellow or olive. Upper surface of heads smooth and glistening. Zoöids of moderate size, somewhat pigmented, and more or less distinctly visible through the test. *D. olivaceum*.

E.—Rounded, attached by most of lower surface. Test very transparent, usually colorless, soft and gelatinous. Zoöids small with the thorax usually pure white and the intestinal loop orange, conspicuously visible through the test. *D. clarum*.

Distoma capsulatum, n. sp.

PLATE XLVI. FIGURE 2. PLATE LVIII. FIGURE 107.

Forms a small rounded or unsymmetrical colony with an uneven surface, which is often slightly raised over the anterior ends of the zoöids. Size of largest colony; 17^{mm} by 11^{mm} across, and 5 to 7^{mm} in thickness.

Test colorless, rather tough and firm, containing many included grains of sand and shell fragments, so that it may become entirely opaque. The zoöids lie in the test inclined at various angles, and are often so surrounded by sand grains or shell fragments, that each appears to be inclosed in a tubular calcareous capsule. In some specimens the whole of the colony is so crowded with included material that no such arrangement is noticeable. Some sand generally adheres to the surface of the colony also. The zoöids do not appear to be arranged in systems.

Though all the colonies found were very small, the zoöids were large and few in number. When removed from the test they are light yellow or buff with the stomach and part of the intestine orange. They often reach 6^{mm} or more in length in the preserved specimens, which are of course somewhat contracted.

The mantle is well provided with longitudinal muscles, which are gathered on the thorax into a rather small number of broad but not very compact or solid bands. These may also be traced some distance back from the thorax, but gradually break up into narrow bands or individual fibers toward the posterior end of the zoöids. Beneath these longitudinal muscles on the anterior half of the body there are fairly strong transverse muscles, which are, however, not

collected into definite bands. The sphincters of the siphons are well developed. The lobes of the branchial opening are often somewhat bifid.

The branchial sac has four rows of narrow stigmata with a considerable number in each row. The tentacles are numerous, of several sizes arranged in more than one circle, somewhat after the manner described below in *D. convexum*.

The intestinal loop is twisted bringing the large globular stomach to the dorsal side of the abdomen. The so-called hepatic gland surrounding the intestine is confined to a very short portion of its length and consists of short tubules of rather large diameter with expanded ends closely clasping the intestine. (Fig. 2.)

The pyriform testes are very numerous, often 20 to 30 in number. None of the specimens examined contained large eggs or embryos.

This is not an abundant species. Five small colonies were collected in 1898 attached to the lower part of a mass of coral. The writer also obtained several colonies at Coney Island, Bermuda, in May, 1901, below extreme low water mark, attached to stones. These were in poor condition, with very few and small zooids.

The species is probably commoner in deeper water than along the shore.

***Distoma convexum*, n. sp.**

PLATE XLIX. FIGURE 16. PLATE LVIII. FIGURE 104. PLATE LIX. FIGURE 118.

Colony forming a thick, fleshy, rounded mass attached by a large part of the lower surface.

The largest colony obtained measures about 24^{mm} across and fully as much in greatest height. The others are of proportionately less height.

The upper portion of the colony is free from included material and the surface is smooth and glistening, but in the lower parts there are many sand grains and shell fragments. The color of the test is a smoky brown or dusky brown (due to scattered cells containing the pigment), very soft and gelatinous yet transparent, so that the zooids can be more or less distinctly seen. They are numerous and closely placed, but no systems can be distinguished, at least not in the preserved specimens. Bladder cells appear to be absent from the test.

The zooids are perceptibly smaller than in the last described species (*D. capsulatum*), the individual figured measuring 4.9^{mm} in

length by 1^{mm} across, when somewhat contracted. Their tissues are yellow, the stomach orange, and in addition many of the cells in the mantle contain brown pigment grains of irregular shape, especially on the anterior part of the thorax.

The musculature (not shown in fig. 16) is similar to that of *D. capsulatum* though the longitudinal bands are rather more numerous, and as in that species, it becomes very weak on the abdomen.

The branchial sac has four rows of stigmata, the number in a row exceeding 20 on each side. The tentacles are evidently arranged much as in *D. adriaticum* (Von Drasche, 3). There is a circle of eight large ones; a little further forward, and alternating with them, eight smaller ones; and still further forward one or more circles of still smaller ones.

The gland surrounding the intestine in this species differs from that of *D. capsulatum*. The tubules of which it consists run lengthwise of the intestine and lie parallel to each other, surrounding the intestine on all sides. As in the last mentioned species, they do not branch. Anteriorly they are of small diameter but increase in size as they follow the intestine backward. After following it some distance they leave it and run toward the stomach. At a point near the latter they converge and unite into the common duct. Along the intestine they are thin-walled tubes composed of an epithelium of flat hexagonal cells with nuclei which do not stain deeply. After leaving the intestine they become suddenly smaller, with thick walls and scarcely visible lumen, close to which the deeply staining nuclei of the cells are placed, and they are provided with a conspicuous basement membrane.

Two colonies were collected in 1898 and several in 1901. The exact localities were not recorded, but they were no doubt taken at points near the eastern end of the group of islands. One of the colonies contained a few larvæ.

***Distoma obscuratum*, n. sp.**

PLATE XLVIII. FIGURE 11.

PLATE LVIII. FIGURES 105 and 106.

Two specimens of this species, which is nearly related to *D. convexum*, but evidently quite distinct from it, were collected in May, 1901, growing on corals in rather shallow water in Castle Harbor. They are of flattened form, measuring between 20 and 30^{mm} across, and are 3 to 4^{mm} in thickness, with rounded edges. They are of a uniform greenish black color, entirely opaque, and of firm semi-cartilaginous consistency.

In external appearance the colonies resemble those of *Cystodytes draschii* so closely that they were taken for that species until they were cut open.

Common cloacal apertures are present. The dark pigment of the test is contained entirely in the numerous test cells. The zooids are pigmented much as described in the case of *D. convexum*, but the pigment is in this case much more thickly distributed and is of an intense black color, so that the whole thorax appears black. There is also much of the black pigment on the vessels of the branchial sac.

The zooids average about the same size as those of *D. convexum*, though they appear to be somewhat less stout, and differ from them but very little in structure.

They have between 15 and 20 stigmata in a row on each side.

The tubules of the gland surrounding the intestine do not pursue parallel courses along the intestine as in *D. convexum*, but resemble rather those of *D. capsulatum*, though they are not so crowded together (fig. 11).

The colonies contain some tailed larvæ.

Distoma olivaceum, n. sp.

PLATE XLVIII. FIGURE 9. PLATE LIX. FIGURE 113.

This species is also closely allied to *D. convexum*, but the form of the colony differs. In this species it consists of a flat-topped more or less distinctly pedunculated head of small size, seldom over 5 to 8^{mm} across, and, including the peduncle, not much over 10^{mm} in height. Many of the heads are very small, but usually a number of them are grouped together in a mass which may cover several square centimeters of the stone or coral on which the colony grows, the separate heads being connected by the expanded lower ends of the peduncles. In shape the heads resemble those of *Distaplia*, but average smaller. Common cloacal apertures are probably present. Occasionally no distinct peduncle can be distinguished, the colony being attached by its lower surface, and in such cases it often becomes wider, though of less height than stated above.

The color also differs from that of *D. convexum* and is retained, at least for a considerable time, in specimens preserved in formalin or even in alcohol. It is some shade of olive, or yellowish olive, or in a few specimens a very dark olive-green. The test is moderately firm, the upper surface is smooth and glistening; the peduncle, however, is coated with an outside layer or pellicle containing fine sand

grains. This coating of sand generally ceases abruptly at the top of the peduncle. The interior of the colony is usually nearly free from sand or shell fragments.

The zooids are light colored, with the stomach and part of the intestinal loop orange. The mantle is less pigmented than in *D. convexum*, the spots are blackish and exceedingly minute, and it is usually only on the anterior end just over the ganglion and over the end of the endostyle that they are sufficiently numerous to conceal the whitish ground-color of the mantle. These two points, however, are in most individuals practically black, so thick is the spotting, and they are visible through the semi-transparent test (especially in light-colored colonies) as black dots, and in many of the specimens are the most conspicuous parts of the zooids.

In structure the zooids resemble those of *D. convexum*. This applies also to the structure of the gland surrounding the intestine. They average, however, somewhat smaller and slenderer than those of *D. convexum*, as a comparison of figs. 9 and 16, drawn to the same scale, will show. There are the same number of rows of stigmata (four) but fewer in each row. There are also fewer tentacles. There are a dozen or more quite long slender ones, also some small ones inserted further forward.

None of the zooids examined contained embryos in advanced stages, or very large eggs.

This species was not among those collected in 1898. In 1901, however, it was abundant, especially on corals in Harrington Sound, but common also under stones along the shore at various places, including Coney Island, Long Bird Island, and Hungry Bay. It appears, though, to prefer deeper water rather than situations near low-water mark.

Distoma clarum, n. sp.

PLATE XLVIII. FIGURE 10.

PLATE LIX. FIGURE 117.

Colony jelly-like, the test usually colorless and transparent in preserved specimens. In life, however, it is slightly opalescent with a greyish, pinkish or sometimes a blue or green cast. The colony is simply a rounded or oval mass without a peduncle, attached by most of the under surface. It seldom exceeds 12^{mm} in width and half that in greatest thickness. The zooids, which are irregularly placed and lie at all angles to the surface (no systems being discernible), are visible through the test with perfect distinctness.

The mantle of the thorax is pure white, not pigmented, while the stomach and more or less of the intestine is yellow or orange. This color fades out in preserved specimens, becoming yellowish or flesh color. In specimens which are in a degenerate condition, the test often becomes infested with parasitic algæ, giving it a dirty and greenish appearance.

Some specimens preserved in alcohol have the zoöids very dark colored, brownish or blackish. I think this may be due to the action of the alcohol or of something contained in it. I have not seen fresh specimens in which they are so colored.

The zoöids are much smaller than in any of the above species. The longitudinal muscles of the mantle are strong and form distinct bands. In consequence of this development of these muscles the zoöids are nearly always found in a condition of violent contraction. This is true of all the species of this genus, but particularly of this one, and most of the zoöids in preserved specimens are generally contracted into a shapeless condition.

There are four rows of stigmata, but a rather small number in each row. Neither are the tentacles very numerous, but they are of two or three different sizes, the largest ones inserted farther back than the smaller ones. In some colonies seven lobes to the branchial aperture is the rule, in others six. The atrial aperture always has six as far as I have observed. There are fewer testes than in any of the larger species of this genus described above. Six appears to be a common number, but in some colonies it is often considerably exceeded.

Specimens of this species collected in April and May are full of large eggs and embryos in all stages. Four or five large embryos, together at least equalling in bulk the individual which has produced them, may sometimes be found under the mantle of one zoöid. Those of most advanced development are nearest the atrial aperture, the others further back, according to their stage of growth.

This species is abundant and may be found on the under side of stones at every suitable place along the shore, and on corals, etc., on the reefs. It is one of the two or three commonest ascidians at Bermuda.

Genus *Cystodytes* von Drasche, 1883.

Differs from *Distoma* in that the abdomen of each zoöid is surrounded by a capsule of calcareous spicules lying in the test. These spicules have the form of circular disks, thin at the edges and

thicker at a point near the center, and slightly concave on the side toward the zoöid. The capsule is formed by a varying number of such disks placed overlapping each other, sometimes several deep.

The zoöids are shorter than those of *Distoma*, and appear to have no vascular appendages. If this be the case, the method of budding must be somewhat modified from that of *Distoma*.

Cystodytes draschii Herdman.

Cystodytes draschii Herdman, Report Voy. Challenger, pt. xxxviii, p. 137.

PLATE XLIX. FIGURE 17. PLATE LVIII. FIGURES 99 to 101 inclusive.

The type of this species, described in the above work, was obtained in 400 fathoms off Barra Grande, Brazil, but Bermuda specimens from shallow water agree almost perfectly with Herdman's description and figures.

It forms flat incrusting colonies, about 5^{mm} thick, and reaching 60 or 80^{mm} across. The surface is smooth and the consistency of the test moderately firm. The colonies are usually quite opaque. The color is a deep, uniform, brownish gray. When the colony is cut the white calcareous capsules surrounding the posterior ends of the zoöids are very conspicuous.

Under the microscope the test is shown to contain enormous numbers of bladder cells, so closely packed in most places that their outline becomes polygonal, and the amount of test substance is actually small.

A spicule of ordinary size measures from 0.1 to 0.3^{mm} in diameter and about 0.03^{mm} in thickness at the thickest point, but somewhat larger ones and of course many smaller ones occur. They resemble the larger kind of spicules of *C. violaceus* shown in fig. 14.

The zoöids are pale yellow in color when removed from the capsule, which is not readily done without tearing them unless the capsule is dissolved away. They are distinctly divided into thorax and abdomen, but by a very short peduncle, if indeed there can be said to be any. In life, however, they must be capable of some extension, and their usual contracted condition is due to the great strength of the longitudinal mantle muscles. These form many distinct bands on the sides of the thorax, but in the region of the peduncle these separate bands run together and unite into a single broad, thick band on each side. On the abdomen, the muscles spread out again. The object of these strong bands is no doubt to retract the thorax and bring it more or less completely within the protection

of the calcareous capsule. The mantle contains a few black-pigmented corpuscles.

The tentacles are very slender and numerous, of two sizes, the shorter inserted, as in *Distoma*, in a separate and more anterior circle. There are four rows of stigmata with but a small number in a row. Both apertures are six-lobed.

This species is rather common in Castle Harbor; off Bailey's Bay; and doubtless in other places at Bermuda, on gorgonians, corals, etc.

Cystodytes violaceus, n. sp.

PLATE XLVIII. FIGURES 12, 13 and 14.

Four small colonies of a species of this genus, evidently distinct from *C. draschii*, were obtained in Castle Harbor, at Waterloo, in May, 1901. The largest measures only about 12^{mm} across and not much over 2^{mm} in thickness. They were attached to the under side of a stone.

The test is semi-transparent, allowing the zooids, or rather their capsules, to be seen, and contains corpuscles with purple pigment, which becomes brown in preserved specimens. The zooids have the stomach yellow, but no pigment cells in the mantle.

The spicules forming the capsules about the zooids resemble those of *C. draschii*, and reach a diameter of about .3^{mm}, but the capsules are less perfect, and in addition there are spicules scattered in the lower layers of the test and taking no part in the formation of the capsules. They are most numerous and conspicuous near the edges of the colony. Most of them are of smaller size than those forming the capsules, being usually only about one-fifth or one-sixth of the diameter of the latter, and they are proportionately thicker, with thick rounded edges, and are readily seen to be built up of radially disposed rods or needles. The spicules of the capsules also have radial striations or markings, but they are much less distinct. (Figs. 13 and 14.) Bladder-cells occur in the test, but much less abundantly than is usual in *C. draschii*.

The zooids are similar to those of that species, but average a little smaller and generally have a smaller number of testes. Many of them contain large eggs in the abdomen.

Sluiter's figures and description (15) show that there is a very striking resemblance, superficially at least, between this species and his *Diplosoma purpureum*, found at Cape Verde, Africa. Though he may have sufficient reason for placing his specimens in the genus

Diplosoma, it must be admitted that he gives nothing, either in the figures or description, which demonstrates or even supports the correctness of his position, and in his figure the numerous bladder-cells and the objects which he considers included "shells of Globigerinas" bear a most extraordinary resemblance to the bladder-cells and spicules of *Cystodytes*. Moreover, in his description he indicates the existence of a number of testes. *Diplosoma* has but two.

The European *Cystodytes dellechiaiæ* Della Valle has also a violet color, and I do not feel very sure that the species here described is really distinct from it.

Genus **Distaplia** Della Valle, 1881.

Colony fleshy, often lobed or pedunculated. Test penetrated by vascular processes of the zooids. Zooids arranged in distinct and usually rather simple systems.

Branchial sac large, with four rows of long stigmata.

Atrial aperture with a large languet.

Stomach ovate. Intestinal loop not twisted.

Reproductive organs on the right side of the intestinal loop.

The larvæ in this genus are remarkably large. The eggs are received into an elongated diverticulum of the atrial cavity which is developed for the purpose, the incubatory pouch, where they undergo development. The youngest embryos are always found in that end of the pouch farthest from the body of the parent.

Distaplia bermudensis, n. sp.

PLATE XLIX. FIGURES 15, 18 and 19. PLATE LIX. FIGURES 108 and 111.
PLATE LXII. FIGURE 130b.

Specimens of *Distaplia* from Bermuda are very variable in respect to the form and color of the colony, yet I cannot find ground for believing that more than one species occurs there. Bancroft (1) reports a similar variability in the Pacific species, *D. occidentalis*. There is reason to suspect that the number of species of this genus occurring in European waters has been considerably over-rated, through failure to make allowance for such variations.

I am unable to identify these specimens with any of the species already described. Some of the colonies closely resemble *D. valli* Herdman (6), but it is doubtful whether that is a good species, and moreover, if the stomach of that species resembles that of *D. magnilarva* Della Valle, as Herdman says, it must be pitted or folded on the inner surface.

The Bermuda form has the stomach smooth-walled within and without, though, when highly magnified, the inner surface is finely granular. No pits or folds are present, except such as may be produced by the contraction of the body, the stomach-wall being very thin and delicate. The smooth-walled stomach is, as far as I know, peculiar to this species.

Some of the specimens have the form of rather flat-topped heads, with more or less abrupt edges, attached by a short peduncle. Such heads are usually 10 or 12^{mm} across the top and (including the peduncle) 12 or 15^{mm} in height, and they often consist of but a single system. Other colonies (figs. 18 and 19) form rather thick but flattened incrusting masses several centimeters across, attached by the greater part of the lower surface. Between these and the heads there is every gradation. The incrusting colonies usually contain several systems, and may be produced into one or more lobes, or more or less distinct heads.

The test is only moderately firm, but the outer layer is somewhat tougher. It is rather opaque, yet the zoöids and the vessels may usually be distinguished. The latter occur chiefly in the peduncle and lower parts of the colonies. They seldom branch or anastomose, and their terminal portions are only slightly enlarged. The test may or may not contain groups or masses of bladder-cells.

No reliance whatever can be placed on the color of the colony as a specific character. Whatever may be the color, it generally becomes darker on the upper surface of the head or colony, especially about the atrial aperture or apertures, and paler on the sides of the colony and on the peduncle, if one is present. Sometimes the upper surface is nearly black, and some white pigment is often present about the orifices. Usually the colonies have a chocolate brown color: this often shades into olive, violet, purple, or rose color in some parts of the colony, or one of these colors may predominate. All these colors turn to a green, blue-green, or yellowish green, or sometimes a deep blue, when the specimen is preserved in formalin.

Two large colonies obtained in 1901 were deep orange-red, almost vermilion, shading to blackish about the atrial orifices. These colonies turned brownish in formalin. Among the specimens obtained by Prof. Verrill in 1898 were a few which were almost white, and others of a dull yellowish olive. These were preserved in formalin, with no notes as to their colors in life.

The zoöids are easily removed from the test. They appear to vary much in size, but this is no doubt largely due to a varying

amount of shrinkage. This is very likely to occur in preserved specimens, as the tissues of the zooids are exceedingly delicate. Well-expanded individuals are beautiful objects, and the internal structure can be made out with greater ease than in any other of the Bermuda ascidians. The mantle is but slightly muscular, the fibers running chiefly obliquely and transversely. It is often more or less pigmented, at other times nearly colorless. The stomach and duodenum are always orange in fresh specimens. The largest and best preserved zooids measure over 3^{mm} in length, and about 1.2^{mm} across the thorax.

The branchial sac has four rows of more than twenty long narrow stigmata on each side, which become shorter as the ends of the rows are approached. A very narrow intermediate transverse vessel crosses the stigmata half way between each principal transverse vessel. This is visible even in quite young buds, where the number of stigmata in a row is still much less than in the adult. The structure of the branchial sac agrees exactly with Herdman's (6) description of *D. rosea* and *D. rallii*.

The branchial orifice has an irregularly toothed margin. This is not apparent when the aperture is much contracted. The atrial opening is placed well back from the anterior end and is very large, with the anterior lip produced into a long pointed languet. There are about 16 tentacles of two sizes placed alternately, but their arrangement and number is not always exactly the same.

As already mentioned, the stomach-wall is not pitted nor folded, but is smooth within and without.

The zooids are usually hermaphroditic, well-developed testes and eggs of considerable size being present at the same time. (Fig. 15.) Some, however, appear to have the organs of only one sex. Some colonies contain great numbers of buds and embryos, the latter usually contained in the long incubatory pouch, which eventually becomes detached from the zooid. I have not observed more than three embryos in a pouch.

Family **POLYCLINIDÆ** Giard, 1872.

Colony usually massive, sometimes incrusting, sometimes lobed or pedunculated. Systems of various shapes, occasionally irregular or wanting.

Zooids elongated antero-posteriorly, and usually divided into three distinct regions; the thorax, abdomen, and post-abdomen.

Branchial aperture 6 or 8 lobed, atrial aperture often with a languet.

Branchial sac generally long, with numerous rows of small round or oval stigmata. It may be papillated, but no internal longitudinal bars occur.

Dorsal lamina with languets.

Stomach-wall smooth or variously folded or pitted. Reproductive organs and heart situated in the post-abdomen. Testis represented by a number of small spermatie sacs.

Gemmation by division of the post-abdomen.

Genus **Amaroucium** Milne-Edwards, 1841.

Distinguished by forming massive, often pedunculated colonies, with elongated zoöids having long post-abdomens, usually six-lobed branchial siphons, the atrial aperture placed well forward, and a large atrial languet. The stomach-wall is, usually at least, longitudinally folded, but in one of the Bermuda species this appears to be a very variable character. The post-abdomen is sessile.

This genus, though almost universally accepted by writers on Tunicata, is but poorly distinguished from *Aplidium* Savigny, which in its typical form has a sessile colony, shorter zoöids, often lacks the atrial languet, and has the post-abdomen separated from the abdomen by a more conspicuous constriction or peduncle. The atrial aperture is also said to be placed further back. Most of these differences are very trifling, and many species could be placed in either genus with equal propriety.

Amaroucium bermudæ, n. sp.

PLATE L. FIGURE 20. PLATE LVIII. FIGURES 96 and 97.

The colony is irregular in shape, seldom much over 30^{mm} across, generally less, with rather flat top and abrupt sides tapering into a more or less distinct peduncle. The combined height of the colony and peduncle often reaches 20^{mm} or more.

The test is firm, almost cartilaginous, but softer in the interior of the colony. It is usually quite free from sand grains, grayish and nearly opaque in life, sometimes with a distinct bluish or pinkish tint. In formalin it becomes more transparent and of a yellowish or flesh-color. There are no bladder-cells. The systems are irregular and the number of zoöids in different specimens of the same size is very variable.

The zoöids are rather large and stout. A fair sized specimen measures 2.3^{mm} long without the post-abdomen, which may itself reach 4 or 5^{mm} in length, though in most individuals it is much shorter. In color they vary from orange to bright vermilion red in life, but gradually fade to yellow in preservation. The color is diffused through most of the tissues, but in very red individuals the mantle of the thorax contains an especially large amount of pigment. The mantle, especially near the anterior ends of the thorax, abdomen and post-abdomen, is often studded with rounded cells, much larger than the ordinary epithelial cells.

Usually there are six lobes to the branchial orifice, but some individuals have more. There is a fairly large atrial languet placed a little anterior to the orifice, which is itself provided with distinct though very short lobes. The usual number of rows of stigmata appears to be about eighteen, with more than a dozen in a row on each side. They are small and round and placed rather far apart. The transverse vessels are very muscular. The tentacles are small and difficult to count.

The presence and arrangement of folds or plications in the wall of the stomach have been made the chief characters by which the genera of this family are distinguished. In the present species, however, it is clear that great importance should not be attributed to them. Usually the stomach of this form has distinct longitudinal folds, but often there are transverse folds also over more or less of the surface, or the transverse folds may even predominate and become the principal ones, exceeding the longitudinal folds in prominence. Some individuals show, on some parts of the surface of the stomach, an areolated condition not far removed from that which is typical of the genus *Morchellium* Giard. Others, again, apparently have the stomach entirely smooth-walled in its natural condition, but in this species the stomach-wall is very thin and liable to become folded by the contraction of the animal incident to preservation, and its original condition is not always easy to determine.

In another species of this genus, *A. constellatum* Verrill, from the New England coast, which normally has a longitudinally folded stomach, I have also observed variations from the usual condition, though not to such a great extent.

Many specimens of this species were collected, both in 1898 and 1901. It was found most abundantly on corals in Harrington Sound, in water of moderate depth, and evidently grows better in such situa-

tions than along the shore. The zoöids often contain larvæ in the atrial cavity.

In the Peabody Museum of Yale University there are some specimens of *Amaroucium* from Fort Macon, N. C., which appear to be of this species.

Amaroucium glabrum Verrill, from the coast of Maine, forms colonies of very similar size and shape.

Amaroucium exile, n. sp.

PLATE L. FIGURE 21.

PLATE LVIII. FIGURE 98.

The colony in this species is rounded or button-shaped. It is not pedunculated and adheres by the greater part of the lower surface. The edges are not abrupt as in the last described form, but rounded, and the consistency of the test is not so firm. It does not generally grow more than 5 or 6^{mm} high and 15 or 20^{mm} wide.

The test is often quite densely crowded with coarse sand grains and shell fragments, in the interior of the colony as well as on the surface; in other cases it is entirely free from such inclusions and is very transparent and almost colorless. Such colonies are very beautiful objects, for the zoöids vary from orange to an even more brilliant red than those of *A. bermudæ*, being sometimes bright scarlet.

The zoöids are smaller and slenderer than in *A. bermudæ*. The systems are irregular. The specimen figured measured a little under 4^{mm} long including the post-abdomen, which was short in this individual.

The chief anatomical differences between this and the last described species appear to be that the present one has fewer stigmata, only twelve or fourteen rows (the number in each row may be slightly less also), and that in this species the stomach-wall is thicker and always distinctly folded longitudinally with a variable but not very large number of folds (generally about 9).

This is a less common species than the last, and though found in the same situations, occurs under stones along the shore more frequently than *A. bermudæ* does. The writer collected it at Coney Island; Waterloo; and Somerset Island, among other places. It was obtained both in 1898 and 1901. Many of the specimens contain larvæ, which begin to secrete test-substance even while still contained in the atrial cavity of the adult zoöid.

This species is related to *A. constellatum* Verrill of the New England coast. The more brilliantly colored specimens of that

form are, when small, of rather similar appearance to those of this species; but the somewhat stouter zoöids, with much more numerous and often much less regular plications in the stomach-wall; the very milky appearance of the test; and the tendency to form wedge-shaped or pedunculated colonies, would serve to distinguish the New England species, even if it did not form massive colonies of vastly greater bulk than this species ever attains.

Family **DIDEMNIDÆ** Verrill, 1871.

Colony incrusting, sometimes thick and massive, not pedunculated. Test usually containing bladder-cells and often calcareous spicules, which are generally of stellate form. Zoöids arranged in complex branching systems.

Zoöids of small size, divided into thorax and abdomen, often with a muscular and vascular process extending out into the test from the region of the peduncle connecting the two divisions of the body.

Branchial aperture six-lobed; atrial plain, or with a languet. Three to six rows of stigmata. Dorsal lamina with languets.

Stomach smooth-walled, externally at least. Intestinal loop twisted.

Reproductive organs on the left side of the abdomen, or more or less ventral, or posterior. Testes few, often only one. Vas deferens often spirally coiled about the testis before leaving it to follow the intestine. There is no oviduct.

Budding from the pyloric region (near the peduncle); thorax and abdomen of the new zoöid formed from separate buds.

The genera *Diplosoma* and *Diplosomoides*, which are often regarded as constituting a separate family, the Diplosomidæ, are here included in this family.

Genus **Didemnum** Savigny, 1816.

Colony generally rather thick and fleshy. Test containing bladder-cells and usually stellate calcareous spicules.

Zoöids with a strong muscular process extending into the test from the ventral side of the peduncle connecting the thorax and abdomen. Branchial orifice six-lobed, atrial plain, with no languet.

Branchial sac with three rows of stigmata.

Testis single, more or less conical in form. The vas deferens makes a number of spiral turns about it before proceeding on its

course to the rectum, which it follows to a point near the atrial orifice.

The Bermuda species of this genus differ more in the habit and character of the colony than in the structure of the zoöids or the form of the spicules. They appear to have the following characters in common :

The zoöids vary in length, according to the species, from less than 1^{mm} to 1.6^{mm} in preserved specimens. The musculature of the mantle consists of a moderate number (perhaps twenty or more) distinct, though slender, bands running longitudinally. Transverse muscles (with the exception of the sphincters) are but slightly developed in the mantle.

The transverse vessels of the branchial sac are, however, provided with strong muscles, and each side of the dorsal lamina a strong muscle-band runs longitudinally in the wall of the branchial sac. These two bands, which run ventrally when they reach the posterior end of the thorax, are joined near the posterior end of the endostyle by fibers from different parts of the wall of the thorax, so that they become quite thick, and passing out in a ventral and posterior direction from the upper end of the peduncle, they unite to form the muscle of the muscular process which extends out into the test.

The tentacles appear to be eight in number, four large and four small ones placed alternately, but I am not certain that there are not more in some cases. The stigmata are long and narrow, about 16 in number on each side in the species with the largest zoöids, and somewhat fewer in the smaller species. The upper and lower rows of stigmata do not contain quite as many as the middle row.

The stomach is round or oval and smooth externally, and more or less yellow in color. The gland about the intestine consists of a small number of tubes clasping it. They branch but little, and their terminal portions are not much dilated.

I have found well developed reproductive organs in only two species (*D. savignii* and *D. porites*), but they are probably similar in the others also. The testis, which is single and obtusely conical, is very large, and is situated on the left side of the abdomen, with its base close against the intestine. The vas deferens leaves it at its apex and makes, usually, from eight to a dozen turns about its conical surface, like the string wound around a top. It leaves it finally about opposite the stomach. The ovary is placed between the testis and the stomach.

Analytical Table of Bermuda species of Didemnum, based on the character of the colony.

A.—Massive and irregular, opaque, consistency firm. Surface roughish; apertures far apart and conspicuous. Spicules uniformly and thickly distributed. Color reddish grey or buff, almost flesh colored.

D. solidum.

B.—Moderately thick, opaque, gelatinous. Surface smooth and glistening; apertures inconspicuous. Spicules confined to a stratum in the interior of the colony, invisible from above. Color rich brown.

D. savignii.

C.—Very thin, incrusting, gelatinous; zooids visible through the test. Surface smooth, apertures inconspicuous. Spicules irregularly distributed. General color blackish and greyish, irregularly mottled, varying in places according to the abundance of the white spicules and of the black pigment in the test and on the zooids.

D. atrocanum.

D.—Massive, partly opaque, consistency moderately firm, surface slightly rough; apertures prominent. Spicules rather uniformly distributed, only moderately numerous. Color greyish, becoming black on parts of the upper surface.

D. porites.

E.—Thin, incrusting, transparent, gelatinous. Surface smooth; zooids visible. Spicules in interior parts of the colony, not numerous enough to greatly diminish the transparency of the colony. Little or no dark pigment.

D. lucidum.

F.—Thin, incrusting, translucent. Surface smooth, zooids more or less concealed by the abundance of spicules, which are so distributed that the surface of the colony shows over the position of each zooid a circular area, more transparent than the intervening spaces, which latter are white and more opaque, owing to the greater abundance of spicules there. Thorax of zooids often dark colored. Colony whitish gray.

D. orbiculatum.

NOTE.—The only specimens of species A and D which were found incrusting branching algae, which no doubt influenced the form of the colony. Colonies growing on smooth surfaces will probably be found thinner and more expanded.

Didemnum solidum, n. sp.

PLATE LI. FIGURES 31 and 36.

PLATE LIX. FIGURE 119.

But one specimen of this species was found. It is a very irregular colony, incrusting a growth of seaweed. In greatest length it measures about 45^{mm}, and reaches 4^{mm} or 5^{mm} in thickness in places. It is entirely opaque and of firm, almost brittle consistency, on account of the abundance of spicules, which are very evenly distributed in all parts of the colony. The surface is, for the same reason, slightly rough to the touch, and the apertures are conspicuous. Bladder-cells are scarce in most points of the colony.

The color is difficult to describe, being a reddish grey or buff, almost a flesh-color, darker above. It fades in preservation. The spicules are very uniform in size and shape, being about .05^{mm} to .07^{mm} in diameter, and have very short and stout, but regular and numerous conical points.

The zooids are light colored and small, and placed rather far apart. They do not much exceed 1^{mm} in length in preservation, and are rather slender. There are probably not more than 12 stigmata in a row on each side.

None of those examined had well-developed reproductive organs.

The colony was obtained at Coney Island, May 16th, 1901, just below low water mark.

Didemnum savignii Herdman.

Didemnum savignii Herdman, Report Voy. Challenger, pt. xxxviii, p. 261.

PLATE LI. FIGURES 27 and 35.

PLATE LIX. FIGURE 112.

The colony is incrusting but rather thick, and of rather soft, gelatinous consistency. The color is a rich brown, darker above, and the surface is smooth and glossy, the apertures inconspicuous and the spicules and zooids invisible from the surface.

The largest specimen measures about 16^{mm} across, and is between 3^{mm} and 4^{mm} in greatest thickness.

The test contains great numbers of bladder cells, especially near the surfaces, where they are so abundant that they assume polygonal forms from mutual pressure. The dark color is due to brown pigment contained in the test cells. These pigment cells are most abundant near the upper surface, where they are irregular in form. In the deeper portions of the colony they are oval and less thickly distributed.

The spicules are very large, often $.1^{\text{mm}}$ in diameter, with numerous long conical or somewhat flask-shaped points. They are chiefly confined to a layer lying about $.5^{\text{mm}}$ to 1^{mm} below the upper surface. In this layer they are abundant and placed near together.

The zoöids are placed close together and mostly nearly perpendicular to the surface. They are rather large (the specimen figured (fig. 35) measured 1.6^{mm} long) and rather dark in color, due to brown pigment in the mantle, especially about the branchial aperture, and to a less extent on other parts of the thorax. The lining of the branchial siphon is particularly dark colored.

They have about sixteen stigmata in a row on each side. In several different individuals I found the number of turns in the spiral portion of the oviduct to be about eight. Herdman gives four or five as the number in his specimen.

The locality of the type of this species, described in the Challenger Report, is given as doubtful, but probably just south of the Cape of Good Hope, in 150 fathoms.

Only two specimens of this species were found at Bermuda, neither of them as large as the type specimen. One was obtained in 1898, the other in 1901, but the exact localities are not recorded.

***Didemnum atrocantum*, n. sp.**

PLATE LI. FIGURES 30 and 34.

PLATE LIX. FIGURE 114.

This species forms very thin incrusting colonies. The largest that were obtained measure 2^{mm} thick and from 30^{mm} to 40^{mm} across. In consistency it is gelatinous, and the spicules are not sufficiently abundant to greatly alter the character of the test.

The spicules are of moderately large size, averaging over $.05^{\text{mm}}$ in diameter, but differ somewhat from those of *D. savignii* in having more numerous points, which are generally somewhat shorter and more or less irregularly rounded or split or broken at the extremities, though some have the regular conical or flask-shaped points, as in the last named species. They are irregularly distributed in the interior of the colonies, being thickly crowded in small patches and absent in other places. Where they are dense their white color makes them noticeable against the grey or blackish yet transparent test. Many bladder cells also occur.

The zoöids are not on an average quite as large as those of the last described species (*D. savignii*). In many of the specimens the mantle cells contain so much black pigment that the whole colony

appears quite blackish, for the zoöids are numerous and closely placed; in other cases they have but little dark pigment, and appear lighter than the greyish test, which also contains a greater or less number of black pigment cells.

I have found this form only at Hungry Bay, where it is common. A number of colonies were collected under stones in the latter part of May, 1901. None of the zoöids appear to have reproductive organs developed.

Didemnum porites, n. sp.

PLATE LI. FIGURE 29 and 33. PLATE LIX. FIGURE 115.

A couple of colonies, the largest about 25^{mm} across and rather thick, were obtained growing on algæ in Bailey's Bay, May 1st, 1901. They differ considerably from *D. atrocantum*, though they are also of a grayish color, becoming black in the upper parts of the colony.

The test is of firm consistency, though bladder-cells are very abundant in some places; the spicules, which exactly resemble those of *D. lucidum* described below, are fairly evenly distributed through the test and come close to the surface, giving it a slightly rough granular character. The apertures of the zoöids on the surface are conspicuous and slightly prominent. The test is opaque.

The zoöids are of good size (1.3^{mm} or 1.4^{mm} long in many cases in the preserved specimen), and have a little black pigment in the mantle walls. In structure they resemble those of *D. savignii*. I have counted ten or eleven turns of the vas deferens in some individuals.

Didemnum lucidum, n. sp.

PLATE LI. FIGURES 26, 28 and 37.

This is a species with very small zoöids (usually less than 1^{mm} in length), which are slightly or not at all pigmented, forming small, fairly transparent, nearly colorless incrusting colonies of slight thickness. Sometimes the anterior end of the zoöid is marked with a little blackish pigment about the aperture and over the ganglion.

The spicules, though varying much in size, are mostly under .04^{mm} or .05^{mm} in diameter. They have long but not very numerous conical points, and are distributed unevenly in the interior parts of the colony, generally not in sufficient abundance to greatly interfere with the transparency of the test. Near the surfaces of the colony they are wanting and there are a good many bladder-cells.

I have not been able to count more than about a dozen stigmata in a row on each side. None of the specimens have reproductive organs in good condition.

One colony of this little species was collected in 1898. In 1901 two or three were obtained in Bailey's Bay and Harrington Sound. One of the specimens grew on a branching alga, the others incrusting coral.

Didemnum orbiculatum, n. sp.

PLATE LI. FIGURES 32 and 33. PLATE LXI. FIGURES 127*a* and 128.

This is a form in many respects intermediate between a true *Didemnum* and a *Leptoclinum*, having the thin colony and abundant spicules characteristic of the latter, yet the large size of the spicules, their form, and the appearance and pigmentation of the zooids show it to be closely related to some of the species just described, and as I have been able to distinguish but three rows of stigmata it seems best to place it in this genus.

The largest specimens found were 25 or 30^{mm} across, and about 2^{mm} thick.

It may be recognized at a glance by the peculiarity in the distribution of the spicules alluded to in the analytical table above. The spicules, which are of fair size (about .04^{mm}), with rather slender conical points, are abundantly and thickly disposed in the test, yet not in such numbers as to give the colony the white, chalky appearance of a *Leptoclinum*, but leaving it a translucent grayish white. The zooids are placed very close together, and there being but a thin layer of spicules over them, each branchial orifice appears in the center of a more transparent circular area of about the diameter of the thorax of the zooid.

The zooids are small (in contraction about 1^{mm} long). They have strong muscle bands in the mantle and contract badly in preservation. The mantle contains much dark pigment on the thorax, so that that part of the body often appears quite uniformly blackish.

This species is common and grows on the undersides of stones near low water in company with colonies of *Leptoclinum*, *Diplosomoides* and *Botrylloides* at almost all suitable places along the shores of the islands. I found it especially common at Long Bird Island and at Waterloo, on Castle Harbor, in April and May, 1901. Many of the zooids then contained large eggs, but I did not observe well developed testes in any of the numerous individuals examined.

Genus *Leptoclinum* Milne-Edwards, 1841.

Differs from *Didemnum* in having four rows of stigmata, and in forming a thin incrusting colony, densely crowded with calcareous spicules, so that the test becomes more or less hard and brittle.

Some species are said to have an atrial languet, but probably these should be placed in another genus.

In some cases the testis is deeply lobed, or it may be completely divided into two glands.

This genus is none too well distinguished from *Didemnum*, but is accepted by nearly all writers. The number of rows of stigmata (though apparently a reliable character in the Bermuda forms) is by no means always invariable, even in the same species, and in the character of the colony every gradation is found between the massive colony of a typical *Didemnum* and the thin, brittle crust of a typical *Leptoclinum*.

In this paper the writer has placed all the forms with three rows of stigmata in *Didemnum*, regardless of the thickness of the colony.

True *Leptoclinums*, with four rows of stigmata, occur in abundance at Bermuda, growing on corals, sponges and algae on the reefs, and on the under side of stones along the shore, up to a point well above low-water mark. It is the most abundantly represented genus of ascidians there.

With only a limited number of specimens at hand, it is easy to classify them into several distinct and well marked species, differing from each other fully as much as some of the forms which are described above as species of the genus *Didemnum*, but with a large number of specimens available for study, the problem is by no means such an easy one, as so many intermediate forms occur. The writer devoted particular attention to collecting examples of this genus during his visit to Bermuda in 1901, but is obliged to confess, after examining a very large amount of material, that he has utterly failed to discover any character or characters by which the Bermuda *Leptoclinums* may be divided into groups worthy of specific rank. Apparently a process of active evolution is going on in the members of this group, at least in the Bermuda representatives of it, and from the hopeless confusion in which the species of this genus generally are involved, it seems not unlikely that this is the case elsewhere as well.

As the differences between the varieties are too great to disregard entirely, the only course open to the writer is to describe the most

striking variations as subspecies. Between these there are an indefinite number of intermediate forms. Nevertheless all these forms appear to have some degree of permanence, and reproduce their peculiarities at least in their immediate descendants, for often a number of colonies attached to the same stone, or growing near together, will have exactly identical characters, indicating a common parentage, while certain others, growing among them, will differ from them, yet agree among themselves.

The relation of these numerous varieties to previously described species of the genus is a difficult question. Naturally their nearest allies would be sought for on the Atlantic coast of the United States and in the West Indies. In neither of these regions has the genus been sufficiently studied.

Sluiter (15) has recently described two new forms, *L. conchyliatum* and *L. cineraceum*, from Jamaica, but these differ from the Bermuda forms, among other things, in the number of stigmata, for he says that they are provided with but from four to six stigmata in a row on each side, while the Bermuda forms have about 12 in those with large zooids, and probably at least 8 or 10 in all cases.

From the Atlantic coast of North America two species only have been described, as far as the writer is aware; *L. albidum* Verrill and *L. luteolum* Verrill, the latter perhaps only a variety of the former. Both of these are found on the New England coast. The Bermuda varieties are quite different from the typical *albidum*, which has spicules of a different type from any of the Bermuda forms (fig. 41), and in most specimens the spicules are much larger than is the case in any of the latter.

Specimens of *L. luteolum*, from Southern New England, however, have spicules more like some of the Bermuda varieties (fig. 40). Yet the correspondence between *L. speciosum* Herdman (6), from Bahia, Brazil, and the commonest Bermuda form is so much closer that it seems best to consider the latter, and consequently the remaining Bermuda varieties, as subspecies of the Brazilian form.

The writer has not ascertained that any of the several varieties here described is confined to any particular locality at Bermuda.

***Leptoclinum speciosum* Herdman.**

Leptoclinum speciosum Herdman, Report Voy. Challenger, pt. xxxviii, p. 274.

The types are from Bahia, Brazil, in 7 to 20 fathoms. I have not found specimens at Bermuda which correspond exactly to the description of the Brazilian examples.

Var. *bermudense*, nov.

PLATE LII. FIGURES 39, 42 and 50. PLATE LXII. FIGURES 130c,
132 and 134.

Colony usually between 2 and 3^{mm} thick (when incrusting irregular objects often very much thicker) and reaching 60 or 70^{mm} in width in some cases. Spicules more abundant in the upper layers of the colony, though generally the extreme upper stratum is free from them, so that the surface is smooth to the touch. The spicules (figs. 39 and 42) are usually rather small (less than 0.025^{mm} in diameter) with a variable but generally very large number of points or rays. Occasional very large spicules occur among the small ones, but this is not peculiar to this variety. In some colonies most of the spicules have their points blunt and broken, in other colonies most of the points are perfect, but generally slightly rounded. As a rule the spicules are not so abundant as to render the test very stiff or brittle. The color is usually pure white, but it often becomes yellowish in preserved specimens. The apertures are generally not prominent.

The zoöids are large (up to 1.5^{mm} long, or more). Their tissues are yellow, the stomach and intestine being orange. They have 12 or more stigmata in a row on each side and 16 tentacles of two sizes. When the zoöids are very large, there are often additional, still smaller tentacles between the larger ones. The testis is generally single, but sometimes it is divided into two. The vas deferens makes about a dozen spiral turns.

This is the commonest form at Bermuda.

Var. *pageti*, nov.

PLATE LII. FIGURE 45.

A dwarf variety of the last. The colonies are small (under 20^{mm} wide) and usually considerably under 2^{mm} thick. They have generally a distinct yellow tint, and the tissues of the zoöids are more strongly orange-tinted than in the last form, sometimes almost red, in which case the whole colony may have a salmon shade.

The zoöids are smaller and proportionately shorter than in var. *bermudense*. The spicules (fig. 45) are, however, similar. They have so many rays that unless highly magnified they appear almost spherical. Surface of colony rather smooth, apertures not conspicuous.

Often found associated with the last described form.

Var. *hamiltoni*, nov.

PLATE LII. FIGURES 43, 44 and 47. PLATE LXI. FIGURE 127b.

PLATE LXII. FIGURE 135.

In this the spicules are larger than in var. *bermudense* and they have coarser and less numerous but often rather longer points, and are more evenly distributed through the test, coming close to the upper surface. From this it follows that the colony is stiffer, harder and rougher than in the two last described forms. The zooids are rather small (usually not much over 1^{mm} or 1.2^{mm} long) and placed near together. Their apertures are rather prominent on the surface. The colonies grow somewhat larger, but not very much thicker (generally about 2^{mm}) than those of var. *pageti*, into which it grades, and with which it is found associated. The colonies are very frequently decidedly yellow in color. It is a very common variety.

Var. *harringtonense*, nov.

PLATE LII. FIGURES 49 and 51.

This forms rather extensive (often 30 or 40^{mm} wide) colonies of moderate thickness (2^{mm} or over), white in color and resembling var. *bermudense*, but having much larger (up to 0.05^{mm}), longer pointed spicules. (Fig. 49.) They are abundantly placed throughout the test and make the colony hard and rough to the touch.

The zooids are decidedly slenderer than in var. *bermudense*. They apparently have about 10 stigmata in a row on each side, short lobes to the branchial orifice, and but one testis. There are 16 tentacles or nearly that number. The vas deferens makes 8 or more turns (fig. 51).

Not common.

Var. *acutilobatum*, nov.

PLATE LII. FIGURES 46 and 52.

Resembles the last externally, but the colonies are rather thinner, and I have not observed such large ones. The spicules are small (0.025^{mm} in diameter), of remarkably uniform size and regularity of form, with very few points, which are conical with bulging sides (fig. 46). The zooids are small and short (fig. 52), about 1^{mm} long in preservation, and are remarkable for the length and sharpness of the lobes of the branchial orifice. The testis is divided into two separate glands, each of which may be two-lobed. The vas deferens makes seven or eight turns.

Not common, but obtained both in 1898 and 1901.

Var. **somersi**, nov.

PLATE LII. FIGURE 48.

PLATE LXII. FIGURE 136.

Forms very small (10 to 20^{mm} wide), flat colonies of a pure white color. They are very thin (often under 1^{mm}) and not very opaque. The zoöids are as small as those of var. *acutilobatum*. They are placed rather far apart. The spicules are large (fig. 48), with regular conical points of some length, and are evenly but often not very closely distributed in the colony. The positions of the zoöids are very conspicuous from the surface, though the apertures are not especially so. There is but one common cloacal aperture to the colony. The branchial apertures of the zoöids have pointed lobes but much shorter ones than those of the last described form.

Quite generally distributed, though not very abundant.

Genus **Polysyncraton** Nott, 1891.

Separated from *Leptoelinum* (which it resembles in having four rows of stigmata) by having a number (sometimes as many as 10) of distinct pyriform testes, arranged in a circle, forming together a conical group, about which the vas deferens makes a few spiral turns: and by possessing an atrial languet.

The type of the genus is from New Zealand (13).

Polysyncraton amethysteum, n. sp.

PLATE LIV. FIGURES 62 and 64 to 67 inclusive. PLATE LVIII. FIGURE 102.

Colony more or less transparent except for a thin layer of spicules on the upper surface. The test is of an amethyst purple or rose purple tint, due to pigment contained in the test cells, while the tissues of the zoöids are bright red. These colors fade out in preservation, the test becoming yellowish and the zoöids yellow or orange. The colonies seldom exceed 30^{mm} in width and 3 or 3.5^{mm} in thickness.

The layer of white spicules on the upper surface of the colony shows in strong contrast to the colors of the test. It may readily be stripped off. The spicules are entirely confined to it. Large areas about the common cloacal openings are entirely bare of spicules, also small oval areas about the branchial orifices, but in these latter may be seen small V-shaped groups of spicules, six in number in each, corresponding to the six lobes of the branchial siphons. This arrangement of the spicules about the branchial openings occurs

sometimes in other genera of this family (*Leptoclinum*, *Didemnum*), but is especially conspicuous here. (Fig. 65.)

The spicules are always small with short and often more or less blunt and broken points. In some colonies they are all very minute, in other specimens they vary more in size (compare fig. 64 with fig. 67 both down to the same scale). The test contains vast numbers of bladder-cells.

The zoöids also vary much in size in different colonies, reaching 1.5^{mm} or more in length in many cases. There are six short lobes to the branchial siphon, and a rather long, somewhat forked languet over the atrial orifice. There are four rows of stigmata with a moderate number in each, and probably eight tentacles.

The male reproductive organs consist of about five (the number varies) separate pyriform testes placed radially with the small ends in the center, where the short ducts arising from them unite to form the vas deferens which coils about the group in the usual manner, making about five turns. The ovary lies between two of the testes on the side toward the stomach, more or less covered by or included in the coils of the vas deferens, except when the eggs become so large that it must extend beyond these limits.

This beautiful species is moderately common, both along the shore under stones, and in deeper water on corals, sponges, etc. It was obtained in Castle Harbor; Harrington Sound; and at Hungry Bay; and was collected both in 1898 and 1901. The specimens contain large reproductive organs and larvæ, and the species would probably be an unusually favorable object for embryological or histological investigation.

Genus **Diplosoma** MacDonald, 1858.

Colony incrusting, generally rather thin. The test is penetrated by more or less extensive cavities continuous with, and regarded as extensions of, the common cloacal cavities, which greatly reduce the amount of test substance, leaving in extreme cases little of it except the thin layer bounding the colony and a thin layer about each zoöid, the latter being retained in position by strands or columns of test substance continuous with the layer bounding the colony. All the rest of the interior of the colony becomes one large cavity. The extent to which this modification proceeds varies in different species and to a considerable degree in different individuals.

The test substance is gelatinous, becoming membranous on the surface, and from its nature, as well as from the extensive cavities

above mentioned, the colony is very soft and delicate. No spicules are present. The test is often very transparent.

The zooids have six lobed or nearly simple branchial apertures, and simple atrial openings.

The branchial sac has four rows of rather large stigmata. The transverse vessels are muscular, and as in *Leptoelinum* there is a muscle band along each side of the dorsal lamina. The bands unite at the posterior end of the thorax, and are prolonged into a muscular and vascular process extending posteriorly and ventrally into the common test. It ends bluntly and is much weaker and less conspicuous than in *Leptoelinum*. I have found it in all the species of this genus described in this paper.

The intestinal loop is twisted and generally bent so that its axis lies about at right angles to that of the thorax. This brings the reproductive organs, which lie on the left side of the abdomen, under the intestinal loop. The stomach is oval and smooth-walled, on the outside at least.

There are two testes placed close together, forming as in *Leptoelinum* a conical mass, but the vas deferens does not coil about them.

With the related *Diplosomoides* Herdman, which has small stellate calcareous spicules, this genus is often made a separate family, the Diplosomidae.

Diplosoma macdonaldi Herdman.

Diplosoma macdonaldi Herdman, Report Voy. Challenger, pt. xxxviii, p. 315.

PLATE LIII. FIGURE 60.

PLATE LX. FIGURE 124.

Colony large (50^{mm} across) and rather thin, not exceeding 2 or 2.25^{mm} in thickness. Test nearly colorless and very transparent, membranous on the surface. The cavities characteristic of the genus are well developed, yet there is considerable test substance about the zooids which adheres very firmly to their mantles and contains here and there a few bladder cells. In addition to the small test cells, there are large oval or slightly irregular cells which stain deeply with plasma stains.

The zooids are also nearly colorless except that the stomach and more or less of the intestinal loop is yellow or orange. This fades out in preserved specimens. The zooids are large for this family, sometimes reaching 1.6^{mm} in length when straightened out and expanded. The mantle muscles are but slightly developed and are mostly transverse.

There are four rows of stigmata, with about a dozen in a row on each side. The stigmata are large with very narrow interstigmatic vessels. The transverse vessels are fairly muscular and contract strongly in preserved specimens, as the rest of the branchial sac is very delicate.

The endostyle is rather narrow. The dorsal languets are long enough to extend more than half way across the branchial sac. They are tentacular in form. The tentacles appear to be about twelve in number, and are of two sizes placed alternately.

This species was described by Herdman from a specimen found in shallow water at Bahia, Brazil.

The large colony here described, which I identify with the Brazilian form, was obtained in April, 1901, in Harrington Sound, on a piece of coral. Another smaller colony was obtained off Bailey's Bay a few days later. It was attached to a sponge, and differs in having somewhat smaller zooids, but there seems to be little doubt that both are of the same species. Some of the zooids contain well developed testes and small eggs, but none of those examined contained large eggs. Nearly all the zooids in each specimen have buds.

***Diplosoma lacteum*, n. sp.**

PLATE LIII. FIGURE 59.

This species forms small, somewhat flattened colonies measuring 10 to 15^{mm} across and 3 to 4^{mm} in thickness when alive. The cavities in the test are enormously developed and only a very thin layer of test surrounds each zooid, while the layer bounding the colony is also very thin, so that preserved specimens are generally collapsed, and present a very different appearance from living ones. This is further increased by the fact that in life the test is opaque and of a milky white color which disappears in preservation, leaving the test colorless and transparent.

There is a little blackish pigment on the zooids, contained in the mantle of the abdomen. The cells constituting the epithelium covering that part of the body are large and flattened, and contain the dark pigment chiefly near the edges, the center being clear and occupied by the nucleus, so that each cell appears as a small dark colored polygon with a clear center.

The zooids measure at least one-third less than those of the last described species, but do not differ in structure as far as I have observed, except that there appear to be fewer stigmata in a row.

The writer collected a number of small colonies of this form under stones near low-water mark at Hungry Bay, May 21st, 1901. One or two specimens were also found in similar situations at Waterloo, on Castle Harbor, about the same date. None of the specimens examined contained large eggs, though in some the testes were well developed.

Diplosoma atropunctatum, n. sp.

PLATE LIII. FIGURE 56. PLATE LVIII. FIGURE 103.
PLATE LXII. FIGURE 137.

This species is closely related to *D. lacteum*, and the writer describes it with some reluctance, as he has but a single specimen. This is a colony about 25^{mm} across, which was found growing on a coral (*Porites*) in Harrington Sound, April 30th, 1901, in water about twelve feet deep. The test, both in the living and preserved condition, is perfectly colorless and transparent, allowing the small zooids, which are but little larger than those of *D. lacteum*, to be seen with the greatest distinctness. This is in strong contrast to the milky white opaque test of living specimens of the last mentioned species. The test cavities are also less developed, leaving more test substance than is usual in *D. lacteum*.

The whole abdomen of the zooid is deeply colored with blackish or dark greenish pigment, contained in the mantle cells as described in the last species, and as the thorax is colorless, the abdomens of the zooids are conspicuous as small black dots, and the colony might easily be mistaken for a mass of eggs of some mollusk.

I found no noticeable differences in the structure of the zooids by which they could be distinguished from those of *D. lacteum*. Many contained both large eggs and large testes.

Genus **Diplosomoides** Herdman, 1886.

Differs from *Diplosoma* only in having stellate calcareous spicules in the test.

Diplosomoides fragile n. sp.

PLATE LIII. FIGURES 57 and 58. PLATE LXI. FIGURE 126.

In appearance, this species resembles a *Leptoclinum*, as it forms very thin, flat, expanded colonies often 60^{mm} or 80^{mm} across, of a very pure white color, which is produced by the abundance of minute spicules. These are generally not much over .02^{mm} in diame-

ter, and have very short, but often very slender and numerous points, which are usually more or less rounded or broken at the ends, though they may be needle-like. The points are so numerous and short that the spicule appears practically spherical when not much magnified. They greatly resemble those of some forms of the genus *Leptoclinum*. In life, the colony is of a purer white color than most of the species of *Leptoclinum* found at Bermuda, but preserved specimens turn slightly yellowish.

This species may at once be distinguished from the other members of the family with which it is found associated by the great delicacy of its structure. It breaks or tears at the slightest touch, and is difficult to remove whole from the object on which it grows. This is due to the extensive development of the cavities of the test as already described in *Diplosoma*. The test is reduced to an upper and lower layer forming the two surfaces of the colony, and a small mass surrounding each zoöid, and the fact that it is in all parts quite densely crowded with the spicules renders the thin layers of test substance very brittle.

The zoöids are large (1.5^{mm} long) and also of very delicate structure. Their apertures are always distinctly visible on the surface of the colony. Their tissues are yellow or orange in color.

The musculature, both of the mantle and of the branchial sac, is very weak. The muscle bands along the dorsal lamina are distinguishable, but the muscular process is rudimentary, if indeed it is developed at all, and the transverse vessels of the branchial sac are not perceptibly muscular. All the vessels of the branchial sac are very slender. There are about a dozen large stigmata in a row on each side. The tentacles are slender and of at least two sizes; I have not determined the number.

The stomach wall is exceedingly thin and often becomes folded, but this is probably not its natural condition.

The reproductive organs resemble those of *Diplosoma*.

This is a very common species, occurring under stones near low-water mark at various points about the islands. I found it particularly abundant at Waterloo, on Castle Harbor, also at Long Bird Island and Coney Island.

Genus **Echinoclinum**, n. gen.

Test gelatinous, becoming tough and membranous on the surface and about the zoöids. The latter are surrounded by a more or less complete calcareous capsule composed of the test spicules.

These spicules are tetrahedral in form, with each angle prolonged into a pointed ray or spine, and usually so placed about the zoöid that one point is directed radially outward. A few are also scattered about in other parts of the test.

Zoöids with rather large branchial sacs with four rows of stigmata. Branchial aperture six-lobed, atrial plain.

Echinoclinum verrilli, n. sp.

PLATE L. FIGURES 23, 24 and 25.

The largest colony of this species which was obtained measured about 12^{mm} across and about 3^{mm} in thickness. The zoöids are arranged in branching systems.

The test is colorless and very transparent in the preserved specimens. I have no notes upon its appearance in life. Though soft and flexible, it is continuous and solid, and no such extensive cavities occur as is usual in *Diplosoma*. On the surface and immediately around the zoöids, where, as already mentioned, most of the spicules are situated, the test is very tough and membranous. Elsewhere it is soft and gelatinous, and contains only a few scattered spicules, and here and there a few bladder cells.

I have not been able to distinguish any muscular processes extending out from the zoöids into the test, but it is almost impossible to remove the zoöids from the above mentioned tough membranous layer of test which surrounds them. It adheres to the mantle very closely at several points. One of these is about the atrial aperture. In addition there are two small areas, one on each side of the posterior part of the thorax, where the mantle and test are very firmly united, but I have made out no vascular processes extending out at these points. Sections of the thorax show that in these places there is a concavity in the contour of the body wall, and a corresponding projection of the common test into it, this being the part which adheres to the mantle.

The spicules vary much in size, the largest measuring about .15^{mm} across from point to point. On each side of the thorax of the zoöids, these are small groups containing smaller spicules than those found elsewhere. Apparently these are at the points above mentioned where the mantle and test adhere together. In addition to the spicules, the test contains some large, round, yellowish green cells, which are probably symbiotic algæ, as well as the usual small test cells.

The zoöids are small (less than 1^{mm} in length in the contracted

state), and pale yellowish in color. The mantle is not noticeably muscular, but there are strong muscles on the transverse vessels of the branchial sac and along each side of the dorsal lamina.

There are four rows of a dozen or more rather long stigmata and apparently about a dozen tentacles. Between the thorax and abdomen the body is constricted into a narrow but rather short peduncle. The mantle is somewhat produced just anterior to the atrial orifice, but hardly sufficiently to be termed a languet. The branchial siphon is short and has six small lobes.

The intestine forms a rather small twisted loop, and the stomach is rounded and smooth-walled externally, though slightly ridged on the inner surface in a longitudinal direction.

Though I have examined a great number of the zoöids, I have not found any with sexual organs developed, but many of them have small buds in the region of the peduncle.

Three small colonies were found in 1898, one of which was growing on a specimen of *Clavelina oblonga*; the other two on a branching alga. None were collected in 1901. I do not know the exact locality where the specimens were obtained.

Family **BOTRYLLIDÆ** Verrill, 1871.

Colony thin and expanded or thick and fleshy. Zoöids always arranged in systems. Test gelatinous, traversed by branching vessels with enlarged terminal bulbs, which are especially numerous near the margins of the colony.

Zoöids short-bodied, not divided into thorax and abdomen.

Branchial sac large, with numerous stigmata and with several internal longitudinal bars on each side, but no folds. Dorsal lamina a plain membrane. Tentacles usually few.

Loop of alimentary canal placed alongside the posterior portion of the branchial sac. Stomach-wall folded longitudinally. A large gastric cæcum is present.

Reproductive organs (both ovaries and testes) developed on both sides of the body. Budding from wall of peribranchial cavity.

Symplegma Herdman presents exceptions to this diagnosis.

Genus **Botrylloides** Milne-Edwards, 1842.

Distinguished from *Botryllus* by having the zoöids arranged in extended branching systems instead of small round or oval ones, and from *Sarcobotrylloides* von Drasche by forming thin instead of thick fleshy colonies.

The form of the systems is not a very satisfactory character on which to base a group of full generic rank, and various writers have attempted to attribute to *Botrylloides* additional distinguishing characters based on the cylindrical form and upright position of the zoöids in the colony, as well as on the position of the atrial siphon, which in this genus is said to be placed near the anterior end, while in *Botryllus* the zoöids are of more ovate form, lie horizontally in the colony and have their apertures more widely separated.

These characters are of very little significance. The form and position of the zoöids is chiefly dependent on the closeness with which they are crowded together in the colony, while the position, form, and length of the atrial siphon depend entirely on the relation of the zoöids to the common cloaca, or the branch of the same into which the zoöid discharges, and to which, of course, the atrial siphon must reach. Great variations in these characters may occur within the limits of a single colony, and they are not even of specific value. The genus must be separated from *Botryllus*, if separated at all, on the strength of its complex branching systems.

As with the Botryllidae of other parts of the world, the Bermuda forms are very variable, both in color and shape, and in the arrangement of the zoöids in the colony, and it is difficult to determine how many distinct species are really represented. The differences between the extremes of variation are ample for regarding them as distinct species. Yet so many colonies with characters intermediate between those of the types described below are to be met with in a large series of specimens, that the writer does not feel justified in giving the new forms which are here described full specific rank, and in this paper all the Bermuda forms, distinct from each other as the typical examples are, will be treated as subspecies of *B. nigrum* Herdman.

***Botrylloides nigrum* Herdman.**

Botrylloides nigrum Herdman, Report Voy. Challenger, pt. xxxviii, p. 50.

Botrylloides nigrum Herdman, Sluiter, Tunicaten von Süd-Afrika, Zoöl., Jahrbücher, vol. 11, 1897.

PLATE LIII. FIGURE 54. PLATE LXI. FIGURE 125.

To this species, described by Herdman from specimens taken "near the island of Bermuda," most of the examples obtained can be referred without much question. It is a common species and was found both in 1898 and 1901, and also by Prof. Goode in 1876.

It forms flat, incrusting colonies, 2 or 2.5^{mm} in thickness, and sometimes 70^{mm} across. There is great variation in respect to the closeness with which the zooids are arranged in the colony in different specimens. Where they are placed close together the zooids are nearly cylindrical and have a nearly upright position; where they are less crowded, they lie more obliquely, with the anterior end turned up, so that the body is curved. There is also great variation in the number and conspicuousness of the test-vessels and their bulbs, and in some colonies the young zooids, or buds, appear between the rows of adults arranged with nearly as great regularity as the adults themselves, but often quite differently colored.

In addition to these variations the color varieties are almost innumerable. Not much weight can be placed on such differences in the case of this family. They do not constitute true varieties, but are mere individual peculiarities. The work of Pizon (14) on certain species of *Botryllus* emphasizes this fact and shows that the colors of the same individual may change from time to time.

In the majority of specimens the zooids are colored some shade of purple, purplish brown, or purplish red; sometimes so dark as to be almost black; at other times very pale and light colored. When the zooids are deeply tinted the test is usually dark colored and pervaded with more or less of the same tint which predominates in the zooids, so that it loses a good deal of its transparency. In light colored specimens it is often nearly colorless, allowing every detail of the external anatomy of the zooids and the test vessels to be seen with great clearness.

The purple pigment which gives the zooids their color is in part diffused through the tissues, but is chiefly contained in cells which occur most abundantly in the mantle near the anterior ends of the zooids. They are also present in other parts of the zooids, especially along the transverse vessels of the branchial sac, and on the walls of the end bulbs of the test-vessels. The purple pigment is also contained in many of the blood corpuscles, and in the cells contained in the bulbs of the test-vessels. The extent of its distribution is very variable.

In some cases this purple pigment is replaced by a light bluish grey pigment, but in preserved specimens this changes to purple.

In addition to this ground color the zooids are usually, though not always, marked with a light colored pigment. It is usually a peculiar and very pure white, which is contained in opaque oval cells of the same size as those containing the ground color. They either

cover the anterior end of the zoöids about the branchial orifice (often obscuring the ground color) or form a ring about it, or in other cases a star-shaped area with about eight rays. Frequently they are scattered over the mantle in small groups, on the bulbs of the test-vessels, and often elsewhere. The white may be replaced by pale greenish, light yellow or (in one specimen) even bright orange. This light colored pigment disappears completely when the animal dies, and the zoöids become some shade of purple, purple-red, or blackish, and the test loses most of the color it possessed during life (even where it was quite dark colored) and becomes much more transparent.

Space will not permit of more particular description of the various colors assumed by different specimens, all of which I consider no more than individual variations of one and the same species. It is, in many of its forms, among the most beautiful and brilliantly colored of compound ascidians, and the name *nigrum* is by no means appropriate, though black colonies do occasionally occur. Herdman wrote his description from alcoholic specimens, which are often black or nearly so.

There are nearly always small groups of very large round cells with purple or purplish red pigment on the mantle along each side of the endostyle. What their nature or function is I am unable to say. Such cells occur also in the varieties *concolor* and *planum*, described below.

The zoöids in this species are rather small. In the contracted state in which they occur in preserved specimens they do not average over 1.5^{mm} in length.

The mantle is (for this genus) fairly muscular and the zoöids in the contracted state are apt to assume the curved cylindrical form which is well shown in fig. 54 and is rather characteristic of the species. The mantle muscles consist of delicate fibers and are chiefly developed in the dorsal region. The transverse vessels of the branchial sac also have muscle fibers.

There are about thirteen rows of stigmata and three internal longitudinal bars on each side. Between each of these there are about three stigmata, but on each side of the dorsal lamina and endostyle there are four or five. The tentacles are eight in number, larger and smaller alternating. The atrial siphon is very large and forms a capacious chamber with a large funnel-shaped opening, the anterior lip of which is prolonged into a languet. The position, form and length of the siphon varies according to the relation of the zoöid to

the common cloacal chamber into which it discharges. It is usually back a considerable distance from the anterior end.

The stomach has about eight or ten longitudinal folds and a large cæcum on the side toward the intestine. With this the duct from the glandular organ about the intestine communicates. The tubes of this organ have large dilated extremities.

The male reproductive organs consist of a large many-lobed testis on each side, near the posterior end of the branchial sac; just anterior to them the ovaries are located. In many colonies none of the zoöids appear to have reproductive organs. Fig. 54 was drawn from such a specimen.

This form is very widely distributed at Bermuda, occurring attached to the under side of stones near low water mark, and in deeper water on the lower parts of corals and gorgonians. One of the specimens obtained by Goode was growing on eel grass as is the common habit of *Botryllus gouldii* Verrill of the New England coast. Sluiter records this species from South Africa.

The internal structure of the zoöids in the two following forms does not appear to differ from that of the typical *B. nigrum*.

Var. *planum*, nov.

PLATE LIII. FIGURE 55.

PLATE LIX. FIGURE 110.

The type specimen was obtained by Professor Verrill in 1898. It covers a number of square centimeters of the surface of a piece of limestone. In the preserved specimen the zoöids appear of a dark purplish color. Some of the mantle cells are especially rich in pigment, giving the zoöids a speckled appearance under the microscope. The peculiarity of the specimen is the greatly flattened and expanded condition of the colony, the zoöids lying on their ventral surfaces, well separated from each other, though arranged in the characteristic elongated systems of a *Botrylloides*.

The zoöids themselves are much flattened and the anterior end is sharply turned up. The mantle is nearly devoid of muscle fibers; it is much larger than the branchial sac, and the atrial siphon opens far back toward the posterior end.

Another specimen, incrusting a piece of coral, was obtained by Prof. Verrill, in 1901, in Harrington Sound. The zoöids are purple in color, but lack the deeply pigmented cells in the mantle. In both colonies the test-substance is transparent and nearly colorless, forming a very thin expanded layer over the object on which the colony grows. I have no notes on their colors during life.

Var. *concolor*, nov.

PLATE LIII. FIGURE 53.

The colony in this variety resembles that of the typical *B. nigrum* in form, though I have not seen specimens measuring more than 30 or 40^{mm} across. The zooids are slightly larger, and the mantle-musculature appears to be generally weaker, so that in preserved specimens the zooids are not generally found contracted into the compact cylindrical shape which, as already remarked, is rather characteristic of *B. nigrum*.

In life the color is a brilliant orange; the zooids, and to some extent the test as well, having this color. It mimics quite closely the color of a species of sponge very abundant in the same situations. In specimens preserved in formalin the orange changes to a brown, red-brown, or even purplish.

Examples were collected in Harrington Sound, Castle Harbor, and at Somerset Id. It appears to be commoner on the reefs, attached to algæ, corals and gorgonians, than it is near low-water mark.

Var. *sarcinum*, nov.

Differs from the typical *B. nigrum* in forming a thick, fleshy colony of gelatinous consistency, with thick rounded edges. The type specimen measures about 50^{mm} across and is from 4 to 8^{mm} or more in thickness. The zooids (purple in color in the preserved specimen) exactly resemble those of a typical *B. nigrum*. The gelatinous test is yellowish with a purplish tinge. It was obtained by Prof. Verrill in 1898.

There are other specimens in the collection which show characters more or less intermediate between this form and the true *nigrum*.

This variety forms a sufficiently thick and massive colony to be placed in the genus *Sarcobotrylloides* von Drasche, which is distinguished from *Botrylloides* only by the thickness of the colony. The writer is inclined to question the necessity of recognizing *Sarcobotrylloides*, even as a subgenus.

Genus *Symplegma* Herdman, 1886.

Symplegma viride Herdman.

Symplegma viride Herdman, Report Voy. Challenger, pt. xxxviii, p. 144, pl. xviii, figs. 7-14.

PLATE L. FIGURE 22.

Herdman described under this name a specimen, taken by the Challenger expedition "in shallow water near Bermuda," forming for it a new genus and placing it, though with some doubt, in the

Distomida. Lahille considered that it should be placed in the Botryllida, and Herdman in his later work has followed him in this. Only a single colony was obtained, and that, as Herdman says, was in poor condition. As far as the writer is aware, the species has not been found since, though through an oversight it was included in Prof. Verrill's (17) statement of the species found in 1898.

The following details are from Herdman's description :

The colony consists of heads connected by branching peduncles. The heads are narrow at the lower end and taper gradually into the peduncles. "The color of the head is a dull green with spots of reddish brown scattered here and there. The peduncle is of a dull greyish yellow color." (These no doubt were the colors of the preserved specimen.) Length of head of average size 12^{mm}, greatest thickness 7^{mm}, length of peduncle about 15^{mm}, thickness 3^{mm}.

The test is tough and firm. Muscle bands of the mantle not large, but numerous and running in all directions. The sphincters of the siphons are especially strong.

The branchial sac is large, with numerous stigmata, and provided with internal longitudinal bars. The dorsal lamina is a plain membrane and there are eight tentacles, all of one size.

The body of the zoöid is not divided into thorax and abdomen. The alimentary and reproductive organs form a mass projecting a short distance beyond the branchial sac. The stomach is folded longitudinally and provided with a cecum.

There are branching vessels in the test, with enlarged terminal bulbs containing corpuscles.

Family **POLYSTYELIDÆ** Herdman, 1886. (**Polyzoidæ** Michaelsen, 1900.)

Colony variable in form, but always without systems, the atrial as well as the branchial aperture of each zoöid opening independently on its surface. Test penetrated by branching vessels with enlarged terminal bulbs.

Zoöids with both apertures four-lobed, if lobes are developed. Branchial sac with many rows of stigmata, with internal longitudinal bars, and often with folds. Dorsal lamina a plain membrane.

Alimentary loop usually lying alongside the branchial sac. Stomach-wall longitudinally folded.

Reproductive organs in the form of polycarps containing either testes or ovaries, or both, attached to the inner wall of the mantle in the peribranchial cavity. They are developed on both sides of the body.

Method of budding pallial (from wall of peribranchial cavity).

The most important work dealing with the classification of the members of this family is that of Michaelsen (12), previous classifications being based upon the form of the colony or other features of little significance.

Michaelsen makes the structure of the reproductive organs the chief character in distinguishing the genera. There is no doubt that this is a great advance toward a natural system, and although his innovations in the nomenclature may not be accepted in every instance, he is amply justified in rejecting many of the older and imperfectly characterized genera.

I have not, however, been able to include either of the two Bermuda forms, here described, in any of Michaelsen's genera. Even if only the structure of the reproductive organs be considered, his definitions would have to be modified (though in one case only slightly) in order to receive them, and I believe that other differences in the anatomy are of sufficient weight to justify the formation of new genera.

Michaelsenia, n. gen.

Colony incrusting. Test thick and leathery. Both apertures four-lobed.

Branchial sac with folds and many internal longitudinal bars.

Reproductive organs consist of a number of hermaphrodite polycarps of rounded or oval form, arranged in two rows (one each side of the endostyle) on the ventral surface of the body, from which they project into the test as papillæ or tubercles, invested by an evagination of the mantle, to the inner surface of which they are attached.

The form for which I have established this genus differs from the genus *Styela* of the Simple Ascidians in only two essential characters: first, in producing buds and forming colonies; second, in the above described arrangement of the sexual organs. In the character and appearance of the test, apertures, tentacles, and branchial sac, as well as in many minor particulars, the resemblance to *Styela* is very striking.

It is most closely related to Michaelsen's genus *Polyzoa* Lesson as far as the structure of the reproductive organs is concerned, though there the testis consists of but one vesicle in each polycarp. In that genus, moreover, the branchial sac is without folds and has but eight internal longitudinal bars on each side, and the form of the colony is very different.

Michaelsenia tincta, n. sp.

PLATE LIV. FIGURES 61 and 63.

PLATE LIX. FIGURE 109.

The examples found contain only a few zooids, from two or three to a dozen, and do not often measure more than 15^{mm} across or 3.5^{mm} in thickness at any point. The surface is finely wrinkled and uneven, often raised over the positions of the zooids, and the edges of the colony are thin and produced some distance beyond the zooids. It is practically free from all incrusting matter. The test-substance is tough and leathery, and opaque, except that about the edges of the colony, or in other places where it is thin and slightly pigmented, it is more or less translucent. The zooids and the test vessels (which have elongated club-shaped bulbs) can usually not be distinguished through it, and in many specimens the number and location of the former can only be seen by the slightly projecting apertures, which do not show their square or four-lobed shape when they are contracted, unless the zooid is removed from the test.

The color is a rather dull carmine-red, deeper about the apertures and paler near the edges and in the lower parts of the colony. Where the pigment is scarce, the test becomes yellowish. When sectioned and stained the test is seen to have a fine fibrillar structure.

The largest zooids measure from 5 to 6^{mm} in length and 2 to 2.4^{mm} across. They lie on the ventral surface, with the anterior end turned more or less abruptly upward, bringing the branchial orifice a little way back from the end, and are much flattened dorso-ventrally. The atrial orifice, which like the branchial is situated at the summit of a low conical projection, is placed at a varying distance from the posterior end.

The mantle, especially the dorsal part, is colored a bright carmine by pigment grains contained in its cells. These grains are situated near the periphery of the cells, the central part remaining clear. The mantle-muscles are weak and not gathered into bands.

There are a great many slender tentacles of two or three sizes, none of them very long.

The branchial sac has three or four distinct folds on each side. On each fold there are about three internal longitudinal bars, and usually one on each intervening space. The internal longitudinal bars are thus situated at unequal distances apart, there being some six or eight stigmata between them in some places and only about two on the folds. The large transverse vessels number about fifteen, but between each pair there is usually a more slender intermediate vessel. The stigmata (which are narrow) often run past

this intermediate vessel from one large vessel to the next. In other places the stigmata are interrupted by the intermediate vessel.

The stomach is long and narrow, deep yellow or brown in color, with many longitudinal folds and a small cœcum on the side toward the intestine. There are a considerable number of short atrial tentacles.

There are a number of polycarps arranged along each side of the ventral part of the body. They are hermaphrodite, containing two large pyriform or oval testes and a number of ova. Often, as sections of the colonies clearly show, they lie in small papillæ or knob-like evaginations of the body-wall which are thus more or less nearly surrounded by the test, and may communicate with the body only by a somewhat constricted neck. It is probably on account of these, as well as because of the large and strong vascular processes arising from the posterior ventral part of the body, that it is very difficult to remove the zooids from the test entire.

Specimens of this species preserved in formalin retain their natural color for a considerable time. In its character and appearance a colony closely resembles a flattened example of some of the simple ascidians of the family Cynthiidae, with which it is found associated, though the numerous apertures serve to distinguish it. The colony looks more like an aggregation of small simple ascidians than a compound ascidian.

This species is found on the under side of stones near low water mark, nowhere in great abundance, but widely distributed, and it was collected in 1901 at nearly all the points about the islands where much collecting was done.

Diandrocarpa, n. gen.

Colony incrusting. Apertures elliptical, without lobes. Tentacles few.

Branchial sac simple; no folds and few internal longitudinal bars. No small intermediate transverse vessels.

Loop of alimentary canal large, placed beside the branchial sac.

Reproductive organs consist of a single mass on each side of the body, each with two large pyriform or lobed testes and a group of eggs.

I form this genus for the species described below, which differs too much from the type of *Gyandrocarpa* Michaelsen to be placed in the same genus with it. (The type of Michaelsen's genus is

Goodsiria placenta Herdman, which forms pedunculated colonies and has a folded branchial sac with numerous longitudinal bars.)

Synstyela monocarpa Sluiter, from South Africa, which is included by Michaelsen in *Gymandrocarpa*, is however closely related to the form here described, and is better placed in this new genus than in *Gymandrocarpa*, and I have so defined the genus that it may be included. Possibly one or two other species might also find their place here. *Synstyela* Giard is rightly rejected by Michaelsen as too poorly defined to be certainly recognized.

***Diandrocarpa botryllopsis*, n. sp.**

PLATE LIV. FIGURE 68. PLATE LIX. FIGURES 120 and 121.

PLATE LX. FIGURE 123.

The colonies are very thin, seldom averaging over 2^{mm} thick, though the surface is slightly raised over the position of each zoöid. In outline they are very irregular, but sometimes measure 60^{mm} or more in the longest direction. Frequently they break up into a number of small colonies, which may remain slightly connected.

The test is very soft and gelatinous with a slightly tougher outer layer. It is transparent and almost colorless after death, but in the living and expanded animal it has more or less of the dark color of the zoöids. The reason for this is not clear, but it may be due in part to greater distension of the test vessels with colored corpuscles in the living animal. These vessels are quite numerous, especially in the marginal parts of the colony, and have club-shaped terminal bulbs, but the latter are not proportionately very large.

The zoöids reach about 2.5^{mm} in length and 1.3^{mm} in width, or slightly larger when fully expanded. They lie on their ventral surfaces, and have the branchial aperture close to the anterior end and the atrial near the middle of the body. The apertures project but little and are elliptical, with the long diameter parallel to the long axis of the body, and without lobes, but sometimes with minutely denticulate edges.

Their color (due chiefly to corpuscles contained in their vessels and in the mantle) is blackish, or some shade of dark purplish brown or brown, sometimes even dark olive. During life the branchial aperture is surrounded by an area of white pigment, or sometimes greenish white, pale salmon, or pale yellow. This has an irregularly stellate outline, and there is also considerable of the light pigment over the region of the ganglion and in small dots at various points on the mantle and on the bulbs of the test-vessels. This pigment

mostly disappears when the animal dies, and the dark pigment of the test and vessels usually becomes lighter and of a more purple tint. The whole coloration is strongly suggestive of the family Botryllidæ.

The zooids taper toward the anterior end, and have the posterior end broad and rounded. They are more or less flattened in a dorso-ventral direction, or somewhat obliquely. The musculature of the mantle is chiefly transverse, but weak and inconspicuous. The tentacles are few in number and are probably of two sizes, placed alternately.

The branchial sac extends practically the whole length of the body and conforms to its shape. The dorsal lamina is a plain membrane. There are four, possibly five, internal longitudinal bars on each side, and four or five stigmata in the meshes of the network thus formed. The transverse vessels appear to be of one size only, but the branchial sac is somewhat irregular and the transverse vessels of the two sides do not meet the dorsal lamina exactly opposite each other. There are about 13 or 14 rows of stigmata.

The stomach and intestine lie on the left side of the branchial sac. The short, curved œsophagus extends ventrally and to the left, and opens into the stomach, which is grooved or folded longitudinally with about ten folds, and lies with its axis directed obliquely forward and somewhat ventrally. The cardiac end is the smaller. From the stomach the intestine, which is in this region of large diameter, proceeds forward and dorsally, then posteriorly and finally bends abruptly forward to form the rectum, which is of smaller diameter. The glandular tubes which surround the intestine have large dilated ends. I have not been able to determine that any atrial tentacles are present. The reproductive glands are generally further forward on the left side than on the right. On each side there are two large pyriform testes placed one behind the other, with their small ends together, and the ovary, which was small in all the specimens examined, was situated between or close against the testes.

The test vessels arise from the posterior part of the ventral side of the zooid.

This is a moderately common species, and was collected in several places, especially, however, at Coney Island, and Waterloo on Castle Harbor. It was obtained both in 1898 and 1901, as well as by Prof. Goode in 1876-77, and generally grows on the under side of stones or other solid objects near or below low-water mark.

ASCIDIÆ SIMPLICES.

Fixed (rarely unattached and never free swimming) ascidians which do not reproduce by budding or form colonies.

The branchial sac is enormously developed, occupying the greater portion of the body and is provided with a very large number of stigmata.

The viscera lie alongside the branchial sac, though they may project behind it to a very slight extent.

This group is usually considered a sub-order.

Family **HALOCYNTHIIDÆ.** (*Cynthiidæ* Lac. Duth., 1877.)

Body usually attached, sometimes stalked.

Test membranous, coriaceous, or sometimes cartilaginous, sometimes incrustated with sand or other substances. Branchial and atrial apertures usually four-lobed.

Branchial sac longitudinally folded, with internal longitudinal bars, which do not bear papillæ.

Tentacles simple or compound.

Intestine on left side.

Reproductive organs attached to the inner surface of the mantle, on one or both sides of the body.

The name of the principal genus of this family was changed by Verrill to *Halocynthia*, as the name *Cynthia* was preoccupied, having been used for a genus of insects.* This change has not been generally adopted, but appears to be required. The family name requires a corresponding change.

Polycarpa Heller, 1877.

Body sessile or more or less distinctly pedunculated.

Branchial sac with about four folds on each side. Tentacles simple. Dorsal lamina a plain membrane.

Reproductive organs consist of numerous small hermaphrodite gonads distributed on the inner surface of the mantle, on both sides of the body.

* Bulletin No. 15, U. S. Nat. Museum, p. 147, 1879.

***Polycarpa obtecta* Traustedt.**

Polycarpa obtecta Traustedt, Vestindiske Ascidiæ Simplicis, Aftryk af Vidensk. Meddel. fra den naturh. Foren. i Kjobenhavn, p. 51, pl. v, figs. 7-8, plate vi, fig. 15, 1882.

Polycarpa obtecta Sluiter, Tuniciers recueillies en 1896 par la "Chazalie," Mém. Soc. Zoöl. France, vol. xi, p. 11.

Polycarpa multiphiala Verrill, Additions to the Tunicata and Molluscoidea of the Bermudas, these Trans., vol. x, part 2, page 591, 1900; vol. xi, pl. ix, fig. 7, 1901.

PLATE LVII. FIGURES 88, 89 and 92 to 94 inclusive. PLATE LXIII. FIGURES 140 and 144. PLATE LXIV. FIGURES 151 and 153.

Though the type of *P. multiphiala* Verrill differs in some points from Traustedt's description and figures of the West Indian form, other specimens from Bermuda agree with the latter more closely, and I do not think there is sufficient reason for regarding the two species as distinct.

The body usually measures somewhat more in length (that is antero-posteriorly) than in breadth (dorso-ventrally) and is, when not distended with water, decidedly compressed in a lateral direction. The test is tough, yet soft and flexible, rather thin toward the posterior end of the body, but thickened and much toughened near the anterior end, so that the siphons, though in reality fairly well developed (as may be seen when the animal is removed from the test), usually appear very short. The surface is sometimes partly covered with sand and shell fragments, in other cases bare. The inner surface is smooth and nacreous.

The color of the test is a dirty yellowish or brownish gray, often darkening to red, brown, or purplish brown about the apertures.

The animal is usually attached by a very small area near the posterior end, which may be thickened or even produced into a very rudimentary peduncle. Sometimes several individuals are attached together in a loosely connected group.

The largest specimens found do not much exceed 45^{mm} in greatest length. They are somewhat less in breadth, and not over 12 to 15^{mm} in thickness when not distended with water.

The mantle is smooth and rather thin, of a uniform dark brown color. The rather narrow muscle-bands run transversely, longitudinally and obliquely, forming a rather open and regular network. The apertures are distinctly four-lobed. The branchial siphon is the longest.

The tentacles are long and more or less brown-pigmented. Verill gives 40 as the number in the type specimen of *P. multiphiata*, but this number is sometimes exceeded. They vary somewhat in size, but no very regular arrangement, except an alternation of larger and small ones, is to be distinguished. Traustedt gives 36-40 as the number of tentacles.

The dorsal tubercle is large; the opening is horseshoe-shaped with incurved, but not spirally rolled, horns. (This was the condition in several specimens examined and agrees with Traustedt's description).

Traustedt states that there are 4 folds on the left and 5 on the right side. Sluiter mentions one specimen with 4 on each side. This I have found to be the case in most of the Bermuda specimens examined, though in one case a rudimentary fifth fold was present on the right side, next to the dorsal lamina. The folds are generally wide. The one nearest the dorsal lamina is the smallest. The internal longitudinal bars are very wide and flattened. They are quite numerous, about four or five occurring between the folds, and sometimes as many as 10 or 11 on one side of a fold. They are separated by 10 or 12 stigmata in the spaces between the folds (14 near the endostyle). This number diminishes to 3 or 4 or less near the summit of the folds, where the bars are so close together that when flattened down against the branchial sac they overlap each other for most of their width, covering the intervening stigmata entirely. The transverse vessels are of various sizes, but are not arranged with great regularity. Small transverse vessels crossing the stigmata without interrupting them are generally wanting.

The alimentary loop is of the same color as the mantle and branchial sac. It forms in some cases a moderately large, open loop; in others a much narrower one (see figs. 92, 93 and 94). The stomach is small. In all cases the alimentary loop is confined to the posterior half of the body.

The gonads are distributed to the number of 20 or more on each side of the body. They are flask-shaped bodies, and are so placed that their orifices are directed toward the atrial siphon. The central part of each is occupied by the ovary, and the oviduct opens at the extreme end of the gonad. The sperm-duct opens on a separate papilla or projection a little distance from the end, and is formed by the union of two branches, one of which runs along each side of the ovary and receives the ducts from the numerous small pyriform testes. (Figs. 88 and 89.) In these figures the ovaries are not fully ripe, and the gonads have an elongated phial-like form. This is one

of the characters upon which Verrill based the species *multipliala*. When the ovaries are ripe and are distended with large eggs, the gonads become thick and swollen, and resemble in shape those shown in Traustedt's figure, though I have not found them developed to such an extent in any of the Bermuda specimens as was evidently the case in the individual figured by the latter author.

This species was collected both in 1898 and 1901. I obtained a few individuals at Coney Island and Long Bird Island, but it appears to be more common on the reefs than along the shore. A number of large specimens were found washed up on the beach, but still alive, at a place known as the "Scaur," on Somerset Island, May 5th, 1901.

Styela MacLeay, 1824.

Body attached, sessile, rarely pedunculated.

Test usually coriaceous.

Branchial sac with four folds on each side, or less. Dorsal lamina a plain membrane. Tentacles simple.

Reproductive organs on both sides of the body, attached to the inner surface of the mantle. Ovaries consist of a small number of elongated glandular tubes. Testes numerous, variously placed in relation to the ovaries.

Styela partita (Stimpson), var. *bermudensis*, nov.

S. partita: PLATE LV. FIGURE 69. PLATE LVI. FIGURES 76 to 78 inclusive.

PLATE LXIV. FIGURES 147 and 149. *S. partita* var. *bermudensis*: PLATE LV. FIGURES 70 to 75 inclusive. PLATE LXIII. FIGURES 142 and 143.

In Prof. Verrill's list (17) two species of *Styela* are mentioned as having been found at Bermuda; *S. partita* (Stimpson), a species originally described from Boston Harbor, and occurring on the Atlantic Coast of the United States from Massachusetts southward, and the Mediterranean species, *S. canopoides* Heller (4), which has also been recorded from the West Indies by Traustedt (16).

After an examination of about 25 specimens of this genus collected at various points about the Bermuda Islands in 1898 and 1901, including those on which Prof. Verrill based his list, I have come to a somewhat different conclusion. The Bermuda specimens vary a great deal in nearly every character, but I cannot satisfy myself from the material available that more than one species is really represented.

None of the specimens correspond exactly to specimens of *S. partita* from Massachusetts (Wood's Hole); though some bear a very strong external resemblance to them, even to the "alternate striping of red and white in the apertures," mentioned by Verrill, which is characteristic of *S. partita*; but as the differences are hardly tangible enough to base a species on, it seems best to consider the Bermuda form as a subspecies of *S. partita*. The specimen in Prof. Verrill's collection, marked *S. canopoides*, does not differ specifically from the others, though it certainly does correspond well with Heller's (4) and Traustedt's (16) description and figures of that species.

This raises the question as to the status of *S. partita* (Stimpson) as a species, and of its relations to *S. canopoides* and other European forms. Metcalf (11) has expressed the opinion that the New England form is only a variety of *Styela aggregata* of Northern Europe. He has not, however, given any detailed statement of his reasons for this belief. Unquestionably the two species are closely allied, but if the New England form is only a variety of a European species, it would seem more reasonable to regard it as a variety of *S. canopoides*, rather than of *S. aggregata*, especially as the latter is a northern species, while *S. partita* is distinctly southern in its distribution. This is, however, a point which I do not feel in a position to decide without a considerable series of European specimens for comparison, and in the present paper I shall confine myself to the consideration of the relations between the Bermuda and New England forms.

Though *Cynthia (Styela) partita* was described half a century or more ago, no account or figures of its internal anatomy have been published as far as I am aware.* The following details are from specimens taken at Wood's Hole, Mass., in July, 1901. They were growing attached to the piles of a wharf, in large masses (sometimes 8^{cm} across), which contained as many as a dozen individuals closely crowded together. The attachment was by the posterior end of the body. Where individuals grow singly, they are often attached by the whole ventral surface, or by a large part of it. In such specimens the branchial siphon may be a little back from the anterior end of the body.

The body tapers rather rapidly at the anterior end, and the atrial siphon is placed well forward and also directed more or less ante-

* Except Professor Verrill's figures of the gonads in this volume (pl. ix, figs. 8, a, b, c), 1901.

riorly. The test is tough and coriaceous, of a dirty yellowish color, becoming a purplish brown or red toward the anterior end of the body. It is not very thick at any point. On the outer surface it is finely wrinkled; within it is smooth and glistening.

The largest of these specimens does not exceed 30^{mm} in length, and most of the individuals are considerably smaller.

When removed from the test the body is ovate, with both the siphons near one end. The mantle is of a yellowish color, and rather thick and opaque, with numerous longitudinal muscle-bands, but few conspicuous bands running in other directions. The internal organs cannot be seen very readily through the mantle.

The tentacles vary in number in different specimens. As a rule the larger the specimen the more tentacles. The individual shown in figure 78 had hardly over 30, those shown in figures 76 and 77 had from 40 to 50. The tentacles are of several sizes. Sometimes they are arranged with some regularity; one tentacle of a given size being placed midway between two of the next larger size and so on; but this arrangement is not very strictly adhered to. Often those of the smallest size will be wanting in many of the places where, according to the above scheme, they should occur, or they may be represented by a mere tubercle, so that it is hard to say whether it should be counted as a tentacle or not. No doubt as the individual increases in size these grow out into tentacles.

The dorsal tubercle is variable in size and form, and its orifice had a different shape in each specimen examined, though always some modification of the U-form. The ends were not spirally coiled in any case. Evidently the form of the dorsal tubercle will not do as a specific character in this genus, if indeed it is of much value in any other genus of this family, which I am inclined to doubt.

The branchial sac has four distinct folds. These vary in size relatively to the interspaces in different individuals. Figure 69 shows a section extending clear across one side of the sac near the middle of the body. (Toward the ends of the body, the sac is more contracted and the number of stigmata between the bars becomes smaller.) It is taken from the individual shown in fig. 77, a fully adult and fairly large specimen. In this it will be seen that there are about 10 stigmata in the largest meshes in the interspaces between the folds (14 each side of the endostyle and 8 each side of the dorsal lamina). In the dorsal part of the sac, the bars are more crowded; and the maximum number of stigmata in a mesh is about eight. The first fold begins at the third bar from the endostyle and there are four

bars between the last fold and the dorsal lamina. There are from seven to ten bars between the base and summit of a fold, varying according to its breadth.

The transverse vessels are of four or five sizes: the smallest cross the stigmata at their middle point without interrupting them. In general they are arranged according to the same scheme as the tentacles, a vessel of a given size being located midway between two of the next larger size, but many irregularities occur. The transverse vessels become thicker as the dorsal lamina is approached.

The above may be taken as the average condition of the branchial sac in a fully adult specimen. Considerable individual variation occurs in the distribution and number of internal longitudinal bars on the folds and interspaces, and in the number of stigmata in the meshes formed by them. In many examples it averages one or two less than in the specimen shown in fig. 69. Figs. 147 and 149 show a part of the sac of such a specimen.

Such variations are merely individual peculiarities. In addition, there are also differences due to the age of the animal. The branchial sac in the individual shown in fig. 78 did not differ materially in structure from those of larger specimens, but when still smaller and evidently immature specimens are examined, the structure of the sac is found to be more or less simplified. One or more of the folds may be wanting or present only in a rudimentary condition, and the number of internal longitudinal bars, as well as of the stigmata, becomes reduced.

The intestinal loop is small and the intestine doubles back so that it comes in contact with the stomach near the middle of that organ, or a little posterior to the middle. The rectum is long and its opening has about a dozen rounded lobes, or more strictly, plications of the edge. The stomach is of a brownish orange color, and has from 18 to nearly 30 longitudinal folds in its wall, the number varying according to the age and size of the individual.

The ovaries consist of stout glandular tubes, usually two on each side (one of which may be forked). They pursue a more or less crooked course from near the endostyle (on the left side from near the intestine) and end near the atrial siphon. The sperm ducts accompany them and the openings are close beside those of the oviducts. In some specimens both orifices may be seen to have a lobed or plicated margin similar to that of the rectum, but the lobes are smaller. The testes are elongated, more or less branched organs of small size with enlarged ends. They are arranged along each side of the ova-

ries in varying numbers, and communicate with the sperm duct which follows the ovary by slender connecting ducts. Usually the larger the individual the more numerous and more extensively branched are the testes, though this is not always the case.

After this description of the New England form it will be sufficient to mention the particulars in which the Bermuda variety differs from it.

In the first place, it is of considerably smaller size, the largest specimen obtained measuring 22^{mm} by 10^{mm}. Most of them were hardly more than half this size. It is not unlikely, however, that if the collections had been made later in the season, larger specimens might have been found.

In external form it appears to vary more than the typical *partita*. It is attached either by a small area near the posterior end or by a part or the whole of the ventral surface, and in the latter case the siphons are both situated on the dorsal surface. The character of the surface of the test is very variable; it is generally roughest near the apertures, which are usually more or less prominent, but whether the ridges and wrinkles of the surface are large or small, regularly or irregularly disposed, low and rounded or prominent and sharp-edged, appears to be a character of no specific value.

The color is generally a more or less reddish or brownish yellow, or grayish yellow, becoming brown or red on the upper surface, especially about the siphons. The colors are brighter and the test proportionately thicker and of a more cartilaginous character than in the New England specimens. The striping of the apertures, which many specimens show in common with the typical *partita*, has been mentioned above.

As figs. 71 to 75 indicate, the form of the body and length and position of the siphons are very variable. The mantle is thinner, less muscular, and more transparent, though of a deeper yellow color in most cases, and the tentacles are rather more numerous, but the branchial sac does not appear to differ essentially from that of New England specimens of similar size.

The more usual form of the orifice of the dorsal tubercle is a U or horseshoe-shape, with one horn curved inward and posteriorly, alongside the other, but not spirally coiled. Considerably more complex forms occur, as is also the case in the true *partita*.

The reproductive organs are similar, but the testes are fewer and often are not branched at all, but merely simple elongated bodies.

This form was found in many localities about the islands and on

the reefs, attached to stones and corals. It is nowhere very abundant, nor did I ever find many individuals growing together or near together. Among the places where it was obtained were Coney and Long Bird Islands, Somerset Island, Harrington Sound, and Waterloo, Castle Harbor. One specimen was obtained at Hungry Bay.

Genus *Halocynthia* Verrill, 1879. (*Cynthia* Savigny, 1816.)

Body sessile or very nearly so, sometimes incrustated with sand. Both apertures 4-lobed.

Test coriaceous, rarely cartilaginous, no spicules.

Branchial sac with 6 or more longitudinal folds on each side. Tentacles compound. Dorsal lamina a continuous but sometimes toothed membrane, or it may be provided with a series of languets.

Intestine on left side forming a rather wide loop.

Reproductive organs developed on both sides.

Halocynthia rubrilabia Verrill.

Halocynthia rubrilabia Verrill, Additions to the Tunicata and Molluscoidea of the Bermudas, Trans. Conn. Acad. Sci., vol. x, p. 589, fig. 7, 1900.

PLATE LVI. FIGURE 83. PLATE LVII. FIGURES 86 and 90. PLATE LXII. FIGURE 133. PLATE LXIV. FIGURES 150 and 152.

Body swollen, oblong or ovate, usually longer than high, attached by the entire ventral surface or by a larger or smaller area near the posterior end which may be produced into a rudimentary peduncle. Siphons of variable length, widely separated, the branchial generally longer than the atrial.

Size 35 to 50^{mm} long, 25 to 30^{mm} high, 20 to 25^{mm} wide.

Test thick and firm (in many specimens remarkably so), deeply and irregularly wrinkled, in large specimens often so covered with extraneous matter that its reddish color shows only faintly. Apertures similar, 4-lobed, the test about them roughly nodulose or warty.

Mantle very muscular, especially on the right side; the muscle bands, of which the longitudinal are the most conspicuous, form a rather irregular, close, opaque network. Many oblique as well as transverse bands occur also. The mantle is yellow with a reddish tinge, usually becoming bright red on the siphons.

Tentacles all simply pinnate, about 20 in number and of various sizes; the larger ones number about a dozen and are thick, tapering to a point and provided with a row of simple pinnae along each side. Dorsal tubercle U-shaped, with more or less spirally coiled horns, which may be both incurved or both curved to the right or left.

The branchial sac has 6 wide folds on each side separated by narrow interspaces on which there are but four or five internal longitudinal bars. There are, however, about 7 or 8 bars on the spaces each side of the endostyle and dorsal lamina. The bars are wide and flattened and placed near together, being separated by only four or five stigmata in the spaces between the folds and by a less number on the folds. Between the base and summit of the folds there are sometimes as many as 14 or 15 bars. The stigmata are short and rather wide.

The transverse vessels are mostly of about the same size with an occasional much larger one. In addition there are the usual fine vessels which cross the middle of the stigmata. There is often much red pigment on the vessels of the sac. The dorsal lamina is provided with a series of slender tentacle-like languets.

Prof. Verrill states that the anus has about 12 lobes. This is not of value as a specific character. One specimen had but 4 barely perceptible lobes. The intestine forms a broad loop. The stomach is but little enlarged and is partly covered by the large greenish hepatic gland which lies dorsal to it.

The reproductive glands are irregularly lobulated or foliated bodies arranged along each side of the genital ducts. When much enlarged they are so crowded that their serial arrangement is not very apparent. On the left side one series of the glands lies within the intestinal loop. Another set lies along the dorsal side of the intestine, the duct following close along the intestine and the glands lying only along one side of it, while in the case of those which lie within the loop, as well as the single set which is present on the right side of the body, they lie on each side of the duct.

This appears to be the commonest member of the family at Bermuda, at least in shallow water, where it is found adhering to stones, shells, corals, etc.

Halocynthia riiseana (Traustedt) var. **munita**, nov.

PLATE LVI. FIGURE 84. PLATE LVII. FIGURES 85 and 87.

PLATE LXIII. FIGURE 141.

In addition to *H. rubrilabia* there is another species of the genus found at Bermuda, but it is much less common. It was only poorly represented by one or two small specimens in Prof. Verrill's collection and he considered it identical with Traustedt's West Indian species, *Cynthia Riiseana*. In 1901, I obtained three good sized specimens, of which the largest measures 28^{mm} by 25^{mm}. The others

were not much smaller. They were growing attached to stones along the shores of Coney Island and Long Bird Island.

From these, though the material is too scanty to give a satisfactory idea of the individual variations which specimens of this species are likely to exhibit, I believe that the Bermuda form is sufficiently different from the West Indian one to justify its description, provisionally at least, as a new variety.

The body is ovate, slightly longer than deep, and decidedly compressed laterally. The test is not thick; it is soft and flexible, light colored, and would be translucent were it not for the dense coating of sand and shell fragments which cover not only the surface, but are more or less buried in the test substance. The area of attachment is small. The siphons are wide apart in two specimens, in the other they are rather near together. They are rather short in all cases. The appearance of the animals is rather that of a *Molgula* than one of the family to which they really belong.

The mantle is thin and more or less transparent with weak musculature. In one specimen the tips of the siphons are pink. None of the other specimens show any red color on any part of the body.

In all these particulars the examples differ from Traustedt's description, in which the test is described as leatherly with a wrinkled surface, and the mantle musculature as very strong.

There are about a dozen large tentacles beside some smaller ones. They differ greatly from those of *H. rubritabia*, the largest ones being bipinnate (fig. 84). The dorsal tubercle, in the specimen in which I examined it, had a U-shaped aperture with one horn incurved, but not sufficiently to form a spiral. The dorsal lamina is provided with numerous tentacular languets. They begin a little way back from the anterior end, the lamina being plain for a little distance.

As in the last described form, there are six branchial folds on each side. There are, however, fewer internal longitudinal bars (I counted only ten or eleven on one side of one of the longest folds) and they are separated by 7 or 8 or even 9 stigmata in the meshes on the interspaces between the folds, instead of 4 or 5 as in *H. rubritabia*. The stigmata are also longer and narrower than in that species, but in other respects the branchial sac resembles that of *H. rubritabia*.

The intestinal loop is rather narrower than in that species and the reproductive organs differ, the gonads being spherical though arranged in a similar manner along each side of the genital ducts, with which they communicate by short branch ducts. There is only one series of reproductive organs on each side. On the left side it lies within the intestinal loop.

Microcosmus Heller, 1877.

Distinguished from *Halocynthia* by the plain, untoothed dorsal lamina, and by the narrow intestinal loop.

Microcosmus miniatus Verrill.

Microcosmus miniatus Verrill, Additions to the Tunicata and Molluscoidea of the Bermudas, Trans. Conn. Acad. Sci., vol. x, p. 590, 1900.

PLATE LVI. FIGURE 79. PLATE LVII. FIGURES 91 and 95. PLATE LXII. FIGURES 129 and 130. PLATE LXIV. FIGURE 148.

Test more or less completely red or dull orange-red externally, rather thick and tough, somewhat cartilaginous. In adult specimens it is much wrinkled and raised (especially on the dorsal surface and about the apertures) into prominent ridges with sharp rough edges. Young specimens are much smoother.

The shape is ovate, more or less elongated; the apertures are widely separated. The attachment is by an area of considerable extent on the ventral side, generally near the posterior end. In external appearance this species closely resembles *Halocynthia rubrilabia*, described above, but is usually colored more intensely and extensively red than that species, and the body is often somewhat more elongated. Internally the test is smooth and pearly and less deeply colored than on the outside.

Size of the largest specimen, 50 by 35 by 25^{mm}.

Removed from the test, the animal is ovate with very widely separated and divergent siphons of very variable size and length in different specimens, both four-lobed. The mantle, especially near the apertures, is more or less tinged with red. Its muscles, stronger on the dorsal part of the body, are gathered into very distinct and moderately thick bands, which for the most part cross each other nearly at right angles and form a rather open network, so that the internal organs are more or less distinctly visible through the mantle.

The tentacles are bipinnately branched. There are about 8 or 10 larger ones alternating with others of smaller size and between them are a variable number of still smaller ones. Even the smallest are somewhat branched. The aperture of the dorsal tubercle had spirally incurved horns in the specimens examined.

The number and arrangement of the folds of the branchial sac proved to be quite constant in a number of individuals of various sizes from about 15^{mm} in length up to individuals of full size. There are nine folds on each side of the sac, but the last one (that nearest the

endostyle) usually reaches only one-quarter or one-third of the distance back from the anterior end, and is often so rudimentary that it is easily overlooked. It is apt to be smaller on the left than on the right side of the body. The eighth fold is generally fairly large and of full length.

As a rule there are four or five internal longitudinal bars in the spaces between the folds and these are separated by from 5 to 8 stigmata. Along one side of a fold, from the base to the summit, there may be a dozen bars (if the fold is a large one), and the number of stigmata between them diminishes from about four near the base to three or two at the summit. The transverse vessels are numerous and rather stout, and the stigmata consequently are not very greatly elongated. There are various sizes of the transverse vessels but apparently no regular scheme in their arrangement. The smallest ones usually cross the stigmata without interrupting them. The larger ones have more or less conspicuous membranes attached to them.

The intestinal loop is very long and narrow, and the two portions lie in contact with each other for the greater part of the distance. The two dark colored hepatic glands lie close against and partially covering the stomach.

The reproductive organs consist of about four double clusters of follicles lying along and extending each side of a slender curved duct, which runs toward the atrial aperture. On the left side one group of follicles lies within the bend of the intestinal loop, the others outside of and dorsal to it and anterior to the rectum.

Fairly common on the reefs and attached to the under side of stones along the shores. Collected both in 1898 and 1901.

This species is closely allied to the West Indian species *M. variegatus* Heller, which is also described and figured in Traustedt's (16) work on the West Indian Simple Ascidians. That species has from 8 to 10 branchial folds, of which three are short and only reach a part of the distance toward the posterior end of the sac. According to Traustedt's figure, it also has very large siphons, but this is a character which varies not only in different individuals, but is largely determined by the state of contraction of the specimen, and would hardly serve to separate the species; while the differences in color are easily explained by the fact that Heller and Traustedt undoubtedly wrote their descriptions from faded alcoholic specimens. The condition of the branchial folds seems, therefore, to be the chief distinguishing character. I have found this to be practically constant in a number of specimens of the present species.

Family **ASCIDIIDÆ** Herdman, 1880.

Body usually sessile, rarely pedunculated. Branchial aperture generally 8-lobed; atrial generally 6-lobed. Test gelatinous or cartilaginous, rarely chitinous or horny.

Branchial sac without folds. Internal longitudinal bars present and usually papillated. Stigmata straight or curved. Tentacles simple.

Alimentary canal on one side of the branchial sac, sometimes extending posteriorly beyond it to a slight extent.

Reproductive organs placed close against or within the intestinal loop.

Genus **Ascidia** Linn., 1767.

Body attached, sessile, rarely pedunculated; surface bare or incrustated with sand. Branchial and atrial apertures placed far apart, usually 8-lobed and 6-lobed respectively.

Test cartilaginous, membranous, or gelatinous, soft or hard, usually crowded with bladder-cells.

Branchial sac sometimes minutely plicated. Stigmata straight. Internal longitudinal bars generally papillated.

Dorsal lamina a continuous membrane, which may be provided with transverse ribs or with teeth. It is continued behind the œsophageal aperture.

Alimentary canal and reproductive organs on the left side of the body.

Ascidia atra Lesueur.

Ascidia atra Lesueur, Descriptions of several new species of *Ascidia*, Journ. Acad. Nat. Sci. of Philadelphia, vol. iii, pt. 1, p. 2, pl. i, fig. 2, 1823.

Ascidia nigra Sav.; Herdman, Prelim. Rep. Challenger, Proc. Royal Soc. Edinb., vol. ix, pp. 460 and 466, 1880.

Phallusia atra Lesueur; Traustedt, Vestindiske Ascidiæ Simplicæ, Aftryk af Vidensk. Meddel. fra den naturh. Foren. i Kjobenhavn, p. 22, pl. iv, fig. 6, and pl. v, fig. 17, 1881.

Ascidia nigra Sav.; Herdman, Rep. Voy. Challenger (Zoöl.), vol. vi, part xvii, p. 210, 1882.

Ascidia atra Lesueur; Sluiter, Tuniciers recueillis dans la Mer des Antilles, etc., Mém. Soc. Zoöl. de France, vol. 11, p. 7, 1898.

PLATE LXIII. FIGURES 138 and 139.

The body is only moderately elongated, with large, anteriorly directed siphons which often have more than the normal number of lobes to the apertures. It is usually attached by the posterior end,

but sometimes by the left side. Its most conspicuous character is the abundant blue-black pigment which colors the test and many of the internal organs as well. In very young specimens the test is nearly colorless and transparent, but the dark pigment begins to appear while the individual is still very small.

The largest specimen obtained at Bermuda measured about 70x30^{mm}. In the West Indies it attains a considerably larger size.

The branchial sac tapers posteriorly. The internal longitudinal bars are provided with curved papillæ somewhat similar to those of *A. curvata* Traustedt illustrated below, but rather longer and more curved. They have a narrow membrane attached to the concave side. According to Traustedt the papillæ are bifid at the extremity. This does not appear to be common in the Bermuda specimens. There are about five or six stigmata in a mesh, and the sac exhibits minute undulations or plications between the internal longitudinal bars. The transverse vessels alternate in size. In addition there are much thicker ones at intervals.

The tentacles are numerous and slender, of several sizes, arranged with some degree of regularity. The dorsal tubercle generally has a U-shaped opening.

This species is common on the reefs and at a little distance much resembles a kind of sponge which abounds there. As already mentioned, the individuals found were of small size compared to those occurring in the West Indies.

It is questionable whether this form is distinct from *Phallusia nigra* Savigny, a European and Red Sea species. As far as I am aware, the only distinction between the two is that the European form has small intermediate papillæ on the internal longitudinal bars, midway between the transverse vessels. Both Traustedt and Sluiter mention their absence in the West Indian form, and I have failed to find them, even in the largest of the Bermuda specimens which I examined.

Herdman (6), though aware of Traustedt's observation, identifies the Bermuda form with Savigny's species, and mentions intermediate papillæ as present in parts of the branchial sac. He does not, however, expressly state that he found them in American specimens, and later may have changed his opinion, as in his Revised Classification of the Tunicata (7) he lists *A. nigra* Savigny and *A. atra* Lesueur as distinct species. *Phallusia violacea* Gould, from Rio Janiero, Brazil, may be identical with this species.*

* U. S. Exploring Expedition, Molluska and Shells, p. 495, fig. 610.

***Ascidia curvata* Traustedt.**

Ascidia curvata Traustedt, Vestindiske Ascidiæ Simplices, Aftryk af Vidensk. Meddel. fra den naturh. Foren. i Kjobenhavn, p. 25, pl. iv, figs. 8, 9, and 10, and pl. v, fig. 19, 1881.

PLATE LVI. FIGURES 80, 81 and 82. PLATE LXIII. FIGURES 145 and 146.

The body is much more elongated than in the last species and tapers gradually toward the anterior end. It is strongly flattened laterally. The atrial siphon is generally situated behind the middle of the body. Both siphons are usually long and often turned to the right, the animal being generally attached by the entire left surface. Great variations in the external form of the body are common. The largest specimen measures about 50^{mm} in length and half as much in a dorso-ventral direction.

The test is greyish or practically colorless and transparent, soft and gelatinous, moderately thick on the right side but very thin and easily torn on the left side. Its surface may be smooth and glossy, allowing much of the internal structure to be seen, or it may be wrinkled or in some cases so incrustated with sand and shell fragments that nothing can be seen through it. The apertures generally have about the number of lobes characteristic of the genus, but they are not readily counted in the contracted state of the orifices. There are markings of light orange brown about the apertures in the living animal.

The mantle is very delicate and transparent. On the right side there are numerous but very slender muscle-bands, mostly transverse or only slightly oblique. They taper off and end soon after passing the median line on the dorsal and ventral surface, leaving the left side practically free from muscle bands except the sphincter muscles of the siphons, which are composed of similar delicate bands placed close together. Very few longitudinal bands are present.

The tentacles are numerous and placed close together, slender and uniformly tapering, of several sizes. The dorsal tubercle is small, U-shaped.

The branchial sac extends for a long distance behind the œsophageal opening. Its internal longitudinal bars are separated by 4 or 5 stigmata; 8 or 10 stigmata intervene between the dorsal lamina and the first bar on each side of it. In some places the transverse vessels are nearly equal in size, in other parts (especially in the posterior portion of the sac) they show more or less tendency to alternate in size. Very large vessels, such as are shown in Traustedt's

figure, do not appear to be frequent. The papillæ are rather stout, of moderate length and somewhat curved. Their ends are obtuse. Those opposite the smaller transverse vessels are smaller. These small transverse vessels are occasionally interrupted and rudimentary though the corresponding papillæ may be present and well developed.

In most parts of the sac there is little or no sign of the undulation or plication common in this genus, the sac being almost flat, but individuals vary in this respect. On the whole the branchial sac is of a simple type. Horizontal membranes are developed only on each side of the dorsal lamina and to a very slight degree on the adjacent parts of the sac. Elsewhere they are inconspicuous or wanting. The dorsal lamina is often nearly plain-edged for most of its length. In other cases it is finely denticulated in the posterior portion of the body.

The stomach and intestine are proportionately small and form a very compact and short loop. The stomach has a few longitudinal folds and during life is of an orange color. This color may also extend to part of the intestinal loop.

The reproductive organs lie between the stomach and intestine and the branchial sac. The duct follows the rectum and ends near the anal opening.

This species was found at Coney Island, Long Bird Island, in Harrington Sound, at Somerset Island, and many other places, attached to stones, shells, etc. It is one of the commonest simple ascidians at Bermuda. Traustedt's specimen (he appears to have had but one) was from St. Thomas, W. I.

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EXPLANATION OF PLATES XLVIII–LXIV.

The figures showing entire zoöids were in all cases drawn with the aid of a camera lucida, as far as the outlines of the body and the principal organs are concerned; the smaller details were necessarily filled in without it. The magnification of the figures of zoöids is uniform; 32 diameters, except in the case of a few forms with zoöids too large to admit of this. It is hoped that these figures will give a better conception of the relative sizes of the zoöids than simple measurements, as the latter fail to give any idea of the state of contraction the animal is in. It has not been possible to get fully expanded specimens in the case of most species, but the degree of contraction, of the thorax at least, may be judged by the course of the endostyle, which is crooked or convoluted in the contracted state, but straight or nearly so when the animal is fully expanded. In all cases they have been represented as if transparent to show the internal structure.

The figures showing spicules are also (with the exception of those of *Cystodytes* and *Echinoclinum*) drawn to a uniform scale, a magnification of 450 diameters, and all were drawn with a camera lucida. In selecting spicules for illustration, neither the largest nor the smallest, nor the extremes of variation in form to be found in the colony, were chosen, but a group was selected that would give a fair idea of the forms and sizes most characteristic of the species or variety.

In regard to the photographs of the simple ascidians, it may not be out of place to say that all the Bermuda species vary endlessly in their external characters and shape, and the writer would caution against the belief that even very great differences in these characters, from the specimens illustrated, are necessarily indicative of difference in species. With the exception of a few (mentioned in the descriptions of the figures), which were taken from living specimens by Mr. A. Hyatt Verrill, all the photographs were made from specimens preserved in formalin.

I am indebted to Prof. A. E. Verrill for the use of the photographs from which plate lxiv and also figs. 138 and 139 were made.

PLATE XLVI.

- Figure 1.—*Clavelina oblonga* Herdman. Zoöid containing embryos and larvae seen from the right side. $\times 12$. Page 334.
 Figure 2.—*Distoma capsulatum* n. sp. Zoöid seen from the left side; showing the arrangement of the mantle muscles. $\times 32$. Page 341.
 Figure 3.—*Rhodozона picta* (Verrill). Zoöid seen from the left side. $\times 8$. Page 335.

PLATE XLVII.

- Figure 4.—*Ectinascidia turbinata* Herdman. Young individual with no reproductive organs developed. Seen from the left side. $\times 16$. Page 338.
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 Figure 6.—*Ectinascidia turbinata* Herdman. Colony of adult individuals. Two-thirds the natural size. (After Herdman.) Page 338.
 Figure 7.—*Clavelina oblonga* Herdman. Colony of four individuals, the two on the left being expanded, the others contracted as usual in preserved specimens. $\times 2$. Page 334.
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PLATE XLVIII.

- Figure 9.—*Distoma olivaceum*, n. sp. Zoöid seen from the left side. Showing the arrangement of the back pigment dots on the mantle (chiefly on the thorax). $\times 32$. Musculature of mantle not shown. Page 344.
 Figure 10.—*Distoma clarum*, n. sp. Zoöid seen from the left side, containing large eggs and larvae. Showing muscle bands of mantle. $\times 32$. Page 345.
 Figure 11.—*Distoma obscuratum*, n. sp. Zoöid (much contracted) seen from the left side. $\times 32$. Musculature of mantle not shown. Page 343.

- Figure 12.—*Cystodytes violaceus*, n. sp. Zoöid (much contracted) seen from the left dorsal aspect, containing two large eggs. Rectum containing pellets of undigested matter. $\times 32$. Page 348.
- Figure 13.—*Cystodytes violaceus*. Small spicules which are scattered in the test. $\times 40$. Page 348.
- Figure 14.—*Cystodytes violaceus*. Large spicules forming the capsules about the zoöids, but occurring to some extent elsewhere in the test. $\times 40$. Page 348.

PLATE XLIX.

- Figure 15.—*Distaplia bermudensis*, n. sp. Zoöid seen from the right side, showing the muscle bands of the mantle. $\times 32$. *i. tr.*=intermediate transverse vessel of branchial sac. Page 349.
- Figure 16.—*Distoma convexum*, n. sp. Zoöid seen from the left side, showing arrangement of brown pigment spots on the mantle. $\times 32$. Musculature of mantle not shown. Page 342.
- Figure 17.—*Cystodytes draschii* Herdman. Zoöid seen from the left side. $\times 32$. Page 347.
- Figures 18 and 19.—*Distaplia bermudensis*, n. sp. Colony of the flattened incrusting form showing the arrangement of the zoöids. Side and top view. $\times 2$. Page 349.

PLATE L.

- Figure 20.—*Amaroucium bermulae*, n. sp. Zoöid with short post-abdomen, seen from the right side. Dorsal languets not represented in the figure. Ovary not developed. *e. c.*=large ectoderm cells on the mantle. $\times 32$. Page 352.
- Figure 21.—*Amaroucium exile*, n. sp. Zoöid seen from the left side containing a large embryo. Dorsal languets not represented. $\times 32$. Page 354.
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- Figure 23.—*Echinoclinum verrilli*, n. sp. Entire colony incrusting a branching alga, showing distribution of zoöids and spicules. $\times 2$. Page 372.
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PLATE LI.

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PLATE LII.

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PLATE LIII.

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PLATE LIV.

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PLATE LV.

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PLATE LVI.

- Figures 76, 77 and 78.—*Styela partita* (Stimpson) from Wood's Hole, Mass. Three individuals, showing the outlines of the body when removed from the test, the alimentary canal and the reproductive organs of the left and right sides. $\times 1\frac{1}{3}$. Page 389.
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- Figure 80.—*Ascidia curvata* Traustedt. Small part of the branchial sac showing part of the dorsal lamina. From the posterior part of the body. $\times 40$. (*h. m.* = horizontal membrane of transverse vessel.) Page 400.
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- Figure 90.—*Halocynthia rubritabia* Verrill. Small piece of the branchial sac from one of the spaces between two folds near the middle of the body. $\times 24$. Page 393.

- Figure 91.—*Microcosmus miniatus* Verrill. Outline of individual (removed from the test) showing alimentary and reproductive organs of both sides. Two-thirds the natural size. Page 396.
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PLATE LVIII.

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ABBREVIATIONS.

[For explanation of any other abbreviations, see description of figure.]

at.	atrial aperture.	od.	oviduct.
br.	branchial aperture.	oe.	œsophagus.
d. l.	dorsal lamina.	ov.	ovary.
d. lg.	dorsal languet.	p.	papilla.
d. t.	dorsal tubercle.	p. c.	pigment cell.
em.	embryo.	pep.	polycarp.
en.	endostyle.	p. s.	pigment spot.
fd.	fold.	r.	rectum.
g.	ganglion.	rep.	reproductive glands.
g. c.	gastric cœcum.	sg.	stigma.
h.	heart.	st.	stomach.
h. g.	hepatic gland.	t.	testes.
in.	intestine.	tn.	tentacle.
i. l. b.	internal long. bar.	tr. v.	transverse vessel.
lg.	languet.	ty.	typhlosole.
lv.	larva.	v. ap.	vascular appendage.
m. a.	muscular appendage.	v. d.	vas deferens.
m. b.	muscle band.		

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ERRATA.

- Page 23, line 6 from bottom, for *Dalabrifera*, read *Dolabrifera*.
 Page 48, line 20, for lix read lxi.
 Page 51, line 39, for Flagg's read Flatt's.
 Page 52, line 15, for 1901 read 1900.
 See also page 62.
 Page 68, line 10 from bottom, for Vaughan, read Gregory.
 Page 69, line 5, for Pl. xii read Pl. xiv.
 Page 93, line 22, for T. read F.
 Page 113, line 8 from bottom, for Eusmillidæ read Eusmilidæ.
 Page 114, under cut, and p. 170, line 25, for *Eusmillia* read *Eusmitia*.
 Page 126, line 22, for Pl. xxi read Pl. xxv.
 Page 128, line 17, for Pl. xxxiii, fig. 4 read Pl. xxv, fig. 3.
 Page 129, last line, for 4551 read 4544.
 Page 137, line 17, for *turgida* read *turgidum*.
 Page 145, line 3 from bottom, for type read types.
 Page 149, line 7, for *Danaï* read *Dancæ*.
 Page 151, line 1, for 400^{mm} read 240^{mm}, for 150^{mm} read 195^{mm}.
 Page 184, line 24, for *Cryptobacia* read *Cryptabacia*, and for *Podobacia* read *Podabacia*.
 Page 190, line 15, for 4557 read 4537.
 Page 194, line 9, for 4543 read 4513.
 Page 200, line 13, for 81 read 80 ; and line 20, omit No. 1901.
 Page 202, line 9, for Fig. 1 read Fig. 2 ; and line 12, for Fig. 2 read Fig. 1.
 Page 203, line 33, for 1487 read 1489.
 Page 204, line 23, omit No. 1901 ; and line 24, for West Indian read Florida.
 Page 245, line 6, for 3063 read 3063a.
 Page 257, line 25, for 4187 read 4167.
 Page 262, last line, for 3063 read 3063a.
 Page 264, line 4, for 3063 read 3063a ; and line 38, for 220 read 222.
 Page 265, line 8 from bottom, for 1686 read 1688.
 See also page 266.
 Page 268, line 2 from bottom ; page 272, line 6 ; page 273, line 28 ; page 274, line 3 from bottom, for Goslin read Gosling.
 Page 280, line for *triangulata* read *triangulatus*.
 Page 282, line 29, for 3194 read 3255.
 Page 351, line 34, for Giard 1872 read Verrill 1871.
 Page 354, line 30, for 9 read 20.



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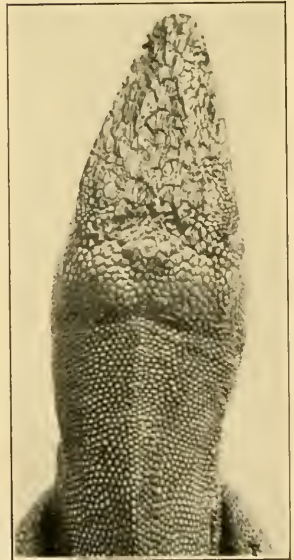
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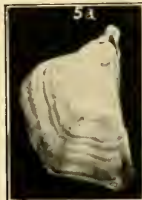
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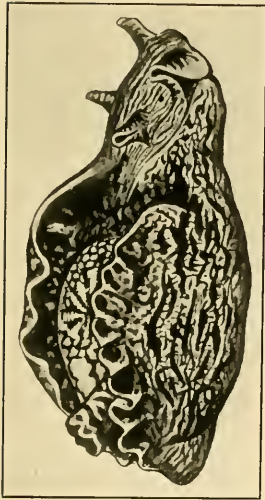


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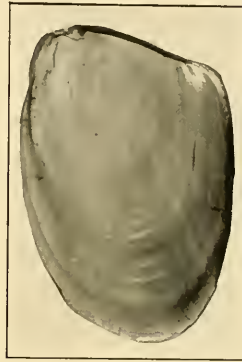
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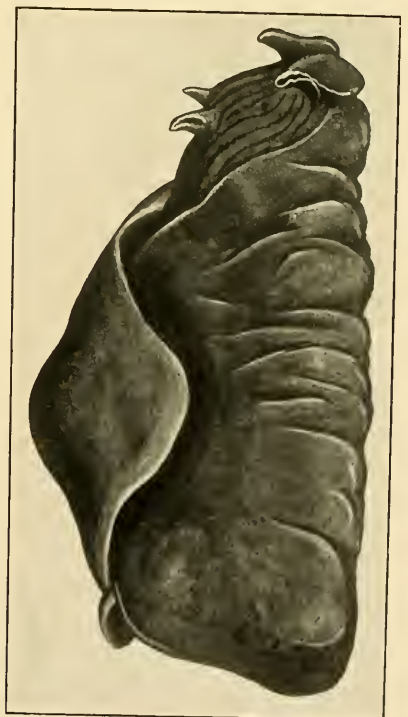


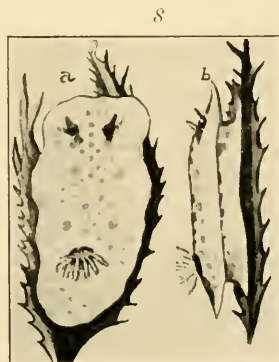
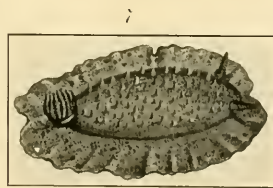
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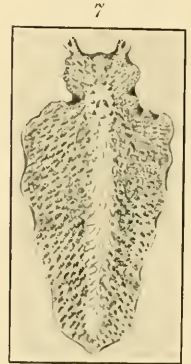
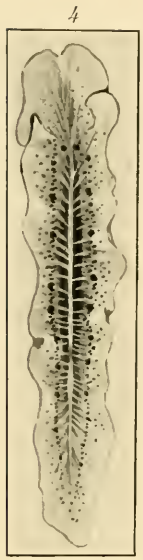


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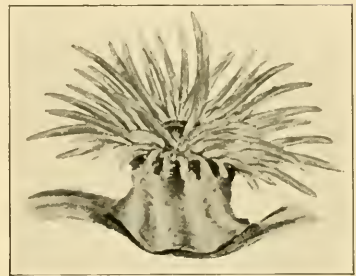




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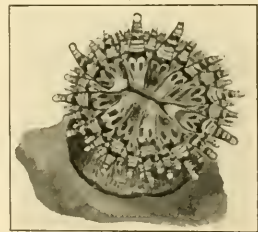
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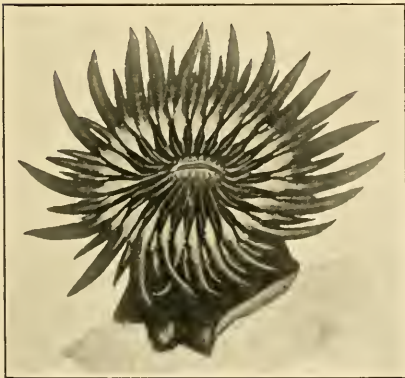
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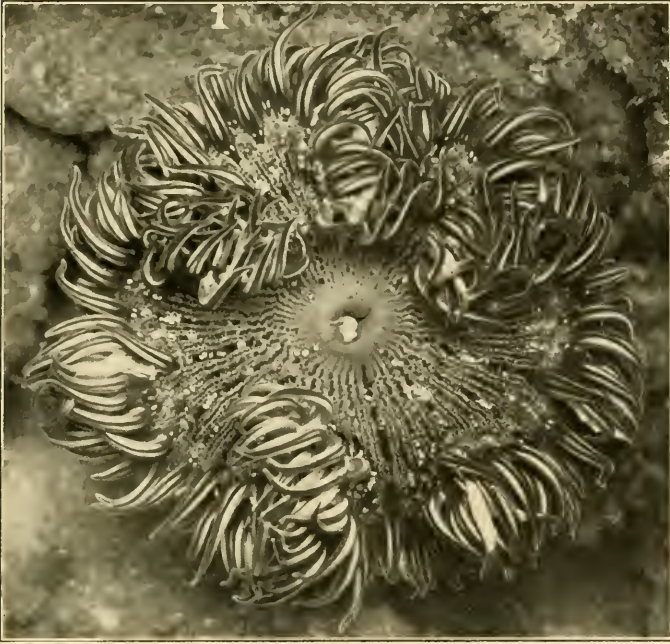


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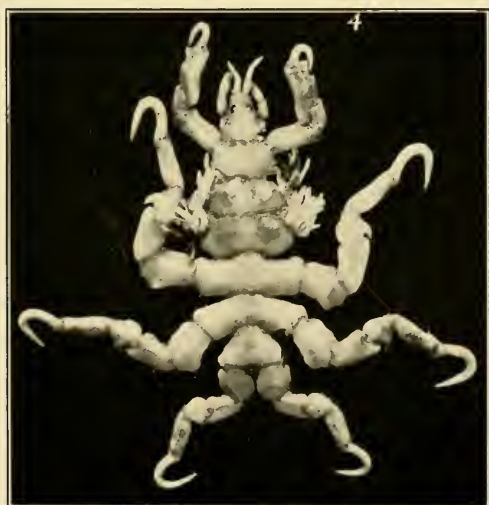
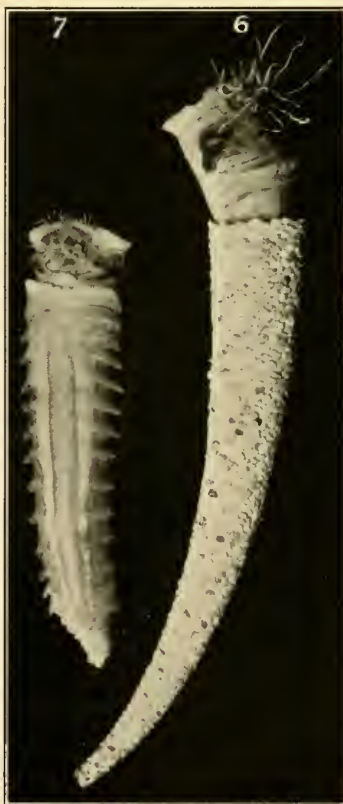
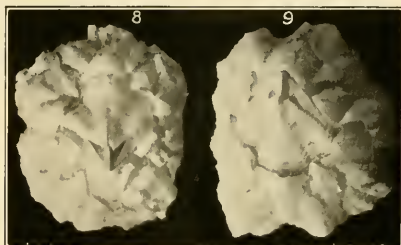


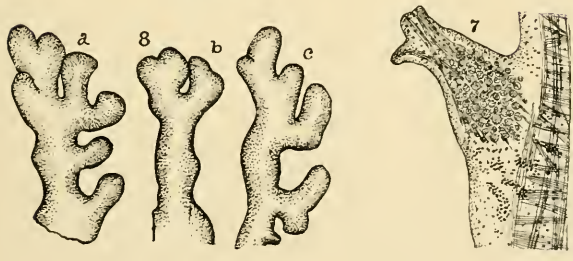
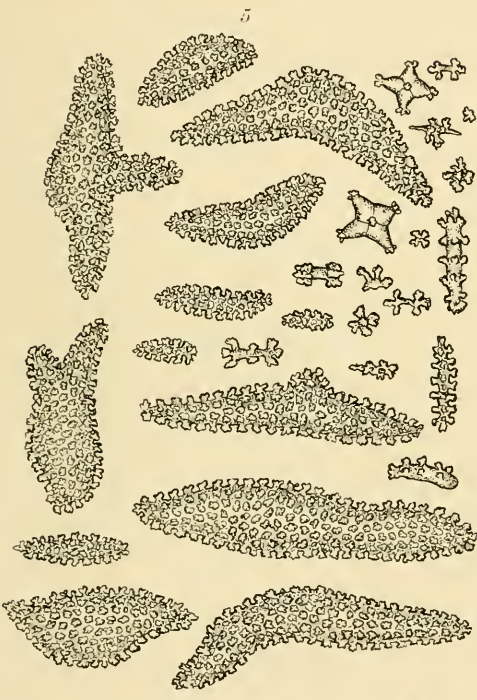
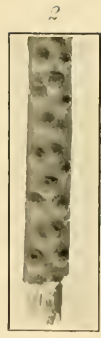
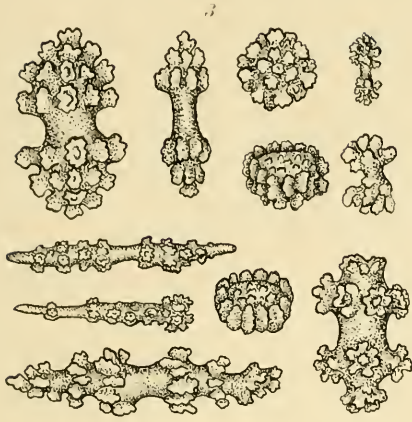
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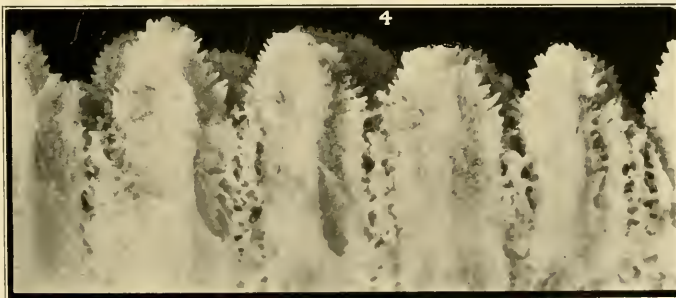
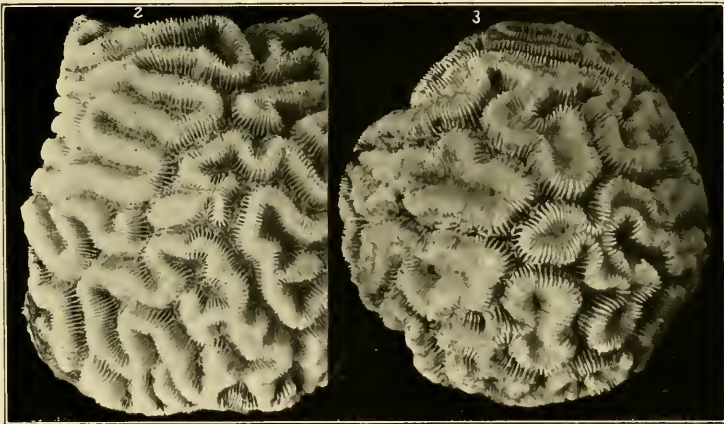


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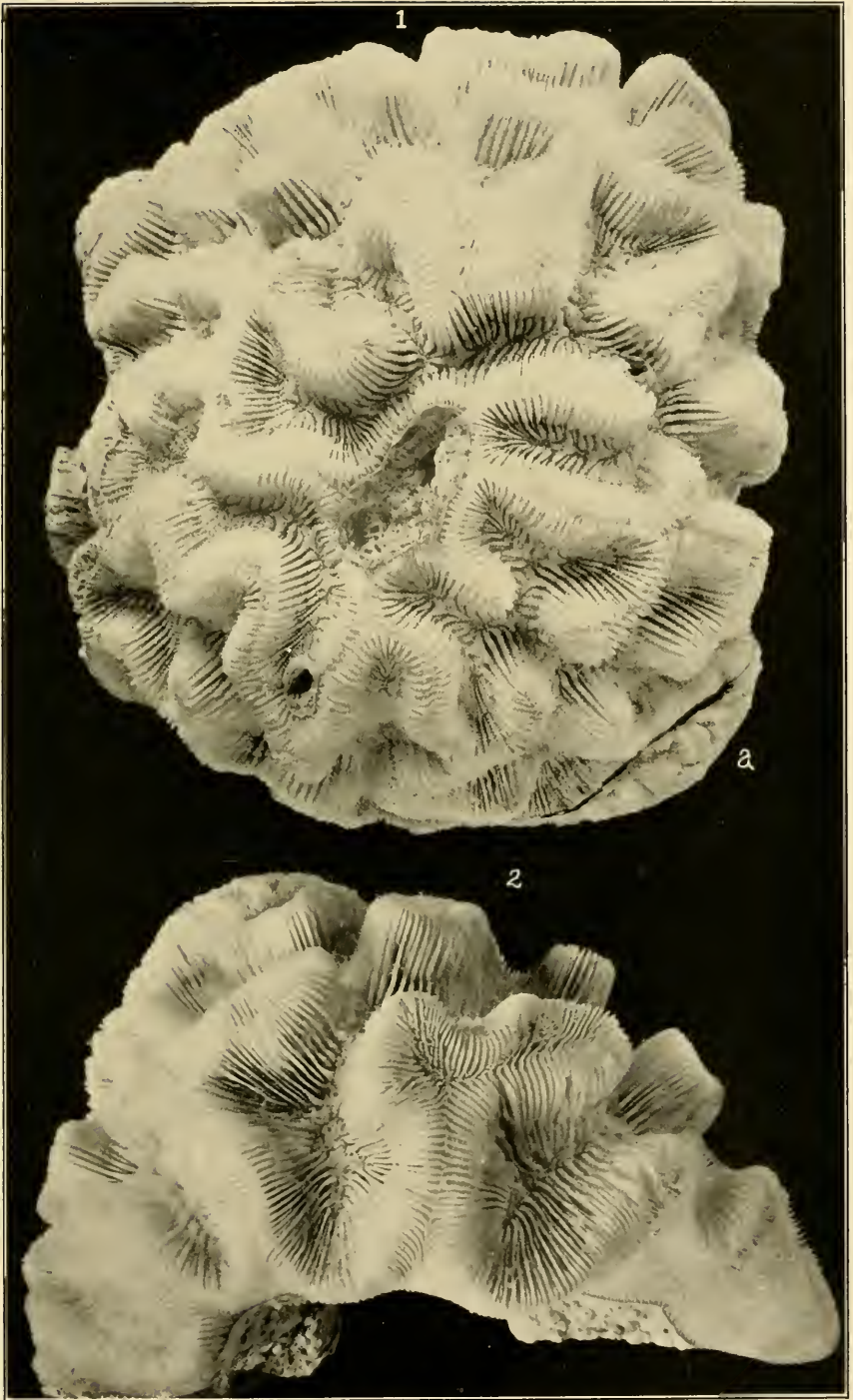




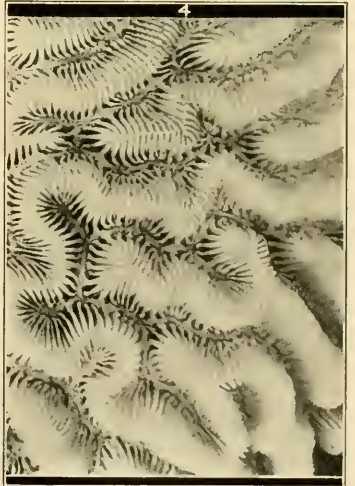
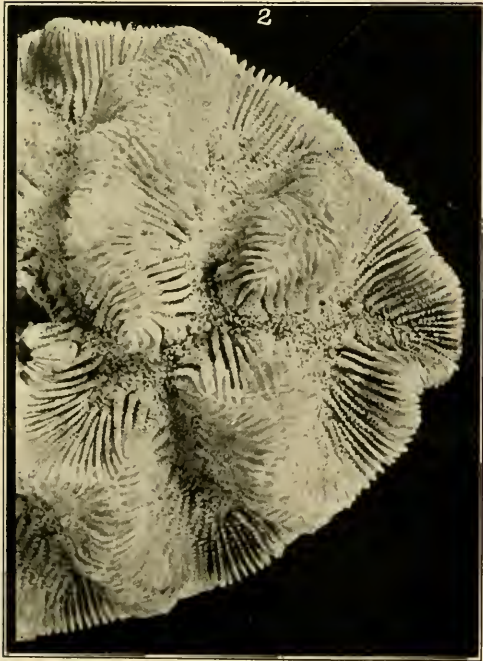
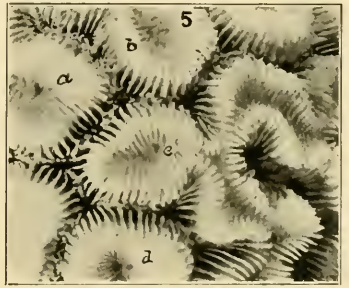
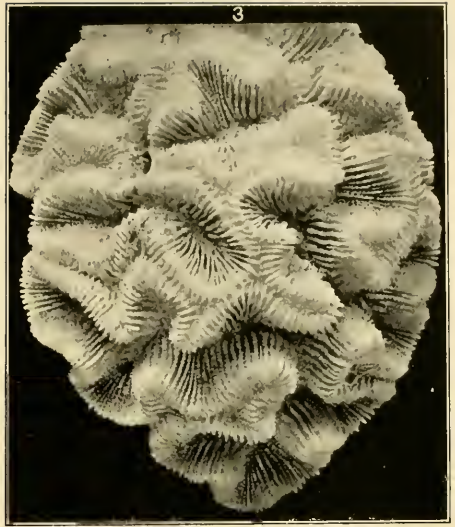
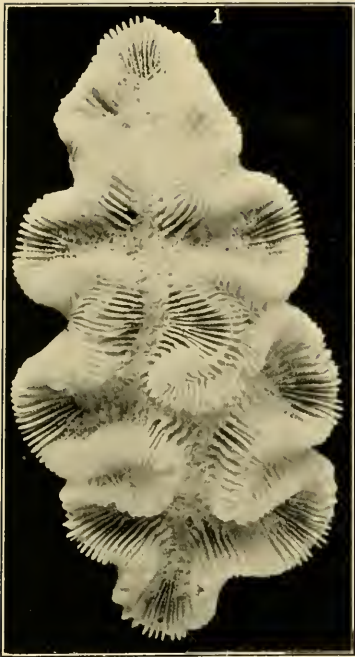
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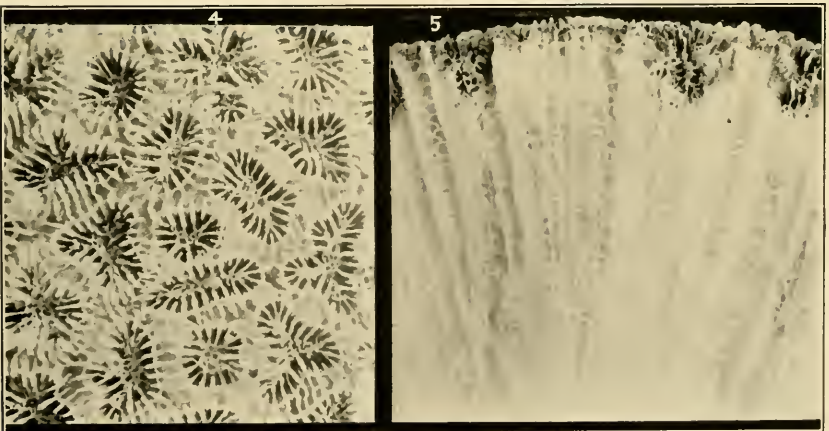
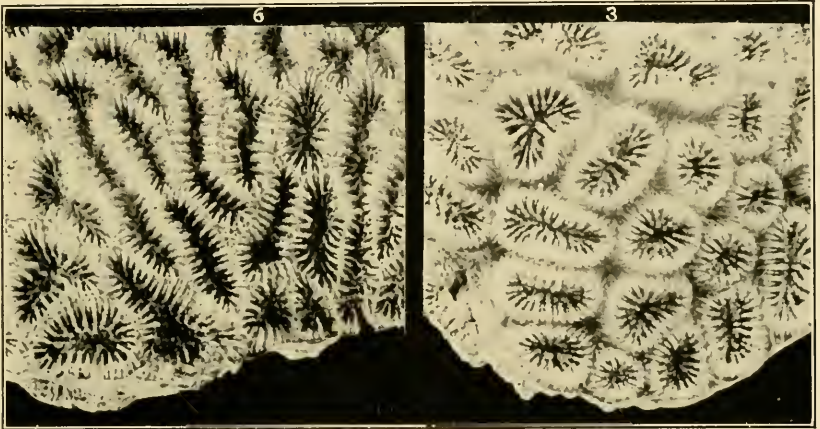
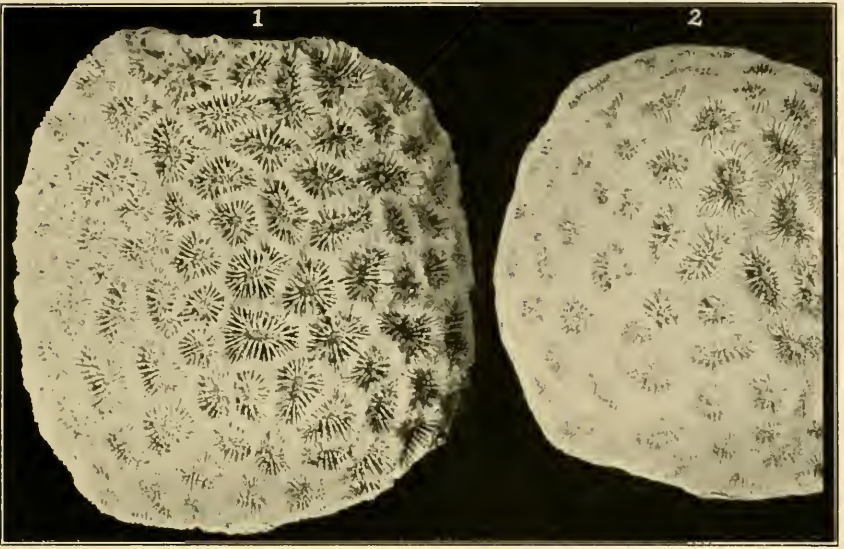
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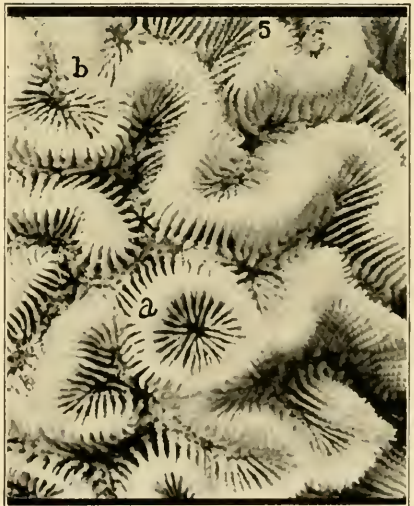
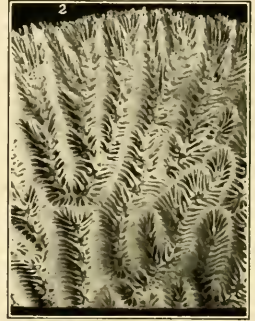
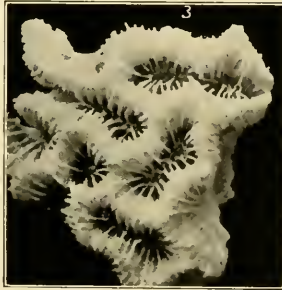
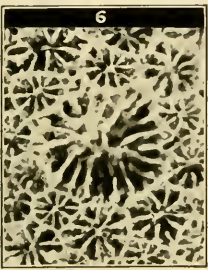
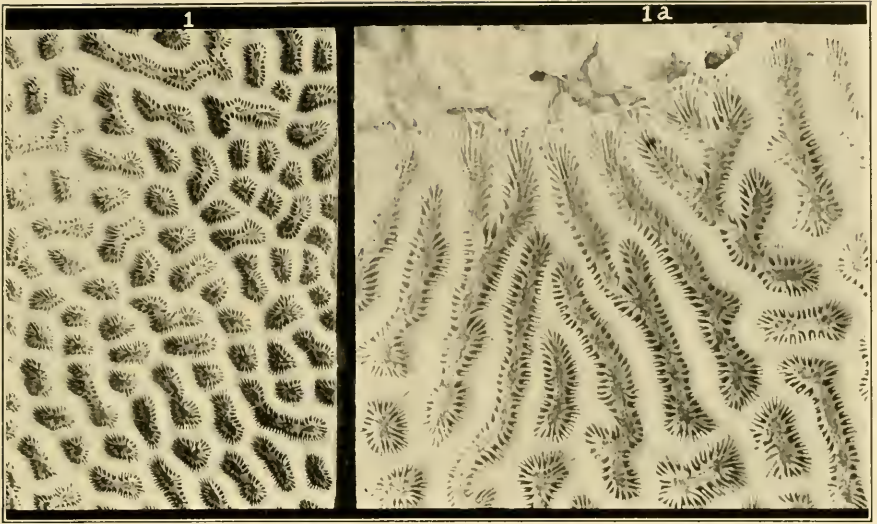
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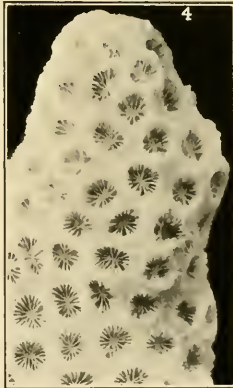
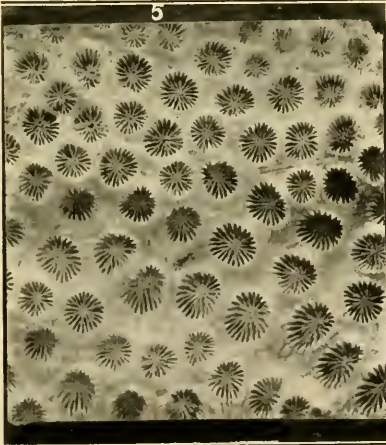
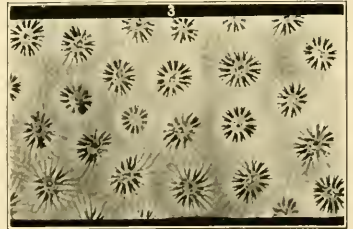
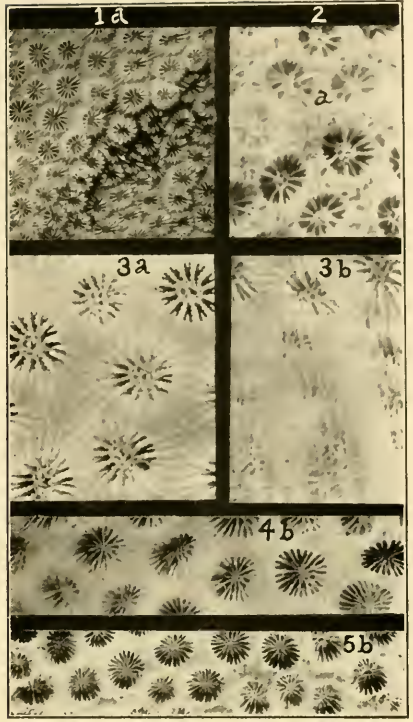
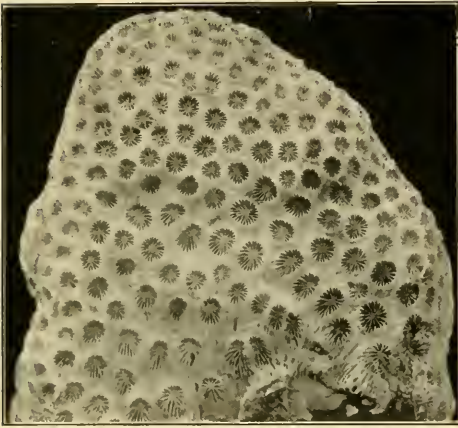
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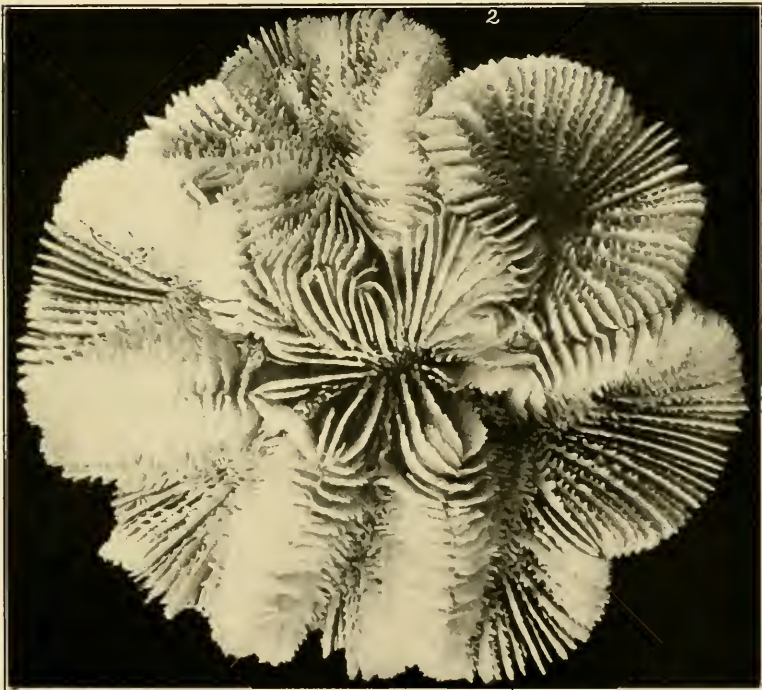
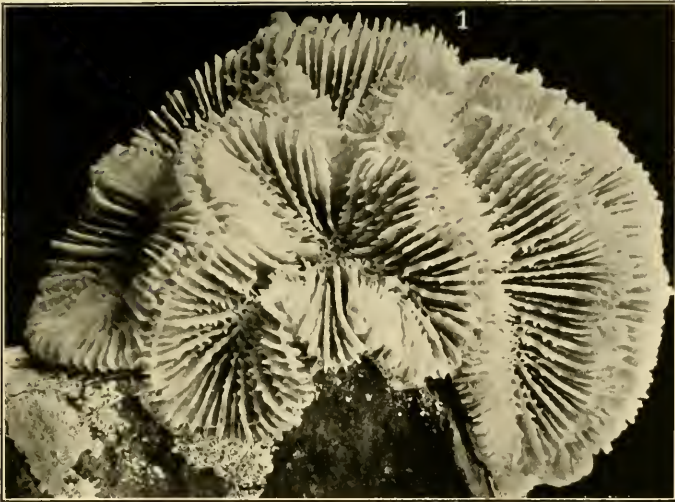
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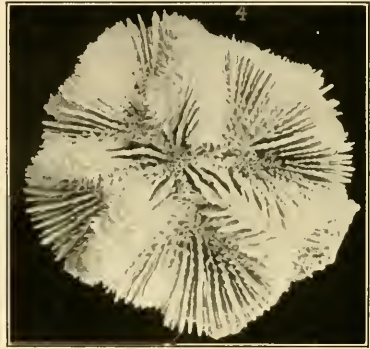
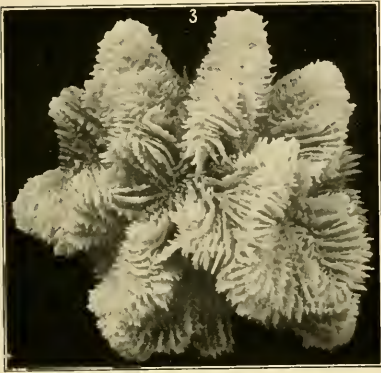
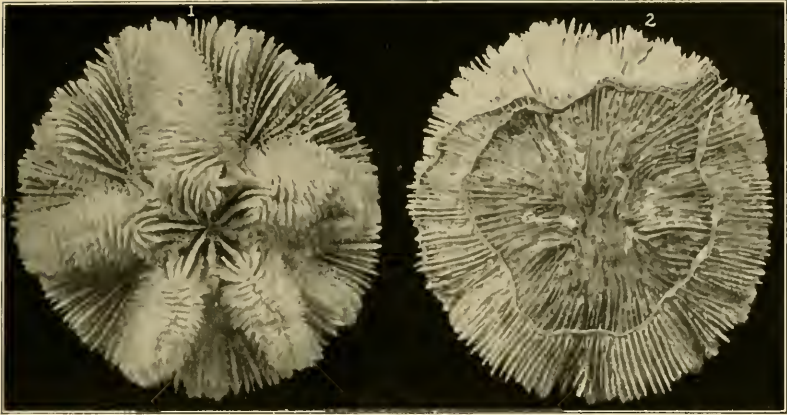
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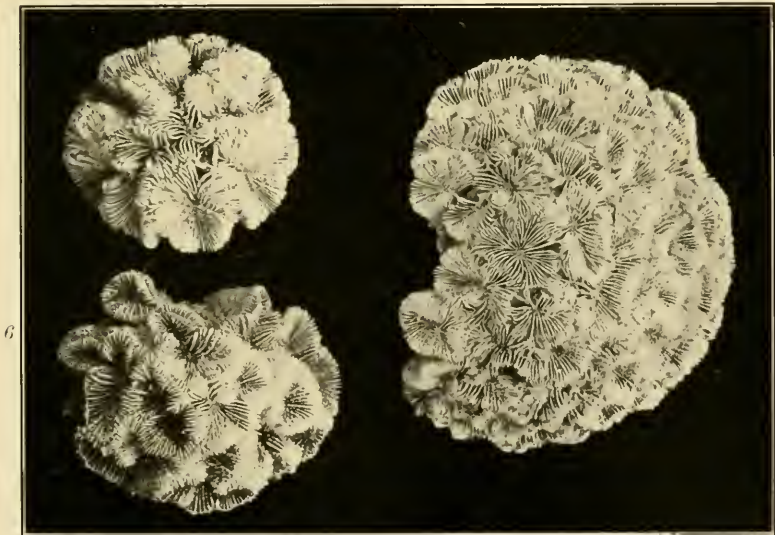


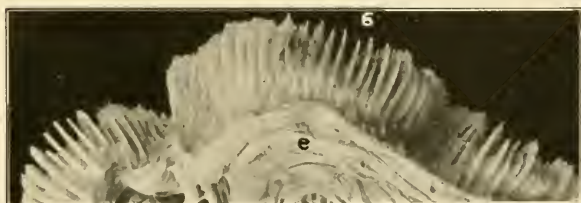
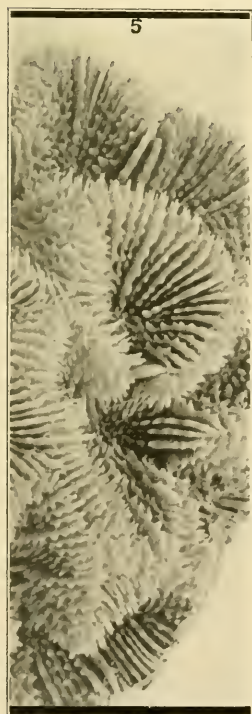
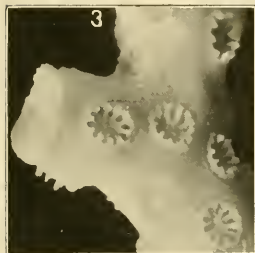
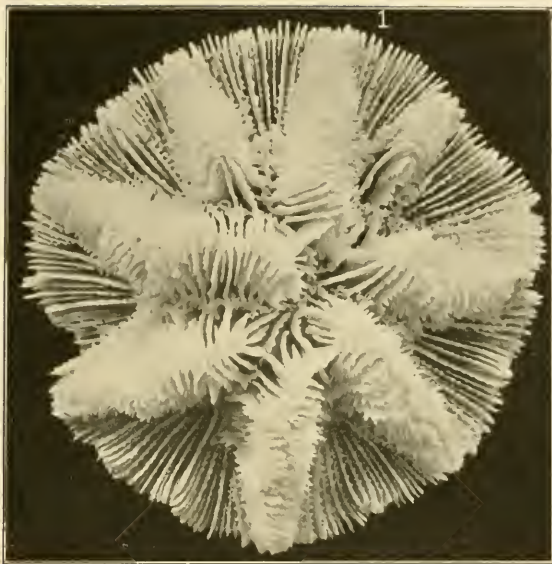
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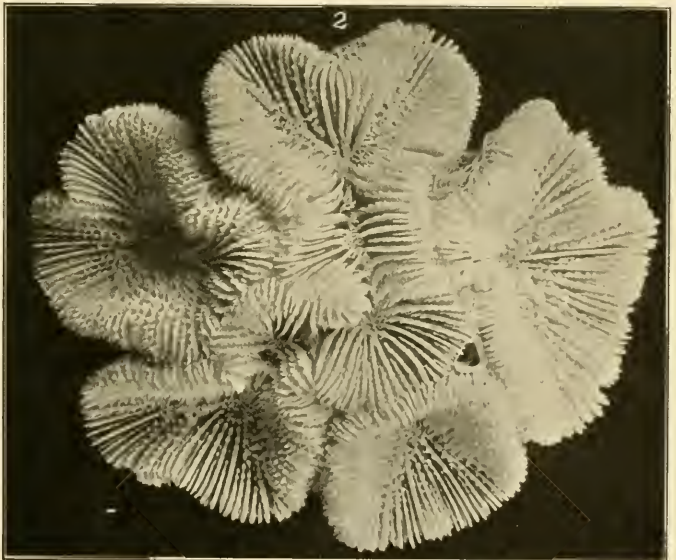
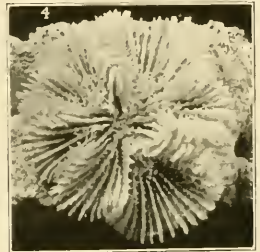
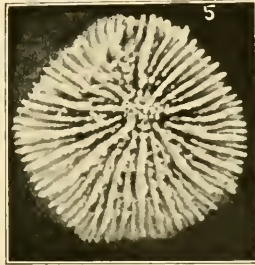
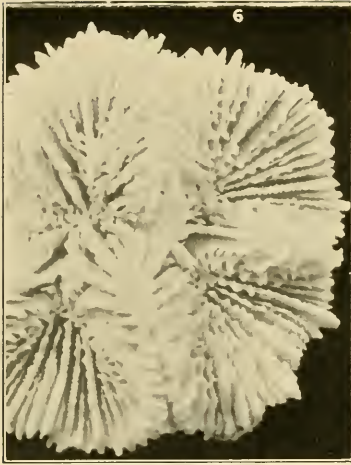


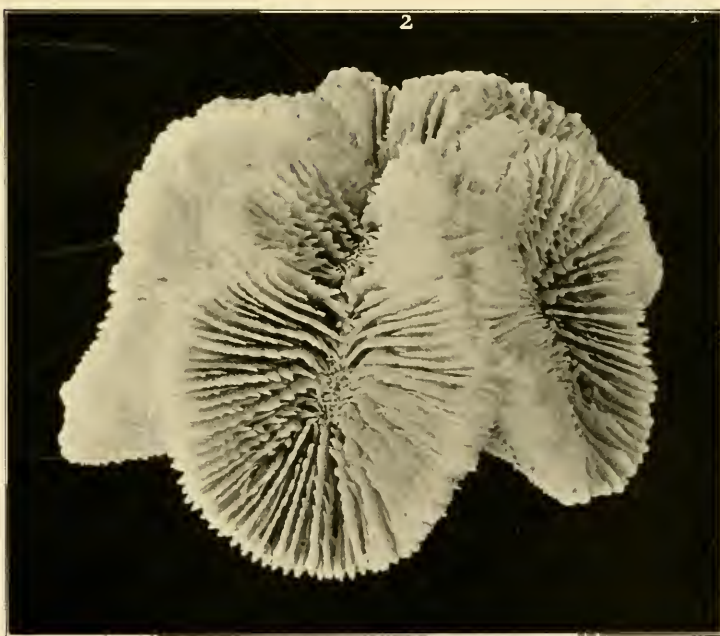
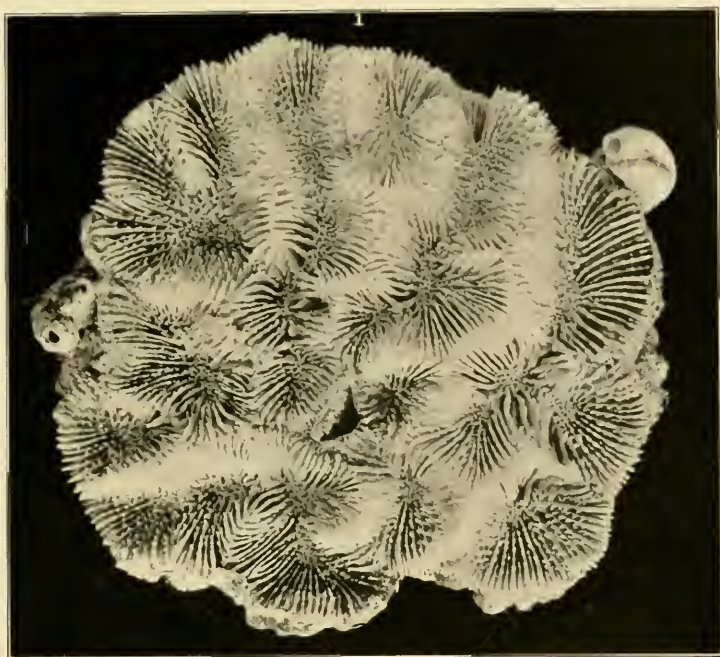
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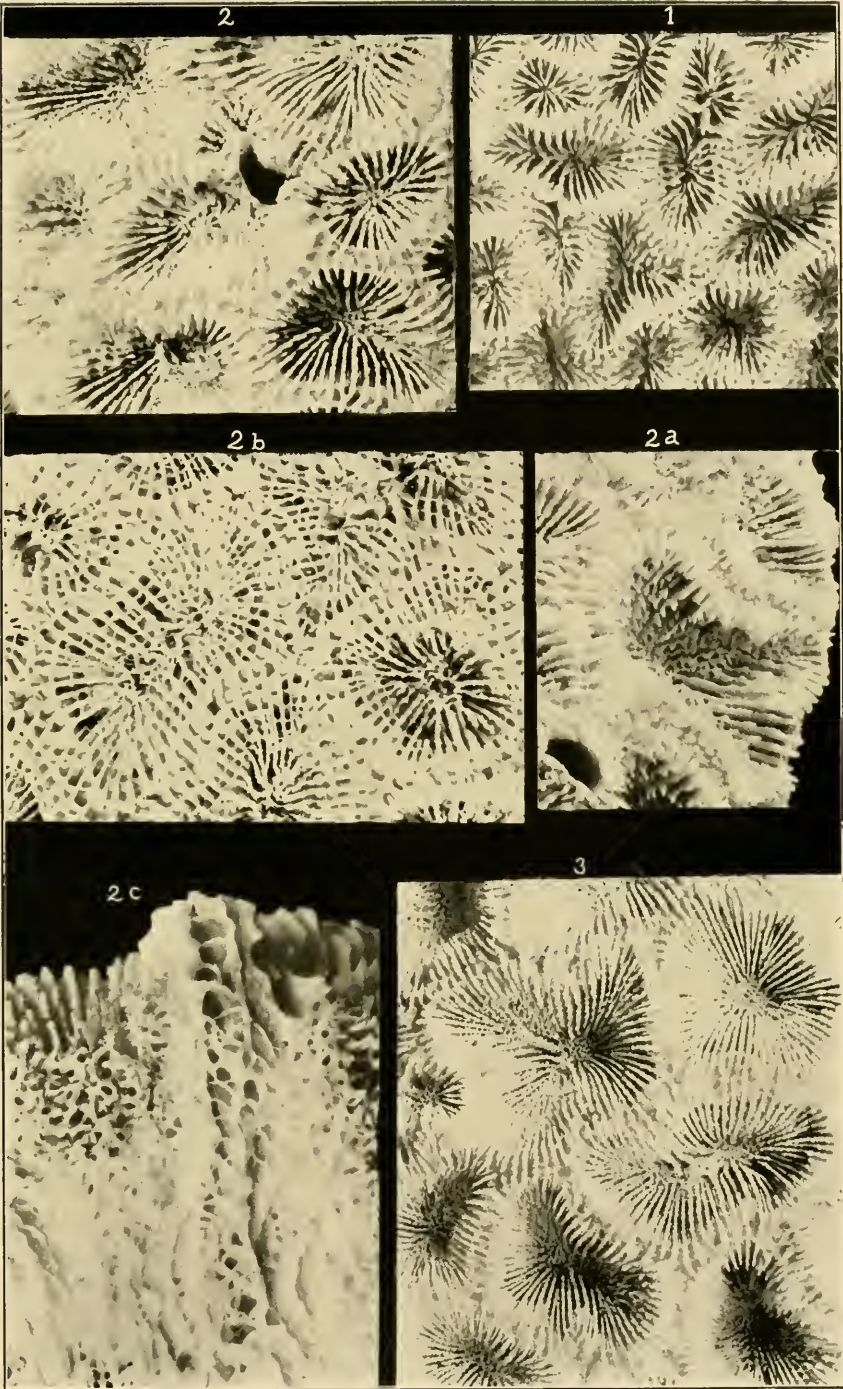




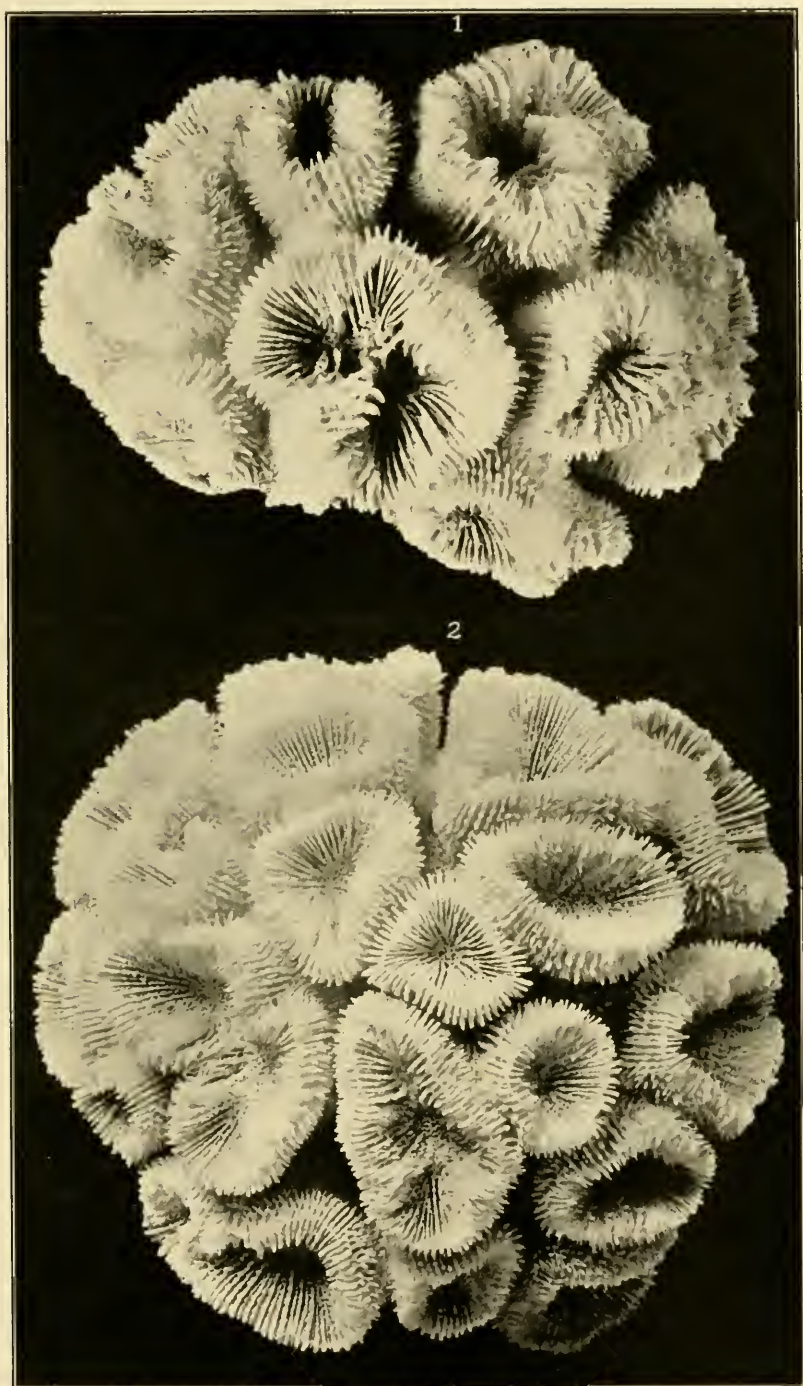




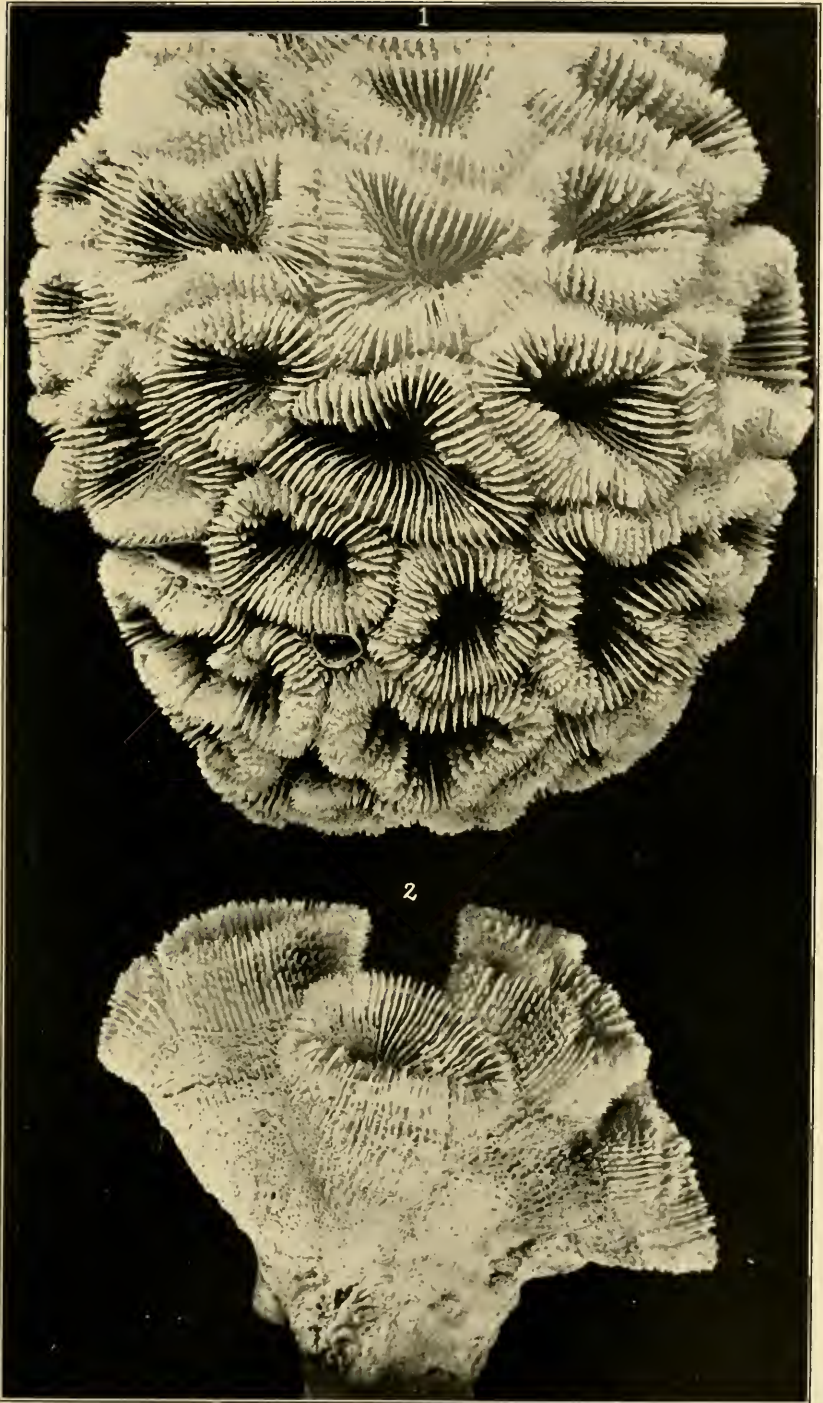
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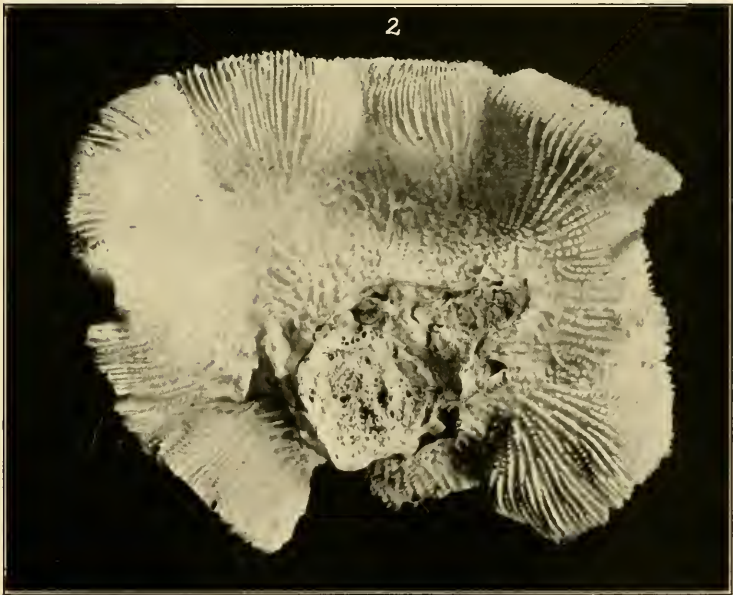
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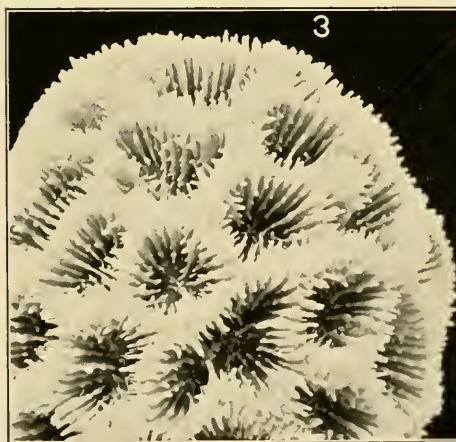
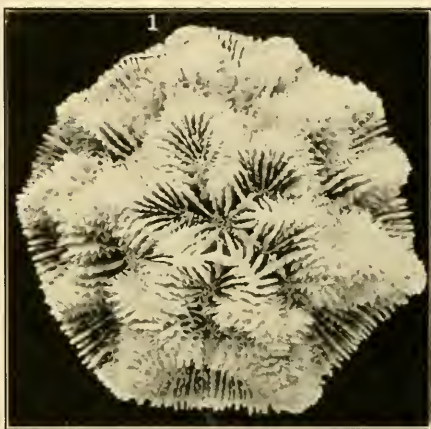
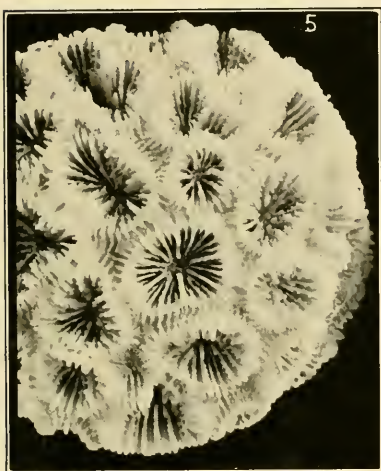
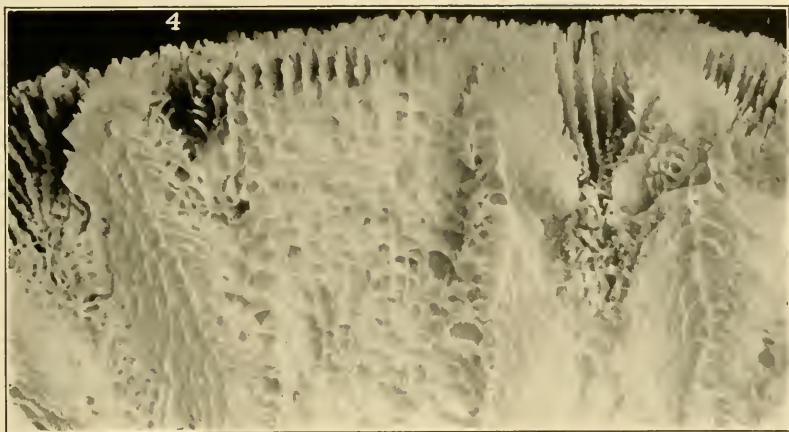
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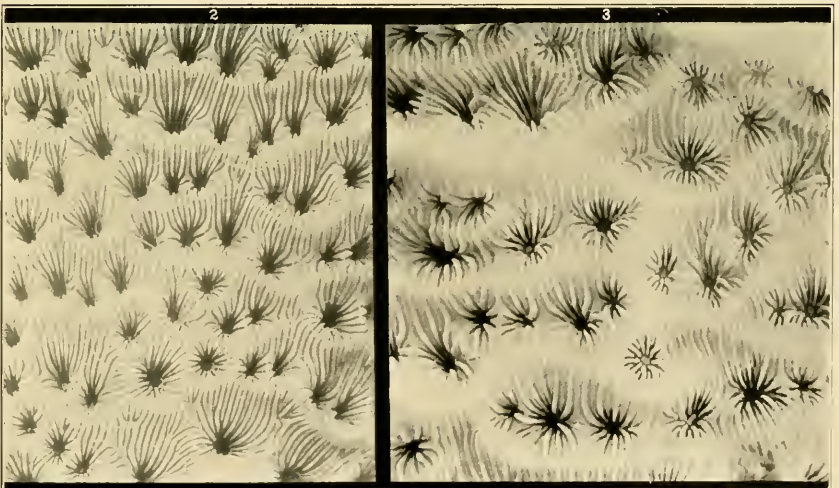
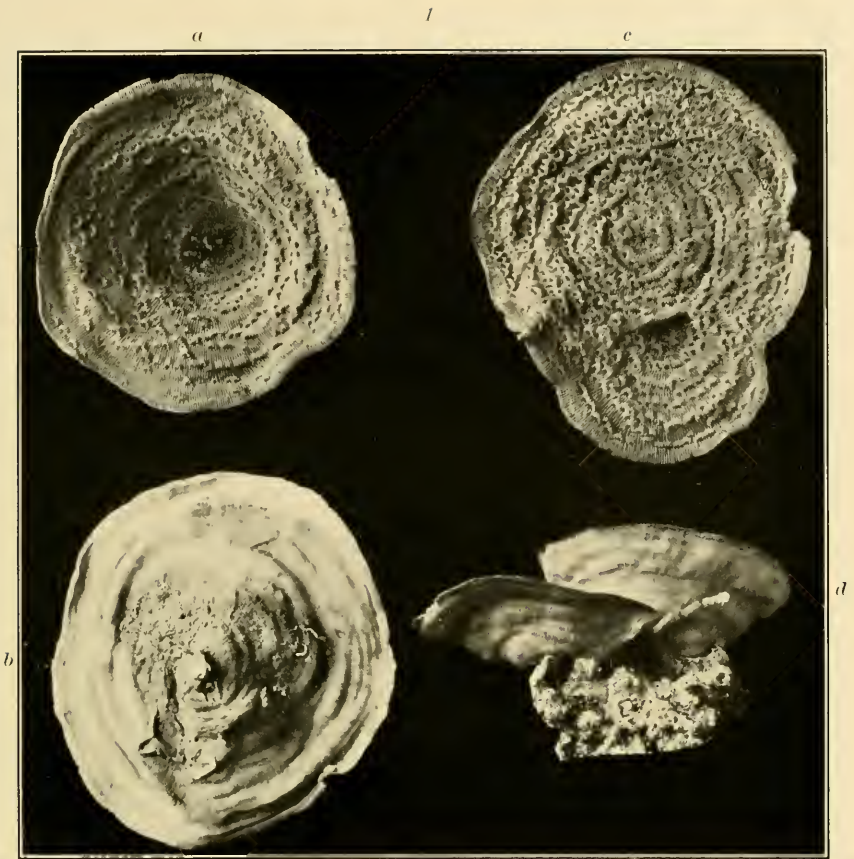


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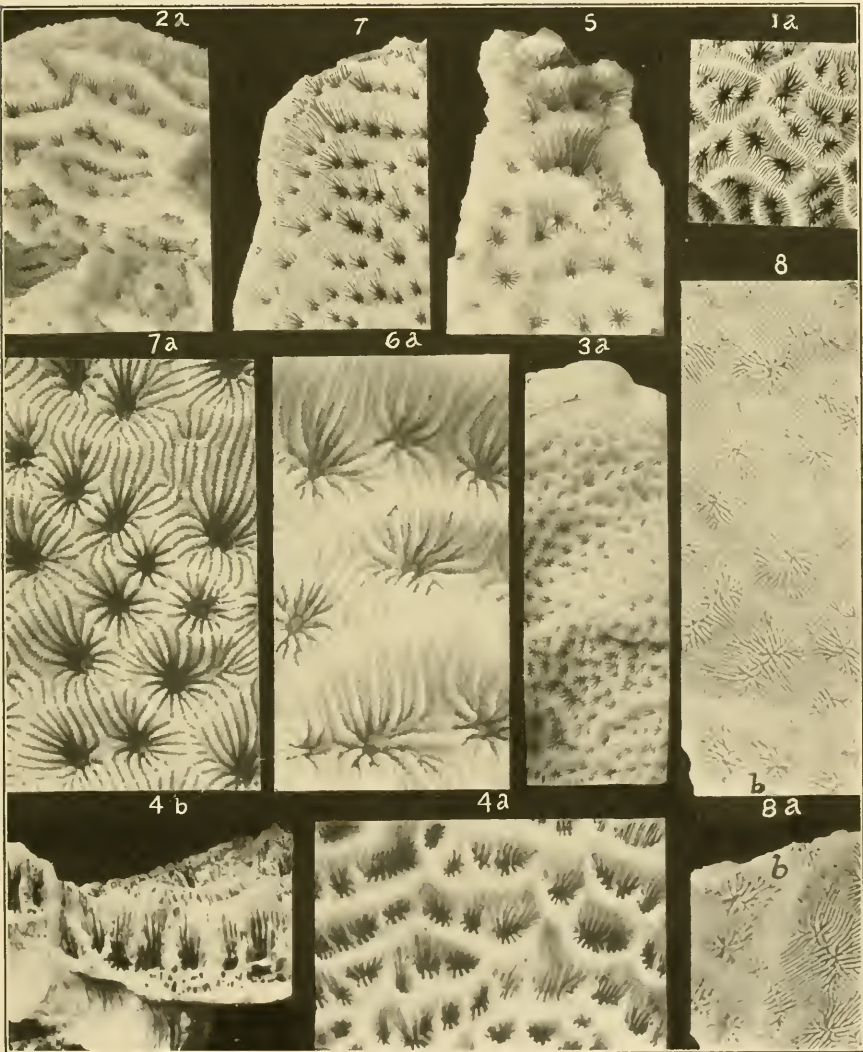
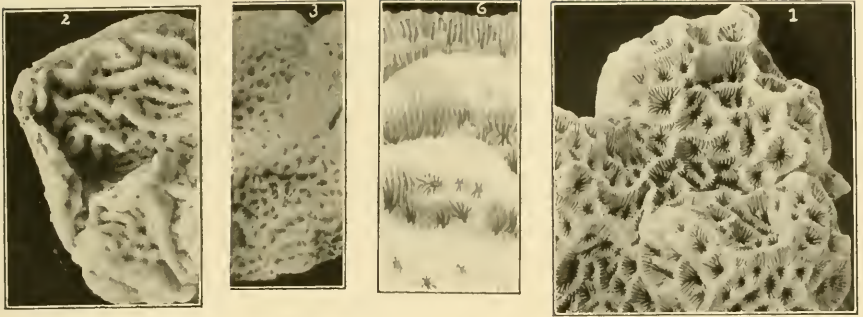


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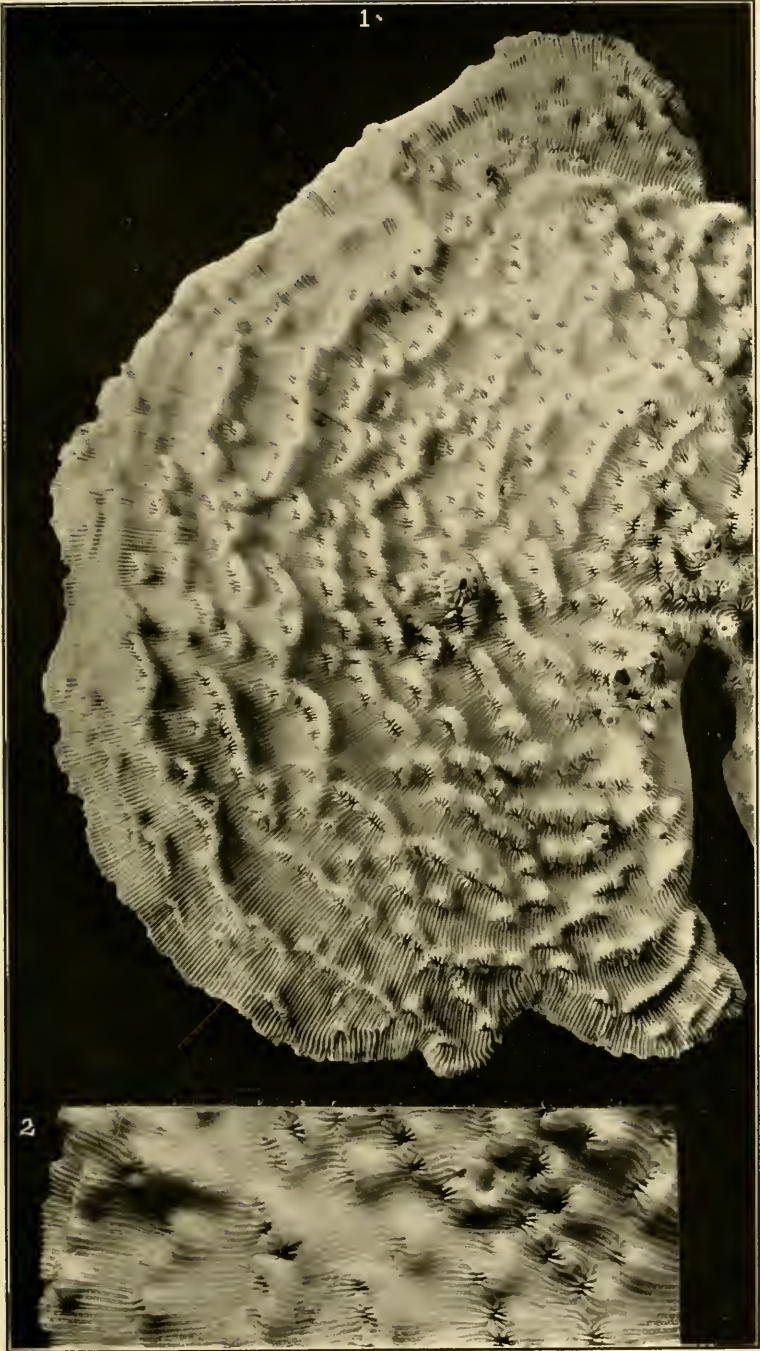




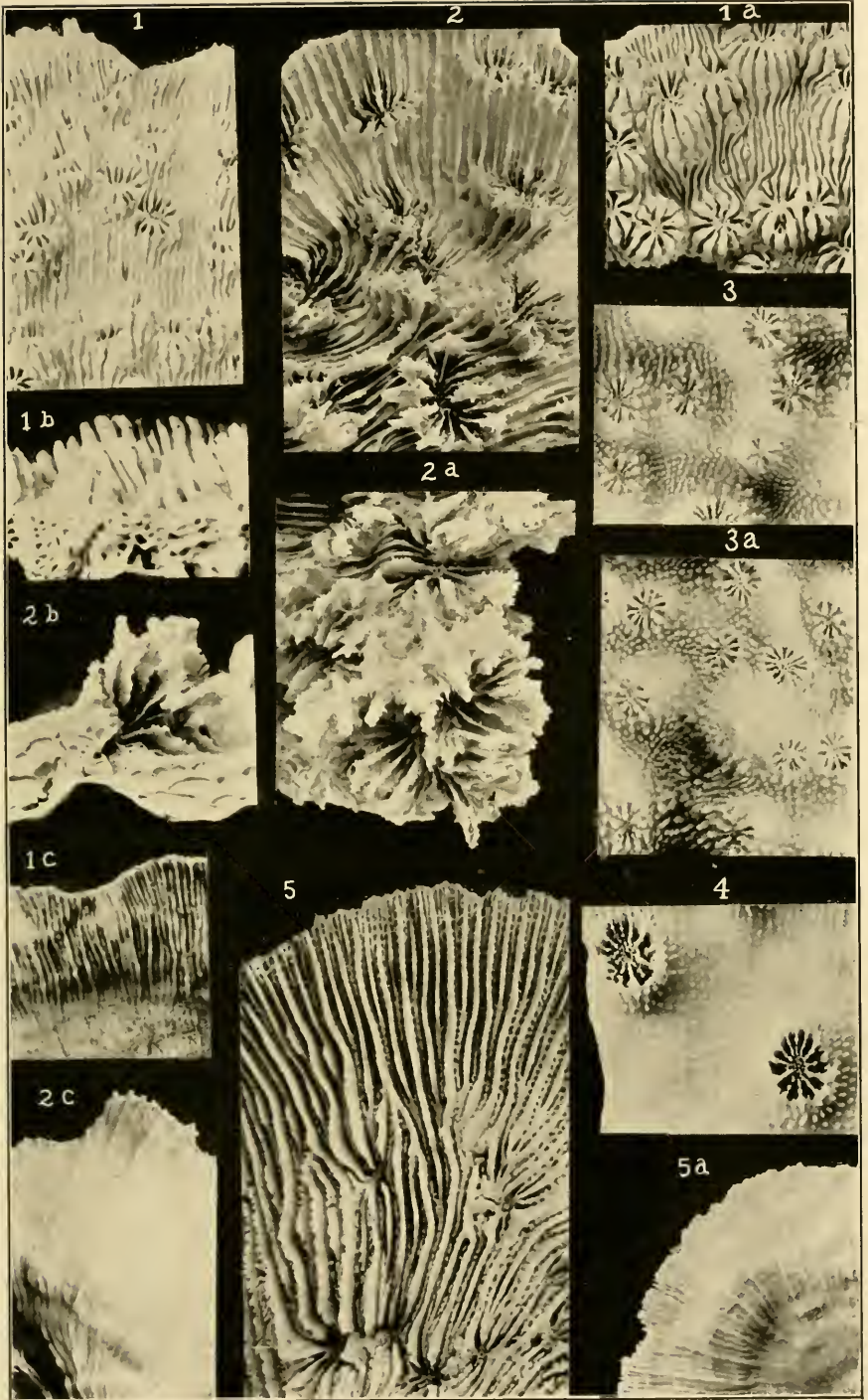
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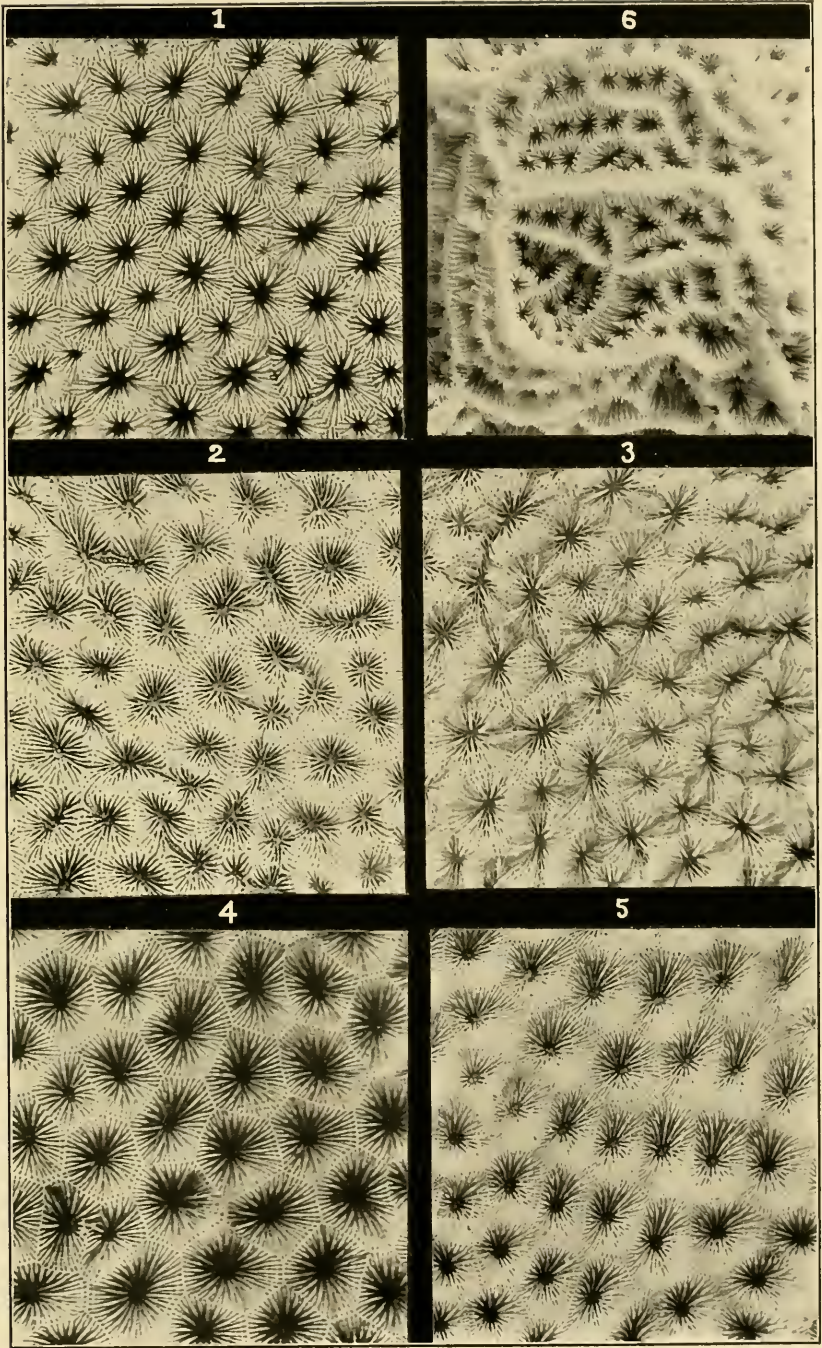
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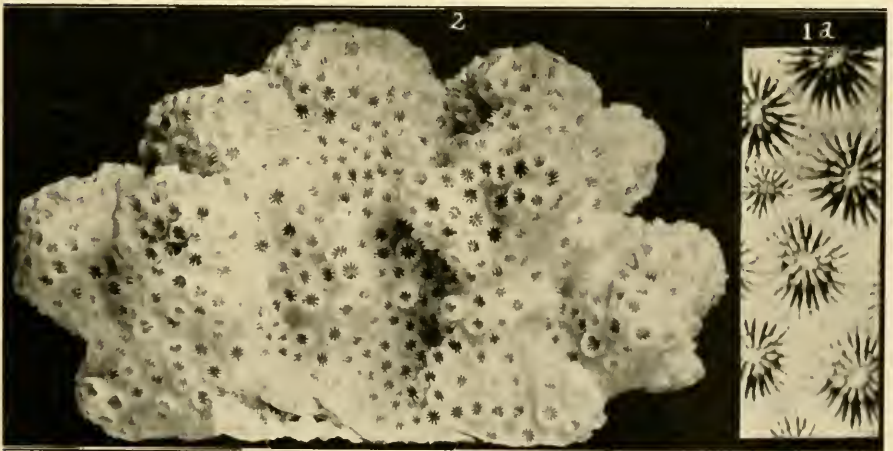
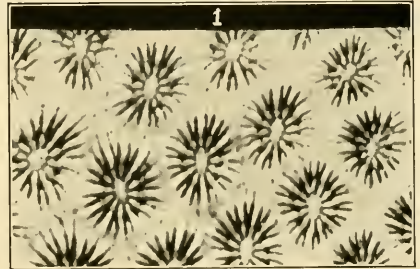
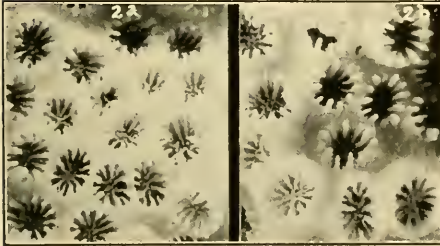
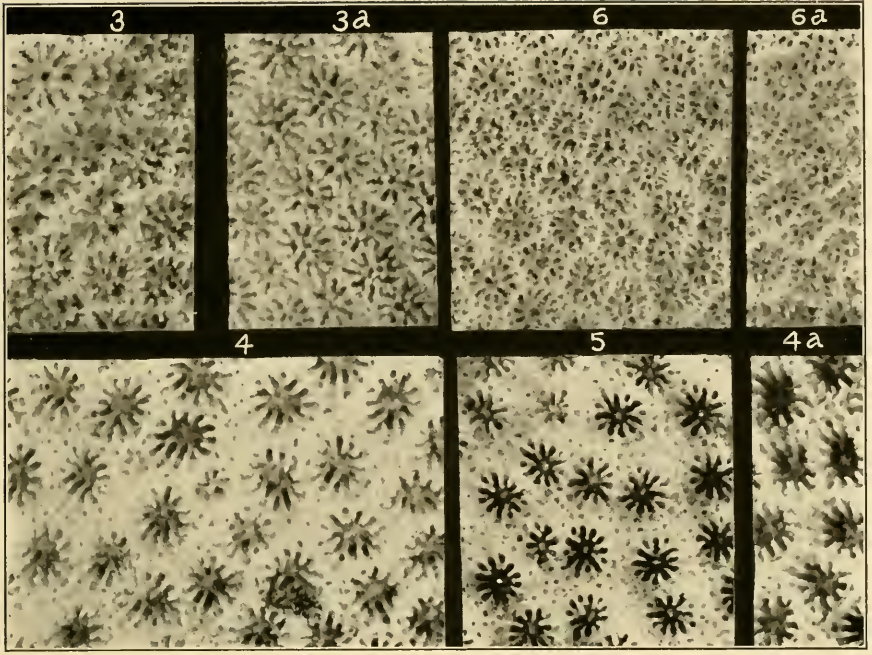
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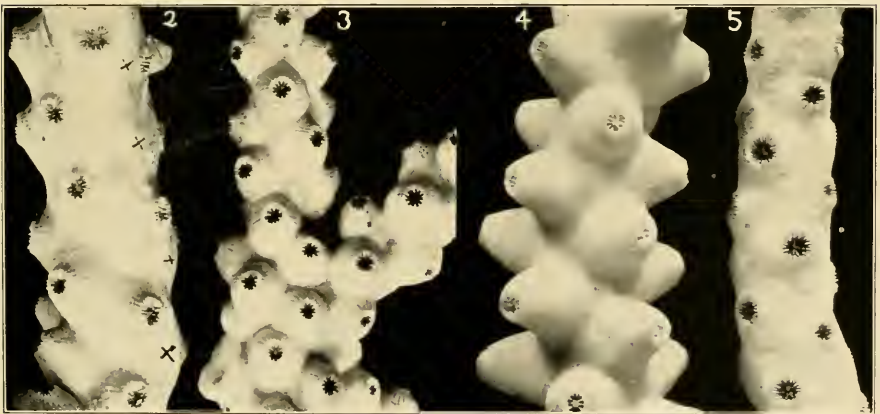
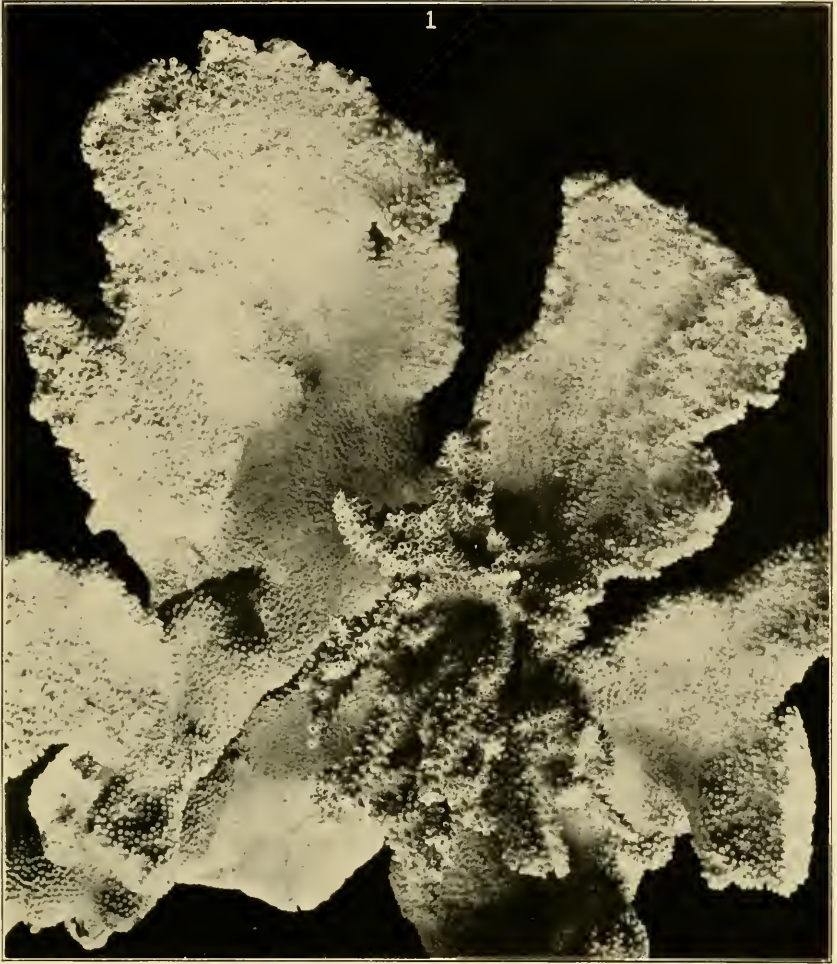


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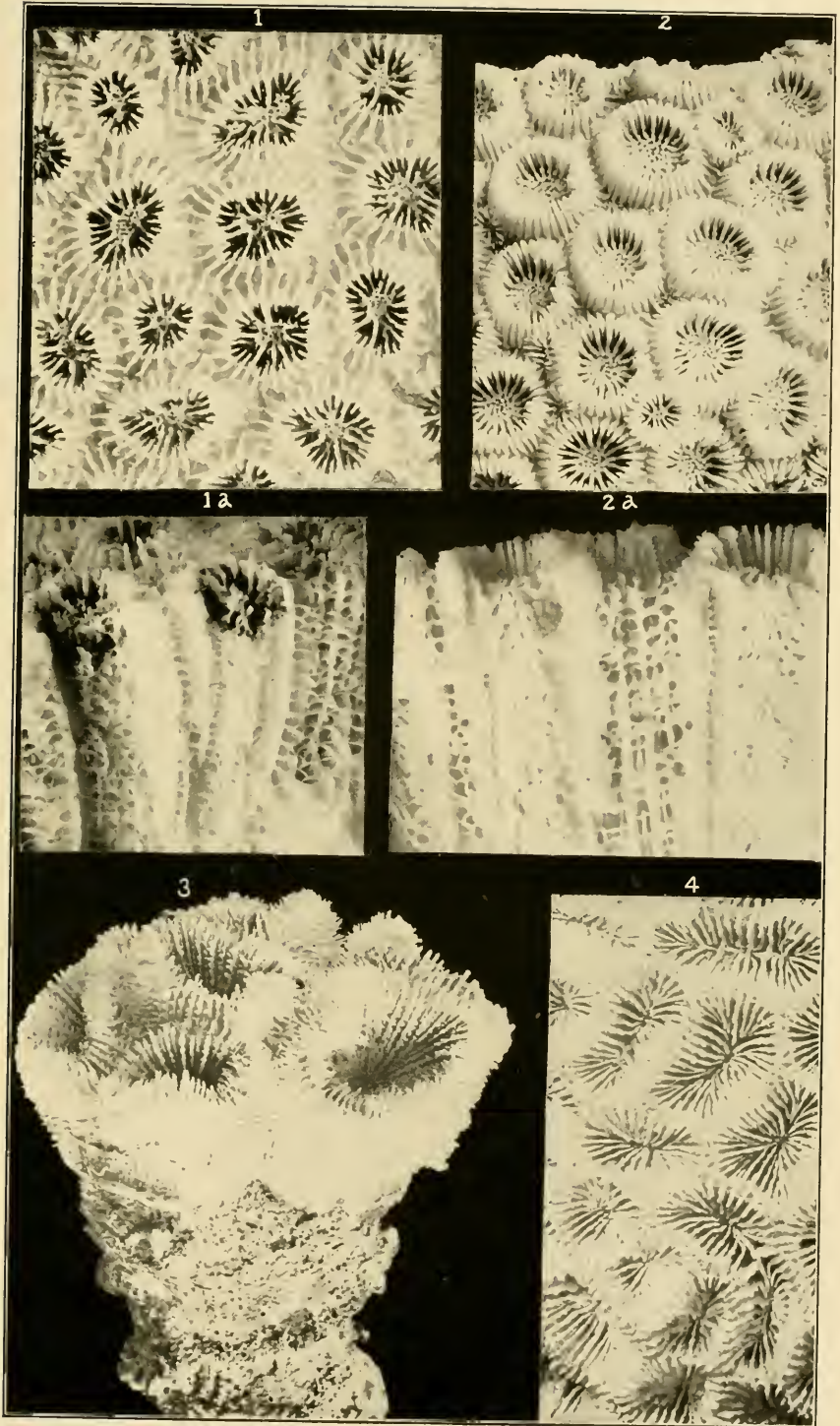


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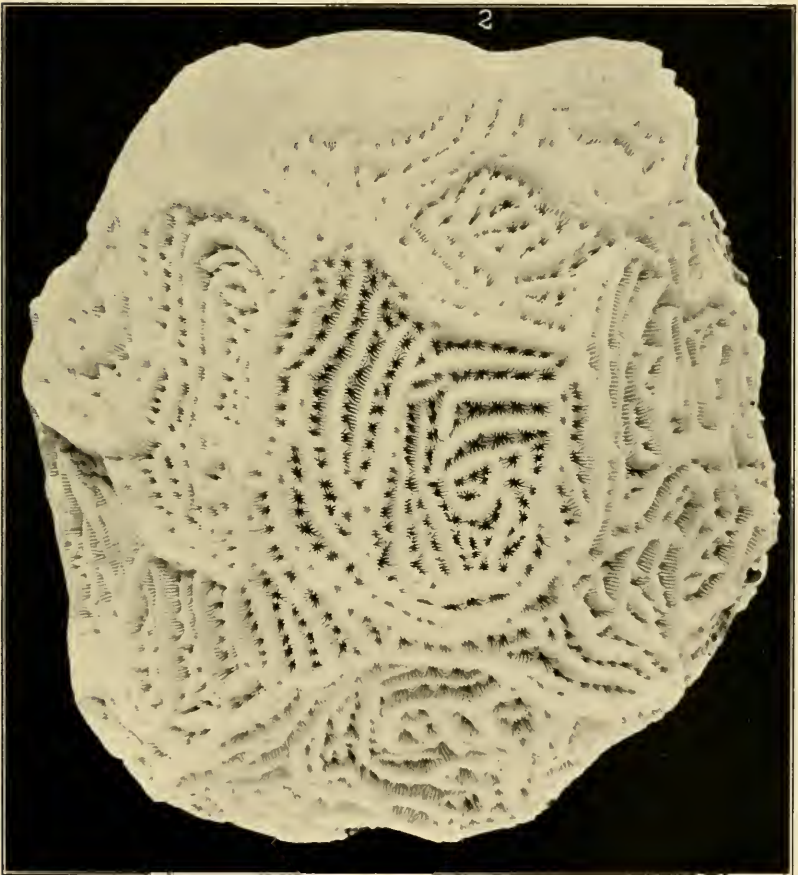
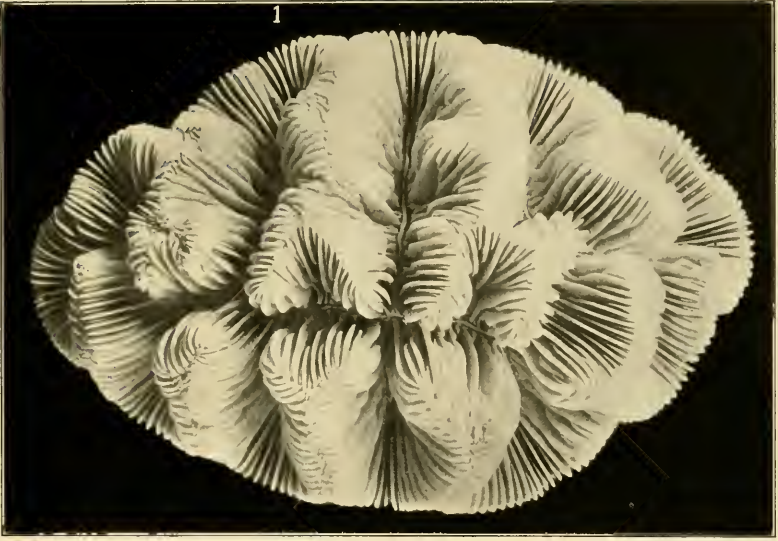


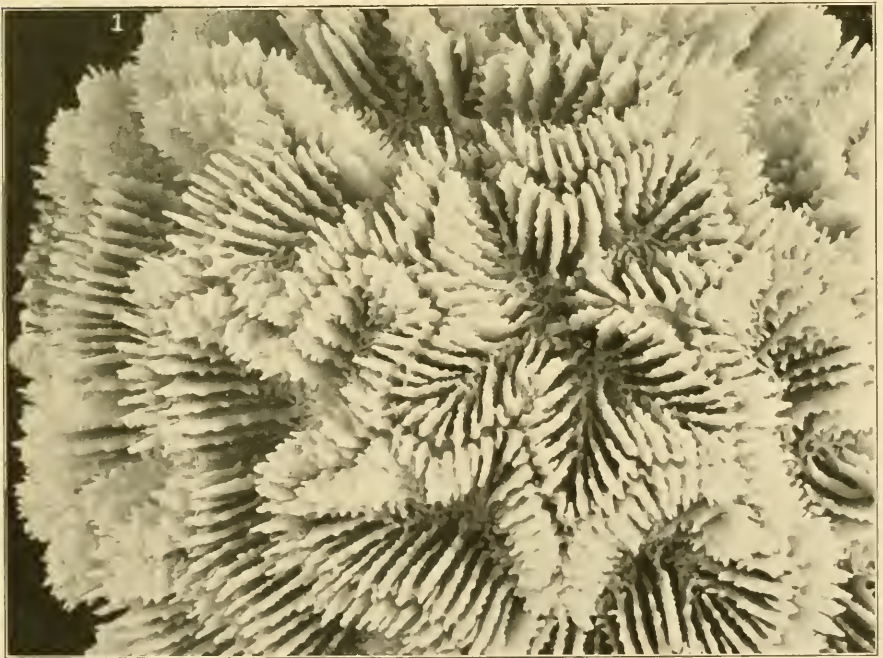
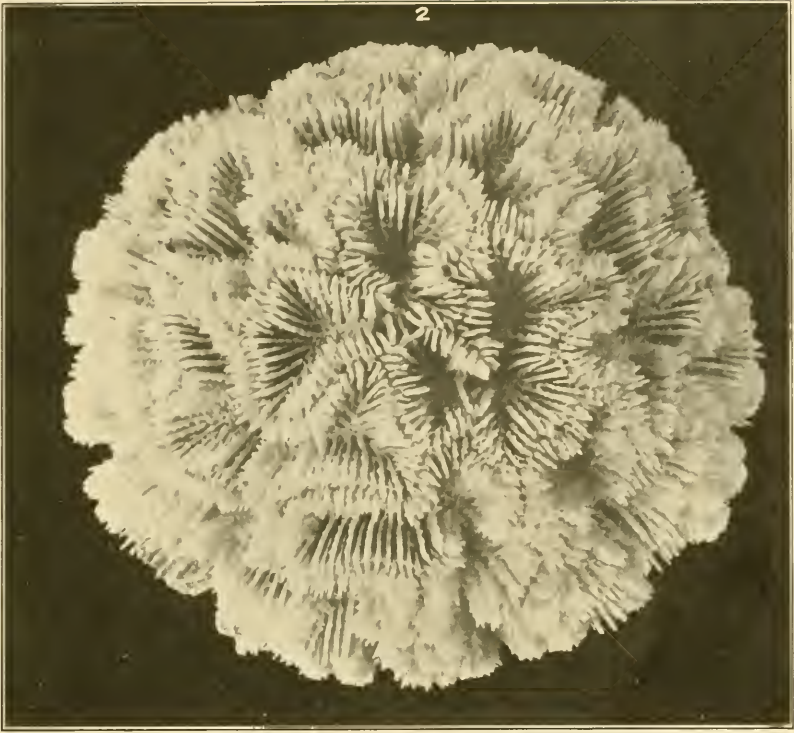


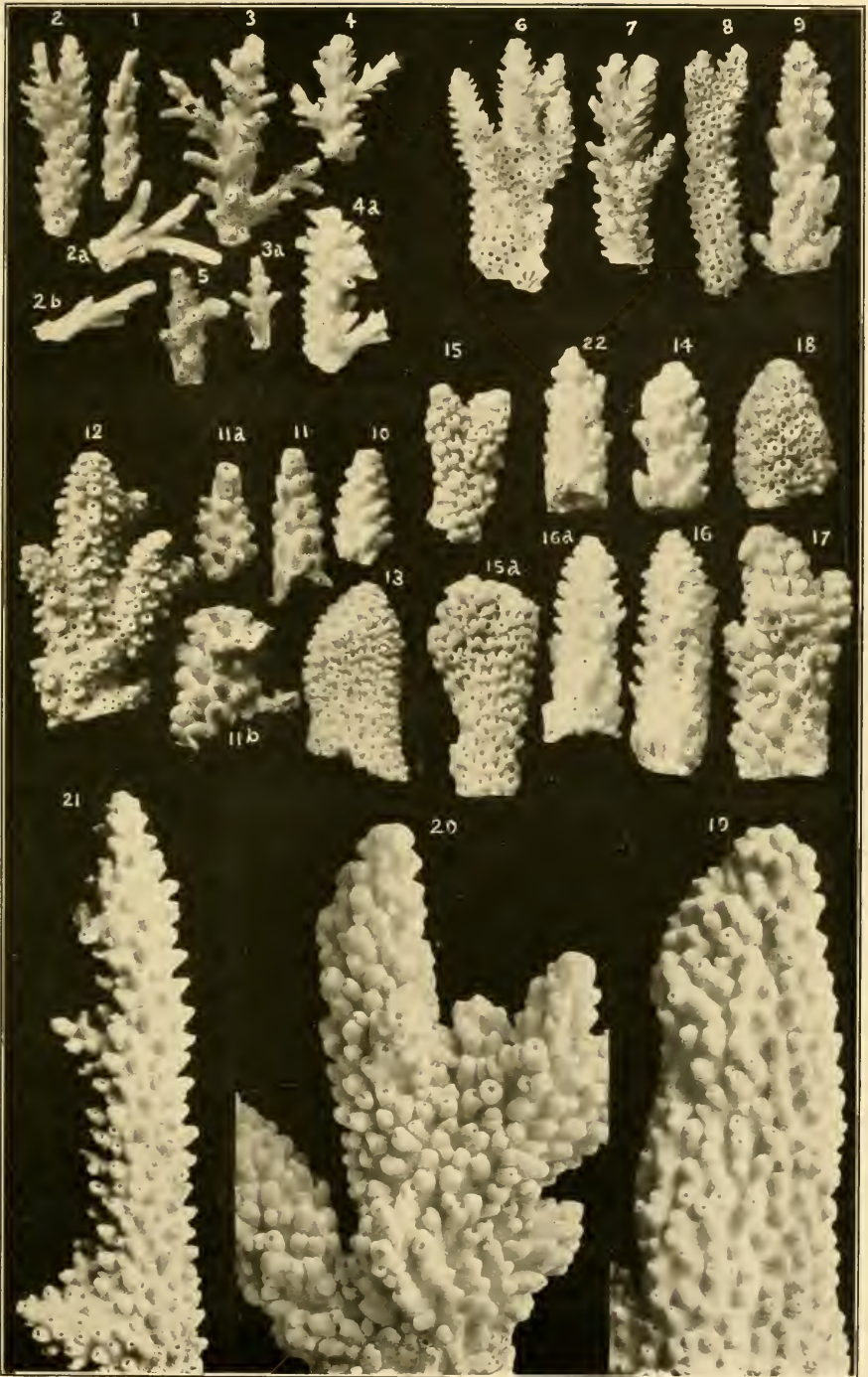
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A. H. Verrill, Phot.

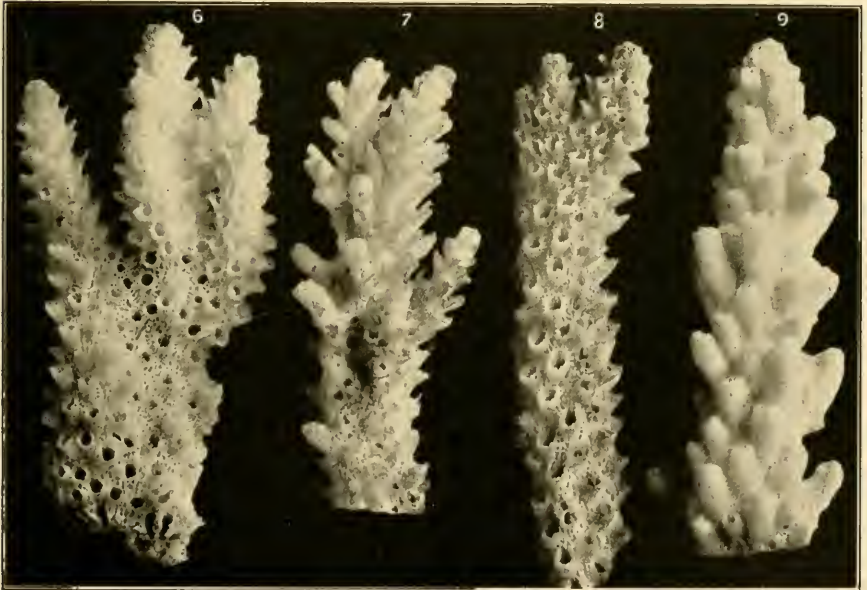
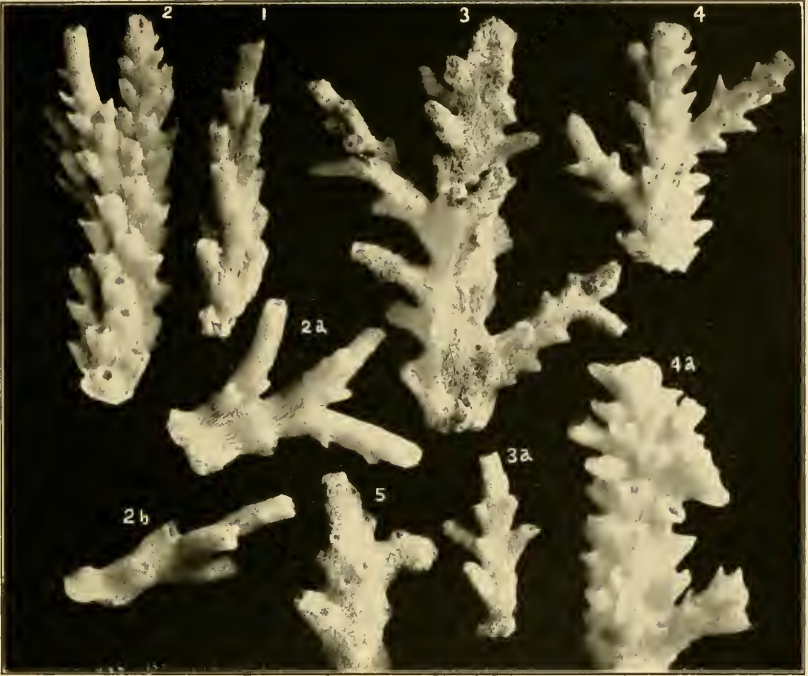


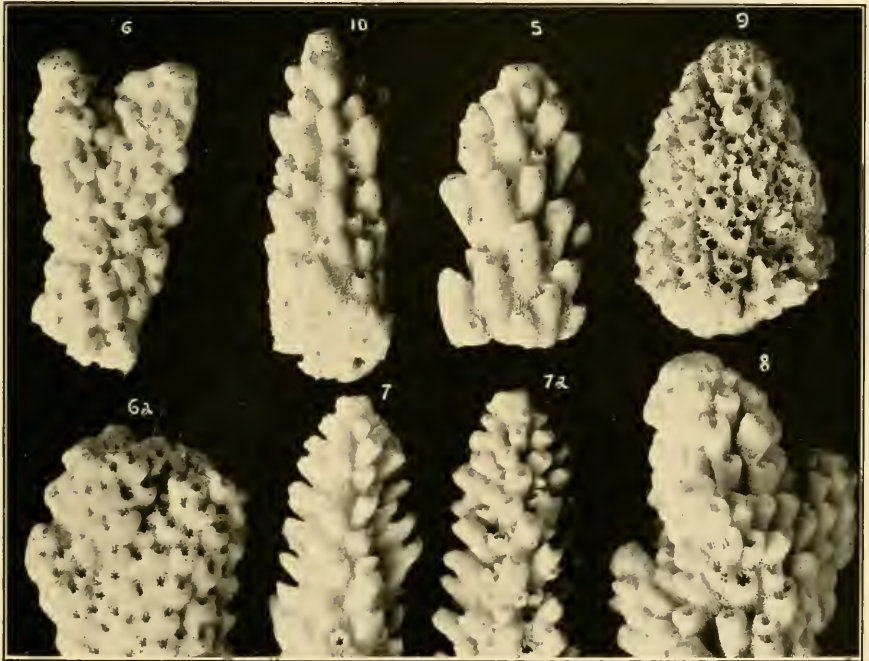
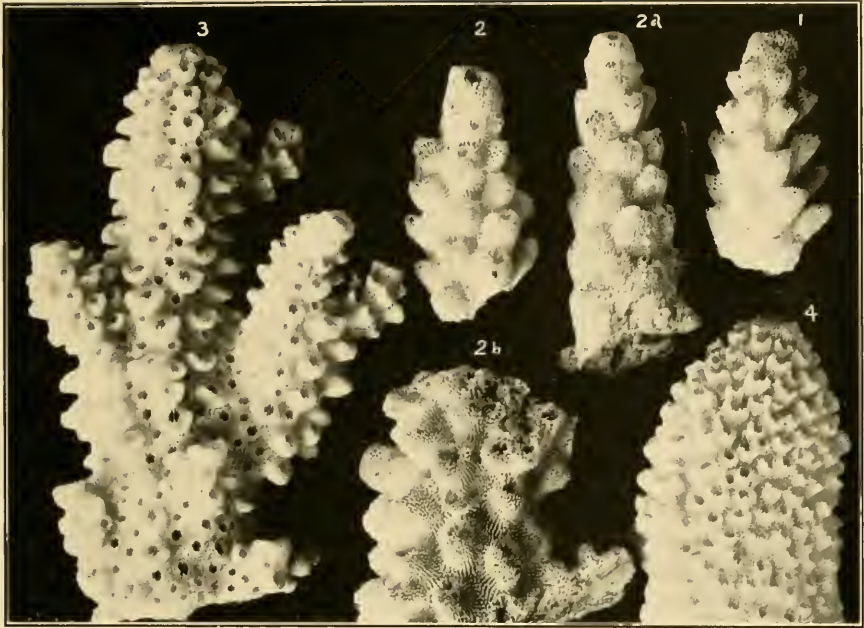


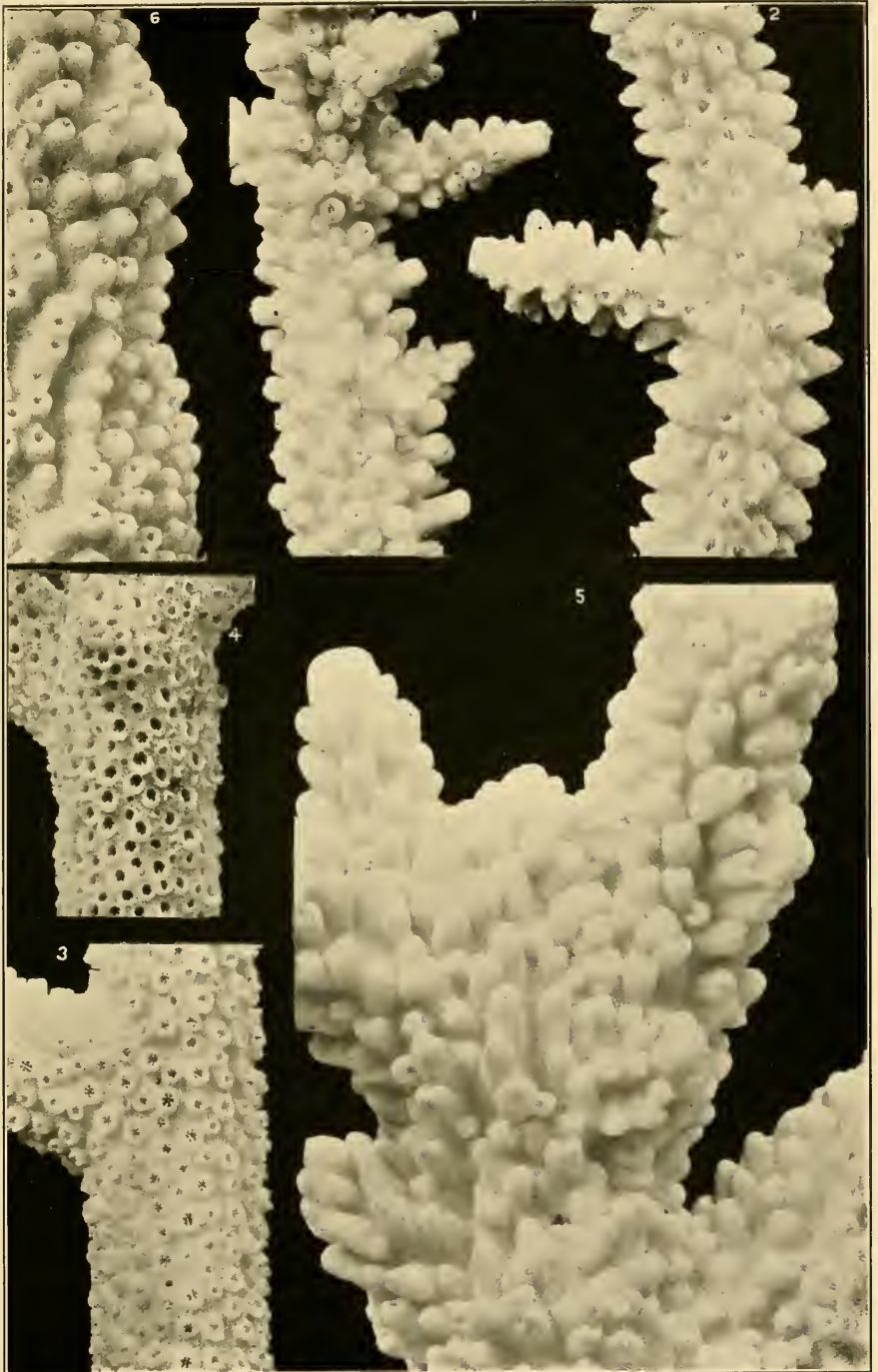


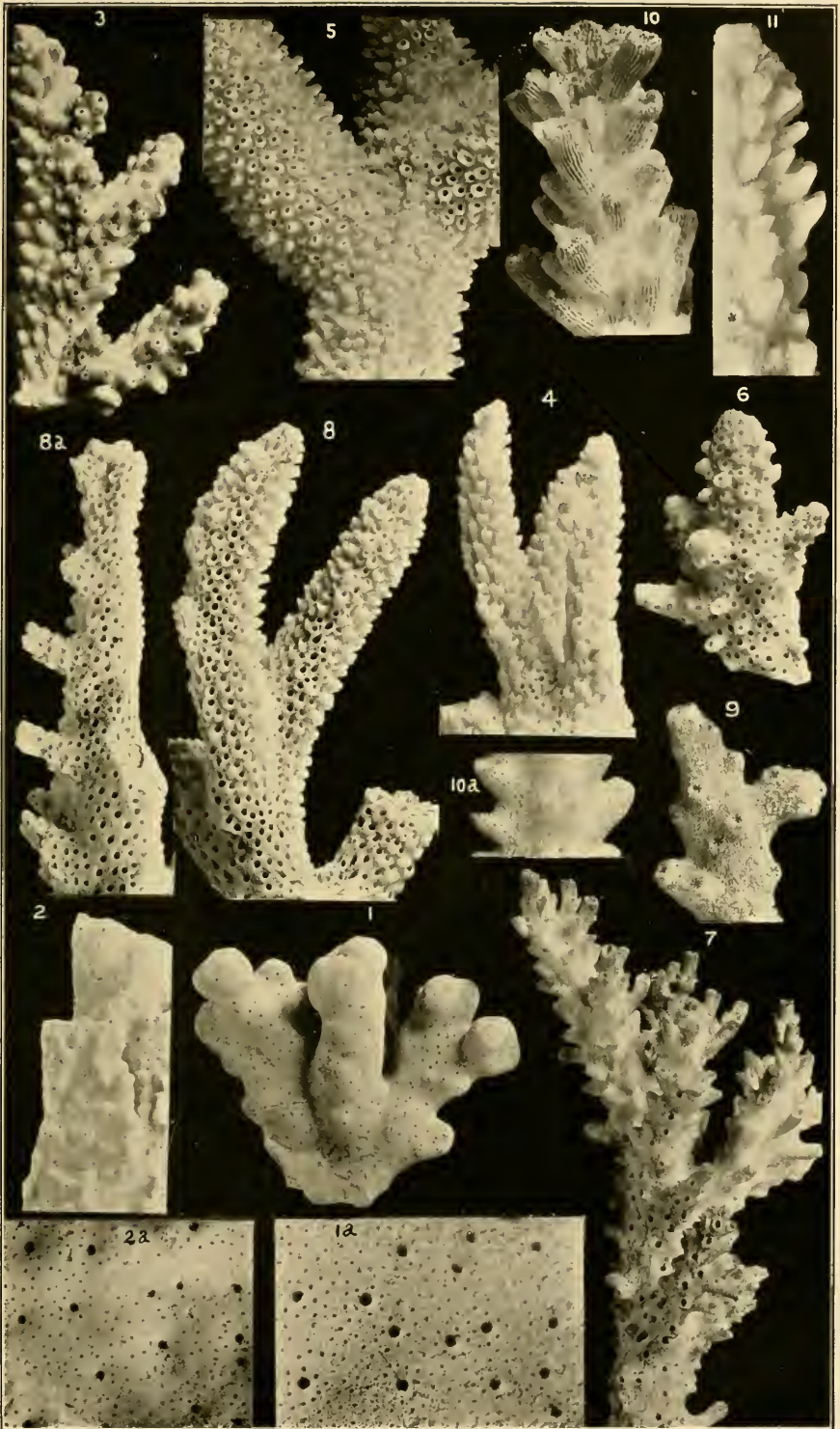
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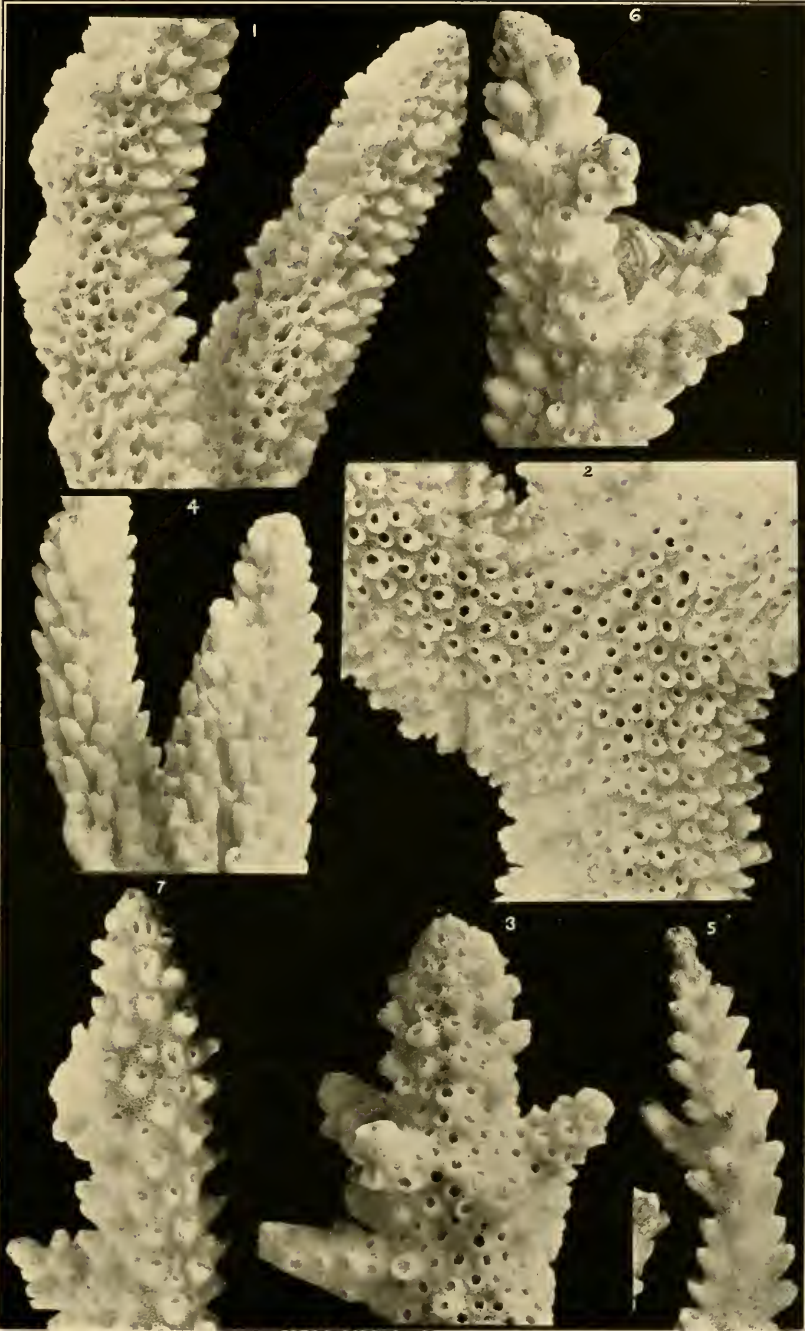
Gill Eng. Co.



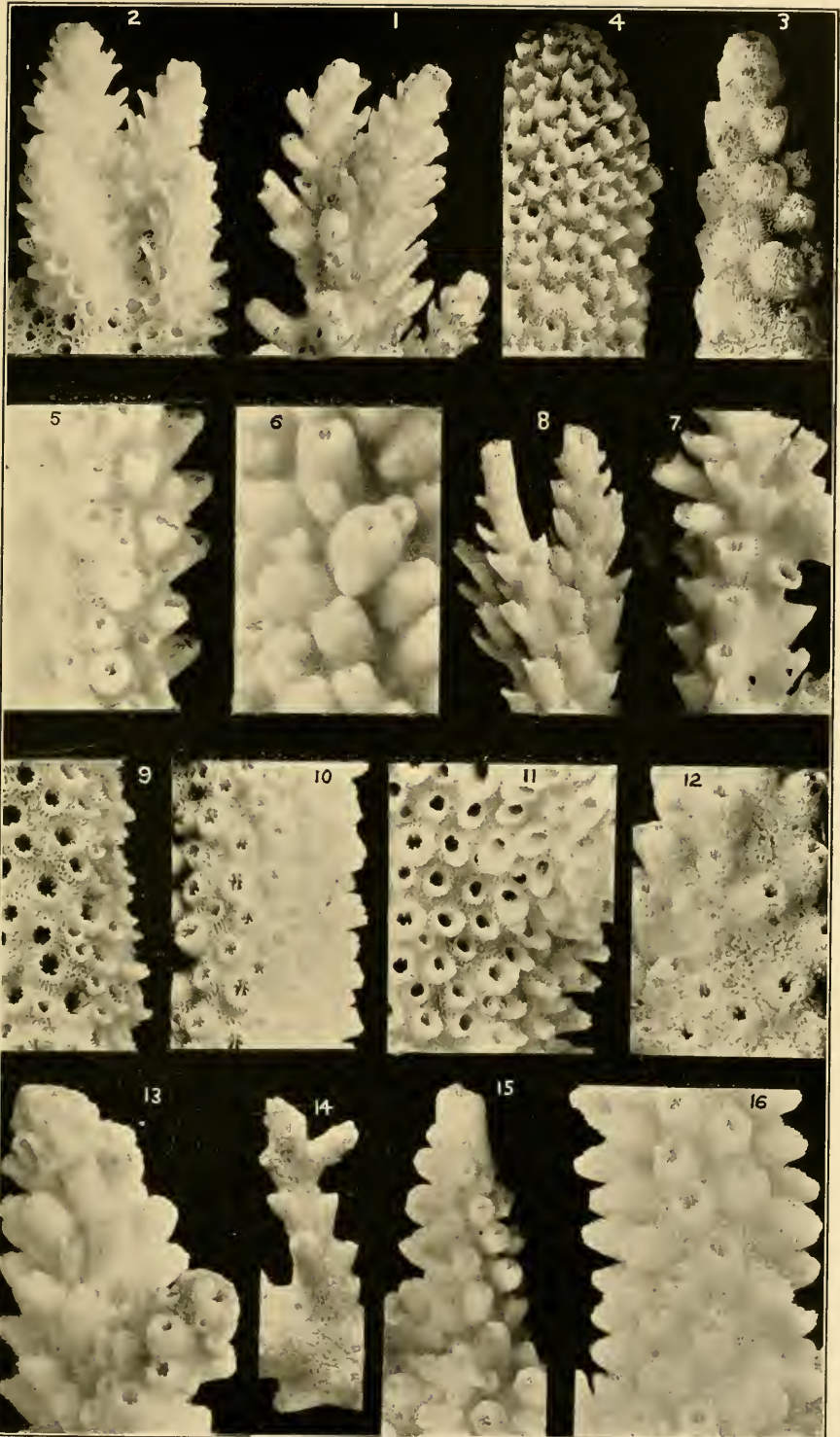


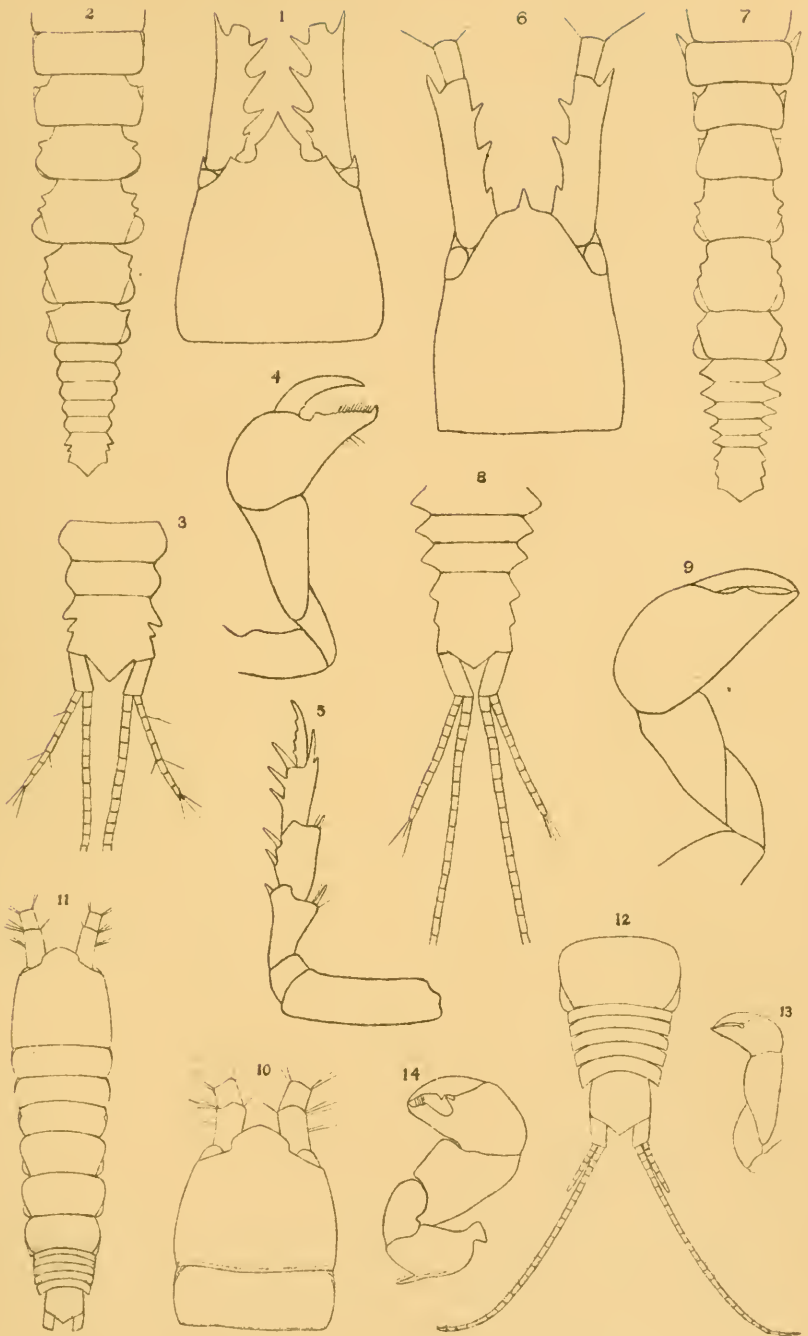


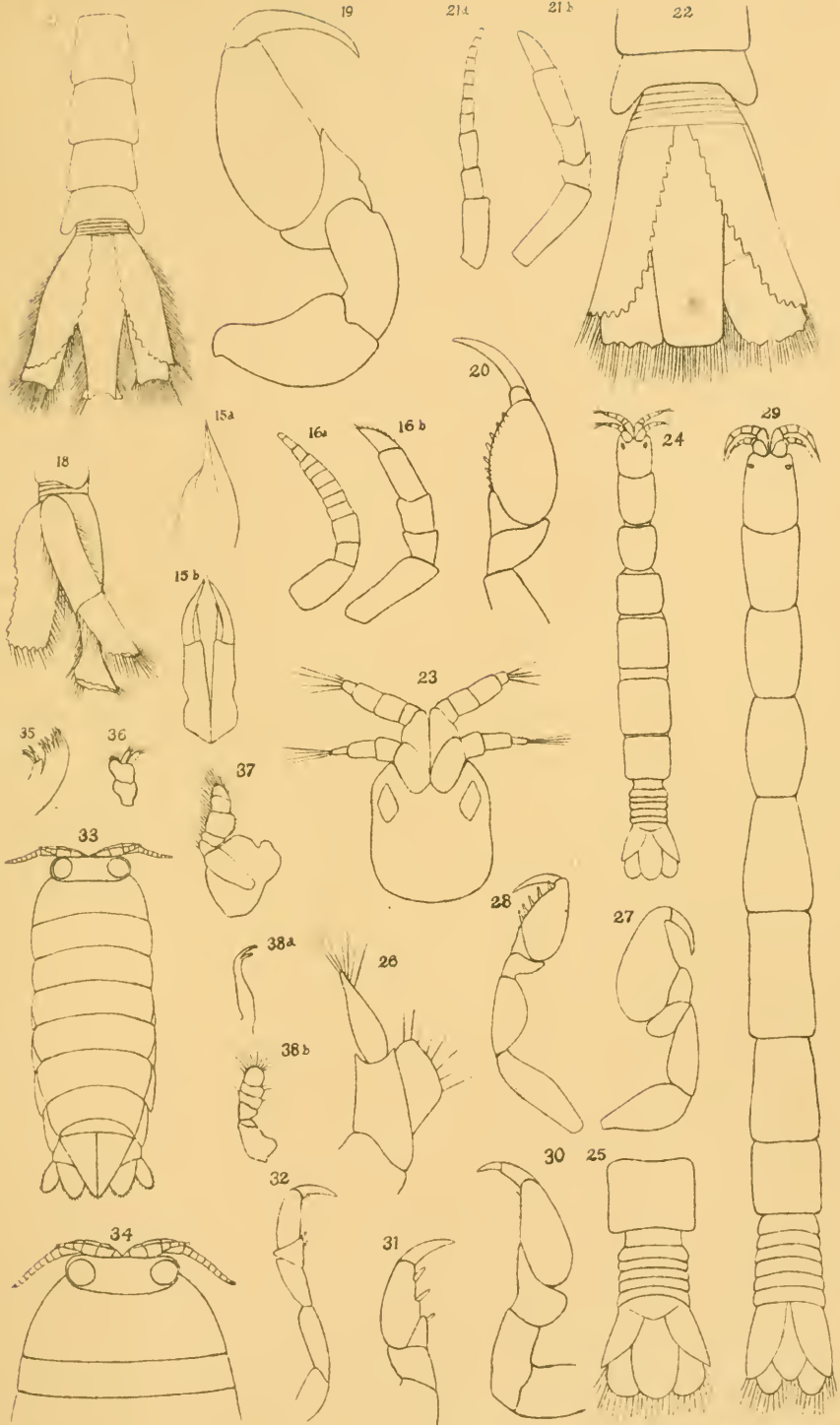


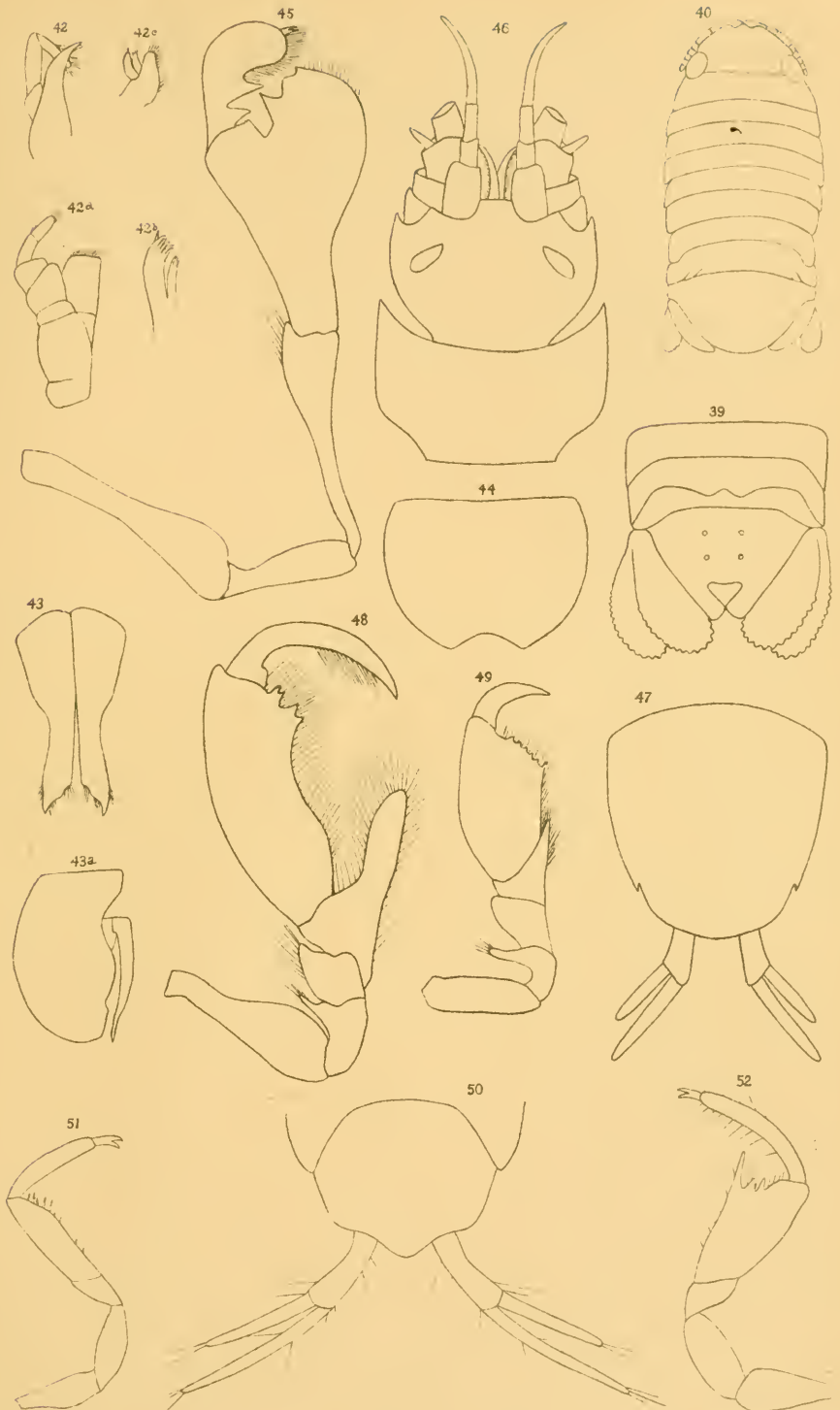


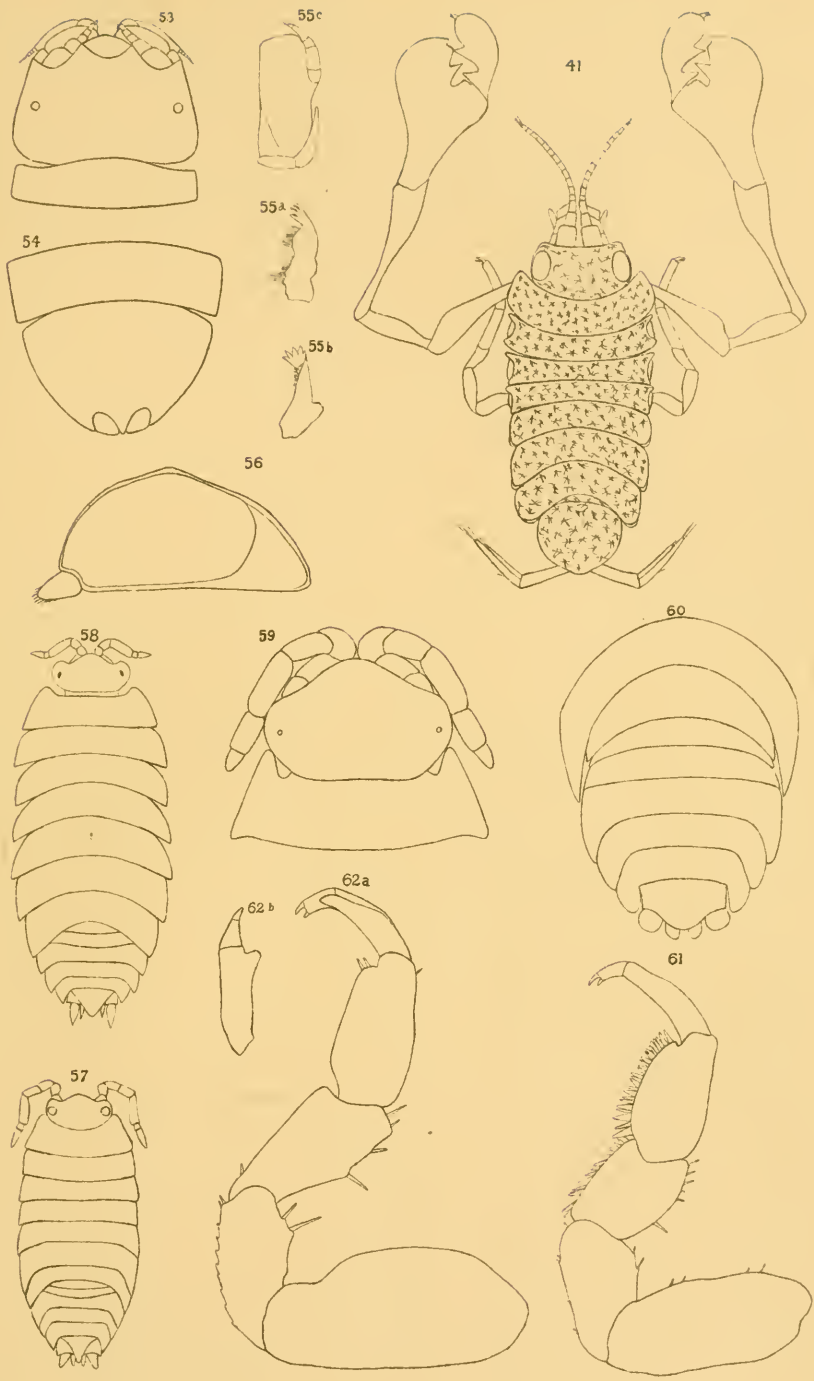
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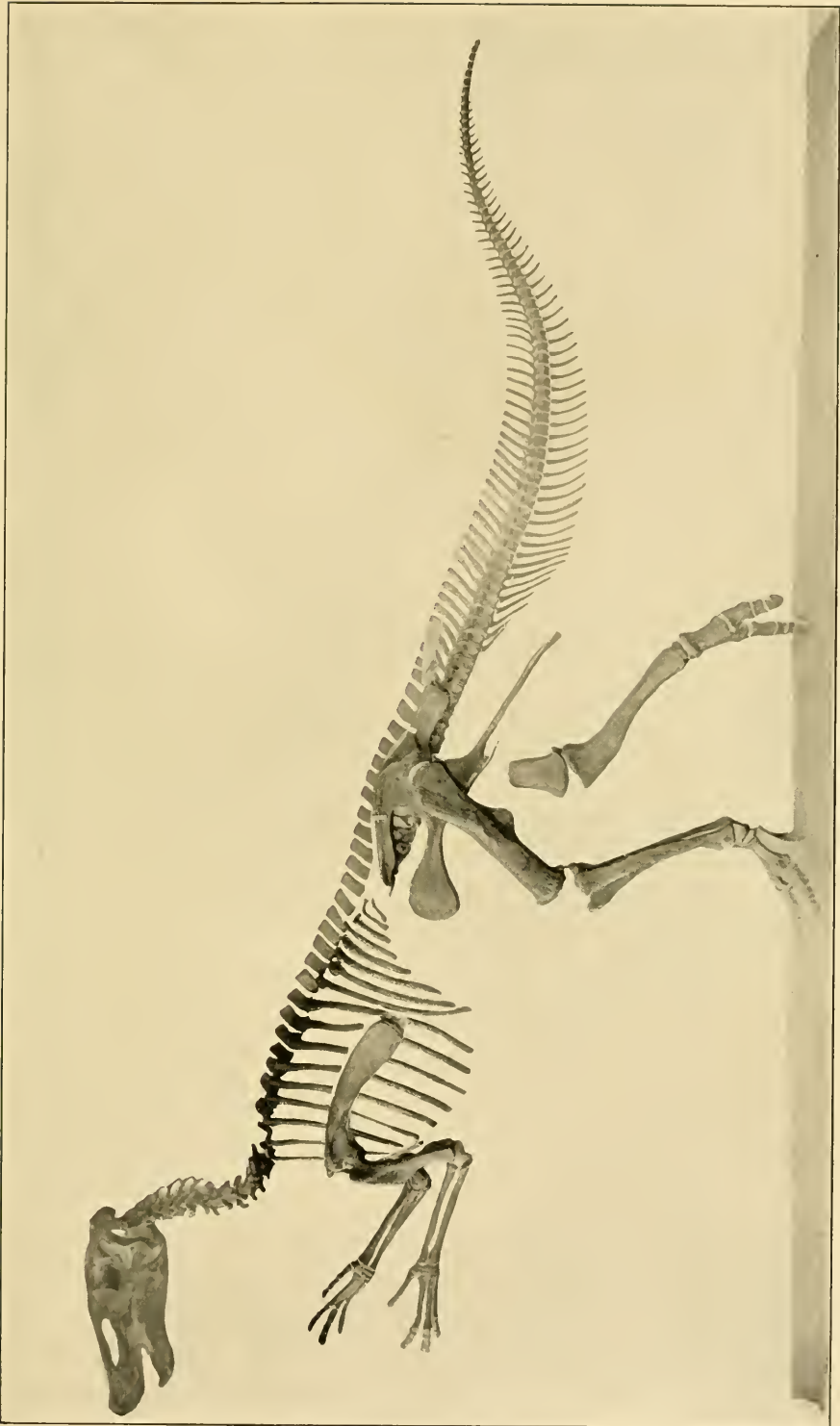








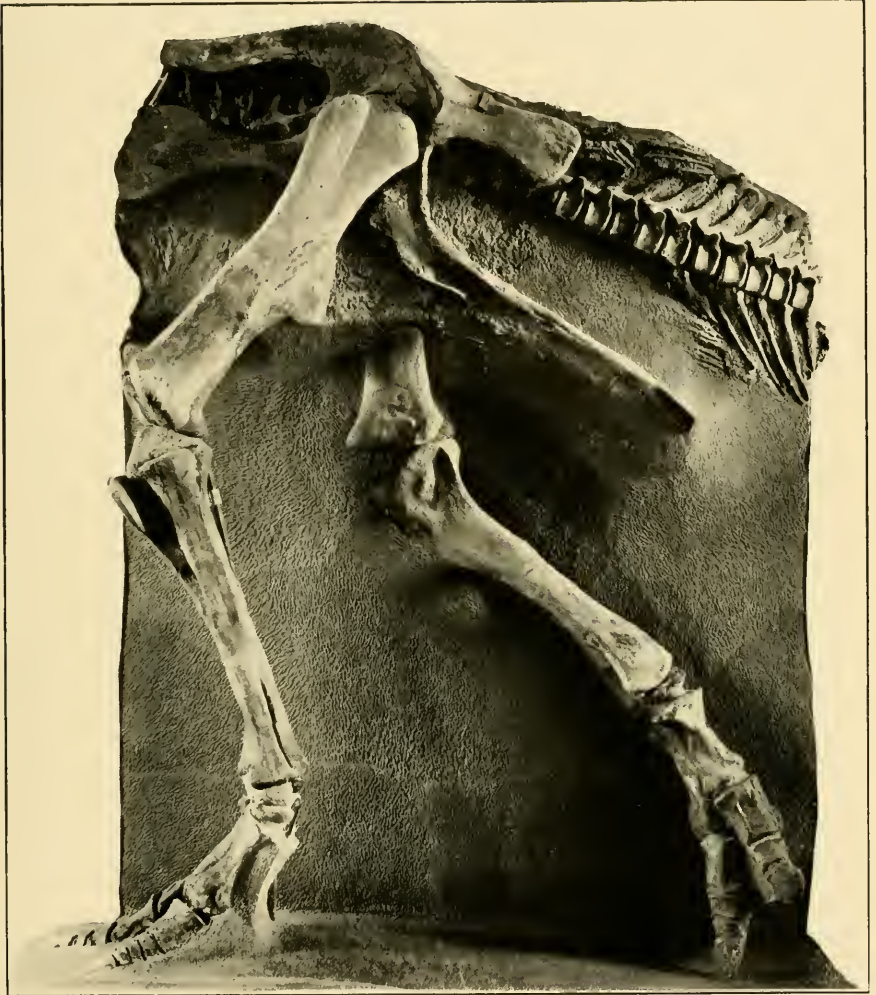




CLAOSAURUS ANNECTENS Marsh. 1/40.



COELOCEROS ANNECTENS Marsh.

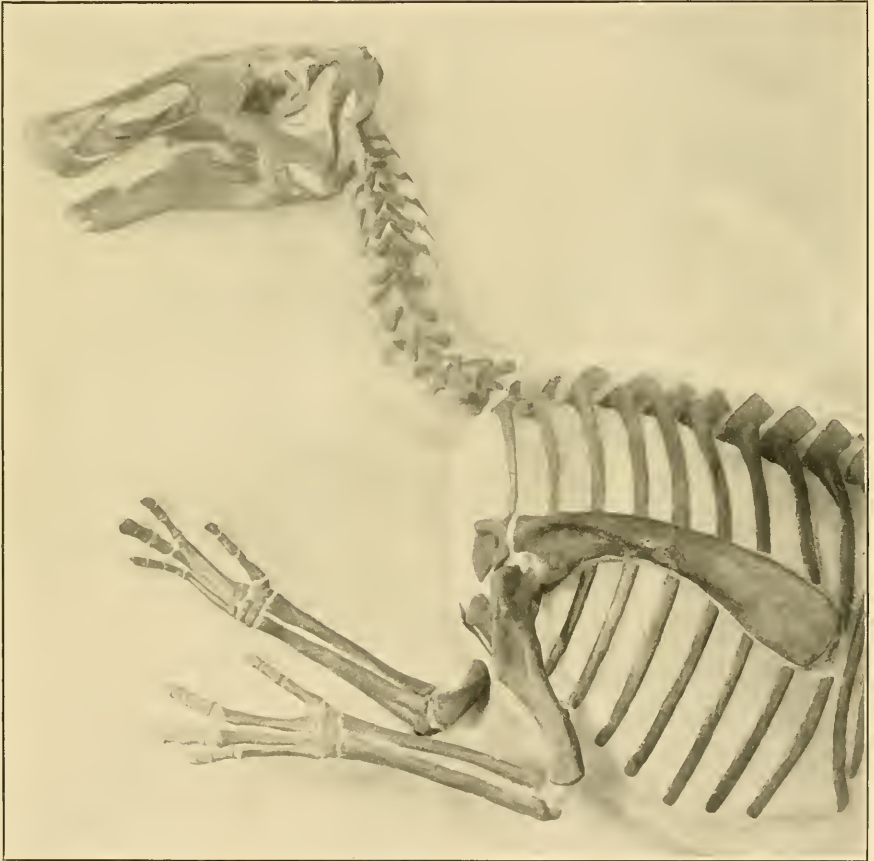


CLAOSAURUS ANNECTENS Marsh. 1/18.

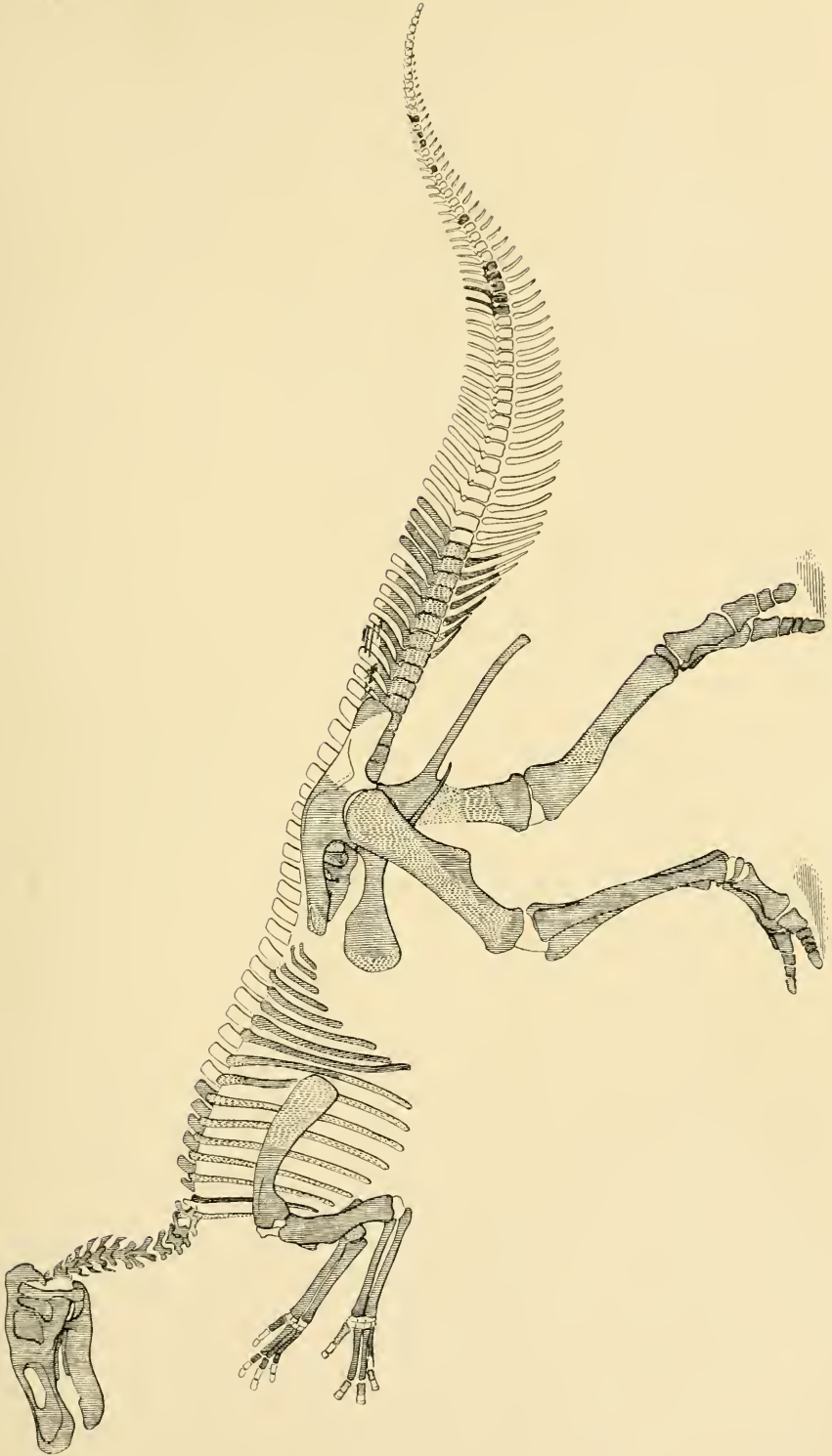
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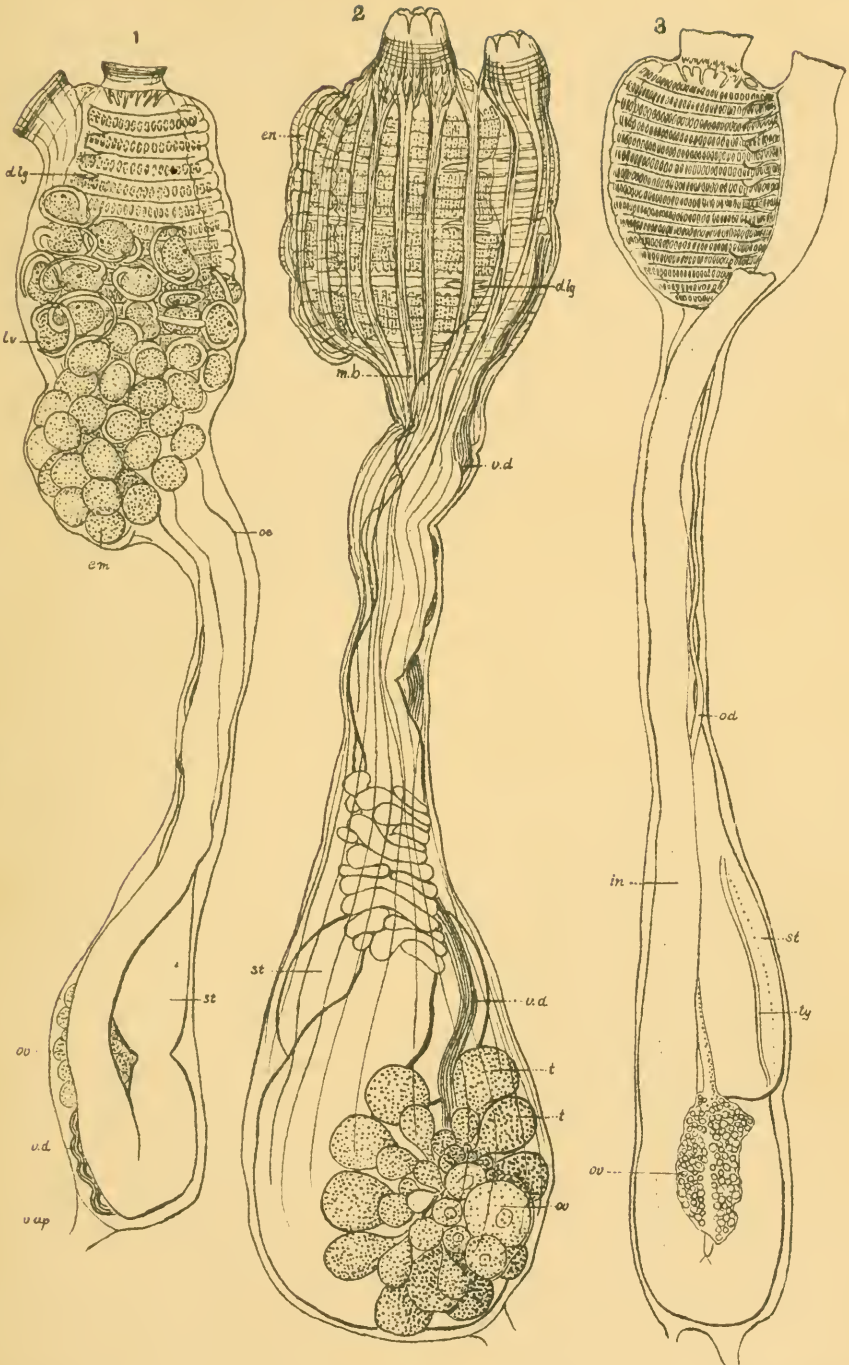
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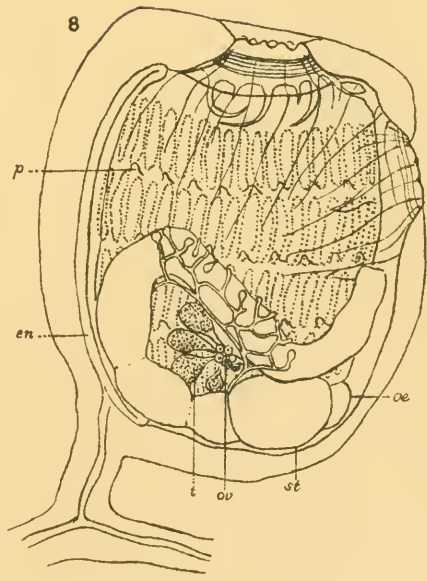
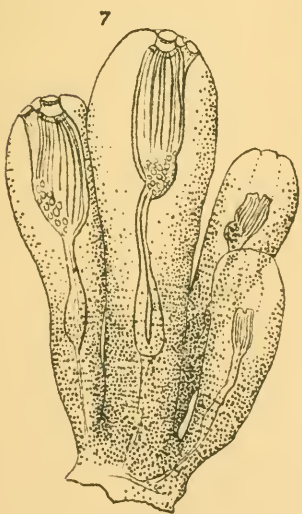
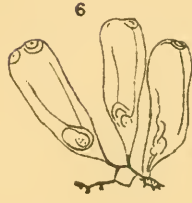
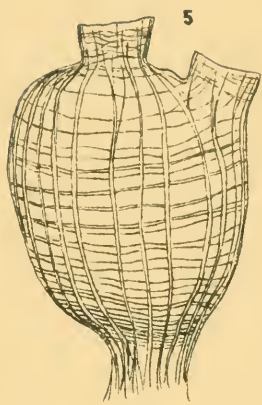
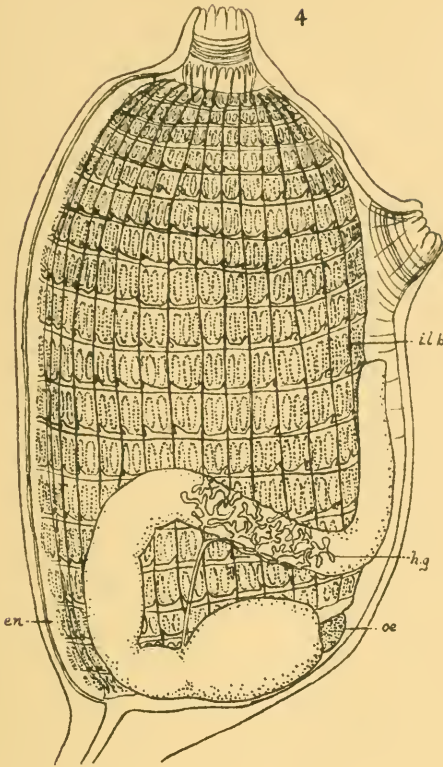


CLAOSAURUS ANNECTENS Marsh.

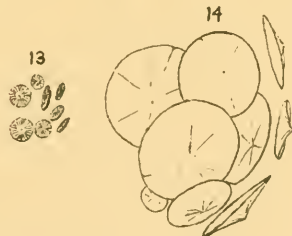
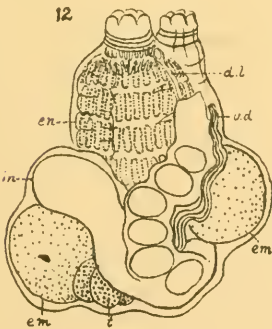
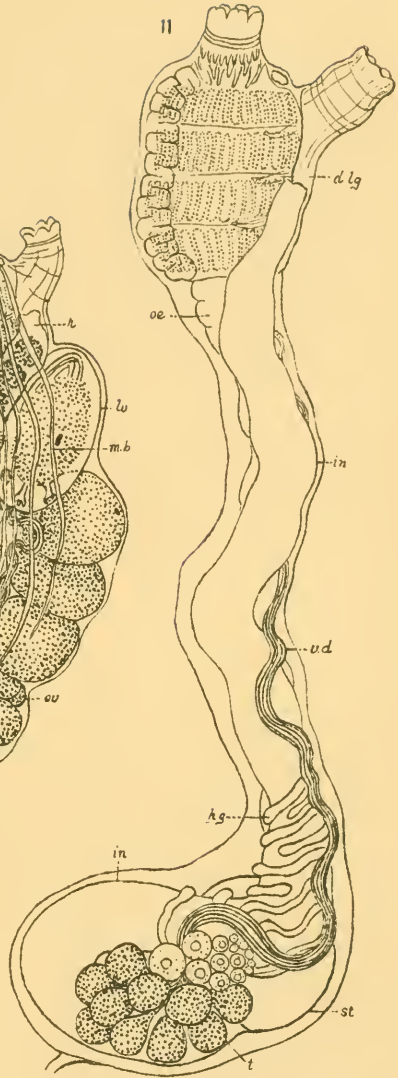
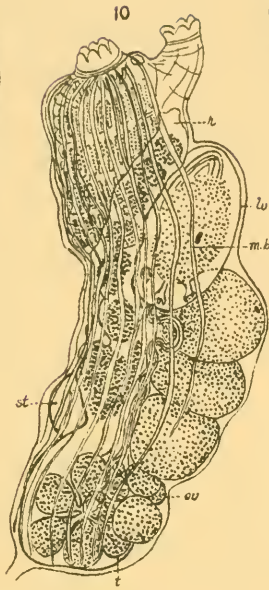
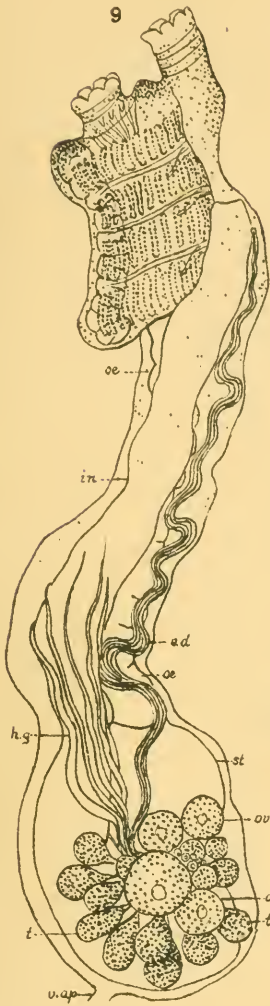


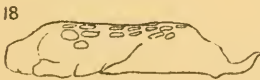
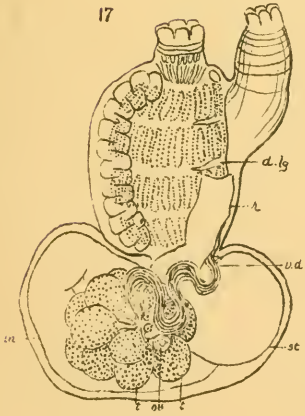
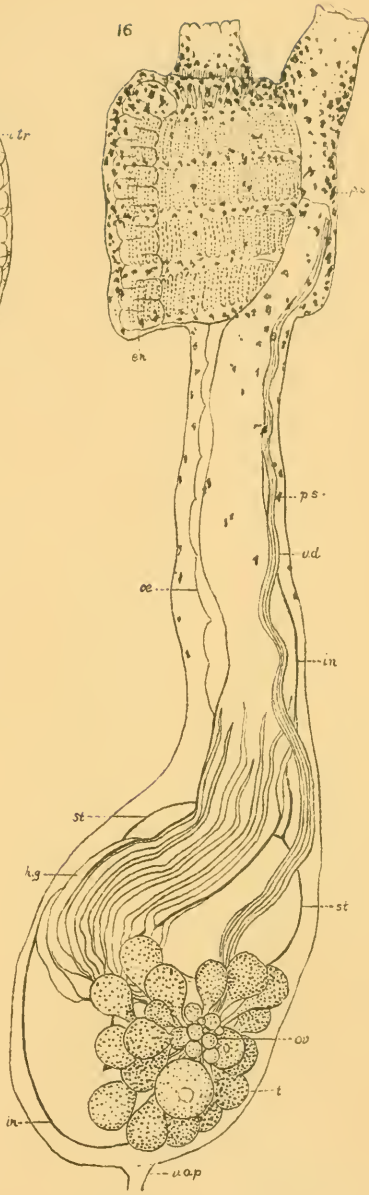
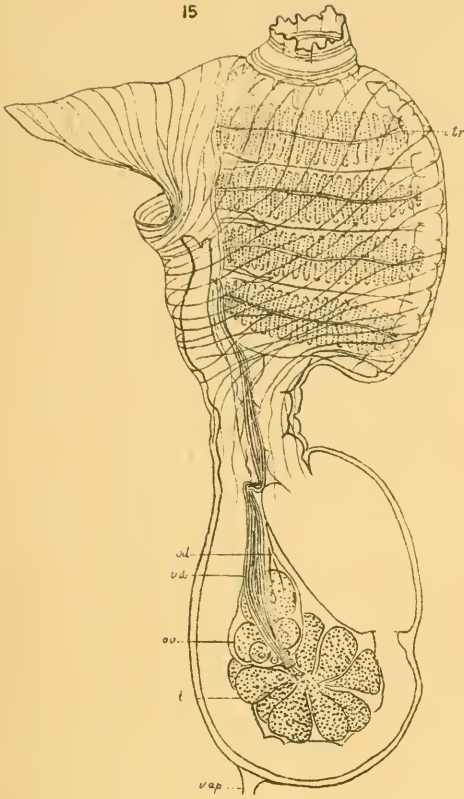
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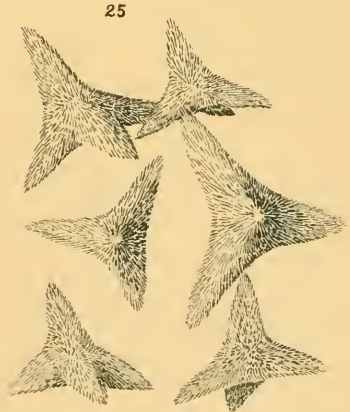
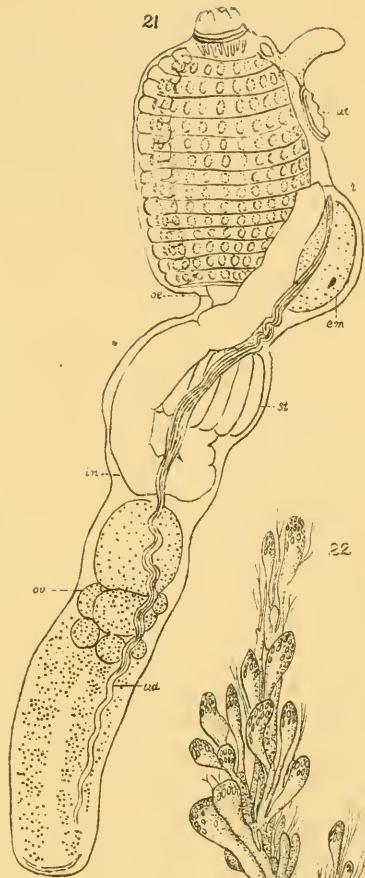
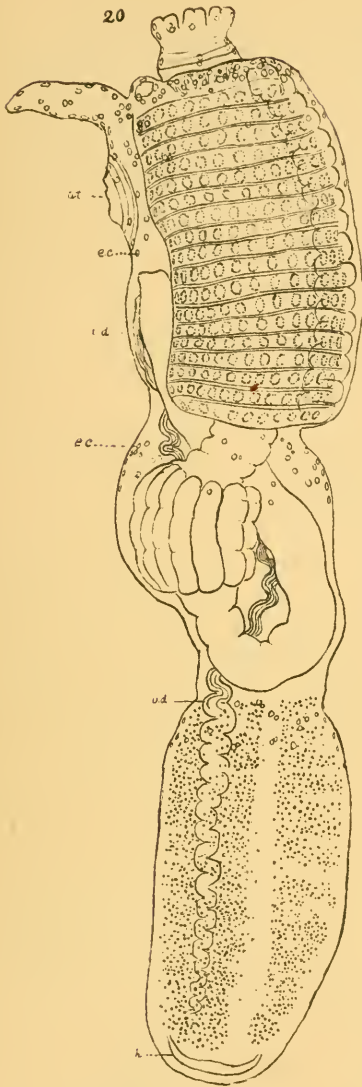


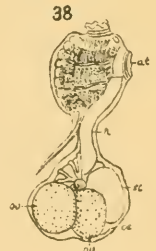
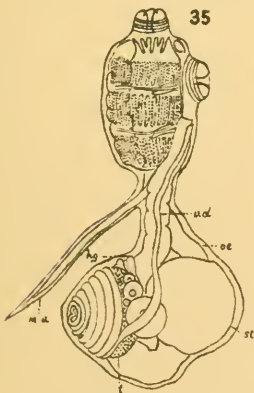
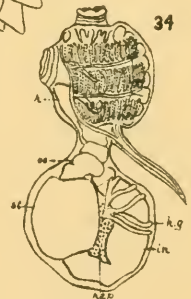
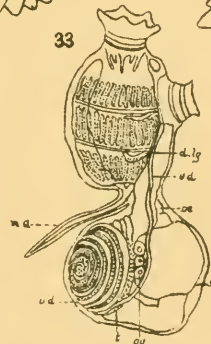
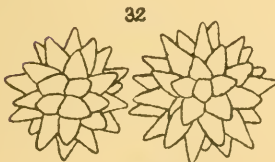
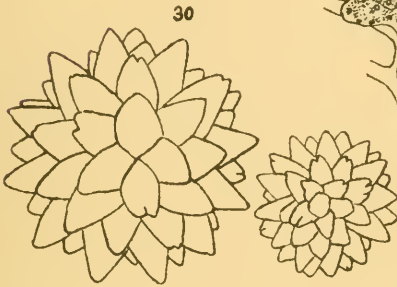
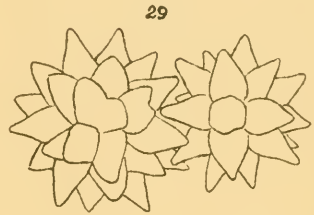
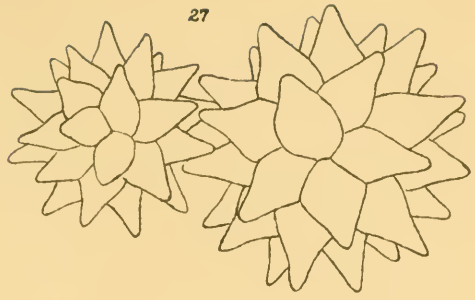


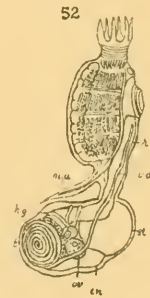
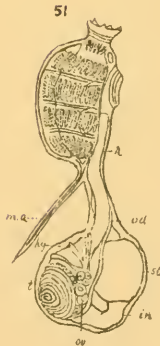
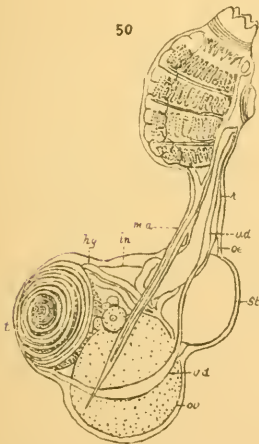
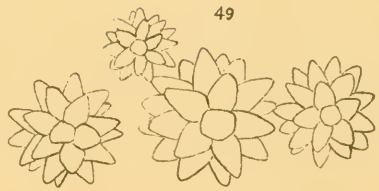
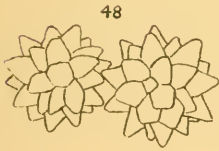
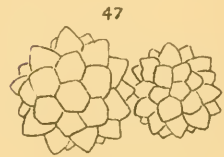
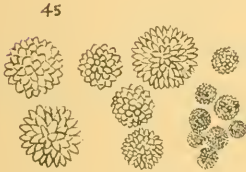
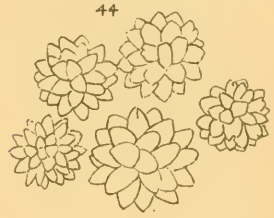
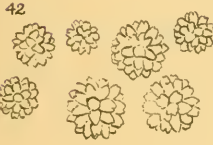
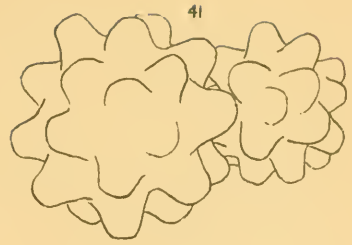


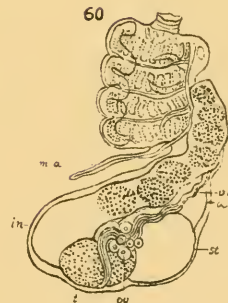
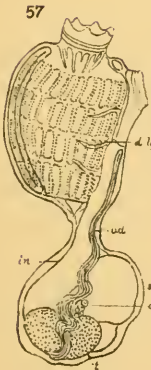
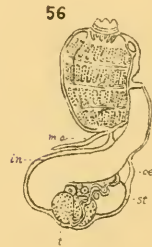
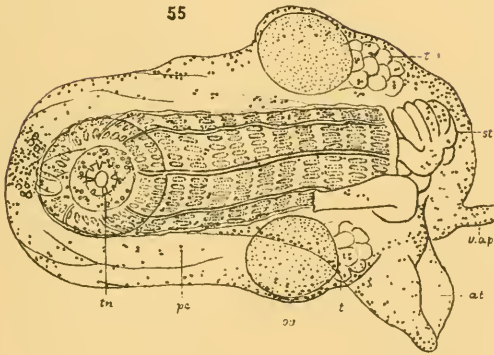
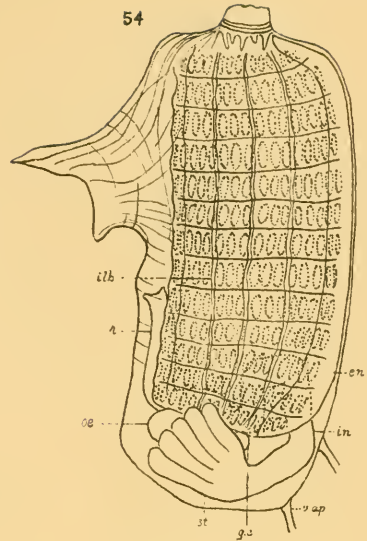
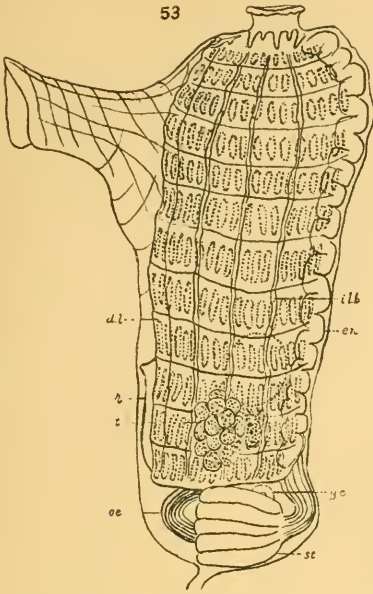


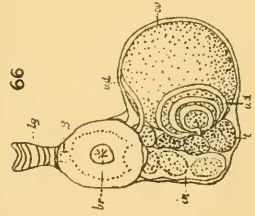
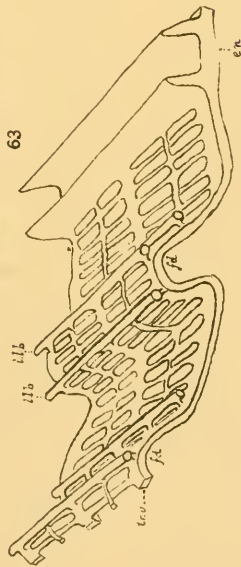
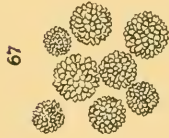
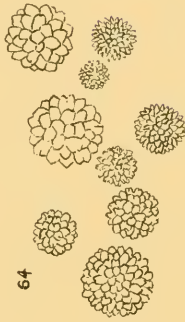
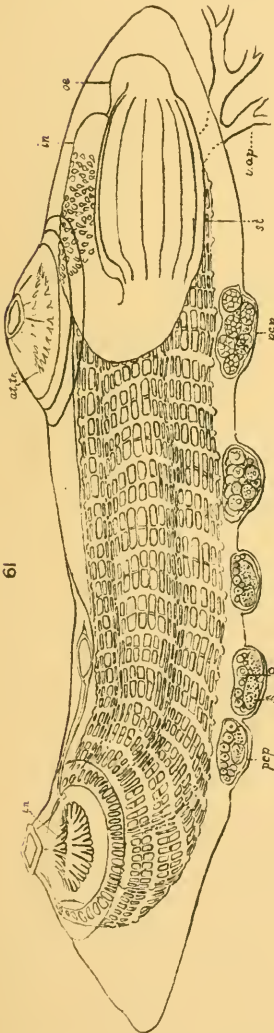
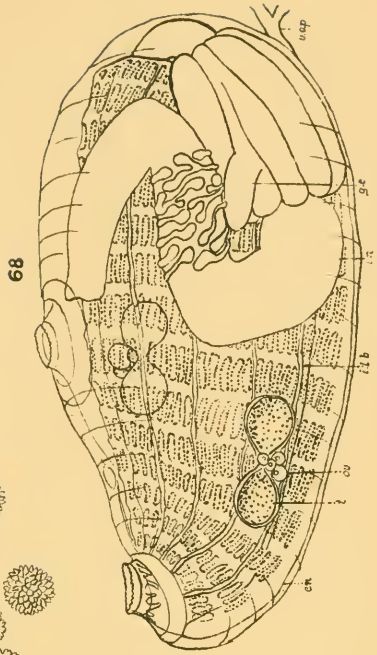
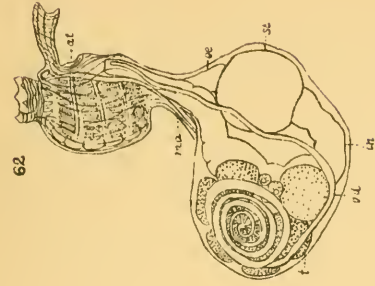


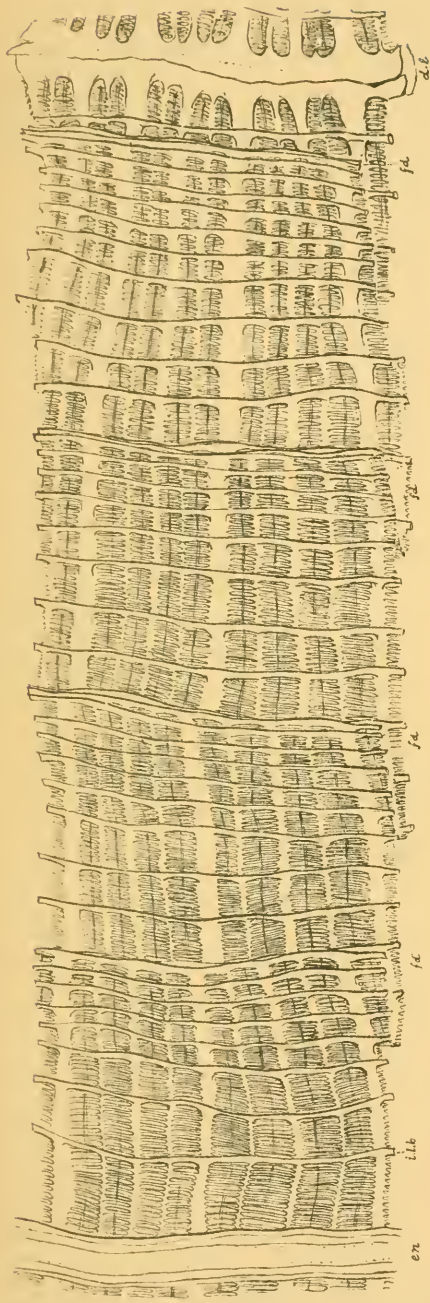




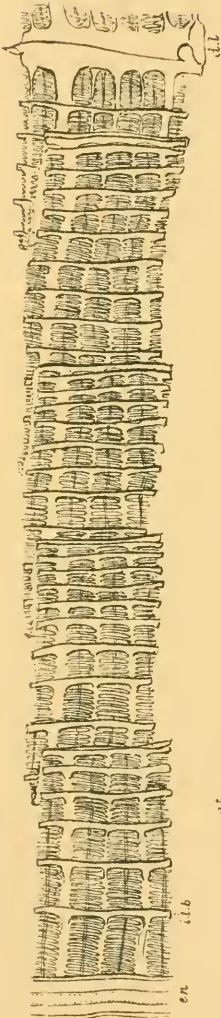








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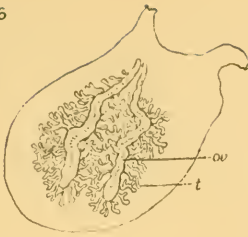


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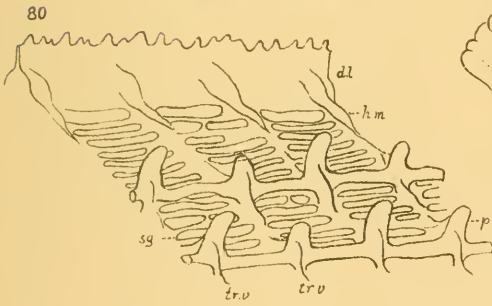
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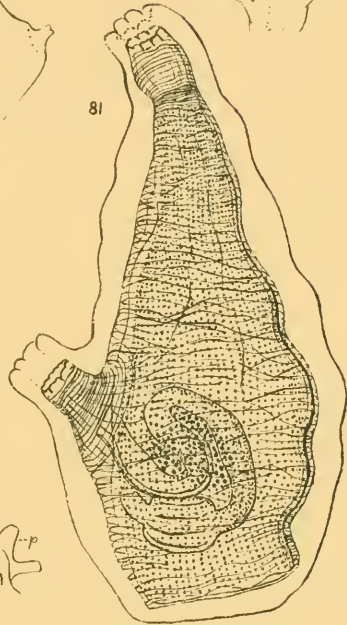
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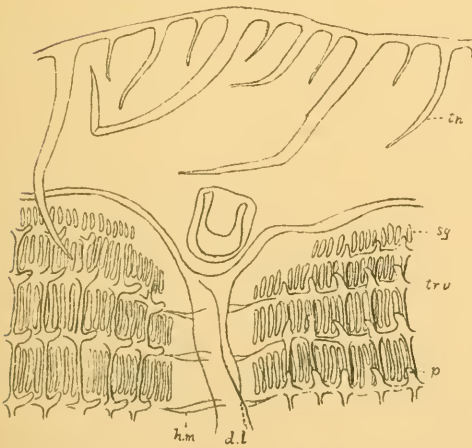


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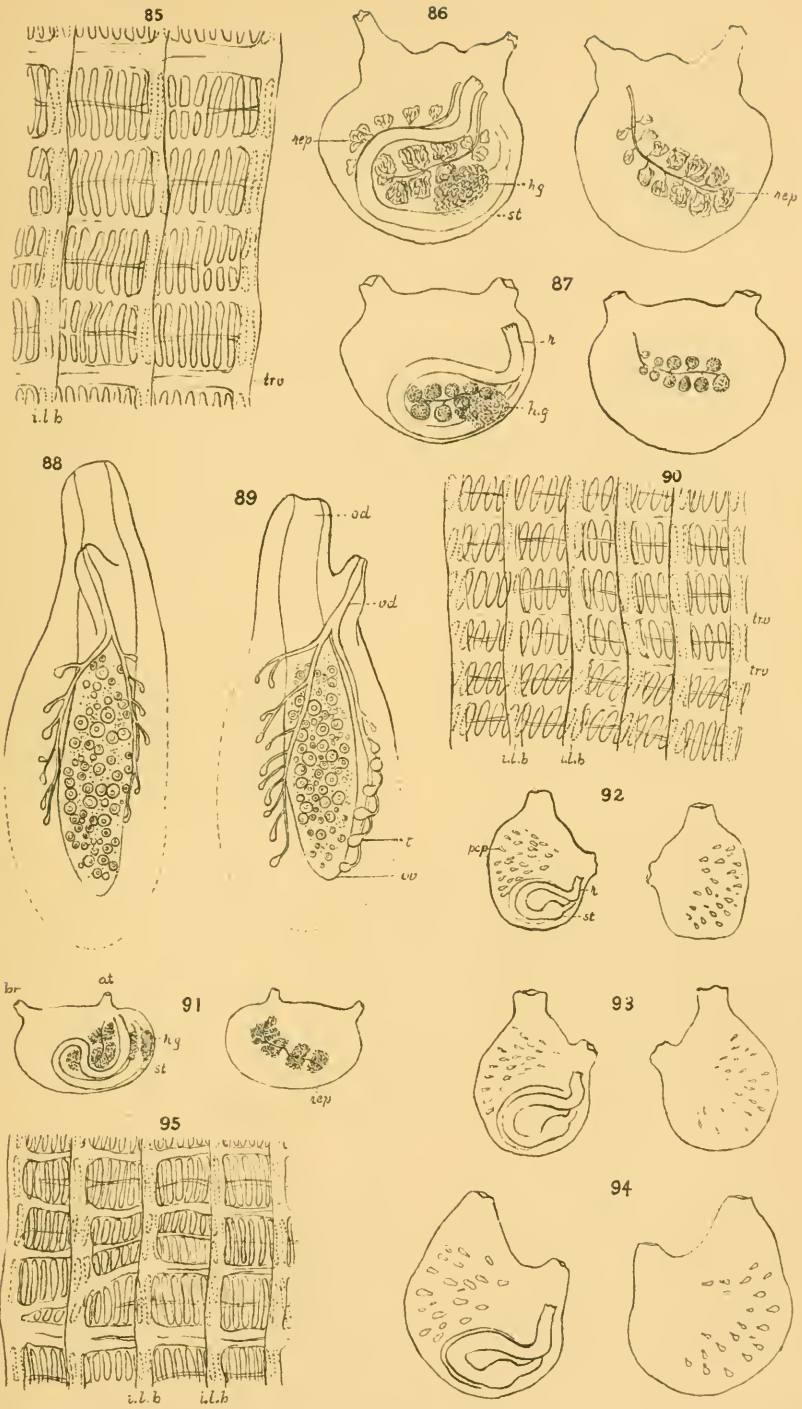
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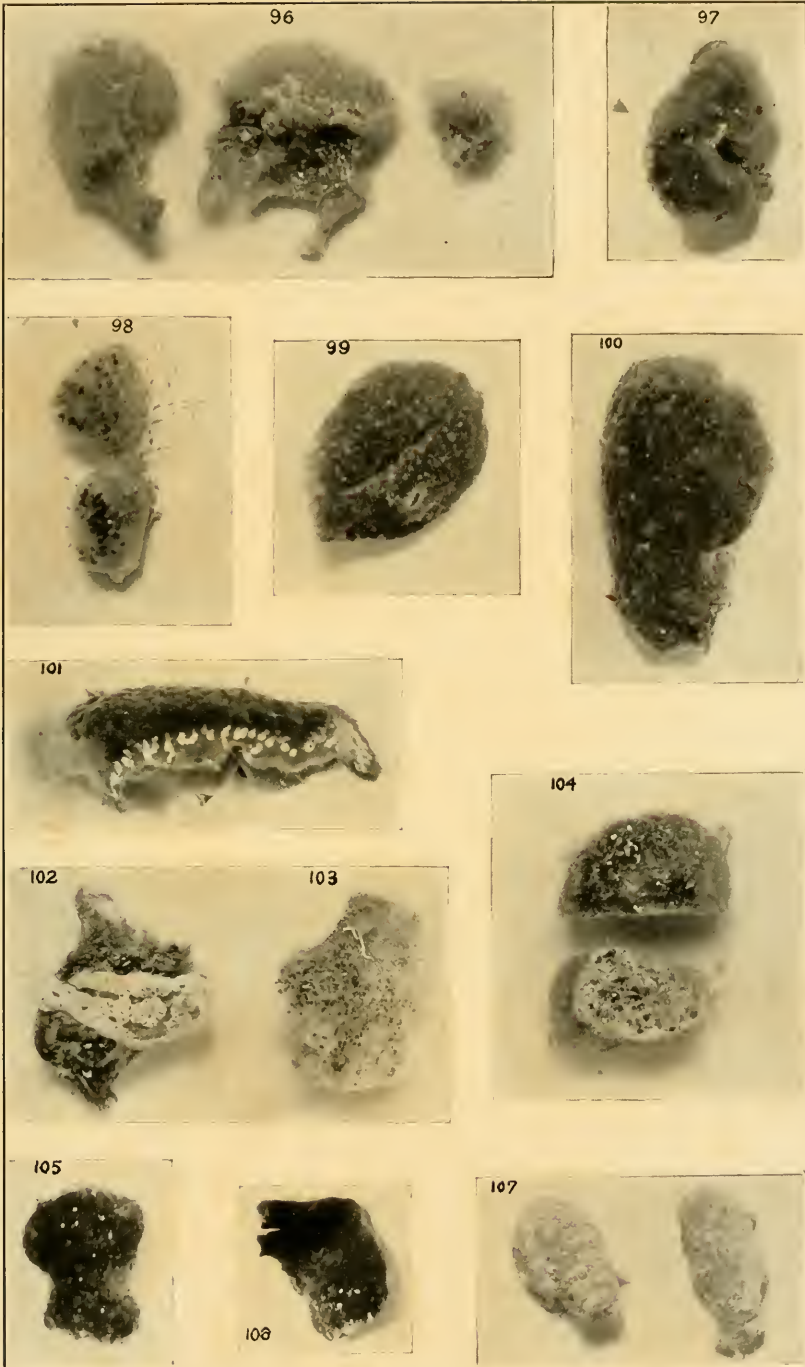


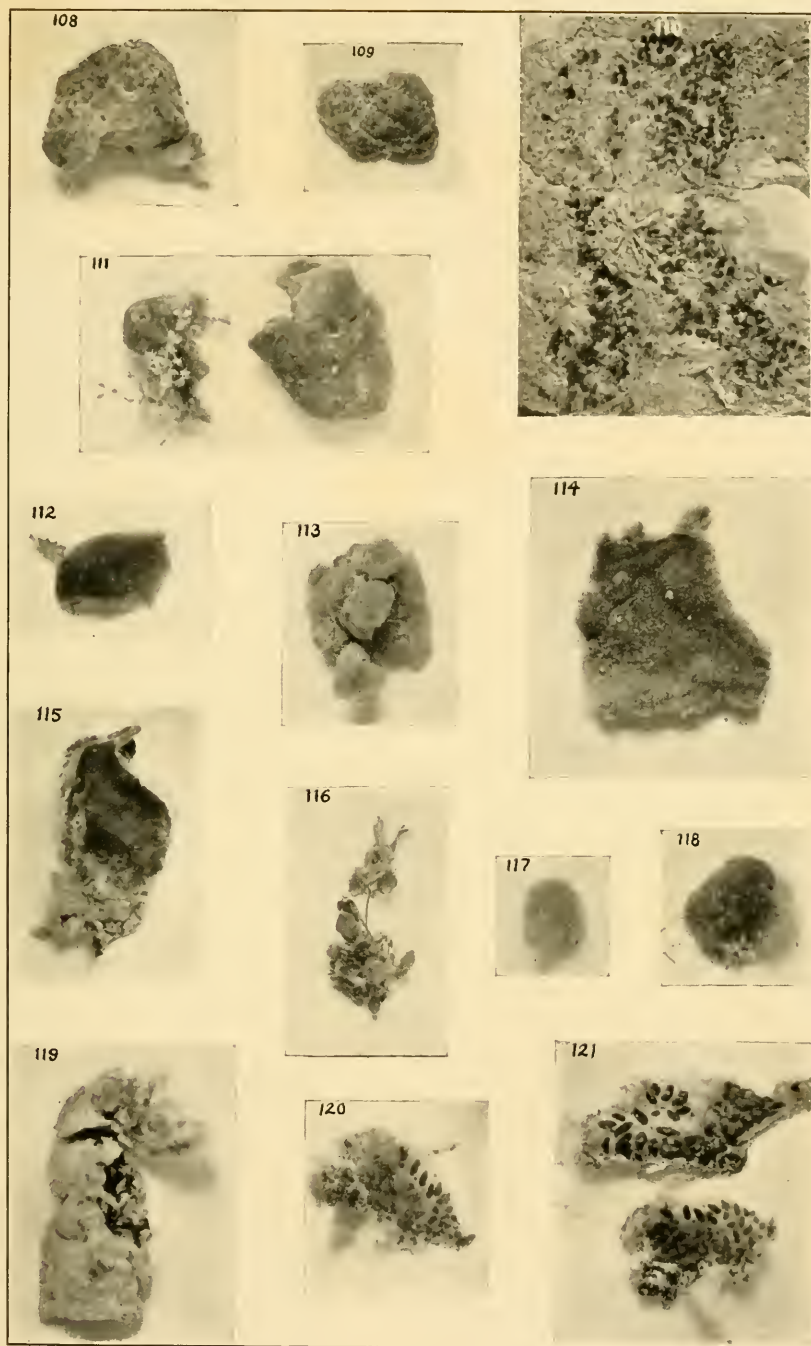
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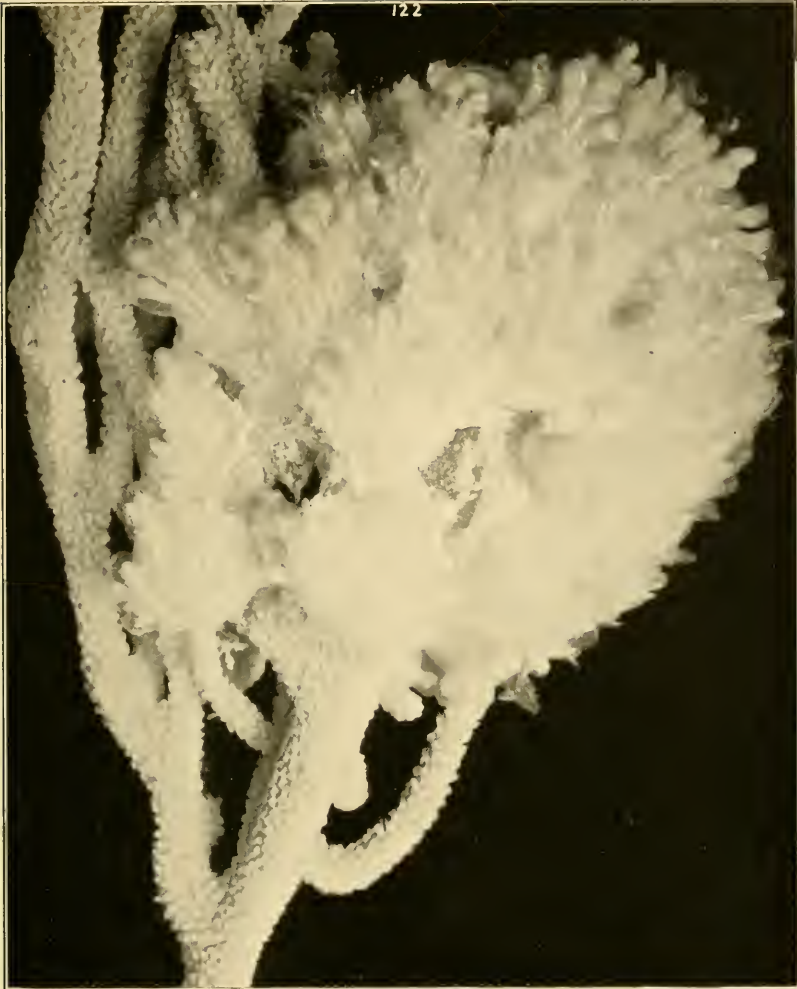
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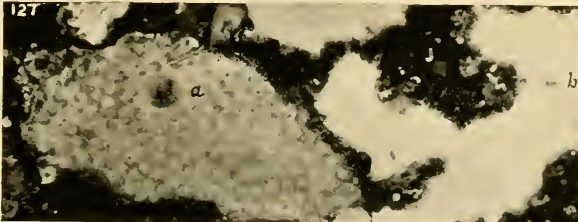
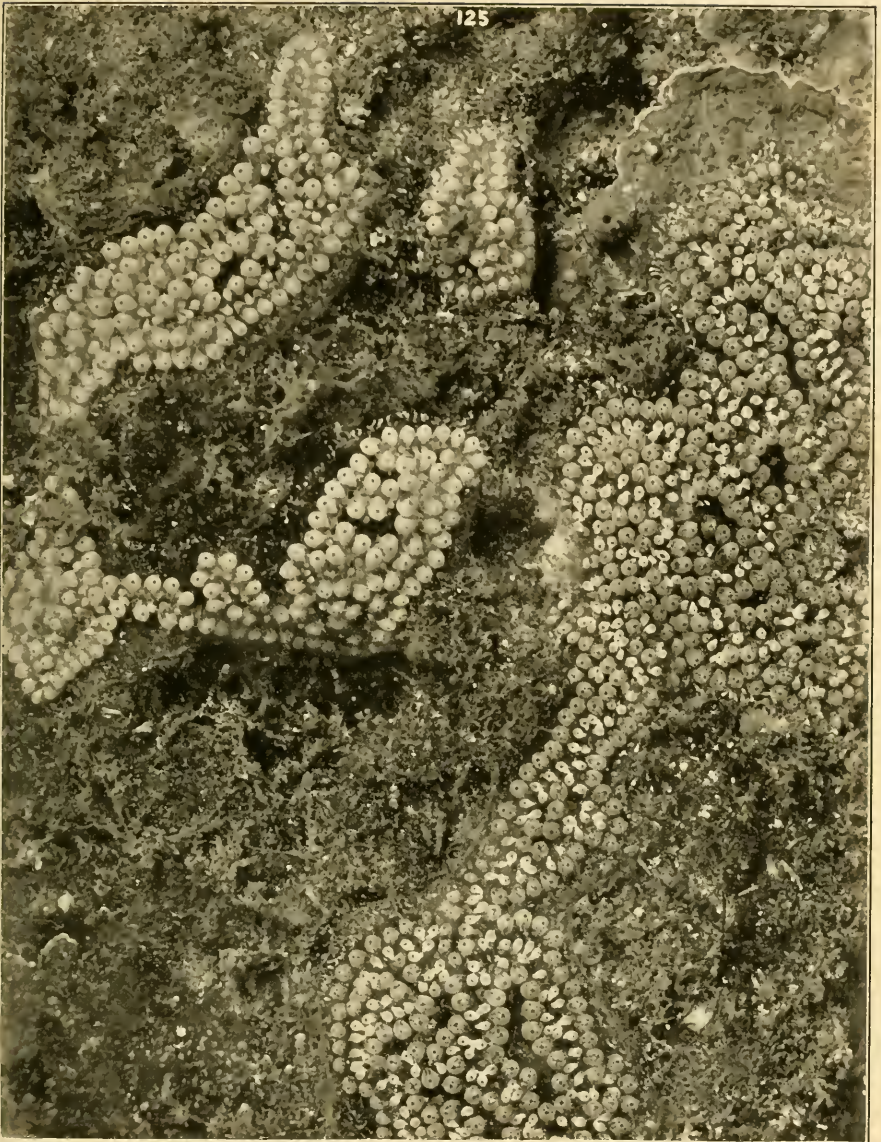




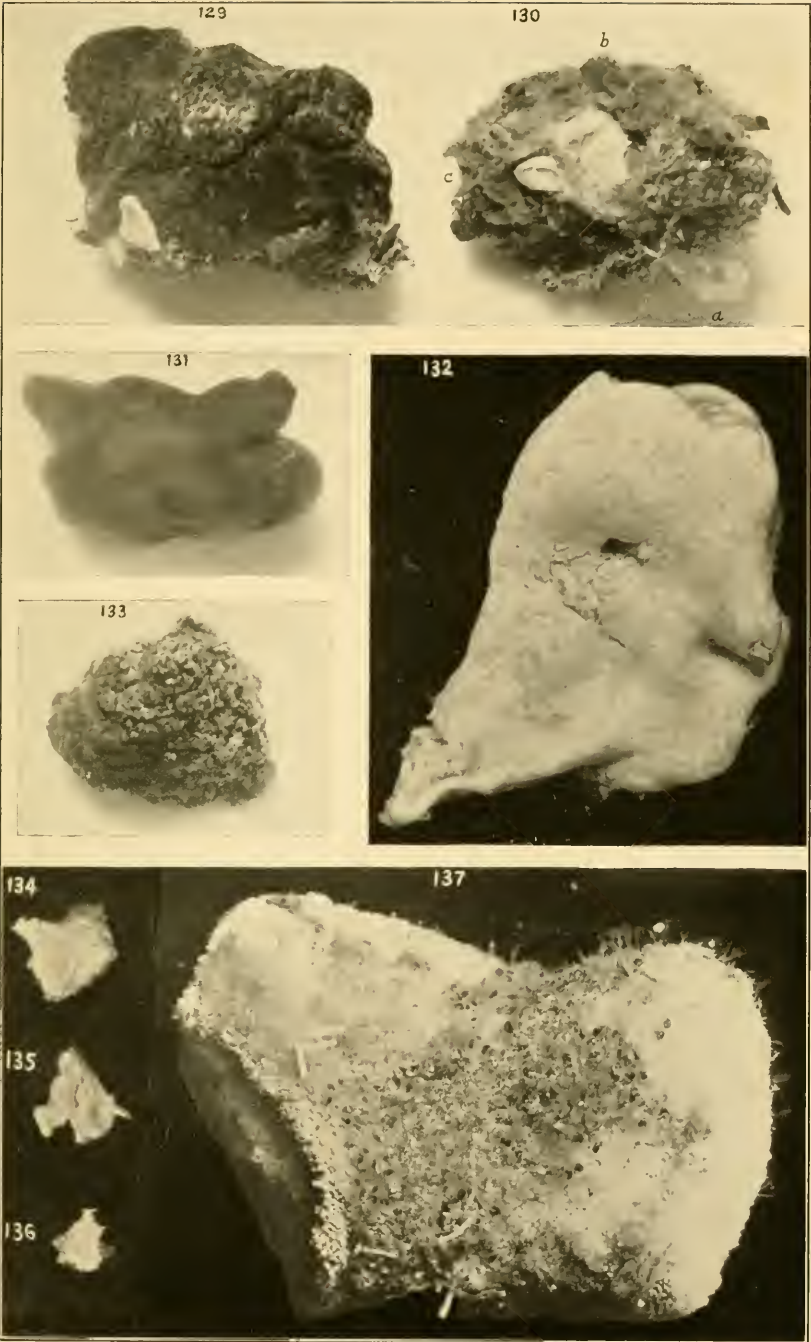




A. Hyatt Verrill, Photo.



A. Hyatt Verrill, Photo.



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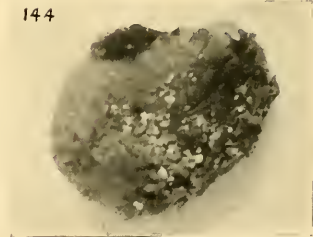
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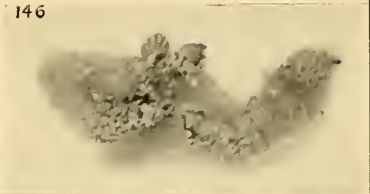


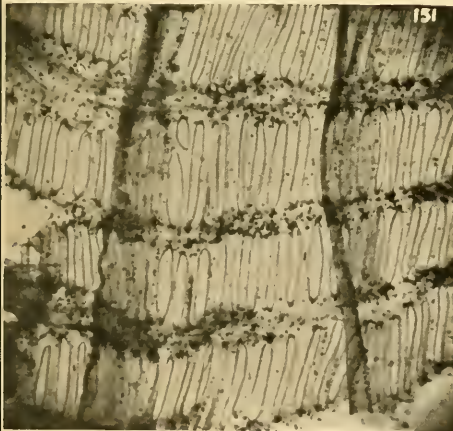
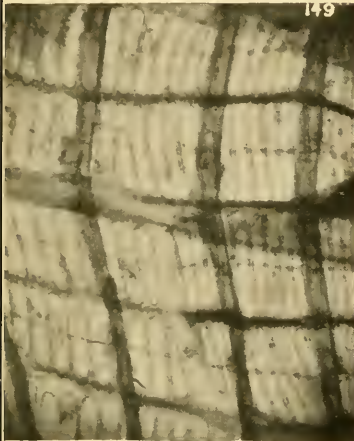
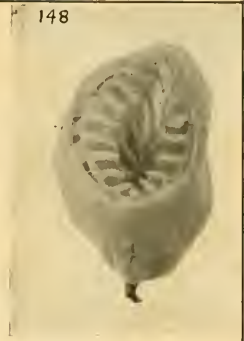
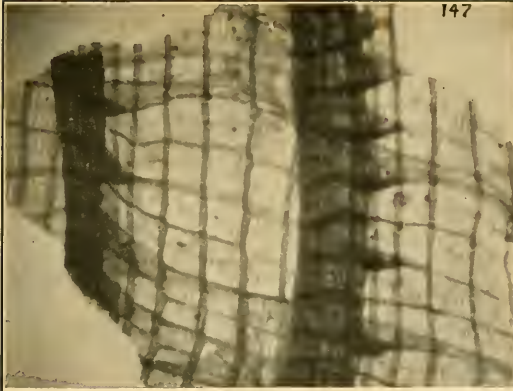
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