THE GENUS HALIMEDA

Siboga-Expeditie
LX

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BY

ETHEL SAREL BARTON
London

With four plates

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Historical.

The genus *Halimeda* belongs to the order *Siphoneae* in the group *Chlorophyceae*.

As represented by *Halimeda Tuna*, it attracted the attention of botanists more than three hundred years ago. The earliest record of it, under the name of *Sertolara*, is in "Dell' Historia Naturale" of Imperato, published in Naples in 1599; where, in addition to a short description, there is an excellent figure of the plant, natural size. Other old writers on Mediterranean plants included this species in their works, to which references are given below under the synonomy of *H. Tuna*. The most interesting of these accounts is given by Bauhin in his Historiae Plantarum lib. XXXIX. p. 802, published in 1651. Here the author describes the various parts of the plant and says it is known to sailors under the name of "Colique". He adds that Imperato sent specimens from Naples to Clusius under the name of *Sertularia*, and that Cortusius received it from Corsica. After referring to various other authors he adds that the plant makes a good dish when treated with vinegar, salt and oil and he concludes this quaint account with a list of the synonomy which existed even at that date.

In 1707 Sir HANS SLOANE includes *Corallina Opuntia* in his Natural History of Jamaica and the specimens there described are to be seen in his Herbarium preserved in the British Museum.

Ellis in "Essay Nat. Hist. Corall. 1755. p. 53", goes into greater detail over the two species now known as *H. Opuntia* and *H. incrassata*, calling them Articulated Corallines of Jamaica and giving figures of the magnified surface view of the joints. This work of Ellis was followed by the publication in 1786 of the Natural History of etc. Zoophytes collected by Ellis and arranged and described by Solander. Here we have for the first time descriptions under the binomial system of five species of the genus, called *Corallina*, and the figures, (natural

size) are so good as to remove all doubt concerning their identity, even in the absence of the original plants which have unfortunately disappeared. The author discusses the propriety of including the genus *Corallina* in the animal kingdom, and decides that the presence of the "calcareous covering" precludes the possibility of regarding them as plants. They may indeed, he thinks, form a connecting link between the two kingdoms.

In 1812 Lamouroux ("Sur la classification des Polypiers coralligères non entièrement pierreux" in Soc. Philom. N. Bull. Paris III. 1812. p. 186) divides off the six species known as *Corallina tridens*, *opuntia*, *monile*, *incrassata*, *Tuna* and *discoidea* from the genus *Corallina* and unites them under the generic name of *Halimeda*, of which he gives a short diagnosis. In 1816 the same author published his "Histoire des Polypiers Coralligènes flexibles" wherein he deals with the genus at some length and gives specific diagnoses and references to literature. Even this author, however, will have none of this genus in the vegetable kingdom and is inclined to be scornful about "a celebrated zoologist M. A. B", who declares *H. Tuna* to be a plant.

The first definite record of the inclusion of *H. Tuna* in the vegetable kingdom, under the name of *Hormisus opuntioides* would seem to have been in an unpublished MS. of Targioni-Tozzetti entitled "Catalogus vegetabilium marinorum". Bertoloni mentions this MS. in his Amoenit. Ital. 1819. p. 281 and gives *Hormisus opuntioides* as a synonym of his name *Fucus Sertolara* (Bertoloni l.c. pp. 224, 316), thus following Targioni-Tozzetti's example in regarding *Halimeda Tuna* as a plant. He says: "Cortice calcareo adventitio huc illuc obtegitur: sed cortex iste nullimodo ei proprius, nullumque in recenti pulpae animalis vestigium. Textura vegetabilis".

From this time onwards *Halimeda* was generally recognised as an alga and new species were created from time to time by various authors. Dr. Harvey's views on the species limits of *Halimeda* were broader than those of later writers and, as is shewn below in the systematic treatment, his breadth of view is more than confirmed by the present investigation.

Similar views as to species limits were not held by the late Prof. J. G. Agardh, who treats of the genus in Till Algernes Systematik VIII. p. 77—89. This author is however the first to suggest a fusion between the filaments of the central strand. He says: "Fila proprie axilia sunt semper numerosa et longitudinaliter excurrentia, invicem conspicue distantia et intertexta et sparsim forsan anastomosibus" . . . He then refers to the somewhat scanty knowledge of the fructification which is described by Derbès et Solier ("Mémoire sur quelques points de la Physiologie des Algues" in Comptes Rendus Suppl. T. I. 1856. p. 1—120. pl. 1—23); by Bompard as a parasitic alga, under the name of *Botryophora dichotoma*, (Hedwigia n°. 9, 1867. p. 129); and by Zanardini, (Iconographia Phycol. Mediterr. Adriat. vol. III, tab. CXII. 1871. p. 129).

In 1888, Professor Askenasy published an account of the algae of the *Gazelle* (Forschungsreise S. M. S "Gazelle". Th. IV. Bot. Alg. p. 11) and here for the first time is an attempt to classify the species on other than external characters. This author gives a fuller description of the internal structure of *Halimeda* than any previous writer and from an examination of the peripheral cells[1]) of the various species, pronounces these cells to be characteristic as regards form and size for

1) I would here explain my use of the term "peripheral cell" in speaking of the termination of the filaments at the periphery of the joints. We have no good word to express the "Rindenschlauche" of the Germans, for "peripheral tubes" does not quite meet the case and might lead to misunderstanding. The word "cell", though technically inaccurate, seems to me to be therefore preferable, especially since these structures have the appearance, in surface view, of cellular tissue.

the species. Under each species he gives the measurements both of the length and breadth of these cells and founds on these grounds a new species and a new variety.

The most important point in Professor ASKENASY's account of *Halimeda* is his description of the central strand of filaments. He shews that not only do these filaments run up like a midrib through the centre of the plant, but that all further growth originates in the first instance from them and that they approach each other at the top of each joint and grow together. He says: "Here their membrane becomes much thickened in places, whereby the connection is still more strengthened, while at the same time large circular or elliptical holes or pits are formed in a definite narrow zone, by means of which the contents of the tubes are placed in quite free communication with each other. Each tube has at the node several such holes and two or more tubes can communicate with each other through several holes".

He illustrates this by figures of the node of *H. incrassata*. Professor ASKENASY then goes on to describe the apex, where these pits are originally formed: "One sees then the central filaments running in a thick bundle to the apex and at the apex itself growing together for a short distance. Here are now formed the holes, which were mentioned above. Seen from above, the ends of the filaments of the central strand form an irregularly bordered group; they are to be distinguished at the first glance from the neighbouring peripheral cells by their considerable size".

The account given by Professor ASKENASY of the growth which takes place to form a new joint is not in all respects in accordance with my observations, which are given under "Internal Structure" on p. 5 below.

The result of an examination of the calcification in *Halimeda* is also given in this paper and as nothing further has been added to our knowledge in this respect, Prof. ASKENASY's results are quoted at length under the heading of Calcification below.

Our knowledge of the genus *Halimeda* was in this position when, by the kindness of Prof. JUDD, the Funafuti collection of *Halimeda* was placed in my hands for identification and examination: and a year later, unfortunately after the publication of the Funafuti results, Mad^me^ WEBER—VAN BOSSE was so kind as to entrust to me the working out of her large collection of this genus made by the Siboga-Expedition in the Dutch East Indies in 1899 and 1900.

This collection, together with the specimens of this genus in the British Museum and Kew Herbaria, and other collections which have with great kindness been lent me for comparison, have formed a sufficiently large series to allow of an attempt being made to delimit the species; with the result set forth below.

Morphological.

EXTERNAL FORM. *Halimeda* is composed of a series of calcified joints, connected end to end like the beads of a chain and branching di-, tri- or polychotomously. The individual plants vary in length up to about 40 cm. and may be prostrate, sparingly branched and straggling, or erect, much branched and forming a close short tuft. Between these two extremes is a large range of variety, probably dependent to a certain extent on depth and movement of the water. So far as I know, there are no records from collectors as to the effect of such

external agency on the habit of *Halimeda* forms; it is rare to find any record even of the depth at which a specimen was found living. At the coral island of Funafuti in the S. Pacific, plants of *Halimeda* grow at a depth of 45 fathoms on the outer slope of the reef, the principal zone being somewhere between 15 and 45 fathoms. The collections brought home from this island are not however large enough to furnish data for any generalisation on the effect of depth or external form.

The individual joints vary largely in size and form. They may be flat or rounded, and either semicircular, cuneate, trilobed, or cylindrical; with or without a thickened margin; ribbed or plane. Several varieties of joint may occur in one and the same plant.

In many species longitudinal ridges, which mark the position of the filaments of the central strand, may be seen running up the middle of each joint (internode). This is the ribbed condition mentioned above.

Calcification. As mentioned above, investigations on the calcification of *Halimeda* were carried out by Professor Askenasy and as I have no new facts to add to his results I quote his remarks in full.

"Most plants of *Halimeda* secrete carbonate of lime within their thallus, thereby giving rigidity and hardness to the joints. In rare cases only, the calcification is slight or entirely absent, as in the specimens of *H. macroloba* [1]) brought home by the *Gazelle*, in the oldest joints of which calcification occurs to only a slight extent. As a rule the calcium carbonate is deposited very early in certain parts, soon after the complete formation of the joint, and these deposits increase with age. Certain parts remain however uncalcified, such as the outer surface of the peripheral cells and in most cases the adjacent portion of their side walls. Hence it is possible, even in the oldest joints, to remove this superficial layer in the form of a thin membrane of uncalcified cellulose, by means of a section parallel to the surface. The only exception is *H. macrophysa*, in which the side walls of the peripheral cells are completely calcified, while the outer surface remains soft and uncalcified. Consequently the peripheral cells do not adhere together after treatment with acid, as is the case in other species, but lie quite free near each other. The secretion of calcium carbonate begins on the outer surface of the side walls of the peripheral cells and soon spreads over the entire space between them. The granules appear first as very small dark spots, which from their number give at first, by transmitted light, a brownish tint to those parts in which they occur. As the secretion continues, there is gradually formed, between the peripheral cells, a firmly connected calcified plate, which soon becomes quite opaque. A surface view of the thallus from above shews first the peripheral network mentioned above and, at a lower focus, the dark calcified mass which is seen to be interspersed with small, circular openings. These openings are the places where the stalks of the peripheral cells pass through the layer of calcification (Kalkplatte). The same thing is seen in a transverse section of the calcified peripheral layer.

According to an analysis of Payen, published in Flora I. 1844. p. 71 the substance of *Halimeda Opuntia* consists of 90.16 % calcium carbonate, 5.50 % magnesium carbonate, 0.54 % calcium sulphate and silica and only 3.8 % organic matter. Thin sections taken through the

1) *H. cuneata* Her.

calcified parts of *Halimeda* become somewhat transparent when mounted in Canada balsam; they shewed an illumination of the field with crossed nicols but to a markedly slight extent, much less, for example, than sections of *Galaxaura*; the best effect was produced from the portions of the calcified plate, which were in contact with the cell walls. The very small crystals of calcium carbonate are at right angles to the lumen of the cell, close to which they appear: this is shewn by the characteristic black cross in polarised light. The deposit increases with age, so that the plate continues to increase in thickness. Thus in the young joints of *H. cuneata*, it is 0.18 mm., in the older joints 0.5 mm. thick. These thick plates are also perforated by the branches of the filaments, in the form of tubes. The central strand remains always uncalcified.

From the above account it may be seen that the spaces between the different branched filaments of *Halimeda* form in each joint a connected system, bounded externally by the peripheral cells and the nodes. In a living condition this system is filled with a liquid of unknown composition. From the manner in which the secretion of calcium carbonate first makes its appearance, one might suppose, especially taking into consideration the conditions in other calcified algae, that these spaces were at least partially filled by swollen membranes. But after both decalcification and staining of *Halimeda*, no gelatinous matter was observed in the calcified portions and it is therefore to be supposed that the calcified plate is largely deposited as a crystalline precipitate from a liquid".

Root. This is sometimes bulbous and short, sometimes longer and cylindrical. It is composed of long, branched, colourless filaments varying in thickness, and often containing starch. These attach themselves to the sand on which the plants grow and a thick stout mass is often formed of over 4 cm. long and about 1 cm. thick.

Internal structure. The thallus of *Halimeda* is composed of continuous branched filaments, in which cross-walls are entirely absent. They form three distinct layers in each joint; 1, a strand of filaments, which runs up the centre of the plant from the root to the apex: 2, a network of branched filaments, the subcortical layer, derived from the side branches of the central strand by repeated divisions; this layer forms the main substance of the joint: 3, a single layer of „peripheral cells" [1]) which are however merely the termination of the filaments of the 2nd layer. These from being closely pressed together, shew a more or less hexagonal form, when seen in surface view. They vary largely in size and may be long and narrow, or short and broad. In form, they may taper gradually upwards from the subcortical layer, or they may widen suddenly from a very short, narrow base. This depends to some extent on the length of surface in contact and the manner of connection between the side walls of adjacent cells. This connection may be brought about in one of three different ways: either the side walls are in contact to a certain distance, varying in different species, and remain so after decalcification; or they lie entirely free in a chalky matrix and thus fall apart on decalcification; or they lie in a cellulose matrix, rendered visible on decalcification, and always remain connected. The manner of connection is not invariably constant in a species.

The diameter of all the filaments diminishes gradually as they branch and pass to the outer surface.

1) See note on p. 2.

The first of these three layers, the central strand, is the core on which the rest of the plant is built up by an elaboration of the branches which it gives off. The central filaments branch trichotomously as a rule, the middle branch of the three continuing its course as a portion of the central strand; while the two side branches push out laterally and themselves branch repeatedly to form the subcortical layer. Each filament of this layer ends in a crown of small branches which are the peripheral cells.

The growth of *Halimeda* is discontinuous, as is perhaps suggested by its jointed appearance. Whenever the filaments of the central strand have produced a certain length of internode, they cease growing and form the resting apex of the joint. At this point they are found in close contact, while in the rest of the joint below they always remain quite free from one another. At the apex, communication is established between the filaments in one of three ways.

1. In some species, as was shewn by Professor Askenasy, (l. c.) openings or pits are formed in the adjacent walls of all the filaments and thus free communication is established throughout the central strand. The pits are very large and numerous so that little remains of the actual walls, except on the boundary of the strand, where of course the pits are entirely absent. Thus all the filaments of the strand become welded into one continous whole. (figs. 34, 35, 36[a], 36[b], 46 and 48). On renewal of growth however, each filament begins again its separate individual course, continues this course unbranched throughout the node, and then, branching trichotomously, begins the formation of the subcortical and peripheral layers of a new internode (joint).

2. In other species, there is no general formation of pits, but communication is effected by fusion of the filaments in groups of two or three. The separate identity of the fusing filaments is completely lost and at the end of the resting period which follows the formation of a joint, the fused portion continues on as a single filament for some little distance to form the node; ultimately the filaments branch di-or trichotomously and begin the formation of the new joint (figs. 4[a], 4[b], 11[b], 16, 30).

3. The third method of communication resembles the second in so far as it is limited to adjacent filaments. But in this case the number of fusing filaments is always two and their identity is not completely lost, for immediately after the fusion they appear again as separate filaments (fig. 25).

As to the duration of the resting period, which follows the completion of each joint, nothing is known. It cannot however be at all prolonged, for a plant with small joints has been known to increase in length by several inches in 6 weeks, when grown under observation at Funafuti. But so far as I know no other experiment has been made on the rate of growth in this genus.

The branching of the plant as a whole is preceded by the branching of the central strand, which always takes place near the base of the joint. The several portions, 3—5, of the central strand run separately to the periphery of the joint in question, where they form separate apical points. At the next period of growth a new joint may arise from each apical point. In many cases however the central strand has branched without the resultant production of new branches of the plant, as the external marking (ribbing) clearly shews.

Cell-contents. Observations on the contents of the filaments in *Halimeda* have necessarily been most unsatisfactory, for want of properly prepared material. I am only able to confirm

Professor Askenasy's results as to the presence of both chlorophyll grains and starch in all parts of the joints. Of the nuclei and cytoplasm I can say nothing at present and can only hope that good material may soon be obtained on which to work out the details of the cell-contents.

Fruit. References to the literature bearing on the fructification are given in the historical summary above.

In this summary, reference to Professor Schmitz' paper "Die Bildung der Sporangien bei der Algengattung *Halimeda*" (Sitzungsber. d. Nied. rhein. Gesellsch. Bonn. 14 Juni 1880. p. 140) has been inadvertently omitted. He describes at some length his observations on the fructification of *H. Tuna* and *H. platydisca*. For the sake of comparison with *H. Tuna*, he refers to a figure by Zanardini (Icon. Phyc. Adriat. et Medit. vol. III. tab. CXII. 1871) of a fertile plant of *H. macroloba*, but the figure in question is described by Zanardini as that of *H. Tuna*; so that the contrast drawn by Professor Schmitz must be considered valueless.

Up to the present time sporangia have only been described on *H. Tuna*, *H. platydisca* and *H. macroloba*. The filaments of the central strand appear to grow out from the margin or from the face of a joint and bear small globose or obovate bodies on short stalks, which contain the zoospores. A description of these zoospores after they have escaped from the sporangium is given by MM. Derbés et Solier l. c. p. 47. "C'est toujours une portion postérieure, arrondie, de couleur verte, et une portion antérieure conique, hyaline. Le rostre nous a paru quelquefois prendre une longeur, une extension relativement très-considérable. Nous avons aperçu plusieurs fois, très-distinctement, deux appendices flagelliformes partant du sommet du rostre, et un autre attaché à la partie postérieure; d'autres fois, ce dernier manquait. Chez d'autres, il n'en paraissait qu'un seul au sommet du rostre, et très-souvent nous n'avons pu en apercevoir aucun, soit en avant, soit en arrière. Quant aux mouvements, ces zoospores sont tout-à-fait comparables aux autres. Nous n'avons pu obtenir ni dépôts ni germinations".

These authors do not mention any sign of conjugation. It is much to be desired that further investigation on the fructification of the various species of this genus could be carried out on living material.

Geographical Distribution. *Halimeda* flourishes principally within the tropical zone, but is not confined to it; for *H. Tuna* is a fairly common plant in the Mediterranean and Adriatic, reaching as far N. as $45^1/_2°$ N. Lat., while *H. cuncata* descends as far as to 32° S. Lat. on the West coast of Australia and to 34° S. Lat. on the East coast of S. Africa.

By some extraordinary chance no less than three species of *Halimeda* are recorded in literature from Kamtschatka: *H. discoidea* Decne, *H. multicaulis* in Kützing's Species Algarum p. 504 and *H. cuncata* Hering in Kützing Tab. Phyc. vol, VII. p. 8. where the detail "Südspitze von Kamtschatka" is added. I have seen in the Kützing Herbarium the original plant of "*H. cuncata*" here figured and find it is *H. gracilis*, which is confined to the tropics. The Decaisne specimen of *H. discoidea*, which I have also seen, bears the inscription: "Kamtschatka, Voyage de la Vénus". It can only be supposed that these plants were drifted to the north by the Japan current and were picked up by the various collectors; for the temperature of the sea round the coasts of Kamtschatka would not allow of the growth of any species of *Halimeda*.

Another unlikely record is that made by Dr. Fleming in his "History of British Animals",

1828. p. 515. He says of *H. Opuntia*: "This species has not hitherto been recorded as a British zoophyte, but is said to inhabit the Atlantic and Mediterranean. I, however, possess a specimen, formerly belonging to the late Dr. WALKER, to which the following note was annexed, in his own handwriting: "Submarine plant from the rocks at Salterness, in Kirkbane. An Bombycina? It covers the rocks with a close turf". It thus appears to be a native of the shores of the Solway Firth. When a joint was macerated in weak acid, the branched tubes supporting the polypi appeared as they are represented by Ellis, ib. tab. xxv. f. A. 1".

What this plant can have been that "covered the rocks with a close turf", it is difficult to say. It could certainly not have been *H. opuntia*, which is confined to the tropics.

Within the tropical zone, in both hemispheres, the genus is well represented and in the Pacific it helps to build up the coral reefs, as is shewn by the presence of *Halimeda* joints in the borings from the floor of the lagoon at Funafuti. Down to 50 feet below the floor of the lagoon, the joints were sufficiently well preserved to shew the large central filaments on decalcification, and at nearly twice that depth joints of *Halimeda* were still to be recognised by their form. It is possible that joints of the same species may be found in the sections of the core brought up from still greater depths.

The geographical distribution of each species will be found below under its own name.

METHODS. The simplest method of preparation for an examination of the peripheral cells of *Halimeda* in surface view is to decalcify with Perenyi's fluid and then to tease out with needles. For a side view of the peripheral cells in some species (*H. Tuna* and *H. cuneata*) it is necessary to cut a section of the thallus and this is most easily done with a scalpel before decalcification, the section being afterwards treated on a slide with Perenyi's fluid.

For an examination of the node it is best to decalcify and then to place on a slide in a drop of strong Eau de Javelle, till the cell-contents have cleared away. Then stain with methylene blue dissolved in alcohol and afterwards tease or not as may be necessary. The whole operation takes about five minutes when once the preparation has been decalcified.

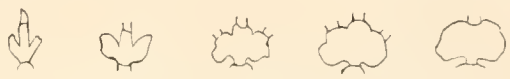
I would gratefully acknowledge my indebtedness to Mad^me^ WEBER—VAN BOSSE for her most kind invitation to work out the collections of *Halimeda*, brought home by the "Siboga" and for lending me specimens from the Kützing and Hauck Herbaria: to Professor ASKENASY, who has lent me many specimens from his Herbarium and has taken much kind interest in my work: to M. HARIOT, who has allowed me to have for examination and study the Decaisne and Bory types in the Paris Museum and has given me much kind encouragement; to M. BECCARI for lending me a type specimen of Zanardini: to Professor NORDSTEDT for taking much trouble in procuring me good photographs of plants, of which he was unable to send me the originals: to Dr. PERCEVAL WRIGHT for lending me some of the Harvey specimens from Trinity College, Dublin: and to Professor ENGLER for allowing me to have a type specimen from the Berlin Museum for examination. I also here gratefully record the kindness shewn me by the late Professor J. G. AGARDH, in lending me the type of *Halimeda cordata*. He wrote to me that at his advanced age it was an effort to him to part with a valuable type specimen even for a few days: but he was kind enough to make the sacrifice and the letter he wrote acknowledging its return was followed a few days later by the news of his death. To Mr. V. H. BLACKMAN

of the British Museum I offer my grateful thanks for his most valuable criticism and suggestions during the writing of this paper; and to all the officials of the Botanical Department I express once more my warmest acknowledgements for the continuation of that kindness and courtesy they have always shewn me and for a share of the ready help and interest which they extend to all visitors to the Department.

Systematic.

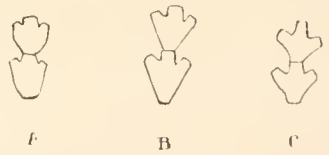
Up to the present time the species of *Halimeda* have all been founded on external characters, with the exception of one species, *H. macrophysa* Ask. and one variety *H. Opuntia* Lam. var. *macropus* Ask., which are both based on the size of the peripheral cells as seen in surface view. Consequently many species have been made and as many more might still be made, for the form of the joints varies very largely and is rarely constant even in individual plants.

Owing to the opportunity of examining large collections, I was able to link together the existing species by so many intermediate forms as to prove the instability of external characters as a basis of classification. Indeed the connecting links were so complete that it would have been necessary, using these characters alone, to reduce the number of species to two; one having flat, unribbed, more or less discoid joints, and the other, joints ribbed and trilobed.



Joints of *H. Opuntia*; all from one plant.

It was however possible that some anatomical character might be found, sufficiently stable to enable one to divide sharply into species this mass of apparently confused forms. To this end the size of peripheral cells, depth of calcification and chromatophores were compared. None of these characters proved any more stable however than the external form, but at last a comparison of the filaments of the central strand at the apex of each joint shewed a marked difference even in plants which were externally very similar. As has been said above, communication between the central filaments as a whole was shewn by Professor Askenasy to take place in *H. incrassata* and *H. macroloba* by means of openings or pits; (figs. 34, 46.) but an examination of apparently typical specimens of *H. Opuntia* Lam., the commonest and most variable species of the genus, shewed an entire absence both of the pits and of the consequent welding of the strand into one connected mass. On the contrary, at the apex of each joint where they naturally become pressed together owing to constriction, it was seen that communication was the result of a breaking down of the side walls between each pair of adjacent filaments. The fusion is however not complete, for in the node the two partially fused filaments are again quite free and continue so in the next joint, branching at intervals, till they again come into contact at its apex (fig. 25).



A. *H. gracilis.*
B. *H. incrassata.*
C. *H. Opuntia.*

This mode of communication between the central filaments was found to be constant in most of the plants ascribed to *H. Opuntia*, but it was also found in the types themselves of *H. cordata*, *H. Renschii* and *H. triloba*. These species were, in the various collections, all connected by intermediate forms with *H. Opuntia*, so that for want of any distinguishing feature I have been compelled to place them all under *H. Opuntia*.

An examination of a Harvey specimen of *H. gracilis*, which often resembles *H. Opuntia* externally, shewed that though the filaments also unite in pairs at the apex of each joint, as in *H. Opuntia*, the fusion is complete and the two filaments continue their course as one. This filament remains unbranched in the node, but branches above, always *trichotomously*, to form the new joint. (fig. 30).

Most of the forms ascribed to *H. Tuna* exhibited still another type of fusion, somewhat resembling that of *H. gracilis*. The same complete fusion takes place between adjacent filaments at the apex of each joint, but the number of filaments which fuse together may be two or three, and instances of both occur in the same joint. The filament, resulting from the fusion, branches later di-or trichotomously, no regularity being observed. (figs. 4^a, 4^b).

In some plants however, owing to the large surface of the filaments in contact at the apex of the joint, they remain attached to each other after treatment and do not easily drop apart as in the plants of *H. Tuna*.

Many forms ascribed to *H. cuneata* shewed a similar type of fusion to that of the plants of *H. Tuna*.

An examination of all but two of the various species which have been described, shewed that there was a definite number of types into which all the various methods of intercommunication of the central filaments in *Halimeda* could be arranged.

It is obvious then that such a character serves as a convenient basis for a classification of the genus and by its use (and by the help of the character of the peripheral cells in two cases) I have been able to define seven distinct species.

Classification by means of this character does not run counter to the old lines of classification, many of the older species being, in the main, rightly defined, but their limits were far too narrow.

The species having been clearly defined, it was possible to gain an idea of the range of variation within the species limit.

The great range of variation, which appears to be so common in marine forms of life, has been a source of much confusion to workers at this genus. Owing to lack of opportunity of examining large numbers of plants together, it was difficult for them to realise the existence of many connecting links, and plants were described as new species which a large collection would have shewn to be but varying forms of existing species. So complete is the series of links connecting all the forms of variation that no form can be regarded as constituting a definite "variety"; but for practical purposes it is advisable to indicate the chief lines of variation within the species, defined by structural characters. The older species and varieties being based on external characters serve fairly well for this purpose, so that for the present I have kept them up as forms under the species as they now stand; and where forms shewing a new line of variation have not hitherto been clearly distinguished, I have placed them under a new form name. By arranging thus the various forms under the species, I have tried to give some idea of the extent and different lines of variation within the species limit.

Under "forma *typica*" I have always given the characters of the first described form of the species.

SIPHONEAE.

Halimeda Lamouroux.

Synopsis of species of *Halimeda*.

A. Central filaments do not fuse, but communicate directly with one another by means of large open pits. (Sometimes in small plants of *H. incrassata* the pits are few or wanting). Filaments at apex of node hang together under treatment.

1. Joints flat, broad, oval or rounded in outline. . . . . 6. *H. macroloba.*
2. Joints thickened below, often cylindrical, upper ones sometimes flattened and trilobed . . . . . 7. *H. incrassata.*

B. Central filaments fuse; usually in pairs or in threes, very rarely more, at the apex of each joint. Filaments separate easily under treatment, except *H. cuneata.*

a. Filaments fuse in pairs. Joints ribbed, much calcified.

1. Fusion incomplete, limited to the surface of contact of lateral walls. 4. *H. Opuntia.*
2. Fusion complete. Fused portion branches later trichotomously in the next joint . . . . . 5. *H. gracilis.*

b. Filaments fuse in twos or threes, very rarely more, branching di-or trichotomously in the next joint. Joints not ribbed, slightly calcified, flat; discoid or cuneate.

1. Lateral walls of adjacent peripheral cells in contact for a quarter to half their length. Filaments hang together at apex of joint under treatment. 2. *H. cuneata.*
2. Lateral walls of adjacent peripheral cells in contact for a very small fraction of their length ($^1/_{25}$ to $^1/_{10}$). . . . . 1. *H. Tuna.*
3. Lateral walls of peripheral cells entirely free; the cells very large in surface view, (about 150 μ in diameter). . . . . 3. *H. macrophysa.*

1. *Halimeda Tuna* Lam.

"Sur la Classif. d. Polyp. corall." etc. in Soc. Phil. N. Bull. Paris III. 1812. p. 186.
Sertolara Imperato, Hist. Nat. 1599. p. 748.
Lichen marinus Clusius, Rar. Plant. Hist. Lib. VI. 1601. p. CCL.
Corallina latifolia and Opuntia marina Cortusi, ex Clusius l. c.
Fucus folio rotundo Bauhin, Pinax. 1623. p. 364.
Lichen marinus rotundifolius Gerard, emac. 1633. p. 1567. (The block used by Clusius came into the possession of Johnson, who used it in this work).
Opuntia marina Parkinson, Theatr. Bot. fol. 12 1640. p. 1294. Ray 77. 5.
Scutellaria sive Opuntia marina Bauhin, Hist. Plant. lib. XXXIX 1651. p. 802. (This author gives an excellent figure of *H. Tuna.*
Sertularia, Opuntia marina Chabraeus, Stirp. 1666. p. 572.
Sea Band-strings Petiveriana Naturae Collectanea I. 1716.
Opuntia marina ou Sertolare Imperato, Marsilli Hist. Phys. de la Mer 1725. p. 65. pl. 7. fig. 31. pl. 8. fig. 32.
Sertularia ramosissima, articulis reniformibus compresso-planis trichotomis Linn. Hort. Cliff. 1737. p. 480. in part.
Sertularia etc. Royen, Flor. Lugd. 1740. p. 523.
Corallina Opuntia Linn. Syst. Nat. vol. I. 1760. p. 805 in part et Ed. 12. 1766. p. 1304 in part.
Corallina Opuntia Pallas, Elench. Zoophyt. 1766. p. 420 (excluding synon. in part).
Corallina Tuna Ellis et Solander, Nat. Hist. Zooph. 1786. p. 111. Tab. 20. fig. e.
Corallina discoidea Esper, Pflanzenthiere Th. II. Corallina. 1798—1806. Tab. XI.

Halimeda Tuna Lamouroux, "Sur l. Classif. d. Polyp. corall. etc." in Soc. Phil. N. Bull. Paris III. 1812. p. 186.
Halimeda discoidea Lamouroux, d°.
Flabellaria tuna Lamarck, "Sur l. Polypiers empâtés" in Ann. Mus. Hist. Nat. tom. 20. 1813. p. 302.
Halimeda Tuna Lamouroux, Hist. Polyp. Corall. 1816. p. 309. Tab. XI. fig. 8.
Fucus Sertolare Bertolini, Amoenit. Ital. 1819. pp. 224, 316.
Halimeda Tuna Lamouroux, Expos. Meth. 1821. p. 27. Tab. 20. fig. c.
Halimeda Tuna Lamouroux, Corallina, 1824. p. 139. pl. XI. fig. 8. *a, b.*
Hormisus opuntioides Targioni-Tozzetti, Cat. veg. mar. M. S. p. 291. fide Bertoloni l. c.
Opuntioides Mich. Tab. ined. 65. Optima. Herb. Mich. fide Bertoloni l. c.
Ulva Sertolara Pollinius., Fl. Veron. vol. 3. 1824. p. 507.
Codium Opuntia Sprengel, Syst. veg. IV. 1827. p. 366.
Opuntia reniforme Naccari, Flor. Ven. vol. VI. Append. 1828. p. 104. n°. 1342.
Flabellaria Opuntia Delle Chiaie, Hydrophyt. 1829. p. 9. tab. X.
Sertolara typus Nardo Oken. Isis 1834. p. 673.
Halimeda Sertolara Zanardini, Syn. Alg. Adriat. 1841. p. 226. Tab. IV. fig. 1.
Halimeda Opuntia De Notaris, Alg. Mar. Ligust. Spec. p. 297. n°. 70 in Mem. R. Accad. Sci. Turin, Ser. II. Tom. IV. May 1842.
Halimeda discoidea Decaisne, Mém. sur l. Corallines in Ess. Classif. Alg. et d. Polyp. calcif. 1842. p. 91.
Halimeda Tuna d°.
Halimeda platydisca d°.
Halimeda Lessonii Bory ex Chauvin Recherches 1842. p. 125.
Halimeda Tuna Kutzing, Phyc. Gen. 1843. p. 310.
Halimeda Tuna Kutzing, Spec. Alg. 1849. p. 504.
Halimeda discoidea d°.
Halimeda papyracea Zanardini, in Flora 1851. p. 37.
Halimeda discoidea Kützing, Tab. Phyc. vol. VII. 1857. p. 8. tab. 21. fig. IV.
Halimeda macroloba d°. tab. 22. fig. 1.
Halimeda Tuna Harvey, Nereis Bor. Amer. 1858. p. 25. Tab. XL. A.
Halimeda papyracea Zanardini, Pl. Mar. Rub. in Mem. Ist. Ven. vol. VII. 1859. p. 288.
Botryophora dichotoma Bompard, Alg. nov. etc. in Hedwigia n°. 9. 1867. p. 129.
Halimeda Sertolara Zanardini, Icon. Phyc. Adriat. 1871. p. 129. vol. III. Tab. CXII.
Halimeda Tuna forma *Albertisii* Piccone, Risult. Alg. d. croc. d. Violante in Ann. Mus. Civ. Stor. Nat. vol. XX. 1884. p. 114. fig.
Halimeda Tuna Hauck, Meeresalgen 1885. p. 482. fig. 212.
Halimeda Tuna Ardissone, Phyc. med. p. 174. in Mem. Soc. Critt. Ital. vol. II. 1887.
Halimeda Tuna J. G. Agardh, Till Alg. Syst. V. 1887. p. 80.
Halimeda Tuna De Toni et Levi, Fl. Alg. Ven. Pt. III. 1888. p. 109.
Halimeda Tuna De Toni, Syll. Alg. vol. I. 1889. p. 518.

Hab. MEDITERRANEAN. — Mediterranean, *Salvadore*! sub nom. "Fucus folio subrotundo", Herb. Sloane vol. 147. fol. 4. *Bonelli*! — Lesser Balearic Islands, *Wittrock and Nordstedt*!, Alg. exsicc. n°. 340. — Marseilles, *Algae Schousboeanae*!, sub nom., "Corallina Opuntia Schousboe", n°. 84. — Marseilles, *Herb. Mus. Brit*! *Hohenacker*!, Alg. mar. sicc. n°. 12. — Antibes, *Herb. Dickie*! *Lenormand*! — Nice, *de Notaris*! — Cagliari et Pirano, *Erb. Crittog. Ital*!, ser. II. n°. 282. — Pirano, *Rabenhorst* Alg. Europa's!, n°. 1135. — Albissola, *Erb. Crittog. Ital*!, n°. 283. — S. Nazzaro, Genoa, *Bompard*!, Erb. Crittog. Ital, ser. II. n°. 72. — Nisita, *Cramer*! — Naples, *Nägeli*! — Adria, *Grunow*! — Argostoli, *Schimper et Wiest*! — Dalmatia, *Herb. Shuttleworth*! — Algiers, *Herb. Shuttleworth*! *Marcucci*!, Un. itin. crypt. 1866. n°. XXIX. — Sardinia, *Frölich*. — Telegraph Cable, Malta, *Gibson*!, "This weed appears at depths from 25 fathoms to 40 fathoms". — Corfu *Lyall*! — Phaleron, *Herb. Rasch*! —

ATLANTIC. Tangier, *Rüben*! — Canaries, *D'Orbigny*!, Hb. Mus. Paris; type of *H. platydisca* Decne. — St. Vincent, Cape de Verde, *Challenger*! *Welwitsch*!, Iter Angolense, n°. 247. — Antilles, *Herb. Shuttleworth*! n°. 298. — "Carolina, Bermudas or Caribees", *Clerk*!, in Herb. Sloane vol. 318. fol. 48. — Barbadoes, *Herb. Dickie*! — Walsingham, Bermuda, *Farlow*! — Guadeloupe, *Mazé*!, n°. 74, ser. I n^os. 33, 148^bis, 390, 3790. — Jamaica, *Sloane*! Herb. Sloane vol. I. fol. 2. — Key West, *Harvey*! *Hooper*!, Alg. exsicc. Am. Bor. Farlow, Anderson and Eaton n°. 41. *C. Messina*!, Phycotheca Bor.-Amer. Collins, Holden and Setchell, n°. 167. — Jupiter Inlet, *Curtiss*!, Algae Floridanae ser. I. — Sisal, Yucatan, *Schott*! n°. 786. — Barra Grande, *Challenger*! — Nicoga, Central America, *Herb. Berkeley in Herb. Kew.*! —

INDIC. Mauritius, *de Robillard*! — Rodriguez, *I. B. Balfour*! — Zanzibar, *Stuhlmann*!, I. n°. 1205^a. — Dar es Salaam, *Holst*!, n°. 1264 pro parte. — Aden, *Ferguson*!, n°. 444. — Ceylon, *Harvey*!, n°. 70. *Ferguson*!, n°. 67. — Singapore, *Beccari*!, sub nom. H. papyracea Zan. — Endeh, Flores, *Weber van Bosse*!, n°. 1110. — Maumeri, Flores, *Weber van Bosse*! n°. 1032. — Pare-Pare, Celebes, *Weber van Bosse*. — de Brill, *Weber van Bosse*!

Siboga-Expedition. Labuan-Badjo! — Key dula, reef! — Tual, reef! — Elat, Great Kei Island, reef! — Buka Bay! — Rotti, reef! — Sumba, Nangamessi! — Fau! — Kabala dua! — Sarasa, Postillon Islands! —

PACIFIC. Parry Shoal, Arafura Sea, *Bassett Smith*! — Macclesfield Bank, China Sea, *Bassett Smith*! — Funafuti, *David*! in Herb. Mus. Brit. n^os. A. 21 pro parte, A. 58. B. 10, 11 and 12. — Ovalau, Fiji Islands, *Graeffe*!, in Herb. Grunow. — Fiji Islands, *Herb. Mus. Brit*! — Mangaia, *Gill*! — Upolu, *Herb. Mus. Brit*! — Friendly Islands, *Home*! *Harvey*!, n°. 21 pro parte. — Minerva Reef, "*Herald*"! — Tongatabu, *Graeffe*! *Challenger*! — Borabora, Society Islands, *Bory de St. Vincent*!, in Herb. Mus. Paris sub nom. *H. Lessonii*. — Sandwich Islands, *Home*! — Victorian Bank, *M^c Donald*! 54$\frac{3}{3}$92. — Payta, Peru, *Sinclair*! — Kamtschatka, "*Voyage de la Venus*"!, in Herb. Mus. Paris sub nom. "*H. discoidea*". —

Plants varying in length to about 20 cm., generally much less; slightly incrusted with lime, branching in one plane. Root short, more or less bulbous. Lowest joint more or less thick, cylindrical or cuneate, often deeply calcified; thickening sometimes extends to several joints above the root. Other joints slightly calcified, varying in form from flat and discoid to elongate-cuneate, not ribbed, margin entire; varying in size to 35 mm. long, 22 mm. broad, averaging 1 mm. thick [1]). The small joints are as a rule much thicker than the large ones, the largest being very thin.

Filaments of central strand fuse in twos and threes at the apex of each joint, the fused filaments varying in length, branching later di-or trichotomously. Filaments as a whole not connected at the point of fusion.

Peripheral cells as a rule regularly hexagonal in surface view; 40 μ to 75 μ across, 75 μ to 100 μ long; sum of length and breadth fairly constant. Side walls of adjacent cells in contact for $^1/_{25}$—$^1/_{10}$ of their length.

forma *typica*.

H. Tuna Lam.

Upper joints small, sometimes rather thick; reniform, discoid, or transversely oblong (fig. 1).

1) The numbers given in relation to external characters refer only to the extremes which have come under my notice. I have, of course, no desire to constrain the species within these limits.

forma *platydisca*.

H. platydisca Decne.

Upper joints large, thin; reniform, discoid or transversely oblong (fig. 2).

forma *Albertisii*.

H. Tuna forma *Albertisii* Piccone.

Joints elongate-cuneate, lower ones often deeply calcified and thick; upper margin rounded (fig. 3).

The list of synonomy under this species is a long one. It will be seen that some of the old authors confused *H. Tuna* and *H. Opuntia*, but since the two species are themselves so distinct externally it is not difficult to determine to which species the descriptions and plates refer.

The names of *H. platydisca* Decne, *H. discoidea* Decne, *H. Lessonii* Bory and *H. papyracea* Zanard. also find their places here for the first time under *H. Tuna*, and this may be considered to require explanation.

Thanks to the kindness of M. Hariot, I have been allowed to examine the type specimens of the first three species, which are preserved in the Paris Museum; their internal characters are identical with those of *H. Tuna* and their external characters come well within the range of variation of this species.

H. platydisca was queried by Dr. Harvey as a synonym for *H. Tuna* in his Ner. Bor. Amer. vol. III. p. 25. as the result of an examination of specimens brought home by him from Key West. These plants I have been permitted to see, through the kindness of Dr. Perceval Wright, and they form a good series of links between *H. platydisca* and *H. Tuna*. Dr. Harvey says of them: "The original *H. Tuna* is a native of the Mediterranean; and possibly the plant now described may be referable to *H. platydisca* Decne, but some of my Key West specimens so closely resemble what I have received from the Mediterranean, that, habitat apart, I cannot find a character to distinguish them. Others are certainly of larger size, with more discoid articulations. If, however, every slight variation in form and size is to be made the foundation of a new species and dignified with a special description and name, the number of species to be established would only be limited by the number of specimens examined; for scarcely two are to be found identical at all points". Plants collected at Cape de Verde and Barra Grande by H. M. S. "*Challenger*" and preserved in the British Museum, confirm this view, shewing gradations in form between *H. Tuna* and *H. platydisca*.

This view of Dr. Harvey did not however find favour with later writers and *H. platydisca* was retained as a species. Professor Schmitz, (l. c.) while admitting the general similarity between *H. Tuna* and *H. platydisca*, believes them to be specifically distinct on account of the difference in their fruit. The fruits of *H. Tuna* are described as *tufts* of sporangiophores, arising from the upper edge of a joint and reaching a length of about 3—4 mm.: those of *H. platydisca* as being *distributed regularly* along the edge of a joint and reaching a length of about 2 mm. In *H. Tuna* the sporangia are borne laterally on the sporangiophore: in *H. platydisca* their position is apical. This last character seems the only one of any importance,

and even that, in the present imperfect state of our knowledge of the fruit, must be considered one of doubtful constancy; so that in face of the great similarity of vegetative characters, there is at present no satisfactory reason for maintaining the two species. I have however preserved *H. platydisca* as a form, to denote one of the lines of variation, along which this species may develop.

Through the kindness of Dr. Beccari I have been allowed to see the type specimen of *H. papyracea* Zanard. the structure of which is identical with that of *H. Tuna*. The joints are somewhat thinner and larger than those in forma *typica*, and the plant must be regarded as standing between forma *typica* and forma *platydisca*.

The geographical distribution of *H. Tuna* shews a wider range than any other species of this genus. It occurs in the Mediterranean, the Indian Ocean, North Atlantic and South Pacific. Its southern limit is the Tropic of Capricorn.

2. *Halimeda cuneata* Hering.

H. cuneata Hering in Flora. 1846. p. 214.
H. cuneata Kützing, Spec. Algarum 1849. p. 505. non Tab. Phyc.
H. cuneata De Toni, Syll. Alg. vol. I. 1889. p. 526.
H. obovata Kützing, Tab. Phyc. vol. VIII. p. 11. 1858. tab. 25. fig. I.
H. obovata J. Agardh, Till Alg. Syst. VIII. p. 86.
H. obovata De Toni, l. c. 1889. p. 523.
H. versatilis J. Agardh, l. c.
H. versatilis De Toni, l. c. p. 524.
H. macroloba Harvey, Phyc. Austr. Tab. CCLXVII et descript. pro parte.
H. macroloba Askenasy, Exp. S. M. S. Gazelle Th. IV. Bot. Alg. p. 14. tab. III. figs. 6, 8, 9, 10 tab. IV, 11.

Plants varying in length to about 20 cm., slightly incrusted with lime, branching in one plane, di-tri-or polychotomously. Root short, more or less bulbous.

Joints sessile or shortly stalked, varying from elongate-cuneate to almost discoid, not ribbed, margin entire, flat or undulating, sometimes thickened, recurved and grooved; varying in size to about 22 mm. long, 25 mm. broad, $^1/_2$—1 mm. thick in middle, and $2^1/_2$ mm. thick at margin. Apex of joint sometimes slightly raised, giving the appearance of a cushion at the base of the node.

Filaments of central strand fuse in twos or threes at the apex of each joint; one filament (rarely two) resulting from each fusion, of varying length, with walls sometimes thick and subtorulose, branching later di-or trichotomously. All filaments closely adhering at the point of fusion. Peripheral cells irregularly hexagonal in surface view; 25 μ to 40 μ across, about 100 μ long. Side walls of adjacent cells in contact for $^1/_4$—$^1/_2$ their length.

Hab. Indic. South Africa, *Krauss*! *Herb. Dickie*! — Port Elizabeth, Cape Colony, *Farquhar*! *Sutherland*! *Weber van Bosse*! *Spencer*! — Port Alfred, *Carr*! — Natal, *Herb. Hauck*! *Evans*! *Keil*! — Madagascar, *Waters*! — Lasgori (Somali Coast) *Hildebrandt*!, n°. 3. — South Arabia, *Lunt*! — Nicobar Islands, *Moravian Missionaries* in *Herb. Mus. Brit*! — Swan River, *Lady Broome*! — Fremantle, West Australia, *Harvey*!, Alg. Austr. Exsicc. n°. 362, sub nom. *H. macroloba*. — W. Australia, *Askenasy*! — Rottnest Island, *Markwell*! Carnac Island, *Clifton*! —
Siboga-Expedition. Fau! — Elat, Great Kei Island! — Dongala. — Bay of Pidjot, Lombok! —

Pacific. Lord Howe's Island, *M^c Donald*! — Matuku, *Askenasy*! — Queensland, *Tully*! —

forma *typica*.

Joints stalked or sessile, cuneate to almost circular, a median joint occasionally elongate, compressed; in stalked joints apex often raised as a small cushion, stalk long, central filaments exposed (fig. 7).

forma *digitata*.

Joints sessile; lower broad, bearing above elongate, compressed, fingerlike joints, often numerous and fringing upper margin of large joints (fig. 9).

forma *undulata*.

Margin of joints undulating, thickened, recurved, grooved (fig. 10).

This species is most closely allied to *H. Tuna*, from which it is often impossible to separate it by outward form alone. But an examination of the internal structure shews that the two species differ in the details of the central strand and the peripheral cells.

On a cursory examination of a longitudinal preparation of the apex of a joint, certain marking on the walls of the filaments suggest that the cavities are connected with one another by means of pores, in a manner similar to that of *H. macroloba* and *H. incrassata*. By means of transverse sections however and of carefully teased preparations it is seen that the walls are quite intact at these points and that the fusion really takes place in the ordinary way described in *H. Tuna*. The peculiar markings are nothing but the result of the close adhesion of the peripheral cells to the central filaments and of these filaments to one another. This adhesion of the filaments prevents them from falling apart easily in preparations and constitutes a difference between this species and *H. Tuna*, where the adhesion is very slight. This appearance is figured by Professor Askenasy (l. c. tab. III fig. 8) under *H. macroloba*. He kindly sent me the original plant for examination and it clearly falls into the *H. cuneata* of my classification. The fusion of filaments which takes place at the apex is not however represented in Professor Askenasy's figure.

The other point of difference between *H. cuneata* and *H. Tuna* lies in the peripheral cells, which in *H. cuneata* are connected along their side walls for $^1/_4$ to $^1/_2$ their length, (fig. 14), whereas in *H. Tuna* the connection varies from $^1/_{25}$ to $^1/_{10}$ of their length (fig. 6).

In consequence of the close adherence of the peripheral cells in *H. cuneata*, they do not drop apart in decalcified and teased preparations, as is the case with other species; it is therefore necessary to cut transverse sections of a joint, in order to see the peripheral cells in side view.

In examining the peripheral cells in surface view of specimens of *H. cuneata*, it is well to remember this connection of the side walls, for if the material be dry the side walls are often crumpled and, as seen from above, give the appearance of much greater thickness than is really the case.

It is thus seen that the distinction between *H. cuneata* and *H. Tuna* depends only on the relative amount of adhesion between the central filaments, and the extent of connection between the peripheral cells. It is therefore not improbable that a series of forms may be found which will unite the two species. Indeed, one such plant exists among the specimens of *Halimeda* brought from Rangiroa by Professor Agassiz in the "*Albatross*". This has the somewhat thick,

discoid joints of *H. Tuna* and the peripheral cells were only slightly connected with one another; but the filaments of the central strand shew the close adhesion at the apex of each joint, characteristic of *H. cuneata*. This plant constitutes the only link I have yet seen between *H. Tuna* and *H. cuneata*, but on the evidence of a single specimen it does not seem right to unite the two species and I therefore keep them separate for the present. It is interesting to note that up to the present *H. Tuna* is the only species recorded north of the tropical zone, while *H. cuneata* is the only one recorded south of it.

The form of the joint varies in *H. cuneata* from being broadly cuneate or circular, to long, straight and fingerlike, as many as 9 of these straight-sided joints arising like a fringe from the upper margin of one cuneate joint. This form I have called forma *digitata* (fig. 9). Dr. HARVEY (Phyc. Austr. vol. V. Pl. CCLXVII) describes and figures a plant from Australia under the name of *H. macroloba*, and this (Alg. Austr. Exsicc. n° 562) has been taken by Professor J. G. AGARDH for the type of his species *H. versatilis*. Dr. HARVEY's figure resembles *H. macroloba*, but the specimen under n° 562 of the Harvey Australian algae in the British Museum shews the internal structure of *H. cuneata*. In the description of *H. macroloba* (Phyc. Austr. l. c.) Dr. HARVEY says most of the joints are broadly cuneate in Australian specimens, "some of the uppermost only verging to roundish or reniform. Specimens from Singapore are not dissimilar, except that some of the medial articulations are either repand or somewhat 3—5 lobed or obscurely fingered". This "fingering" is not figured, but the expression probably refers to the elongate narrow joints which are found scattered singly among the much larger joints. This occurs in plants from Australia and S. Africa, even in those which in all points resemble HERING's typical form. There is therefore no external character in *H. versatilis* to distinguish it as a special form of *H. cuneata* and it must therefore be included under forma *typica*.

In certain plants, generally those found on S. African coasts, some of the joints are stalked. The central filaments, which compose the stalk and are thus freely exposed, have thickened walls and are often subtorulose in shape. In these joints the point of fusion of the central filaments is surrounded by a small cushion of tissue raised above the upper margin of the joint.

Some of the specimens of *H. cuneata* from the Siboga Expedition have joints of which the margin is very undulating, thick, recurved and grooved. These I have called forma "*undulata*" (fig. 10). Up to the present I have not seen them from any other locality.

H. cuneata is only recorded from the Indian and Pacific Oceans. It advances further south than any other species of the genus, its most southerly recorded limit being Port Elizabeth on the S. E. coast of Cape Colony. Its presence there is probably to be connected with the warm current which flows south from the Indian Ocean to Cape Agulhas.

3. *Halimeda macrophysa* Ask.

Halimeda macrophysa Askenasy, Forschungsreise S. M. S. "*Gazelle*". Th. IV. Bot. Algen. 1888. p. 14. tab. IV. figs 1—4.
Halimeda macrophysa De Toni, Syll. Alg. vol. I. 1889. p. 520.

Hab. INDIC. — *Siboga-Expedition.* N. E. point of Timor! — Paternoster Islands! — Muaras reef!

PACIFIC. — Matuku, "*Gazelle*"! — Tongatabu, *Graëffe*!

Plants small, usually not exceeding 10 cm., fragile, branched in one plane di-or trichotomously.

Joints almost semicircular to reniform and ovate-elliptical, flat, unribbed, margin entire, thickened; varying in size to 24 mm. broad, 15 mm. long, 0.5 mm. thick.

Filaments of central strand fuse in twos or threes at apex of joint, fused filament varying in length, branching later di-or trichotomously. Peripheral cells 150 μ to 175 μ across in surface view; up to 230 μ long. Separated from one another by a mass of calcification.

This species is closely allied to *H. Tuna*, from which it is distinguished by the size of the peripheral cells, which are the largest known in the genus. They are about three times the size of the average peripheral cells in *H. Tuna* and six or seven times the size of the average of those in *H. Opuntia*. Their size and form are clearly visible to the naked eye and they give the plant a characteristic pitted appearance not seen in any other species. Their side walls are calcified throughout their length and are widely separated from those of adjacent cells by a thick incrustation; on decalcification, therefore, the cells drop apart. The stalk-like base of each peripheral cell is very short; and the subcortical layer is markedly insignificant as compared with that of other species, being composed of short filaments, each filament producing only a few peripheral cells.

The central filaments above the point of fusion, in most species quite bare of branches, give rise in *H. macrophysa* to a few scattered branches, bearing at their ends one or two peripheral cells (fig. 16. p.).

Although size of the peripheral cells forms as a rule an unstable character in this genus, it has till now been found constant in *H. macrophysa*. The smallest cells seen in this species have not measured less than 150 μ across, while in *H. Tuna*, which shews the same mode of fusion of the central filaments, the peripheral cells have not been seen to exceed 75 μ across. Were it not for this difference *H. macrophysa* could no longer be retained as an independent species, but would be merely a form of *H. Tuna*. The links which may connect the two species as regards this character have however yet to be found; in the meantime *H. macrophysa* seems best considered specifically distinct.

This species is only recorded at present from the Eastern side of the Indian Ocean and from the South Pacific. It has not been collected north of the Equator.

4. *Halimeda Opuntia* Lam.

"Sur la Classif. d. Polyp. corall. etc." in Soc. Phil. N. Bull. Paris III. 1812. p. 186.
Corallina latifolia, et Opuntia marina Plukenet, Phytogr. Tab. 26. fig. 1. Almagestum 118, London 1696, non Cortusi.
Corallina opuntioides, ramulis densioribus, et foliis magis sinuatis atque corrugatis Sloane, Nat. Hist. Jam. vol. I. 1707. p. 57. XVI. Tab. 20. fig. 2.
Sertularia ramosissima, articulis reniformibus compresso-planis trichotomis Linn. Hort. Cliff. 1737. p. 480. in part, et Royen, Flor. Lugd. 1740. p. 523. in part.
Articulated Coralline of Jamaica Ellis, Essay. Nat. Hist. Corall. 1755. p. 53. pl. XXV. figs. B. b.
Corallina Opuntia L. Syst. Nat. vol. I. 1760. p. 805. in part.
Corallina Opuntia Pallas, Elench. Zoophyt. 1766. p. 420.
Corallina Opuntia Esper, Pflanzenthiere. Th. II. Corallina. 1798—1806. Tab. I.
Corallina opuntioides minor Petiver, Pterigraphia. 1767. Tab. XX. fig. 19.
Corallina Opuntia Ellis et Solander, Nat. Hist. Zooph. 1786. p. 110. Tab. 20. fig. b.

Corallina Opuntia Gmelin, Linn. Syst. Nat. Ed. XIII. 1790. p. 3836. n⁰. 1.
Flabellaria multicaulis Lamarck, "Sur l. Polyp. empâtés" in Ann. Mus. Hist. Nat. tom. 20. 1813. p. 302.
Flabellaria Opuntia Lamarck, l. c. p. 303.
Halimeda Opuntia Lamouroux, "Sur l. classif. d. Polyp. corall. etc." in Soc. Phil. N. Bull. Paris III. 1812. p. 186.
Halimeda Opuntia Lamouroux, Hist. Polyp. Corall. 1816. p. 308.
Halimeda multicaulis Lamouroux, l. c. p. 307.
? *Halimeda irregularis* Lamouroux, l. c. p. 307.
Halimeda opuntia Lamouroux, Expos. Méth. 1821. p. 27. tab. 20 fig. b. (The figure is taken from Ellis and Solander. l. c.).
Halimeda opuntia Lamouroux, Corallina 1824. p. 139.
Halimeda multicaulis Lamouroux, l. c.
Halimeda Opuntia Decaisne, Mém. s. l. Corallines in Ess. Classif. Alg. et d. Polyp. calcif. 1842. p. 90.
Halimeda multicaulis Decaisne, l. c. p. 91.
Halimeda triloba Decaisne, l. c. p. 90.
Halimeda Opuntia Kützing, Phyc. Gen. 1843. p. 310. tab. XLIII. fig. 2.
Halimeda Opuntia Kützing, Spec. Alg. 1849. p. 504.
Halimeda multicaulis Kützing, l. c.
Halimeda triloba Kützing, l. c.
Halimeda Opuntia Kützing, Tab. Phyc. vol. VII. 1857. p. 8. tab. 21. fig. 1.
Halimeda multicaulis Kützing, l. c. fig. II.
Halimeda triloba Kützing, l. c. p. 9. tab. 22, fig. III.
Halimeda Opuntia Harvey, Ner. Bor. Amer. 1858. p. 23. Tab. XI. B.
Halimeda Opuntia J. G. Agardh, Till Alg. Syst. V. 1887. p. 83.
Halimeda cordata J. Ag. l. c.
Halimeda opuntia Zanardini, Plant. Mar. Rub. in Mem. R. Ist. Ven. vol. VII. 1858. pl. II. p. 288.
Halimeda triloba Zanardini, l. c.
Halimeda multicaulis Zanardini, l. c.
Halimeda Renschii Hauck, "Ueber einige von J. M. Hildebrandt im Rothen Meere u. Ind. Ocean gesammelte Algen". Hedwigia Hft. V. 1886. p. 167. et Notarisia 1886. p. 254.
Halimeda Opuntia Askenasy, Forschungsr. S. M. S. "Gazelle". Th. IV. Bot. Alg. 1888. p. 13.
Halimeda Opuntia et var. De Toni, Syll. Alg. vol. I. 1889. p. 522.
Halimeda cordata De Toni, l. c.
Halimeda Renschii De Toni, l. c. p. 525.
Halimeda cuneata Kütz. var. *elongata* Barton, On the Forms, with a new species, of *Halimeda* from Funafuti" in Journ. Linn. Soc. Bot. vol. XXXIV. 1900. p. 480. Plate 18. figs. 4 and 5.

Hab. ATLANTIC. — Jamaica, *Sir Hans Sloane*! Herb. Buddle! in Herb. Sloane vol. 114—116, p. 37. *Humphrey*! in Phycotheca Bor. Amer. Collins, Holden and Setchell n⁰. 123. — America, *Barham*! in Herb. Petiver, Herb. Sloane, vol. 157. fol. 2. — *Herb. Plukenet*! in Herb. Sloane, vol. 91. fol. 61. — Guadeloupe, *Mazé*. nos. 36! 800! 933! 1515! 1621! 1909! — St. Croix, *Börgesen* in Wittrock, Nordstedt, Lagerheim, Alg. Exsicc. n⁰. 1201! — Barbadoes, *Rawson and Watts*! *Herb. Gray*! — Tortola, *Cleve* in Herb. Askenasy et in Wittrock et Nordstedt, Alg. exsicc. n⁰. 148! — St. Thomas, *Mertens*! — Danish West Indies, *Hohenacker*! Meeresalgen n⁰. 414. — Grenada, *Murray*! — Aruba, *Suringar*! — Key West, *Harvey*! *Hooper* in Alg. Exsicc. Am. Bor. Farlow, Anderson and Eaton, n⁰. 40! — Old Rhodes Key, *Curtiss*, Algae Floridanae Ser. 1! — Brazil, *Wilson Barker*! — Honduras, *Dyson*! —

INDIC. — Mohilla Island, *Kirk*! — Johanna-Pomoni, Comoro Islands, *Hildebrandt*!, n⁰. 1889, sub nom. *H. brevicaulis*. — Mauritius, *Pike! Lady Frances Cole*! *Herb. Mus. Brit*! — Rodriguez, *Balfour*! — Red Sea, *Hohenacker*!, Meeresalgen n⁰. 358. *Forskaal*!, in Herb. Agardh sub. nom. *H. cordata*. — Kosseir, *Schimper*!, Unio itiner. 1837. n⁰. 932. — Suakin, *Schweinfurth*! — "Dried rare and chiefly Indian plants", *Petiver*!, in Herb. Sloane, vol. 100. fol. 2. — Ceylon, *Harvey*!, n⁰. 71. *Ferguson*! n⁰. 88. — Diamond Island, *Herb. Dickie*! — Andaman

Islands, *Prain*! — Gulf of Manaar, *Thurston*! — Singapore, *Ridley*!, n⁰. 101. — Borneo, *Kjellman*!, Wittr. et Nordst. Alg. exsicc. n⁰. 341. — Maumeri, Flores, *Weber van Bosse*!, n⁰. 1020. — Macassar, *Weber van Bosse*! —

Siboga-Expedition. North Ubian, 16.2 m.! — Elat, Great Kei Island! — Jedan Island. 10.8 m.! — Banda! — Sailus ketjil, Paternoster Islands! — N. E. corner of Timor, 36—54 m.! — Saleh bay, Sumbawa, 14—18—28.8 m.! — Bawean Island, 28.8 m.! — Kabala dua, reef! — Station 65ª. 120 m.! — Noimini, S. coast of Timor, reef! — Kangeang Island! — Dobo, Aru Islands! — Sailus-besar, Paternoster Islands! — Sanana, Sula-Besi! — Roma Island, reef! — Salibabu, Lirung, reef! — Binongka Island, reef! — Island Tanah-Djampeah, 30 m.! — Siau Island! — Taam Island 15—18 m.! — Savu! — Labuan Tring, Lombok! —

PACIFIC. — China Sea, *Baume*! Herb. Mus. Paris sub nom. *H. triloba* Decaisne. — Philippines, *Cuming*!, 2235. "*Challenger*"! — Parry Shoal, Arafura Sea, *Bassett Smith*! — Solomon Islands, *Guppy*! — New Guinea, *Kärnbach*!, n⁰. XXVIII. — Admiralty Islands, "*Challenger*"! — Ponape Island, Caroline Islands, "*Albatross*"! *Christian* [1])! — Caroline Islands, *Mertens*! — Funafuti, *David*! nᵒˢ. A. 31 pro parte, A. 54, A. 58, B. 5, B. 10. "*Albatross*"! — Friendly Islands, *Harvey*! n⁰. 92. — Fiji, *Herb. Mus. Brit*! — Tongatabu, "*Challenger*"! *Graeffe*! *Home*! — Upolu, *Herb. Mus. Brit*! — Tahiti, "*Challenger*"! Niau, Paumota, "*Albatross*"! — Fakarawa, "*Albatross*"! — Rangiroa, Mohegan reef, "*Albatross*"! — Honolulu, "*Challenger*"! — Sandwich Islands, *Home*! — Capricorn Group, *Jukes*! —

Varying from a straggling plant up to 25 cm. long, sparingly branched in one plane; to a thick tuft with numerous radiating branches; with all intermediate forms.

Joints very variable; more or less flat, deeply calcified, sessile or stalked [2]): discoid, cordate, trilobed, or broad in the middle and narrowed at both ends, clearly or indistinctly ribbed. Size varies to about 12 mm. long, 20 mm. broad, 75 mm. thick between the ribs.

Filaments of central strand fuse in pairs at apex of each joint; fusion incomplete, limited to surface of contact of lateral walls. Each filament after separation continues for short distance unbranched, branching later di-or trichotomously.

Peripheral cells 20—50 μ across, in surface view; rarely 60 μ long; side walls in contact for about $^1/_{12}$ of their length.

forma *typica*.

Often forming an irregular mass, much branched and in more than one plane; distinctly ribbed, so that the rounded upper margin appears waved; lower margin forming more or less of a right angle with the midrib; joints not overlapping each other (fig. 19).

forma *cordata*.

H. cordata J. Ag. l. c.

Joints rounded, prolonged below into two well-marked auricles, which overlap the lower joint (fig. 21).

forma *triloba*.

H. triloba Decne. l. c.

Joints markedly trilobed, segments deeply cut, thick, ribs distinct (fig. 20).

1) Dr. CHRISTIAN notes about this specimen: "Kom". From Mutok Harbour—S. Coast. A narcotic seaweed found on the detached reefs in the lagoon, used for stupefying the Karaiak or Tentumoi, a species of jellyfish living in the cracks of the coral".

2) The stalk in *H. Opuntia*, when present, is not specially differentiated, as in *H. cuneata* but is merely the narrow inferior part of the joint.

forma *hederacea*.

Joints trilobed, not deeply cut, lobes spreading in the form of an ivy leaf, ribs distinct (fig. 23).

forma *elongata*.

H. cuneata var. *elongata* Bart. l. c.

Joints trilobed, not deeply cut, not spreading, side lobes sometimes reduced to slight enlargement at or above the middle of a joint (fig. 24).

forma *Renschii*.

H. Renschii Hauck l. c.

Plant forming compact, circular tuft, branches radiating from the centre. Upper joints small, thin, irregularly round or transversely ovate, indistinctly ribbed (fig. 22 and 22*a*).

This species from its extreme variability was formerly divided into several species, varieties and forms, and indeed the variations are so great that viewed apart from intermediate forms and without regard to internal characters, the extreme forms would certainly have to be regarded as distinct species. But in consequence of being fortunate enough to have had in my hands a large number of plants of this species, it has been possible to trace the gradations which lead from one form to another and so to link together even the most extreme forms.

The manner of fusion of the central filaments at the apex of each joint forms an unfailing test for *H. Opuntia*. It is the only species in which fusion of filaments takes place in pairs and is at the same time incomplete, being limited to the surface of contact of the lateral walls. Communication between each pair of filaments is effected by a breaking down of the side walls at the points, where they become pressed together at the apex of each joint. Above this point however the two fused filaments are again quite free and remain for a certain distance unbranched, till they again give rise to the subcortical tissue to form the next joint (fig. 25).

This method of fusion is also found in the type specimens of *H. triloba*, *H. cordata* and *H. Renschii*, which are therefore here placed under *H. Opuntia*; but since they indicate the various external directions of variation within the species, they are retained as forms in accordance with the method already indicated.

In a paper by myself, published in 1900 (Forms of Halimeda from Funafuti. Journ. etc.), a new variety is described under the name of *H. cuneata* Kütz. var. *elongata*. An examination of the central strand of the plant here described shews that the manner of fusion is that characteristic of *H. Opuntia* and since the external form is fairly well marked it is included here as *H. Opuntia* forma *elongata*. (The type specimen of *H. cuneata* Kütz. is shewn below to be a plant of *H. gracilis* Harv.).

In the same paper it is stated that the single joints of *Halimeda*, which were brought up in the borings made into the floor of the lagoon, are fragments of *H. Opuntia* var. *macropus*. This statement was made as the result of classification based on the size of the peripheral cells and it was only after examination of the central strand that I was able to discover the mistake. The joints in question shew filaments with a mode of fusion characteristic of *H. Opuntia* and in external form they come nearest to either forma *triloba* or forma *cordata*.

It is thus seen that it was possible to indicate five different forms of *H. Opuntia*, under the names already existing for definite species and varieties; but there remained still a small number of plants among the collections, sufficiently unlike the plants already dealt with as to be worthy of record. The joints of such plants resemble ivy leaves; I have therefore founded on them the form *hederacea*.

I would once more strongly emphasize the fact that it is impossible to regard these forms as anything more than indications of the several directions of variation, exhibited by the joint. This is especially well shewn in *H. Opuntia*, where a plant is rarely found in which all the joints are sufficiently alike to allow of it being placed under one form only and in many plants there are joints which represent as many as three different forms.

H. Opuntia is confined to the tropics, where it is common in all oceans.

5. *H. gracilis* Harv.

Halimeda gracilis J. Agardh, Till Alg. Syst. VIII. p. 82.
Halimeda gracilis De Toni, Syll. Alg. vol. I 1889. p. 521.
Halimeda cuneata Kützing, Tab. Phyc. vol. VII. 1857. p. 8. tab. 21. fig. III.
Halimeda cuneata Kützing in De Toni, Syll. Alg. vol. I. 1889. p. 526.
Halimeda laxa Barton, Journ. Linn. Soc. Bot. vol. XXXIV. 1900. p. 479. Pl. 18. figs. 1—3.
Halimeda Opuntia var. *intermedia* Grunow in Herb.
Halimeda Opuntia var. *crassiuscula* Grunow in Herb.

Hab. ATLANTIC. — St. Thomas, *Challenger*! — Fernando Neronha, *Challenger*! —

INDIC. — Bentotta, Ceylon, *Ferguson*! in Herb. Grunow sub nom. *H. opuntia* var. *intermedia* Grun. — Ceylon, *Harvey*!, n⁰. 72. *Ferguson*!, nos. 88, 160. *Dr. Ondaatje*! —
Siboga-Expedition. Postillon Islands, 30 m.! — Aru Islands! —

PACIFIC. — Honolulu, *Grunow*!, in Herb. Grunow sub nom. *H. opuntia* var. *crassiuscula* Grun. Tintaga, Funafuti, *David*! nos. A. 31. A. 34. — Torres Straits, "*Challenger*"! "Kamtschatka", *Tilesius* in Herb. Kützing! —

Plants varying in length, reaching to more than 40 cm., thickly calcified below, less so above in long plants; branched in one plane. Branches short and numerous, or long and few.

Joints cuneate to subcylindrical; not ribbed, margin of branched joints slightly undulating, $^1/_2$—9 mm. long, $1^1/_2$—11 mm. broad, 1—2 mm. thick.

Filaments of central strand fuse in pairs, fusion complete, single fused filament branching later trichotomously (fig. 30).

Peripheral cells 30—45 μ across, surface view; 50—75 μ long. Side walls usually connected for about $^1/_{12}$ of length. Cells directly in contact or lying in a matrix of cellulose, rendered visible by decalcification.

forma *typica*.

Joints more or less cuneate, walls of peripheral cells thin, directly in contact (fig. 28).

forma *laxa*.

H. laxa Bart.

Plant long, straggling, branches few, distant. Joints mostly subcylindrical, less calcified

than in forma *typica*. Walls of peripheral cells directly in contact or lying in cellulose matrix (fig. 29).

This species often resembles externally certain forms of *H. Opuntia* and of *H. incrassata*, but in internal structure it is at once to be distinguished from both. The filaments of the central strand in *H. gracilis* fuse in pairs as in *H. Opuntia*, but in *H. gracilis* the fusion is complete, the two filaments continuing for a short distance as one and branching later *trichotomously* (fig. 30). In *H. incrassata* there is no fusion of filaments, but communication is established by means of pits; so the difference between it and *H. gracilis* is at once obvious in a preparation.

There is a certain resemblance in the manner of fusion between *H. gracilis* and *H. Tuna*; but in *H. gracilis* all the filaments fuse in pairs and the resulting filament branches later trichotomously; while in *H. Tuna* the filaments fuse in twos or threes indiscriminately, and the resulting filament branches later di-or trichotomously with equal irregularity. *H. Tuna* is externally also quite distinct from *H. gracilis*.

In my paper on "Forms of Halimeda from Funafuti", (l. c.) I described, on characters of external form and peripheral cells, a new species, *H. laxa*. The great length of the specimens, the diffuse habit and the width of cellulose separating the peripheral cells caused me to regard the Funafuti plants as distinct from all hitherto described species. However, a later examination of the central filaments shewed the type of fusion characteristic of *H. gracilis*. It was difficult at first to admit that this plant which resembled a giant *Amphiroa* must be considered as a form of *H. gracilis*; but in the collections to which I had access there were a few plants which were distinctly intermediate in external form and habit between *H. laxa* and *H. gracilis*. Furthermore in the original description of *H. gracilis* (Till. Alg. Syst. l. c.) the branches are said to be "longos simpliciusculos", which character is only present to a slight degree in Dr. HARVEY's plants from Ceylon, but is very strongly marked in the Funafuti specimens. There can thus be no doubt that *H. laxa* must now be regarded as an extreme variation, but one which comes quite clearly within the limits of the species *H. gracilis*.

The straggling habit of the Funafuti plants is perhaps to be connected with the depth at which they were found, 35 and 37 fathoms. The label attached to the specimens does not state whether they were actually growing at that depth; but this is not improbable, since other plants of *Halimeda* were found living at Funafuti at a depth of 45 fathoms.

In KÜTZING's Tab. Phyc. vol. 7, tab. 21 fig. III. a plant is figured under the name of *H. cuneata* and the locality is given on p. 8. as Kamtschatka. A reference is given to the description of *H. cuneata* Hering in KÜTZING's Species Algarum p. 505, but that description applies to the true *H. cuneata* of Hering. The figure of the "Kamtschatka" plant is however entirely unlike *H. cuneata* Hering and has therefore been referred to by later writers on this genus as *H. cuneata* Kütz. Professor ASKENASY (l. c.) describes under this name plants from the Anchorite Islands and in DE TONI's Sylloge Algarum (l. c.) descriptions are given of *H. cuneata* Her. and *H. cuneata* Kütz.

Through the kindness of Mad.me WEBER—VAN BOSSE, the possessor of the KÜTZING herbarium, I have been allowed to examine the original plant from which the KÜTZING figure was taken. The internal structure and external habit are those of *H. gracilis*, to which species

it undoubtedly belongs. Why the locality should have been given as Kamtschatka remains a mystery.

The Anchorite Islands plant of Professor Askenasy, described as *H. cuneata* Kütz., proves to be *H. incrassata* Lam.

Under the name of *H. obovata*, a plant is figured and described in Kützing's Tab. Phyc. vol. 8. p. 11 tab. 25. fig. I. This is the true *H. cuneata* Hering, of which it is an excellent figure.

The geographical distribution is limited, so far as is at present known, to the tropics. *H. gracilis* occurs in the Indian and Pacific Oceans and sparely in the N. Atlantic.

6. *H. macroloba* Decne.

Halimeda macroloba Decaisne, Arch. Mus. Hist. Nat. Paris. tom. II. 1841. p. 118. Ess. Classif. Alg. mém. Corall. 1842. p. 91.
Halimeda macroloba Kützing, Sp. Alg. 1849. p. 504.
Halimeda macroloba Zanardini, Plant. Mar. Rub. Mem. Istit. Veneto. vol. VII. 1859. p. 287.
Halimeda macroloba Harvey, Phyc. Austr. [1]) 1863. Tab. CCLXVII. descript. pro parte.
Halimeda macroloba J. G. Agardh, Till Alg. Syst. VIII. p. 81.
Halimeda macroloba De Toni, Syll. Alg. vol. I. 1889. p. 520. synon. pro parte.

Hab. Indic. — Nosi-bé, *Hildebrandt*!, Flora von Madagascar, n°. 54. — Madagascar, *Last*! — Mohilla, Comoro Islands, *Kirk*! — Lamu Harbour, Zanzibar, *Hildebrandt*! n°. 1917. — Djedda, Red Sea, *Fontanier*!, in Herb. Mus. Paris. *Schimper*! Unio itin. 871. — Arabia, *Botta*!, in Herb. Mus. Paris. — Red Sea, *Mc Andrew*! *Mc Donald*! — Aden, *Ferguson*!, 444(1). — Dar es Salaam, *Holst*!, n°. 1264. — Ceylon, *König*! — Termaklee Island, S. Andamans, *Kurz*! — S. Andamans, *Herb. Dickie*! — Singapore, *Griffith*! — Tidal coral reef, Keeling Atol, *Darwin*!, n°. 3638. — Philippines, *Cuming*!, 2233. — Labuan, Borneo, *Kjellman*!, in Wittr. et Nordst. Alg. exsicc. n°. 339. *Burbidge*! — Macassar, Celebes, *Weber van Bosse*!, in Hauck et Richter Phykoth. univ. n°. 274. — South Celebes, *Weber van Bosse*! 928. — Bima Bay, *Weber van Bosse*! — Aru Islands, "*Challenger*"! —
Siboga-Expedition. Sailus-ketjil, Paternoster Islands! — Island Fau! — Elat, Great Kei Island, reef! — Noimini, S. E. coast of Timor, reef! — Landu bay, Rotti, reef! — N. E. coast of Timor, 36—54 m.! — Dammer Island, 27—54 m.! — Entrance to Bima bay! — Kangeang Island! — Sulu Island! — South Celebes! —

Pacific. — Lakemba, Fiji, *Harvey*! — Friendly Islands, *Harvey*!, n°. 21 pro parte. — Samoa, *Powell*! — Upolu, *Herb. Mus. Brit*! — Queensland, *Dietrich*! in Herb. Askenasy. — Albany Island, *Müller*! — Cape Flattery, Australia, *Algae Müllerianae*!

Plant varying in length to about 16 cm., not deeply calcified, branched in one plane. Root generally bulbous, rarely cylindrical, sometimes reaching 40 mm.

Joint immediately above root short, thick, subcylindrical, stalk like; other joints very irregular, discoid, oval, cuneate, and other forms, not ribbed, thick, sessile; margin thick, entire or irregularly lobed. Largest joint about 20 mm. long, 28 mm. broad, 2—3 mm. thick.

Filaments of central strand do not fuse, but communicate with each other at apex of joint, by means of large open pits.

Peripheral cells 30—40 μ across, surface view 75—150 μ long; only held together by a chalky matrix, thus dropping apart on decalcification.

1) The figure there given most closely resembles *H. macroloba*, but I have seen no specimen of that species from Australia. The alga referred to as n°. 562 Alg. Austr. Exsic. was made the type of *H. versatilis* by Prof. J. G. Agardh and is synonomous with *H. cuneata* Hering. The description includes characters of *H. macroloba* and of *H. cuneata*.

Some confusion has existed in herbaria between this species and *H. Tuna* forma *platydisca*. They may be distinguished, however, externally by the thickness and the smooth, shining appearance of the joints in *H. macroloba*, which are rather more deeply calcified than the thin joints of *H. Tuna* forma *platydisca*.

As regards internal structure, the mode of fusion of the central filaments is entirely different from that of *H. Tuna*. In *H. macroloba* the filaments do not fuse, but communicate with each other at the point of contact by means of pits in their walls. These pits are so large that the whole strand has almost the appearance of one large tube with the bounding wall against the peripheral cells. This is clearly to be seen in a surface view of the growing point or in a transverse section of the apex of any joint, where the central filaments appear as one, with the original boundaries of the separate tubes only marked by the fragments of the side walls still remaining. Communication between the filaments is however limited to this point; above it each filament is free, and after a short distance branches, generally trichotomously, to aid in the formation of the next joint.

The branching in *H. macroloba* takes place in one plane, but I have seen in one plant indications of a joint growing out at right angles from the face of another joint, as in *H. Opuntia*.

The geographical distribution of *H. macroloba* is not wide, the species being almost entirely confined to the Indian Ocean. A few records only have been made from the Pacific Islands.

7. *H. incrassata* Lam.

"Sur l. Classif. d. Polyp. Corall. etc." in Soc. Phil. N. Bull. Paris III. 1812. p. 186.
Lichen marinus rotundifolius Buddle, M. S. in Herb. Sloane. vol. 114—116, fol. 137.
Articulated Coralline of Jamaica Ellis, Essay Nat. Hist. Corallines 1755. p. 53. Pl. XXV. figs. A. a.
Corallina incrassata Ellis and Solander, Nat. Hist. Zoophytes 1786. p. 111. Tab. 20. fig. d.
Flabellaria incrassata Lamarck, "Sur l. Polypiers empâtés" in Ann. Mus. Hist. Nat. tom. 20. 1813. p. 302.
Halimeda incrassata Lamouroux, "Sur l. Classif. d. Polyp. corall. etc." in Soc. Phil. N. Bull. Paris III. 1812. p. 186.
Halimeda incrassata Lamouroux, Hist. Polyp. corall. 1816. p. 307.
Halimeda incrassata Lamouroux, Expos. méth. 1821. p. 26. Tab. 20. figs. D. d.
Halimeda incrassata Lamouroux, Corallina 1824. p. 139.
Halimeda incrassata Decaisne, Mém. s. l. Corall. in Ess. Class. Alg. et d. Polyp. Calcif. 1842. p. 91.
Halimeda incrassata Kützing, Phyc. Gen. 1843. p. 310.
Halimeda incrassata Kützing, Spec. Alg. 1849. p. 504.
Halimeda incrassata Harvey, Nereis Bor. Americ. 1858. Pt. III. p. 24.
Halimeda incrassata Harvey, Phyc. Austr. vol. III. 1860. Pl. CXXV.
Halimeda incrassata J. G. Agardh, Till. Alg. Syst. VIII. p. 85 et vars.
Halimeda incrassata Askenasy, Forschungsreise S. M. S. Gazelle Th. IV. Bot. Algen. 1888. p. 13. Tab. III. figs. 1, 7. Tab. IV. figs. 5, 6, 10.
Halimeda incrassata et vars. De Toni, Syll. Alg. vol. I. 1889. p. 522.
Corallina monile Ellis and Solander, Nat. Hist. Zooph. 1786. p. 110. Tab. 20. fig. c.
Halimeda monile Lamouroux, "Sur l. Classif. d. Polyp. corall. etc." in Soc. Phil. N. Bull. Paris III. 1812. p. 186.
Halimeda monile Lamouroux, Hist. Polyp. Corall. 1816. p. 306.
Halimeda monile Lamouroux, Expos. Méth. 1821. p. 26. Tab. 20. fig. c.
Halimeda monile Lamouroux, Corallina 1824. p. 138.

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Halimeda monile Kutzing, Phyc. Gen. 1843. p. 310.
Halimeda monile Kützing, Spec. Alg. 1849. p. 505.
Halimeda monile Kützing, Tab. Phyc. vol. VIII. 1858. Tab. 26. Fig. 1.
Halimeda incrassata var. *monilis* Harvey, Nereis Bor. Americ. Pt. III. 1858. p. 24.
Halimeda monile J. G. Agardh, Till Alg. Syst. VIII. p. 88.
Halimeda monile De Toni, Syll. Alg. vol. I. 1889. p. 525.
Corallina tridens Ellis and Solander, Nat. Hist. Zooph. 1786. p. 109. Tab. 20. fig. a.
Halimeda tridens Lamouroux, "Sur l. Classif. d. Polyp. corall. etc." in Soc. Phil. N. Bull. Paris. III. 1812. p. 186.
Halimeda tridens Lamouroux, Hist. Polyp. corall. 1816. p. 308.
Halimeda tridens Lamouroux, Expos. Méth. 1821. p. 27. Tab. 20. fig. a.
Halimeda tridens Lamouroux, Corallina 1824. p. 139.
Halimeda tridens Decaisne, Mém. s. l. Corall. in Ess. Classif. Alg. et d. Polyp. calcif. 1842. p. 91.
Halimeda tridens Kutzing, Phyc. Gen. 1843. p. 310.
Halimeda tridens Kützing, Spec. Alg. 1849. p. 505.
Halimeda tridens Kützing, Tab. Phyc. vol. VII. 1857. p. 9. tab. 22. fig. II.
Halimeda tridens Harvey, Nereis Bor. Americ. Pt. III. 1858. p. 24. Tab. XLIV. fig. c.
Halimeda tridens J. G. Agardh, Till Alg. Syst. VIII. p. 87.
Halimeda tridens De Toni, Syll. Alg. vol. I. 1889. p. 524.
Halimeda cylindracea Decaisne, Mém. s. l. Corallines in Ess. Classif. Alg. et d. Polyp. Calcif. 1842. p. 91.
Halimeda cylindrica Kützing, Spec. Alg. 1849. p. 505.
Halimeda cylindrica Mazé et Schramm, Alg. d. l. Guadeloupe 1870—77. p. 86.
Halimeda cylindracea J. G. Agardh, Till. Alg. Syst. VIII. p. 87.
Halimeda cylindracea De Toni, Syll. Alg. vol. I. 1889. p. 524.
Halimeda polydactylis[1]) J. G. Agardh, Till Alg. Syst. VIII. p. 89.
Halimeda polydactylis De Toni, Syll. Alg. vol. I. 1889. p. 526.
Halimeda cuneata Askenasy, l. c. Tab. III. fig. 2. 3. 4. 5. 12. Tab. IV. fig. 12.
Halimeda Opuntia var *macropus* Askenasy, l. c.
Halimeda multicaulis var. *debilis* Grunow. in Herb.
Halimeda multicaulis var. *coarctata* Grunow. in Herb.

Hab. ATLANTIC. Jamaica, *Herb. Buddle in Herb. Sloane* vol. 114—116, fol. 137. — W. Indies, *Clerk*! in Herb. Sloane fol. 318. p. 48. — Bahamas, *Catesby*! — Antilles, *Herb. Shuttleworth*! n° 299. — Guadeloupe, *Mazé*! n°s 109 1st ser. 351. 819. 829. 830. — Guadeloupe, *Duchassaing*! — "*Challenger*"! — St. Thomas, "*Challenger*"! — St. Vincent, *Elliott*! — St. Cruz, *Herb.* Bermuda, *Dickie*! — Grenada, *Murray*! — Key West, *Harvey*! *Messina*! in Phycoth. Bor. Amer. Collins, Holden and Setchell n° 273. — Bahia Honda, Key, *Curtiss*!, in Algae Floridanae ser. I. sub. nom. *H. tridens.* — Brazil, *Blauner*! n° 266. —

INDIC. Nosi-bé, *Hildebrandt*!, Flora von Madagascar, n° 1. — Termoklee Isl. S. Andamans, *Kurz*! — S. Andamans, *Herb. Dickie*! — Seychelles, *Perville*!, 1841 in Herb. Mus. Paris sub nom. *H. cylindracea.* Dec. — Tidal Coral Reef, Keeling Isl. *Darwin*! —
Siboga-Expedition. Rotti reef! — Sailus ketjil, Paternoster island! — Landu Bay, Rotti! — Binongka reef! — Borneo-bank, Kabala dua, reef! — Tual, reef! — Buka Bay, Rotti! — Saleh Bay, Sumba! — Savu! — Sarasa, Postillon Islands! —

PACIFIC. Macclesfield Bank, China Sea, *Bassett Smith*! — Anchorite Islands, *Askenasy*! — Admiralty Island, "*Challenger*"! — Funafuti, *David*!, A. 21 pro parte. — Ovalau, Fiji, *Harvey*! — Fiji, *Herb. Mus. Brit.*! — Friendly Islands, *Harvey*!, n° 93. — Minerva Reef, "*Herald*"! — Tongatabu, "*Challenger*"! *Graeffe*! — Vavau, *Askenasy*! — Mangaia, *Gill*! —

1) In Herbaria this name is sometimes seen in AGARDH's own writing as *stenodactylis*, clearly an error for *polydactylis*.

Samoa Islands, *Graeffe*! — Sandwich Islands, *Home*! — Noukahiva n° 2, *Herb. Kew*! — Cape York, "*Challenger*"! — Torres Straits, "*Challenger*"! — Albany Island, *Mueller*! — Queensland, *Dietrich*! *Kilner*! — Norfolk Island, *Herb. Mus. Brit.*! — Fakarawa, "*Albatross*"! — Rangiroa, Mohegan Reef, "*Albatross*"! — Rangina, "*Albatross*"! —

Plants varying in length to about 20 cm., thickly calcified as a rule, especially below. Branched in one plane. Very variable in habit; long and tapering, or short and flabellate, or forming small tufts; with all intermediate forms.

Root bulbous or cylindrical.

Joints sessile, ribbed, tridentate, cuneate, cylindrical, or discoid, often welded together at base of plant and forming flabellate mass. Lower cylindrical joints sometimes 8 mm. in diameter; upper cylindrical joints often 8 mm. long, 1—2 mm. in diameter; tridentate joints to 14 mm. broad.

Filaments of central strand either communicate with each other at apex of joint by means of pits of varying size, or, rarely, free throughout.

Peripheral cells 15—50 μ across in surface view. Length very variable, surface of contact slight, up to about $^1/_{12}$ of length.

forma *typica*.

Lower joints deeply calcified, sometimes forming a cylindrical, unbranched stem; adjacent cylindrical joints connected by lime to form fan shaped base; upper joints more or less trilobed (fig. 39).

forma *monilis*.

H. monile Lam. l. c.

Joints thick, deeply calcified, moniliform, cylindrical, sometimes compressed; branched joints cuneate, truncate, often bearing four or five joints along the upper margin (fig. 40).

forma *Lamourouxii*.

H. incrassata var. *Lamourouxii* J. Ag. l. c.

Lower joints broadly cuneate or trilobed; upper joints more or less reniform, thin, compressed, not deeply calcified, upper margin lobed (fig. 41).

forma *ovata*.

H. incrassata var. *ovata* J. Ag. l. c.

Plant small, generally forming short tufts. Lower joints usually cuneate, truncate; upper joints small, circular, not deeply calcified, indistinctly ribbed, sometimes slightly lobed on upper margin.

Filaments of central strand quite entire or connected by small and few pits (figs. 42, 47).

This form occurs mainly in the Pacific Ocean, but there are also specimens of it in the "Siboga" collections.

forma *tripartita*.

Lower joints deeply calcified, simple, cylindrical; upper joints often tripartite, deeply cut, segments cylindrical (fig. 43).

forma *pusilla*.

Plant small; joints slightly calcified, compressed, tridentate, not very deeply cut, or subcylindrical (fig. 44).

forma *rotunda*.

Plant slightly calcified; lowest joints simple, cylindrical, all other joints semicircular or discoid, indistinctly ribbed (fig. 45).

H. incrassata is almost as variable a plant as *H. Opuntia* and its forms have been described as several distinct species, as is seen by the list of synonyms above.

The type specimen of *H. incrassata* (*Corallina* Ellis and Solander) has unfortunately been lost, but the excellent figure given (Ell. et Sol. Nat. Hist. Zooph. l. c.) leaves no doubt as to the form of the plant designated by this name. Specimens of it are common in most herbaria and an examination of the mode of fusion in the central strand shews the pits described and figured under *H. incrassata* by Dr. Askenasy (l. c.). The pits in this species are smaller than those of *H. macroloba*, but they vary in size. In some forms, notably forma *ovata*, the pits are often either wholly wanting or are so small that they are only made visible by careful staining. This partial or entire absence of pits may however occur in other forms of *H. incrassata*, though it has only been seen in stunted plants with small joints: which is cause and which effect it is difficult to say. It may be argued that in a classification founded on the mode of fusion of the central filaments, it is illogical to class together as one species plants in which the filaments communicate by means of pits, and plants in which the filaments neither fuse nor communicate at all. But among the specimens of *H. incrassata*, to which I have had access, there have been plants representing all gradations of this character from filaments with well-developed pits to those which were entirely free and shewed even no trace of thin places on their unusually thick walls (fig. 47). Thus it was obviously impossible to regard those plants, in which the central filaments are free at the apex of a joint, as anything more than a form of growth of *H. incrassata*. This internal variation is most often found in small tufted plants from the Pacific Ocean, corresponding in outward form to Prof. J. G. Agardh's var. *ovata*. Unfortunately it was impossible to obtain the original plant of var. *ovata* for examination, but a photograph of it, natural size, was most kindly sent me by Professor Nordstedt, which shews that at least in outward form my Pacific plants with free central filaments correspond with var. *ovata*. Plants shewing entire or partial absence of pits occurred among the "*Albatross*" collections; in a markedly trilobed form approaching forma *Lamourouxii* in the "*Siboga*" collections: and in two plants from Funafuti, which come under A. 21 in the paper referred to above. It was also interesting to find that the type specimen of *H. Opuntia* var. *macropus* Ask. kindly lent me by Professor Engler shews small and few pits in the central filaments, combined with the external characters of forma *typica*, namely, the thick base and trilobed upper joints. The plant is however small and stunted.

The type specimen of *H. monile* (*Corallina monile* Ell. et Sol.) is also missing, but an examination of plants, corresponding in external form with the Solander figure, shewed well-

developed pits in the central strand. As regards its inclusion among the synonyms of *H. incrassata*, it is interesting to note the views of Lamouroux and of Dr. Harvey. Lamouroux (Hist. Polyp. Corall. flex. 1816 p. 307), remarks on the presence in the same individual plant of the characters which distinguish *H. monile* and *H. incrassata* and suggests that they should at most be regarded as only varieties of the same species. This suggestion he repeats in his later work "Exposition Méthodique des genres de l'ordre des Polypiers", 1821, p. 27, but possibly for want of material to decide the point himself he does not go further and unite the two species. This was however carried out by Dr. Harvey in his Nereis Boreali-Americana (Pt. III. 1858 p. 24.) where *H. monile* is given as a variety of *H. incrassata*, in consequence of the joints characteristic of the two species being frequently found on one and the same plant, among specimens collected by the author at Key West.

I have here kept up the name *monilis* to indicate the form of this species, in which the joints are mostly cylindrical, as figured by Solander (l. c.).

An examination of the type specimens of *H. cylindracea* Decne. kindly lent me by M. Hariot, and of *H. polydactilis* J. Ag., shew that both these plants are merely forma *monilis* of *H. incrassata*. Both of them have well-marked pits in the central strand at the apex of each joint.

The type specimen of *H. tridens* (*Corallina tridens* Ell. et Sol.) is unfortunately not to be found and it is therefore only possible to depend on the original, rather unsatisfactory, figure and the accepted view of later botanists as to the nature of this species. The Kützing figure of *H. tridens* in Tab. Phyc. l. c. is an exact representation of the plant under that name in the Kützing Herbarium, now in the possession of Madame Weber-van Bosse. This plant shews the well-developed pits in the central strand and has a long unbranched base, the joints composing it being so thickly calcified as almost to obliterate the divisions between them. This apparent absence of articulation is noticed by Professor J. G. Agardh (Till Alg. Syst. l. c. p. 87) who wonders what the plant may be from which the Kützing figure is taken.

The plants under the name of *H. tridens* in Herbaria are specimens of *H. incrassata*, as is shewn by their internal structure. The joints of such plants are not often quite so regularly tridentate as in the original figure of Ellis and Solander, which however represents only a fragment. Dr. Harvey remarks of *H. tridens* Lam. (Ner. Bor. Amer. l. c.) that it is nearly related to *H. incrassata* and is perhaps only a variety. The external characters of *H. tridens* are however not sufficiently distinct from those of forma *typica* to render it necessary to retain it as a form of variation.

Among the "*Siboga*" collections there were plants of *H. incrassata* indicating lines of variation other than those already known. One of these strongly resembles the trilobed form of *H. Opuntia*, the joints being markedly tripartite, and the segments thin and cylindrical. This I have called forma *tripartita*.

Another form had almost circular joints, strongly resembling those of *H. Tuna*, forma *typica*, but differing externally in being faintly ribbed. This I have called forma *rotunda*.

Among the already existing varieties of *H. incrassata*, there is a var. *tridentata* Duchass. recorded from Guadeloupe. M. Hariot was so kind as to search in the Paris Museum for the

original plant, but the only specimen of *Halimeda* which had been collected by Duchassaing at Guadeloupe bore the inscription: "Halimeda incrassata in Guad. leg. Fr. Duchassaing". This plant M. Hariot was good enough to send me and both its internal structure and external form are those of *H. incrassata* f. *typica*. The lower joints are very thick and much calcified, while the upper joints are of the usual tridentate type common in *H. incrassata*. If this plant should be the original of the var. *tridentata*, it becomes impossible to maintain *tridentata* as a form. The var. *tridentata* Duchass. is absorbed into forma *typica* and the name, which would have well described my forma *tripartita*, must disappear to avoid future confusion.

This species has only been recorded from the tropics. It is fairly common in the West Indies and occurs also in the Indian and Pacific Oceans.

Species inquirendae.

Halimeda brevicaulis Kutzing, Tab. Phyc. vol. VIII. 1858. p. 11. Tab. 25. fig. II.
Halimeda nervata Zanardini, Plant. Mar. Rub. in Mem. Ist. Ven. vol. VII. 1859. p. 289. Tab. XII. fig. 2.
Halimeda rectangularis J. G. Agardh, Analecta Algologica, Cont. I. 1894. p. 100.

List of Synonymy.

In this list there is indicated, so far as possible, the exact form of the species, to which the synonym refers. Where the species name stands alone in the second column, forma *typica* is to be understood.

Articulated Coralline of Jamaica Ellis.	*Halimeda incrassata* Lam.
Botryophora dichotoma Bompard.	*H. Tuna* Lam.
Codium Opuntia Sprengel.	*H. Tuna* Lam.
Corallina discoidea Esper.	*H. Tuna* Lam.
Corallina incrassata Ellis and Solander.	*H. incrassata* Lam.
Corallina latifolia et Opuntia marina Cortusi.	*H. Tuna* Lam.
Corallina latifolia et Opuntia marina Plukenet.	*H. Opuntia* Lam.
Corallina monile Ellis and Solander.	*H. incrassata* Lam.
Corallina Opuntia Ellis and Solander.	*H. Opuntia* Lam.
Corallina Opuntia Linn.	*H. Tuna* Lam. and *H. Opuntia* Lam.
Corallina opuntioides minor Petever.	*H. Opuntia* Lam.
Corallina opuntioides, ramulis densioribus, etc. Sloane.	*H. Opuntia* Lam.
Corallina tridens Ellis and Solander.	*H. incrassata* Lam.
Corallina Tuna Ellis and Solander.	*H. Tuna* Lam.
Flabellaria incrassata Lamarck.	*H. incrassata* Lam.
Flabellaria multicaulis Lamarck	*H. Opuntia* Lam.
Flabellaria Opuntia Delle Chiaie.	*H. Tuna* Lam.
Flabellaria Tuna Lamarck.	*H. Tuna.*
Fucus folio rotundo Bauhin.	*H. Tuna* Lam.
Fucus Sertolare Bertoloni.	*H. Tuna* Lam.
Halimeda brevicaulis Kützing.	Species inquirenda.
H. cordata J. G. Agardh.	*H. Opuntia* Lam. forma *cordata.*
H. cuneata Kützing.	*H. gracilis* Harv.
H. cuneata Kützing var. *elongata* Barton.	*H. Opuntia* Lam. forma *elongata.*
H. cylindracea Decaisne.	*H. incrassata* Lam. forma *monilis.*
H. cylindrica Kützing.	*H. incrassata* Lam. forma *monilis.*
H. discoidea Decaisne.	*H. Tuna* Lam.
H. incrassata Lamarck var. *monilis* Harvey.	*H. incrassata* Lam. forma *monilis.*
H. irregularis Lamarck.	? *H. Opuntia* Lam.
H. laxa Barton.	*H. gracilis* Harv. forma *laxa.*
H. Lessonii Bory.	*H. Tuna* Lam.
H. monile Lam.	*H. incrassata* Lam. forma *monilis.*
H. multicaulis Lam.	*H. Opuntia* Lam.

Halimeda nervata Zanardini.	Species inquirenda.
H. obovata Kützing.	*Halimeda cuneata* Hering.
H. Opuntia var. *macropus* Askenasy.	*H. incrassata*. Lam,
H. papyracea Zanardini.	*H. Tuna* Lam. forma *platydisca*.
H. platydisca Decaisne.	*H. Tuna* Lam. forma *platydisca*.
H. polydactylis J. G. Agardh.	*H. incrassata* Lam. forma *monilis*.
H. rectangularis J. G. Agardh.	Species inquirenda.
H. Renschii Hauck.	*H. Opuntia* Lam. forma *Renschii*.
H. Sertolara Zanardini.	*H. Tuna* Lam.
H. tridens Lam.	*H. incrassata* Lam.
H. triloba Decaisne.	*H. Opuntia* Lam. forma *triloba*.
H. versatilis J. G. Agardh.	*H. cuneata* Hering.
Hormisus opuntioides Targioni-Tozzetti.	*H. Tuna* Lam.
Lichen marinus Clusius.	*H. Tuna* Lam.
Lichen marinus rotundifolius Gerard, emac.	*H. Tuna* Lam.
Opuntia marina Parkinson.	*H. Tuna* Lam.
Opuntia marina ou Sertolare Imperato.	*H. Tuna* Lam.
Opuntia reniforme Naccari.	*H. Tuna* Lam.
Opuntioides Mich.	*H. Tuna* Lam.
Scutellaria sive Opuntia marina Bauhin.	*H. Tuna* Lam.
Sea Band-strings Petiver.	*H. Tuna* Lam.
Sertularia, Opuntia marina Chabraeus.	*H. Tuna* Lam.
Sertularia ramosissima, articulis reniformibus etc. Linnaeus.	*H. Tuna* Lam. and *H. Opuntia* Lam.
Sertolara Imperato.	*H. Tuna* Lam.
Sertolara typus Nardo.	*H. Tuna* Lam.
Ulva Sertolara Pollinius.	*H. Tuna* Lam.

EXPLANATION OF PLATES.

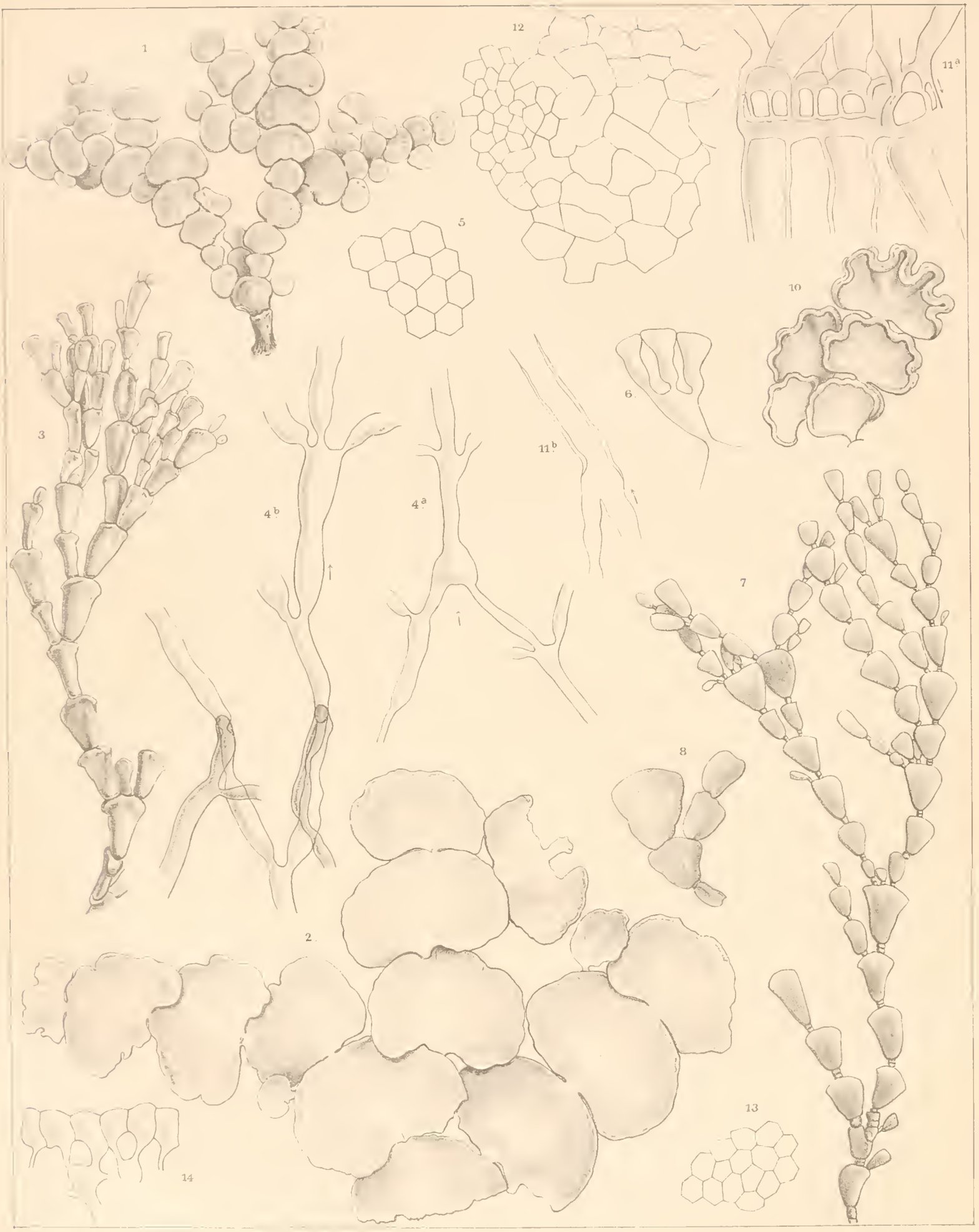

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PLATE I.

Figs. 1—6. *Halimeda Tuna.*

Fig. 1. Forma *typica*, nat. size.
Fig. 2. Forma *platydisca* (Canaries. Type of *H. platydisca* Decaisne). Nat. size.
Fig. 3. Forma *Albertisii* (Funafuti). Nat. size.
Fig. 4*a* and *b*. Filaments of central strand shewing mode of fusion. × 65.
Fig. 5. Peripheral cells, surface view. × 140.
Fig. 6. Peripheral cells, longitudinal view. × 140.

Figs. 7—14. *Halimeda cuneata.*

Fig. 7. Forma *typica*. (South Africa.) Nat. size.
Fig. 8. Forma *typica*. Fragment shewing sessile joints. Nat. size.
Fig. 9. (Plate II.) Forma *digitata*. (Siboga-Exp.). Nat. size.
Fig. 10. Forma *undulata*. (Siboga-Exp.). Nat. size.
Fig. 11*a*. Several fusing filaments from periphery of central strand, shewing scars which have almost exactly the appearance of pits. The filaments are seen fusing in pairs above and continuing their course in the node as single thick-walled tubes. × 140.
Fig. 11*b*. Two fusing filaments from middle of strand. × 65.
Fig. 12. Optical transverse section through apex of plant just below the ends of the fused filaments, shewing a portion of central strand and adjacent peripheral cells. × 140.
Fig. 13. Peripheral cells, surface view. × 140.
Fig. 14. Peripheral cells, longitudinal view. × 140.

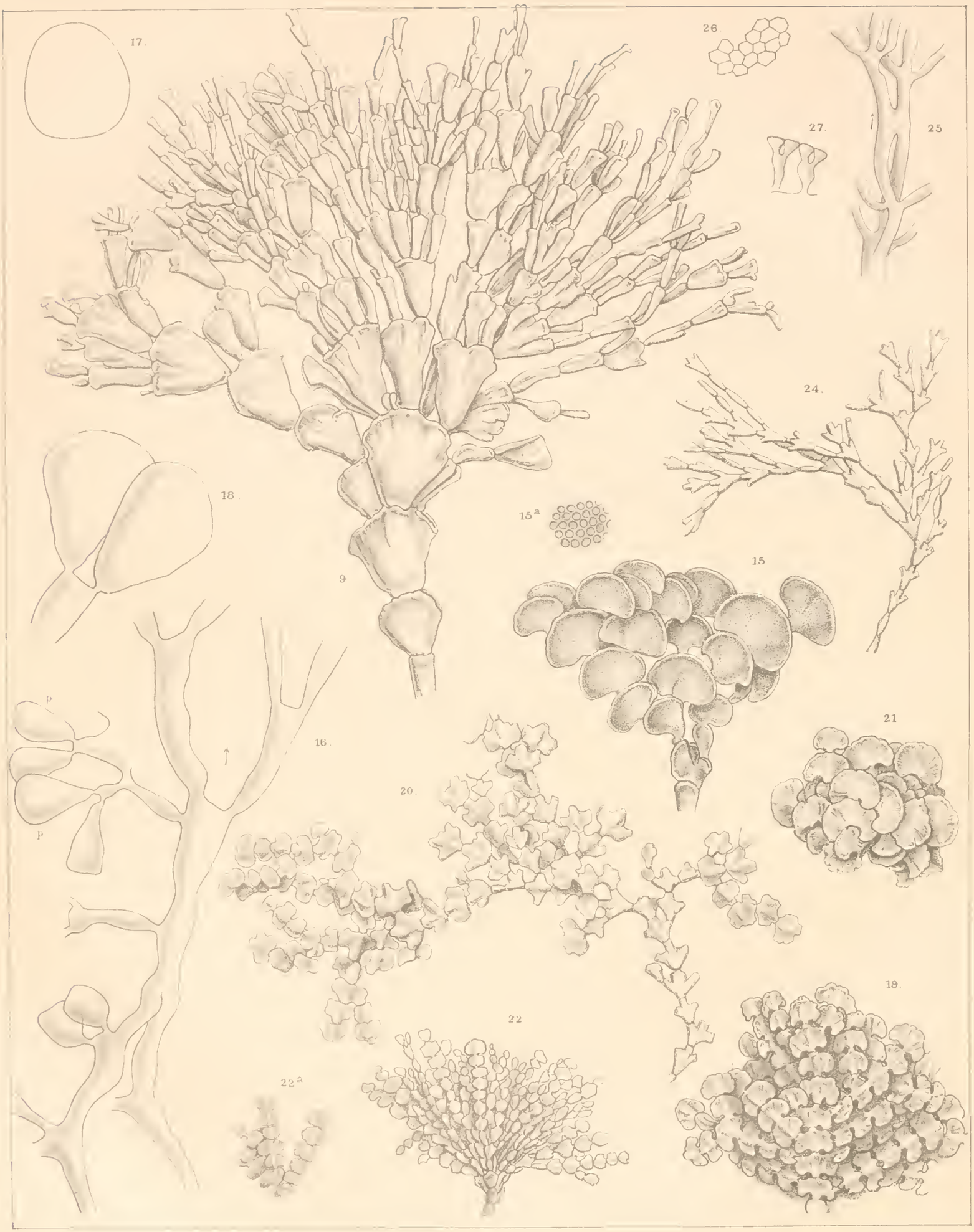

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PLATE II.

Figs. 15—18. *Halimeda macrophysa.*

Fig. 15. Habit of plant. (Siboga-Exp.). Nat. size.
Fig. 15*a*. Portion of surface of joint. × 15.
Fig. 16. Filaments of central strand; shewing mode of fusion, and origin of peripheral cells (p. p.) from the fused portion. × 65.
Fig. 17. Peripheral cell, surface view. × 140.
Fig. 18. Peripheral cells, longitudinal view. × 140.

Figs. 19—27. *Halimeda Opuntia.*

Fig. 19. Forma *typica*. Nat. size.
Fig. 20. Forma *triloba*. (China Sea, Herb. Mus. Paris, type of *H. triloba* Decaisne). Nat. size.
Fig. 21. Forma *cordata* (Red Sea, Herb. Agardh. Type of *H. cordata* J. Ag.). Nat. size.
Fig. 22. Forma *Renschii*. (Comoro Islands, authentic specimen). Nat. size.
Fig. 22*a*. Forma *Renschii*. (Siboga-Exp.) shewing rounded joints. Nat. size.
Fig. 23. (Plate III). Forma *hederacea*. (Siboga-Exp.). Nat. size.
Fig. 24. Forma *elongata*. (Siboga-Exp.). Nat. size.
Fig. 25. Filaments of central strand, shewing mode of fusion × 65.
Fig. 26. Peripheral cells, surface view. × 140.
Fig. 27. Peripheral cells, longitudinal view. × 140.

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PLATE III.

Figs. 28—32. *Halimeda gracilis.*

Fig. 28. Forma *typica*. (Ceylon. Harvey, n°. 72). Nat. size.
Fig. 29. Forma *laxa*. (Funafuti, type of *H. laxa* Bart.). $^1/_2$ nat. size.
Fig. 30. Filaments of central strand, shewing mode of fusion. × 65.
Fig. 31. Peripheral cells, surface view. × 140.
Fig. 32. Peripheral cells, longitudinal view. × 140.

Figs. 33—38. *Halimeda macroloba.*

Fig. 33. Habit of plant. (Botta, Arabia. Decaisne specimen in Herb. Mus. Paris). Nat. size.
Fig. 34. Filaments of central strand in longitudinal view, shewing pits at point of fusion. × 140.
Fig. 35. Optical transverse section through apex of plant, just below the ends of the fused filaments; shewing half of the central strand, the irregular outline of which is clearly seen. The external walls of the outer filaments form one continuous layer, which sharply delimits the strand. At * a few peripheral cells are shewn. × 140.
Fig. 36*a*. One of the inner filaments from Fig. 35. × 365.
Fig. 36*b*. Longitudinal view of two filaments, similar to that of 36*a*. × 365.
Fig. 37. Peripheral cells, surface view. × 140.
Fig. 38. Peripheral cells, longitudinal view. × 140.

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PLATE IV.

Figs. 39—51. *Halimeda incrassata.*

Fig. 39. Forma *typica*. (West-Indies). Nat. size.
Fig. 40. Forma *monilis*. Nat. size.
Fig. 41. Forma *Lamourouxii*. (Siboga-Exp.). Nat. size.
Fig. 42. Forma *ovata*. (Pacific Ocean). Nat. size.
Fig. 43. Forma *tripartita*. (Siboga-Exp.). Nat. size.
Fig. 44. Forma *pusilla*. (Siboga-Exp.). Nat. size.
Fig. 45. Forma *rotunda* (Siboga-Exp.). Nat. size.
Fig. 46. Filaments of central strand, longitudinal view, shewing pits at point of fusion. × 140.
Fig. 47. Filament of central strand from forma *ovata*, shewing its course without fusion from one internode to the next. In the node the wall is much thickened; this is represented by the shading. × 65.
Fig. 48. Optical transverse section through apex of plant, just below the ends of the fused filaments, shewing the whole of the central strand. The external walls of the outer filaments form one continuous line which sharply delimits the strand. At * a few peripheral cells are shewn. In the lower part of the figure three peripheral cells are seen surrounded by central filaments. × 140.
Fig. 49*a*, *b*. Two groups of peripheral cells, surface view. × 140.
Fig. 50. Peripheral cells, longitudinal view. × 140.
Fig. 51. Rhizoids. × 140.

RÉSULTATS DES EXPLORATIONS
ZOOLOGIQUES, BOTANIQUES, OCÉANOGRAPHIQUES ET GÉOLOGIQUES
ENTREPRISES AUX
INDES NÉERLANDAISES ORIENTALES en 1899—1900,
à bord du SIBOGA
SOUS LE COMMANDEMENT DE
G. F. TYDEMAN
PUBLIÉS PAR
MAX WEBER
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aan boord H. M. Siboga onder commando van
Luitenant ter zee 1e kl. G. F TYDEMAN

UITGEGEVEN DOOR

Dr. MAX WEBER
Prof. in Amsterdam, Leider der Expeditie

(met medewerking van de Maatschappij ter bevordering van het Natuurkundig onderzoek der Nederlandsche Koloniën)

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