The Genus *Polysiphonia*, Grev., a critical Revision of the British species, based upon Anatomy.

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(Plates 22–25.)

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The object of the following paper is to work through critically the British species of *Polysiphonia*, but at the same time to investigate thoroughly their organs of attachment. An attempt having been made to collect material from various localities, the neighbourhood of Swanage was finally decided upon as the special area for purposes of this paper, a series of visits being subsequently made at different times of the year. The nature of the rock and tilt of the strata was found to influence the distribution of marine algæ, even if one only considers the mechanical action of the water. The area chosen is very varied geologically, so that species can be found which need sheltered bays for their habitation, as well as those which are able to persist on rocky headlands exposed to the full force of the tide. Studland is a sheltered bay, eroded in sandy Tertiary beds. It is not only valuable for its own flora, but for the numbers of specimens which are washed into the bay after rough weather. West of Ballard Down the Wealden is exposed, the beds consisting of sand and clays, while between Durlston Head and St. Alban's Head the Portlandian forms the coast-line, 19 feet of Portland stone forming the base of the cliffs in Durlston Bay. The mud flats of Poole Harbour form another type of hunting-ground, where local conditions cause marked variability in the form of certain species. In the marine lake of Poole Park a floating form of *P. variegata* has been found and given to me for description by Mr. A. D. Cotton. Between the Haven, at the entrance of Poole Harbour, and Sandbanks, a number of groins run out into the sea, and these are particularly rich in some of the smaller Polysiphonias.

Material which can only be obtained by dredging has been sought after at Plymouth from the 'Oithona,' belonging to the Marine Biological Station, and useful shore-collecting for individual species has been done near Wembury and on the island off Looe, as well as at Ilfracombe, Torquay, and near Berry Head. A few rare species which it was not possible to obtain by collecting have been examined at the Royal Botanic Gardens, Kew, the Natural History Museum, South Kensington, and in the herbarium of Mrs. Griffiths at Barnstaple.

Former systematic descriptions of the group have been worked through critically, attention having been paid to the general detailed anatomy of the

thallus, which in many of the essential points is curiously similar throughout the genus. The study of the attachment organ has been of considerable interest, largely on account of the gradual increase in complexity which is visible in the group. The form of the attachment organ has been correlated with the general anatomy of the species, and the parasitism of *P. fastigiata* has been proved.

The elimination of false synonyms has been possible after consulting the records and collections at Kew and the Natural History Museum. An attempt has also been made to bring together those plants which are forms of some previously recorded British species, but through environmental modification have been given a new specific name, or have been re-named by British workers without due consultation with the records of foreign species. A key to the species, based on purely vegetative characters, has also been compiled, and *P. spiralis* is described for the first time. In order that the paper may be more complete for reference, a summary of the literature on the development of the reproductive organs of the genus has been inserted.

The paper deals exclusively with the genus *Polysiphonia*, of which 24 species are recorded, types which are now grouped with the Pterosiphonias having been reserved. The two groups are distinguishable by their respective methods of branching. In the Pterosiphonias the branching is markedly pinnate throughout the plant, both branches and ramuli being set at acute angles.

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Historical.

The genus *Polysiphonia* was originally described by Agardh in 1817 under the name of *Hutchinsia*, but that name is inadmissible owing to a group of the Cruciferæ having been previously given that generic name by Robert Brown. In 1822 Bonnemaison substituted the term *Grammita* for that of

Hutchinsia. This, however, was objected to by Greville (Fl. Edinensis, 1824, p. 308) owing to the possibilities of confusion with *Grammitis* which had already been used for a group of Fungi, and by Swartz in 1801 for a genus of Ferns, which was a synonym for *Polypodium*. Greville therefore devised the term *Polysiphonia*, which has persisted in spite of the indignation of Desmazières (**21**), who was reluctant to abandon the term which had the privilege of seniority, for one "qui paraît devoir son existence au caprice."

Morphology.

The *Polysiphonia* plant consists of a branched thallus, bearing numerous ramuli. In perennial forms like *P. elongata* the ramuli are shed annually before the winter, the plant being re-clothed in the spring. At the tips of the branches and of the ramuli, clusters of fine filamentous hairs are borne in many species, and on these the antheridia are produced. Tetraspores are borne in the ramuli, and cystocarps may be developed either on the ramuli or on the branches of the thallus. The attachment of the plant is effected by the development of numerous rhizoids.

Anatomy.

The species are divisible into two main groups :—

(*a*) Ecorticate,

(*b*) Corticate.

The anatomy of the ecorticate forms consists solely of siphons, that is of cells which extend the whole length of the articulation (Pl. **22**. fig. 5). In the corticate forms, however, in addition to the siphons, there are cells present at the periphery of the thallus which are much shorter than the siphons and smaller in diameter. These form a mosaic which may extend over the whole plant as in *P. fruticulosa*, or may only occur on the lower parts as in *P. violacea* (Pls. **25**, **24**. figs. 78, 59).

The thallus consists throughout the group of one central siphon and a band of primary pericentral siphons numbering from 4 to 20 or even more. These may be surrounded by alternating bands of smaller siphons, and bounded externally by one or more rows of cells, in the corticate forms. The pericentral siphons are usually parallel to the main axis. In *P. atro-rubescens*, *P. nigrescens* var. ε. *affinis*, and occasionally in *P. fibrata*, however, a slight spiral formation is visible, and the same phenomenon is well defined in what is believed to be a new species, and has been here described as *P. spiralis*.

P. urceolata will serve to typify the ecorticate species. The thallus consists here of one central siphon, and four pericentral in each articulation. The central siphon is much smaller than the pericentral ones, and there is protoplasmic continuity throughout the plant. The upper and lower ends of the siphons are connected by almost colourless strands of protoplasm, which

contain very few granules, and which pass through a lenticular patch in the adjacent end-walls of contiguous cells. In the central siphon this connecting filament is rather larger than in the pericentral, and is deeper in colour. At the point through which the protoplasm passes there is a lenticular thickening round the margin of the aperture, while the actual diaphragm is like a perforated plate (Pl. **22**. fig. 1). There is also a lateral connection of the central with the pericentral siphons on the tangential walls. The form of the connection is uniform throughout, but the lateral connections are not necessarily at a uniform level throughout the articulation, during the whole life of the plant.

Each siphon contains a mass of pink protoplasm, embedded in which are a number of red chromoplasts. The plastids are not so numerous in the central siphon, and in the pericentral ones they are usually arranged near the periphery of the thallus. The nucleus does not stain very readily, but after prolonged treatment with iodine may be observed in the younger parts of the thallus, where it is very large compared with the diameter of the cell (Pl. **22**. fig. 3).

The apical cell is a rounded and flattened cone, filled with granular protoplasm and containing a large nucleus. When growth proceeds, a thin disc is separated by a wall from the base of the cone, but the wall is perforated in five places, through which strands of protoplasm pass, one central and four pericentral strands. At a later stage there is a longitudinal fission of the disc into a central mass and four pericentral portions. The four pericentral parts then become separated longitudinally by walls, but retain a protoplasmic connection longitudinally and laterally with the contiguous siphons and the central siphon respectively. As Massee has pointed out (**42**. p. 198 *et seq.*), the increase in size of a *Polysiphonia* is the result of two methods of cell formation. The axial row of siphons by which the thallus increases in length is the result of the division or segmentation of the apical cell, while the increase in thickness is due to "gemmation" from the axial cells.

There is a slight variation of form in the thallus of *P. fastigiata*. In the young state the protoplasm of the central siphon fills the whole cell-cavity. Later, however, the wall becomes thickened, particularly in the upper and lower parts of the siphon. As a result the cell contents are shut down into a flattened mass, which is connected with the central siphons above and below by a narrow strand of protoplasm passing through the thickened walls (Pl, **22**. fig. 4). In this case the pericentral siphons are connected with the central at a uniform level in each individual articulation, the protoplasmic strands penetrating the wall and uniting with the protoplasm of the central siphon. There is a well-defined thickened rim visible at the point through which the protoplasmic strand passes from one cell into the next. There has been a considerable amount of controversy as to whether these openings are maintained in the older state of the plant. Schmitz (**50**. p. 215) considers that

protoplasmic continuity is maintained throughout the life of the cells. Massee (**42**. p. 198) thinks that the opening becomes closed by the growth of a cellulose plate, to the margin of which the primordial utricle is attached. He considers, however, that fine protoplasmic threads pass through minute holes in the plate, and so maintain the continuity of the protoplasm. Harvey Gibson (**27**. p. 129) has shown, however, that in *P. fastigiata*, at any rate, the canal is closed in the older parts of the plant. Fine granular striæ are visible, but maceration shows these to be a fringe of fine threads arising along the margin of the plug and quite independent of the protoplasmic contents of the canal.

The structure of the corticate species is similar to that of the ecorticate, but in addition to the formation of the primary pericentral siphons in the manner described for *P. urceolata*, there may be an additional formation of secondary and tertiary siphons by "gemmation" from the primary and secondary respectively. When small cells are developed round the periphery these are produced from the outermost layer of the siphons in a similar manner. This is particularly well seen in *P. elongata*, where protoplasmic continuity is clearly visible in a median longitudinal section of the thallus. In some of the large corticate forms of which *P. elongata* is typical the system of protoplasmic continuity is more complex than in the ecorticate species. In the very early stage there is one connection at each end of the central siphon, but as the plant increases in size, four strands are developed round the central one in each central siphon, while additional strands also occur in the pericentral siphons. If there is more than one row of corticating cells at the periphery, the outer layers are formed by gemmation from the inner, and protoplasmic connections are maintained.

The mode of branching is variable throughout the group. It may be monopodial, axillary, or pseudo-dichotomous. Rosenvinge (**35**. p. 222) investigated the development of *P. violacea*. He found that in this axillary type the two daughter-cells of the apical cell are unequal in size, giving the impression that the smaller cell is cut off from the larger. In *P. fastigiata*, however, very marked pseudo-dichotomy is visible. The apical cell is divided by two oblique walls, and the branches grow out on either side at right angles to the inclined septa.

Attachment Organs.

The Polysiphonias are usually attached, the only exception being occasional floating forms of particular species. A floating form of *P. variegata* was found in the marine lake of Poole Park, and is described on page 308.

The substratum varies with the species, and may be rocks, stones, shells, wood, or other algæ. When growing on other algæ the Polysiphonias are epiphytic, with the exception of *P. fastigiata*, which derives food from its host *Ascophyllum nodosum*. The usual type of attachment organ is formed of a

number of rhizoids, which may or may not develop discs at their distal ends, depending on the nature of the substratum. The formation of these rhizoids presents a feature of considerable interest, as a gradual increase of complexity is traceable, which can be correlated with the anatomy of the species.

The rhizoids are thick-walled, and are formed principally by the lateral proliferation of primary pericentral siphons in ecorticate forms such as *P. macrocarpa*. In corticate forms, however, where the thallus is bounded by small cells, the rhizoids are formed from these latter, and not from the siphons themselves. Fig. 5 (Pl. **22**) shows the development of a single rhizoid from a pericentral siphon in *P. macrocarpa*. The formation of rhizoids from the corticating cells of *P. nigrescens* is shown in fig. 6 (Pl. **22**). When the rhizoids ramify among the small filamentous algæ and debris on the surface of a rock, they do not develop discs at their extremities (Pl. **25**. fig. 64). If, however, the tip of the rhizoid comes into contact with some firm object such as a fragment of rock or shell, or some larger alga, a flattened expansion begins to form. This eventually becomes lobed, but no septation takes place (Pl. **22**. fig. 2). The formation of a disc is a direct response to the stimulus of contact. If the rhizoid attaches itself to a sand grain, the disc bends over and partially encloses the grain. Derick (**20**. p. 251) states that the rhizoids of *P. violacea* are separated from the corticating cells by a wall, but I have never observed a wall at the base of a rhizoid in any species of *Polysiphonia* that I have examined. The rhizoids are unicellular, and are usually unbranched, but in *P. urceolata* an occasional tendency to branch may be observed although no septation takes place.

Where *Polysiphonia* grows on another alga epiphytically, as, for example, *P. violacea* on *Chorda filum*, rhizoids are formed which adhere to the surface of the host by means of their expanded discs. Penetration does not take place, but the host is frequently a little distorted, and has fewer chromatophores in the part of the thallus below the discs.

The question naturally arises as to the exact means by which the disc is attached to the substratum. It must adhere either like a sucker, or by the purely mechanical means of fitting in among the crevices of the substratum, or by the secretion of a cement. Careful observation and sections have failed to reveal any lifting of the centre of the discs either individually or in the aggregate, and the presence of large forms like *P. elongata* on a perfectly smooth water-worn pebble near a jetty, seems to indicate, that purely mechanical adherence by fitting in with the crevices of the substratum is an inadequate explanation. Where the substratum is irregular, this latter method no doubt aids in the attachment, but it is not sufficient when acting alone on certain substrata. It appears, therefore, that the thickened discs consist partly of a cementing substance which helps to fix the alga. It was suggested that there might be some chemical combination of the secretion with the substratum, but I have been unable to find any trace of chemical

change in cases where examination proved possible. It seems most probable that the alga adheres largely by the action of its own gelatinous wall membrane, the formation of the disc giving increased surface for attachment.

A modification of the disc occurs in *P. fastigiata*. The rhizoids actually penetrate the tissues of the host, and at the tip the wall is thin and the cell is filled with granular contents. If a section of the *Ascophyllum* thallus be taken, it is noticeable that certain of the host cells near the tip of the rhizoid are darker in colour than their neighbours, and that similar dark cells are present at places where the rhizoid has passed at an earlier stage. A number of sections were taken, and the rhizoid-tip was found closely applied to certain darkened *Ascophyllum* cells. This suggested that the rhizoid attacked these cells, the swollen tip acting as an haustorium (Pl. **22**. figs. 7, 8). Rattray (**48**) believed that a partial parasitism must occur in the association, and Tobler-Wolff (**55**) observed the dark cells, but no definite statement of parasitic habit was made in either case.

With a view to ascertaining whether the contents of the *Ascophyllum* cell had been changed by contact with the *Polysiphonia*, a chemical test was applied. *Ascophyllum nodosum* does not contain starch in the form in which it is usually found, but the food-store stains red when treated with a solution of vanillin in concentrated HCl. Sections were therefore placed for a moment in the solution, then washed and examined in water, and it was found that the contents of the ordinary *Ascophyllum* cells became bright red, whereas the dark cells gave no reaction. It is evident, therefore, that the *Polysiphonia* obtains food from the cells of the host which it attacks (Pl. **22**. fig. 8).

Where there is an extensive growth of the parasite, the *Ascophyllum* frequently has a somewhat stunted and more rigid thallus in the immediate neighbourhood of the *Polysiphonia*. This, however, is probably due to some extent to the increased strain to which it is subjected, with an increased surface for the action of the waves, and is not solely due to the semi-parasitic habit of the *Polysiphonia*. As Rattray (*loc. cit.*) has pointed out, it is not absolutely necessary for the life of *P. fastigiata* that it should be fixed to any host, as it occurs, though comparatively rarely, growing on a rocky substratum. When this happens, however, its vegetative growth is less perfect, although it may be exposed to similar conditions with regard to depth and general environment. The fact only bears out the view that a direct advantage is gained by an epiphytic habit.

In order to illustrate the degree of complexity which is visible in the attachment organs of the genus, four types may be selected.

1. *P. urceolata*.

The young plant is usually attached to the substratum by two rhizoids which are developed by longitudinal proliferation of the base of the primary

siphons ; the actual number is, however, subject to slight variation. These rhizoids are terminal in origin, and not lateral like the subsequent ones. As growth proceeds and the thallus branches, any pericentral siphon of a procumbent branch may develop a rhizoid, and thus afford additional strength for the attachment of a colony. Ultimately then, the colony is attached by a large number of rhizoids which arise from the main axis and low branches, but there is no aggregation into any special form.

In this type of attachment the tips of the rhizoids may ramify among the algæ and debris, and not become expanded as in the figure of *P. fœtidissima* (Pl. **25**. fig. 64), or they may develop expanded discs as in *P. urceolata* itself, or become swollen as haustorial organs, as in *P. fastigiata*.

2. *P. nigrescens*.

The main principle of the attachment is similar to that of *P. urceolata*, but at the extreme base of the thallus a row of corticating cells frequently occurs. This appears to be correlated with the closer development of rhizoids, and the fact that an aggregation is possible whereby the discs of the colony adhere mechanically to each other, making an uninterrupted surface at the base of the attachment. This mechanical coherence of the discs is not so marked in the ecorticate species of *Polysiphonia*, and it appears that the phenomenon is made possible by the presence of the corticating cells and consequent closer development of the rhizoids, and is also facilitated by the presence of a greater number of pericentral siphons than is present in the group typified by *P. urceolata*. It appears to be the first step towards the aggregation of the individual discs into a single large attachment organ, such as is seen in *P. elongata*, but there is no sign of the coalescence of the upper parts of the rhizoids.

3. *P. fruticulosa*.

P. fruticulosa is corticate throughout, and rhizoids are formed in large numbers from the corticating cells. There is, however, a special adaptation which is of interest. The young plant is attached at the base by a number of terminal rhizoids. When branching takes place, certain of the lower branches are procumbent for a short distance, and themselves branch alternately as they creep along the substratum. Of these secondary branches, the upper ones continue growth in an upward direction, while those on the under side of the thallus become stunted and short. The corticating cells of these stunted branches send out large numbers of rhizoids, and the whole branch appears to be devoted to the function of attachment (Pl. **25**. fig. 78). The tip of the branch frequently bends round the thallus of any small alga which it may encounter, and thus affords additional strength. A few rhizoids may develop from the procumbent parts of the original branches, but the principal means of attachment is the modified branchlet. There is no mechanical

cohesion of the upper parts of the rhizoids, but the expanded bases may fit in together, though I have never found a definite plate such as one sees in *P. nigrescens*.

4. *P. elongata*.

P. elongata is typical of the most complex form of attachment which is exhibited in the genus. A median longitudinal section shows that the siphons themselves, as well as the corticating cells, take part in the formation of the large disc by means of which the plant is attached (Pl. **24**. fig. 47). The central and pericentral siphons, together with a large number of corticating cells, are elongated longitudinally into rhizoids, and as elongation takes place, the cells and siphons at the base spread out, so that a bigger surface is available for attachment. The outer rhizoids develop discs comparable to those of *P. urceolata*, but the discs of the inner rhizoids are smaller on account of crowding. The upper parts of the latter mechanically coalesce to form a pseudo-tissue, and it is only on the outside at the extreme base of the attachment that the separate walls of individual rhizoids may be discerned. With this form of attachment it is only the base of the main axis which is involved, so that none of the branches are procumbent, and consequently plants with an individual axis are characteristic, instead of a colony as in *P. nigrescens*.

Taking these four species as typical of the groups which they represent, it is apparent, therefore, that the more complex type of attachment organ can be correlated with the development of cortication in the genus. In the simple ecorticate forms the attachment organ consists of rhizoids which are developed by the proliferation of the siphons themselves. As cortication begins to be visible, the smaller outer cells form the attachment, and there are signs of an aggregation into disc-like form. When the whole plant is corticate, the attachment is either formed by means of a modified branch as in *P. fruticulosa*, or the siphons and corticating cells take part in the formation of a disc as in *P. elongata*. Intermediate forms occur, as for example *P. Brodiæi*, where the original disc is comparable to *P. elongata*, but the procumbent branches afford additional mechanical strength by sending out rhizoids at their bases.

Reproduction.

Tetraspores.

Tetraspores are borne in the ramuli, and may either occupy the tip of the ramulus, as is usual in *P. urceolata*, or may be intercalary in development as in *P. Brodiæi*. As Massee (**42**. p. 198 *et seq.*) has pointed out, the tetrasporangium originates in the same way as the pericentral siphons, and in *P. fastigiata* occupies a space equal to that occupied by two siphons. Two daughter-cells are developed on the outside by gemmation from the tetrasporangium (Pl. **22**. fig. 9), which is in communication with the axial siphon

by a protoplasmic strand. The tetrasporangium divides into two transversely, the basal cell remaining inconspicuous, while the upper one grows rapidly. The wall becomes definite and the contents assume a dark colour. The nucleus of the tetraspore mother-cell has been shown by Yamanouchi (**62**. p. 401 *et seq.*) to contain 40 chromosomes, and as a result of reduction division the nuclei of the tetraspores contain only 20. After the division of the nucleus, the contents of the mother-cell divide into four parts, which arrange themselves in a definite way. One remains at the base of the cell near the point of communication with the basal cell, two occur over this one, and the fourth at the top of the large oval cell. As the tetraspores increase in size, the neighbouring siphons become pushed outwards, resulting in a distorted ramulus.

Antheridia.

The antheridia are developed at the tips of the branches, where they either replace the whole of one of the jointed filamentous hairs, or else one arm of the first branch of a dichotomous hair. In material of *P. nigrescens* from Plymouth Sound each antheridium replaced an entire hair, and the filamentous axis was continued for a considerable distance beyond the tip of the antheridium. The antheridia are elongated, somewhat cylindrical, and often slightly curved. The structure of the antheridium has been described by Yamanouchi (**62**. p. 401 *et seq.*). A filamentous axis extends down the centre, and on this the flattened stalk cells are borne. The sperm mother-cells which give rise to the antherozoids are formed on the stalk cells, and large numbers of oval sperms are developed, each containing a large vacuole.

Cystocarps.

The development of the cystocarp has been worked out in detail by Phillips (**46** & **47**. pp. 289–301), Schmitz (**50**), Yamanouchi (**62**. p. 401 *et seq.*), and others. Oltmanns (**44**. p. 99 *et seq.*) showed that the real sexual act is the union of the male and female gamete nuclei in the carpogonium, and that the auxiliary cells are probably only concerned with the nourishment of the cystocarp. Previous to this work, the act of fertilization and the secondary fusions concerned with the auxiliary cells were all included in the sexual process.

According to recent work by Yamanouchi (*loc. cit.*) and Phillips (*loc. cit.*) the procarp in *P. violacea* consists in the beginning of a short branch of three or four cells. The most important of these is the cell of the axial siphon lying next to the apical cell. This divides to form five pericentral cells, which completely surround it. One of these is the "pericentral cell," which will give rise to the carpogonial branch. The nucleus of the pericentral cell divides nearly parallel to the axis of the procarp, cutting off a cell which develops the carpogonial branch. The pericentral cell later gives rise to a group of auxiliary cells. The carpogonial branch consists of four cells, the terminal of which becomes the carpogonium and develops a trichogyne.

The nucleus of the carpogonium divides to form two nuclei, one of which becomes the female gamete nucleus ; the other enters the trichogyne, which becomes elongated and constricted where it joins the carpogonium.

When a spermatium becomes attached to the tip of the trichogyne, the walls between dissolve and the contents of the sperm enter. The sperm nucleus, which contains 20 chromosomes, passes into the carpogonium ; the male and the female nuclei lie in close proximity, while the trichogyne nucleus disintegrates and the trichogyne shrivels. The nuclei in the carpogonium fuse, and a set of auxiliary cells are developed by the pericentral cell round the fertilized carpogonium. With the fusion of the two nuclei the number of chromosomes is brought up to 40, and the sporophyte generation has begun. The carpogonium then fuses with the auxiliary cell, which lies between it and the pericentral cell. A fusion with the pericentral cell itself follows immediately, and the fused sexual nucleus, which has divided into two, moves down to the pericentral cell. After this, the passage between the carpogonium and the auxiliary cell closes, and the carpogonium remains isolated, finally breaking down with the three sister-cells of the carpogonial branch. During the formation of the auxiliary cells from the pericentral cell, each nucleus in the first three cells of the carpogonial branch divides, the daughter-nuclei lying side by side in pairs. The protoplasmic connection which exists between the auxiliary and pericentral cells becomes larger, and the nuclei of the auxiliary cells move towards the pericentral cell. This general union results in the formation of a large cell, which was called by Phillips (**46**. p. 289) the "central cell." It contains many nuclei, two of which are sporophytic, the others gametophytic. The sporophytic nuclei divide and the central cell develops lobes, into each of which a sporophytic nucleus passes. The nuclei again divide, and a carpospore is cut off terminally, the lower part remaining as a stalk cell, attaching the carpospore to the central cell. After the formation of the carpospores, the central cell increases in size greatly, absorbing the stalk cells. The envelope of the cystocarp is developed from the peripheral siphons of the original procarpic branch, and is lined with delicate filaments, the paranemata, which arise from the cell of the axial siphon. The cystocarp is urn-shaped, with an ostiole at the top, through which the carpospores are discharged.

Summary.

Species of British *Polysiphonia* may be classified according to their anatomical differentiation. The thallus consists of a central siphon, surrounded by four or more pericentral siphons. In the corticate forms, external cells are also present which do not extend for the complete length of an articulation. Protoplasmic continuity is present throughout the plant in the young stages, although later some of the connecting pits may become closed.

Growth takes place by two methods of cell formation—division from the apical cell and "gemmation" from the axial cells.

The form of the attachment organ varies with the species, and is influenced by the nature of the substratum. Four types may be distinguished :—

1. The ecorticate plant is originally attached by rhizoids, which are developed from siphons by longitudinal proliferation. Later, siphons of procumbent branches also develop rhizoids. Rhizoids may have discs at their distal ends when they encounter a hard substratum, or may ramify among filamentous algæ without expanding, or may be swollen to form haustoria in certain species.

2. Species having a number of siphons or a beginning of cortication at the base show elementary aggregation of the rhizoids to form a large disc, the expanded tips of the rhizoids themselves interlocking mechanically. Procumbent branches also develop rhizoids which give additional strength, and the cells as well as the siphons aid in the formation of the attachment organ.

3. *P. fruticulosa*, which is originally attached by a number of longitudinally developed rhizoids, and, later, certain procumbent branches which are stunted function specially in the formation of the attachment organ.

4. Species with an upright habit, which do not branch near the base, develop a large disc-like expansion at the base of the thallus. Such forms are always corticate. The siphons and corticating cells at the base all grow downwards longitudinally and form rhizoids. The rhizoids cohere mechanically with each other, so that a pseudo-tissue is formed.

Sexual and asexual organs of reproduction are present in the group. Tetraspores are either intercalary or are borne terminally. The tetrasporangium originates in the same way as the pericentral siphons, subsequently dividing into two, the upper of which develops four tetraspores.

Antheridia are borne at the tips of the branches and ramuli, each antheridium either replacing a filamentous hair or one arm of a dichotomous hair.

Cystocarps are borne on the branches and ramuli. They are urn-shaped, with an ostiole at the top, which is occasionally sinuous and through which the carpospores are discharged.

A classification and description of the individual species follows, together with a key for identification.

Enumeration and Classification of Species of *Polysiphonia* according to their Anatomical Differentiation.

I. Ecorticate Species.

A. Four primary pericentral siphons.

1. *P. insidiosa.*
2. *P. macrocarpa.*
3. *P. rhunensis.*
4. *P. spiralis.*
5. *P. urceolata.*

B. More than four primary pericentral siphons.

1. *P. atro-rubescens.*
2. *P. fastigiata.*
3. *P. furcellata.*
4. *P. obscura.*
5. *P. opaca.*
6. *P. Richardsoni.*
7. *P. simulans.*
8. *P. subulifera.*

II. **Corticate Species.**

A. Four primary pericentral siphons.

1. *P. elongata.*
2. *P. elongella.*
3. *P. fibrata.*
4. *P. fibrillosa.*
5. *P. spinulosa.*
6. *P. violacea.*

B. More than four primary pericentral siphons.

1. *P. Brodiæi.*
2. *P. fœtidissima.*
3. *P. fruticulosa.*
4. *P. nigrescens.*
5. *P. variegata.*

Key to Species.

1.	Axis consisting of 4 primary pericentral siphons, with or without cortication	20
	More than 4	2
2.	Axis consisting of 5 primary pericentral siphons	3
	More than 5	4
3.	Articulations 3 or 4 times longer than broad in lower parts of axis; siphons spirally placed	*P. Richardsoni.*
	Articulations shorter than their breadth near the base; siphons irregular	*P. variegata.*
4.	Axis consisting of 6 primary pericentral siphons, with or without cortication	8
	More than 6	5
5.	Axis consisting of 7 primary pericentral siphons, with or without cortication	8
	More than 7	6
6.	Axis consisting of 8–11 primary pericentral siphons, with or without cortication	7
	More than 11	11
7.	Zone of cells present in older parts, outside primary siphons	8
	Not so	9
8.	Ramuli slender and regularly distributed over the younger branches.	*P. variegata.*
	Ramuli borne close together, giving plant a tufted appearance	*P. Brodiæi.*
9.	Pericentral siphons spirally curved	*P. atro-rubescens.*
	Not so	10
10.	Colour bright brick-red	*P. furcellata.*
	Colour dark brownish-red	*P. fœtidissima.*
11.	Axis consisting of 12–14 primary pericentral siphons, with or without cortication	12
	More than 14	17

12.	Pericentral siphons spirally curved	*P. atro-rubescens.*
	Not so	13
13.	Maximum height of plant $\frac{1}{2}$ inch	*P. obscura.*
	Not so	14
14.	Plant corticate throughout	*P. fruticulosa.*
	Not so	15
15.	Colour bright brick-red when fresh	*P. subulifera.*
	Not so	16
16.	Central siphon small	*P. simulans.*
	Central siphon occupying about half the radius of thallus in transverse section	*P. nigrescens.*
17.	Filaments decumbent; plant not more than $\frac{1}{2}$ inch high	*P. obscura.*
	Not so	18
18.	Usually parasitic on *Ascophyllum nodosum*, and containing conspicuous central siphon	*P. fastigiata.*
	Not so	19
19.	Zone of corticating cells present outside the primary siphons at extreme base of main axis	*P. nigrescens.*
	Axis consisting solely of about 20 pericentral siphons, and one central, ecorticate throughout	*P. opaca.*
20.	Plant ecorticate	21
	Plant corticate	28
21.	Siphons spirally curved in principal branches	23
	Not so	22
22.	Plants gelatinous, occurring in tufts about 1 inch in height	*P. macrocarpa.*
	Not so	24
23.	Articulations one or $1\frac{1}{2}$ times as long as broad	*P. spiralis.*
	Articulations 6–8 times as long as broad	*P. fibrata.*
24.	Colour deep full red	*P. urceolata.*
	Not so	25
25.	Articulations 4–6 times as long as broad	26
	Not so	27
26.	Ramuli dichotomously branched	*P. fibrata.*
	Ramuli alternate or unilateral	*P. insidiosa.*
27.	Plant greyish in colour. Articulations 3 or 4 times as long as broad	*P. insidiosa.*
	Colour reddish-brown. Articulations 2 or 3 times as long as broad.	*P. rhunensis.*
28.	Plant pale straw-coloured or brownish	*P. fibrillosa.*
	Not so	29
29.	Ramuli tapering at base and apex	*P. elongata.*
	Not so	30
30.	Plants tufted from the base	31
	Having conspicuous main axis	32
31.	Ramuli dichotomous	*P. fibrata.*
	Ramuli alternate	*P. spinulosa.*
32.	Axils of lower branches markedly obtuse	*P. elongella.*
	Axils of lower branches acute	*P. violacea.*

I. ECORTICATE SPECIES.

A. Four primary pericentral siphons.

1. P. INSIDIOSA Crouan, Flor. Finist. 1867, p. 156 (non Grev.).
Grammita Richardsoni Crouan in Desmaz. exs. 1209, 1842 (non Hook.).
G. insidiosa Desmaz. exs. 1209 [corrected label].
P. havanensis var. *insidiosa* J. G. Ag. Spec. Alg. ii. 1863, p. 960.

Icones. Crouan, Flor. Finist. 1867, pl. 24. fig. 154. Bornet & Thuret, Recherch. sur la Fécond. des Florid., Ann. Sc. Nat. Bot., 5e sér. vii. 1867, pl. 12. figs. 18–20. *Exsiccata.* Crouan, Alg. mar. Finist. no. 293, 1852. Desmazières, exs. no. 1209 (with fig.), 1842. Lloyd, Alg. Ouest Fr. no. 296, 1854.

DESCRIPTION.—*Habit.* Occurring in tufts, branched from the base. Branching pseudo-dichotomous, ramuli alternate or unilateral. Diameter of the branches variable, attenuate upwards. *Siphons.* 4 pericentral and very small central. *Colour.* Greyish-brown, becoming black in drying. *Anatomy.* Articulations visible throughout the plant. Lower articulations and those of the ramuli once or twice as long as broad, those of the upper parts of main branches 3–4 times their breadth. Cell contents tending to adhere to inner wall of pericentral siphons, probably accounting for the greyish colour of the plant when fresh. *Attachment organ.* Plant attached to substratum by a number of rhizoids, each bearing a disc at the distal end. Rhizoids formed by lateral proliferation of pericentral siphons on creeping parts of lowest branches. *Reproductive organs.* Tetraspores borne in distorted ramuli. Antheridia cylindrical, obtuse at the apices. Cystocarps ovate, sessile on the ramuli.

P. insidiosa has not been described before from this country. It is not mentioned by Harvey (**28**), Batters (**9**), or De Toni (**22**). Agardh regards *P. insidiosa* as a simple form of *P. havanensis* (**2**. p. 960), but Thuret (**54**. p. 85) does not support this view. There appears to be sufficient difference both in habit and anatomical characters to confirm the view that *P. insidiosa* is a distinct species; moreover, its branches are much more variable in size than those of *P. havanensis*. *P. insidiosa* might be confused with some forms of *P. rhunensis*, but the antheridia of the former have longer stalks. Also the branches of *P. rhunensis* arise alternately and the articulations are shorter.

Habitat. Occurring on muddy rocks, large stones, and on other algæ at extreme low-water mark. Rare.

British Records. Yarmouth, Studland, Swanage, Weymouth (leg. A. D. Cotton, 1908), and Torquay.

Distribution in Europe. Occurring off the coast of N.W. France.

2. P. MACROCARPA Harv. in Mackay's "Flora Hibernica," iii. 1836, p. 206.
P. pulvinata Harv. Phyc. Brit. pl. 102. B, syn. 108 (excl. syn.).
P. sertularioides Holmes & Batters, Rev. List, 1892, p. 94.

References. Agardh (**2**) ii. p. 969 ; Batters (**9**) p. 79 ; Cotton (**16**) p. 138 ; De Toni (**22**) iv. p. 870 ; Hauck (**31**) p. 219.

Icones. Harvey, Phyc. Brit. *l. c.* *Exsiccatæ.* Crouan, Alg. mar. Finist. no. 288 (excl. syn.), 1852. Wyatt, Alg. Damnon. no. 215.

DESCRIPTION.—*Habit.* Occurring in roundish tufts, rarely more than an inch in height. Main branches showing marked tendency to pseudo-dichotomy, ramuli unilateral or alternate, generally backwardly directed. *Siphons.* 4 pericentral and small central. *Colour.* Dark reddish-brown. *Anatomy.* Length of articulations variable, 3–4 times as long as broad in the main branches, 2–3 times their breadth in the smaller branches, frequently not more than half their breadth in the ramuli. *Attachment organ.* Young plant attached to substratum by two rhizoids formed by longitudinal proliferation of pericentral siphons. Later, the siphons of procumbent branches form numerous rhizoids, each bearing a well-developed disc. The latter encircle angular fragments when the plant grows on a sandy substratum. *Reproductive organs.* Tetraspores borne in the ramuli, intercalary in development. Cystocarps stalked, urn-shaped, elongated at the apex with a contracted ostiole, very large in proportion to the diameter of the filament.

P. macrocarpa was wrongly united with *Hutchinsia pulvinata* Ag. and *Conferva pulvinata* Roth, Cat. ex Phyc. Brit. (**28.** p. 120), but rightly presented by Batters (**9.** p. 79). Bornet (**11.** p. 306) suggests that *P. macrocarpa* is a form of *P. sertularioides*, although he has kept them apart. *Hutchinsia pulvinata* Ag. has six pericentral siphons, and has been separated by Areschoug as *P. hemispherica* (**11.** p. 306).

Habitat. Occurring on rocks between the tide-levels and creeping in the sand. Common.

British Records. North Ronaldsay, Berwick, Cullercoats, Brighton, Isle of Wight, Studland, Swanage, Portland, Torbay, Plymouth, Fowey, Falmouth, Sennen Cove, Mount's Bay, Padstow, Ilfracombe, Anglesea, Hilbre Island, Ardrossan, Saltcoats, Bute, Port Stewart, Balbriggan, Miltown Malbay, and the Channel Islands.

Distribution in Europe. Atlantic and Mediterranean coasts.

3. P. RHUNENSIS Thuret, Études Phyc. 1878, p. 84.

Reference. Oltmanns (**45**) i. p. 600 *et seq.*

Icones. Thuret & Bornet, Études Phyc. 1878, pl. 41. Oltmanns, Morph. und Biol. der Algen, 1904, fig. 377.

DESCRIPTION.—*Habit.* Occurring in tufts, 8–10 cms. in length, branched from the base. Branches arising alternately, upper parts being clothed with

numerous ramuli. Filaments attenuate upwards, varying from ·5–·05 mm. in diameter. *Siphons*. 4 pericentral round small central. *Colour*. Reddish-brown. *Anatomy*. Articulations visible throughout the plant ; 2–3 times as long as broad in the middle parts of the main branches, diminishing to a length equal to their breadth in the ramuli, and shorter than their breadth near the attachment organ. Tips of branches clothed with dichotomising fibrillæ during the summer. *Attachment organ*. Young plant attached by rhizoids with discs at their apices, the rhizoids being formed by longitudinal proliferation of pericentral siphons. Later, rhizoids produced by pericentral siphons of procumbent branches. *Reproductive organs*. Tetraspores borne in swollen and distorted ramuli. Antheridia cylindrical, obtuse, rounded at their apices, borne on the dichotomising fibrillæ. Cystocarps very shortly stalked, almost sessile, ovate, with short ostiole which is frequently sinuous.

Habitat. Occurring on rocks and stones near low-water mark. Rare.

British Records. Plymouth, Trevone Bay, and Ilfracombe.

Distribution in Europe. In France on the inter-tidal roadway called Le Rhun, connecting the mainland at Saint-Vaast la Hougue with the little island of Tatihou.

4. P. SPIRALIS Batten, spec. nov.

Frondes rubiginose-fuscescentes, cæspitosæ, pollicares vel usque ad 25 mm. altæ, e filis repentibus ortæ, irregulariter divisæ, chartæ adhærentes. Rami inferiores repentes substrato adfixi, copiose rhizoidiphori, articulis instructi diametro brevioribus, siphonibus rectis. Rami ascendentes et erecti articulis instructi diametro usque ad 3-plo longioribus et siphonibus valde sed regulariter contortis. Articuli quatuor siphonibus instructi, circa siphonem centralem dispositis, sectione transversali quadratum formantes, semper ecorticati. Tetrasporangia in ramulis non contortis, articulis iterum brevioribus. Antheridia et cystocarpia non visa.

Habitat ad saxa, in regione inferiori litorali, ad Durlston Head, Swanage, Britanniæ.

Legit auctor.

DESCRIPTION.—*Habit*. Occurring in small tufts rarely more than an inch in height. Branches either arising alternately or showing a marked tendency to a unilateral arrangement, the latter being accentuated in the parts bearing tetraspores. Ramuli often backwardly directed, though not as conspicuously as in *P. macrocarpa*. Substance gelatinous, adhering to paper. *Siphons*. 4 pericentral round large central. *Colour*. Brownish. *Anatomy*. Articulations no longer than their breadth in the procumbent parts of the plant, 3 times as long as broad in the upright branches, diminishing in the ramuli. Pericentral siphons parallel to the long axis of the filament in the lower parts of the plant and in the ramuli, but spirally

curved in the main branches. *Attachment organ.* Young plant attached at the base by two rhizoids formed by longitudinal proliferation of basal siphons. Later, numerous rhizoids are formed by lateral proliferation of procumbent branches, the siphons of which are parallel. *Reproductive organs.* Tetraspores are intercalary in development, and are borne in the ramuli. Antheridia and cystocarps have not yet been recorded.

The species somewhat resembles *P. macrocarpa* Harv. in outward appearance, but a slight torsion of the branches is visible to the naked eye, and the colour is much darker than in *P. macrocarpa* Harv. *P. spiralis* differs from *P. platyspira* Kütz. (**37.** xii. p. 63) in that the branching is not pseudo-dichotomous in the former species. The spiral twisting of the siphons is comparable to that of *P. havanensis* Kütz. (**37.** xiii. p. 72), but the branching and general habit of the plant are dissimilar. The large size of the central siphon makes it clear that the plant is not a young form of *P. urceolata* which is exhibiting a variation, and the length of the articulations bears out the view. *P. macrocarpa*, too, has a much smaller central siphon than *P. spiralis*.

Habitat. On rocks and groins near low-water mark.

British Records. Dorset at Durlston Head, Swanage, and between Sandbanks and the Haven.

5. P. URCEOLATA Grev. Flora Edinensis, 1824, p. 309.

P. formosa Suhr (not Harvey) in Flora, xiv. (1831), p. 709.
Grammita uncinata Bonnem. (not *P. uncinata* Kütz.) Ess. d'une class. des Hydro. loc., Journ. de Physique, xciv. 1822, p. 191.
P. denticulata Kütz. Tab. Phyc. xiii. 1863, p. 28, tab. 90 (*e-g*).
P. stricta Kütz. Tab. Phyc. xiii. 1863, p. 25, tab. 78 (*d–g*).
P. patens Kütz. Tab. Phyc. xiii. 1863, p. 29, tab. 91 (*c–e*).
Conferva urceolata Lightf. ex Dillw. p. 82, suppl. pl. G.

References. Agardh (**2**) ii. p. 970; De Toni (**22**) iv. p. 875; Hauck (**31**) p. 221; Falkenberg (**24**) pp. 150, 152.

Icones. Kützing, Tab. Phyc. *l. c.* Harvey, Phyc. Brit. 1846–51, pl. 167. syn. 106. *Exsiccatæ.* Desmazières, exsic. no. 1207, 1842. Lloyd, Alg. Ouest Fr. no. 174, 1854. Wyatt, Alg. Damnon. no. 133.

DESCRIPTION.—*Habit.* Occurring in tufts from 15–23 cms. long. Branching pseudo-dichotomous in the main branches, ramuli alternately branched and arising alternately, often flexed. *Siphons.* 4 pericentral round minute central. *Colour.* Deep red. *Anatomy.* Length of articulations 3–5 times their breadth in the principal branches, approximately equal to their breadth in the lower parts of the plant and rather shorter in the ramuli. *Attachment organ.* Main axis of young plant attached at the base by one or two rhizoids, the central siphons of procumbent branches producing rhizoids

later, which bear discs or branch-like structures at their apices. The contents of the rhizoid pass into the branches, but no wall is formed. *Reproductive organs.* Tetraspores borne in the upper parts of the ramuli, usually extending to the tip. Antheridia elongated, narrow, and stalked, borne on the tips of lateral ramuli. Cystocarps shortly stalked, elongated, borne on the upper branches and ramuli.

There seems to be no adequate reason for putting *P. formosa* Suhr into a separate species. J. G. Agardh, Sp. Alg. ii. p. 971, and Batters (9) p. 79 regard *P. formosa* Suhr as a variety of *P. urceolata* (Lightf.), and this appears to be the maximum amount of separation which is justifiable. *P. formosa* Suhr has longer articulations than *P. urceolata* (Lightf.), and is more gelatinous when young. *P. urceolata* (Lightf.) is usually considered to be an annual, appearing in summer, but specimens occur at Kew, collected by Mrs. Griffiths, in which the base of the branches are clothed with a few broken ramuli, large tufts occurring at the top. This is evidently due to the lower branches having existed through the winter, and then in spring thrown off tufts of fresh ramuli. The same phenomenon has been observed in specimens obtained from Plymouth. Specimens obtained from the Nothe Pools, Weymouth (leg. A. D. Cotton, 1908) were pale pink when fresh, but became very dark in drying. The plants were 6·5 cms. in height, and the articulations of the main branches rather shorter than is typical for the species.

Habitat. Occurring on rocks, limpet shells, and large algæ, particularly *Laminaria*, near low-water mark. Common.

British Records. Scotland, Northumberland, Durham, Yorkshire, Norfolk, Kent, Sussex, Hants, Dorset, Devon, Cornwall, Cheshire, Isle of Man, Wales, Ireland, and the Channel Islands.

Distribution in Europe. Atlantic shores of Northern Europe.

B. More than four primary pericentral siphons.

1. P. ATRO-RUBESCENS Grev. Flora Edinensis, 1824, p. 308.
   P. Agardhiana Grev. Scot. Crypt. Flora, iv. 1826, p. 210.
   Conferva atro-rubescens Dillw. Brit. Conf. 1809, pl. 70.
   C. nigra Hudson, Flora Anglica, 1798, p. 595.
   P. discolor (Ag.) Kütz. Spec. Alg. 1849, p. 825.
   P. nigra Batt. Catal. Brit. Mar. Alg. 1902, p. 81.

References. Agardh (2) ii. p. 1035 *et seq.*; De Toni (22) iv. p. 938; Hauck (31) p. 243.

Icones. Greville, Scot. Crypt. Flora, *l. c.* Dillwyn, Brit. Conf. *l. c.* Harvey, Phyc. Brit. pl. 172. syn. 125. Kützing, Tab. Phyc. xiii. 1863, p. 26, tab. 82 (*d–g*). *Exsiccatæ.* Desmazières, exs. no. 1205, 1842. Crouan, Alg. mar. Finist. no. 309, 1852. Lloyd, Alg. Ouest Fr. no. 16, 1854. Wyatt, Alg. Damnon. no. 134.

DESCRIPTION.—*Habit*. Plants attaining a length of 30 cms., main axis often pseudo-dichotomously branched, smaller branches arising alternately, the whole being clothed with short spine-like ramuli. Small branches and ramuli tapering at the base and apex. *Siphons*. 8–14 pericentral and large central. *Colour*. Dark red when young, later becoming almost black. *Anatomy*. Articulations no longer than their breadth in the procumbent parts, 2–3 times as long as broad in the principal parts of the main branches, becoming gradually shorter near the apices. Pericentral siphons spirally curved in the main branches, less so in the smaller branches and ramuli, and parallel to the long axis of the branch in the procumbent parts. *Attachment organ*. In the young plant the lowest articulations have fewer pericentral siphons, and two or more of the latter are elongated into attachment rhizoids with discs at their extremities. After branching has occurred, rhizoids are developed from the procumbent parts of the lowest branches by proliferation of pericentral siphons. *Reproductive organs*. Tetraspores are intercalary in origin and developed in swollen ramuli. Cystocarps sessile or very slightly stalked and broadly ovate with a large open ostiole.

Habitat. Occuring on rocks, stones, and shells such as *Pecten maximus*, only exposed at low tide or obtained by dredging. Not common.

British Records. Orkney, Elgin, Aberdeen, Kincardine, Forfar, Fife, Edinburgh, Haddington, Berwick, Northumberland, Yorkshire, Norfolk, Essex, Kent, Sussex, Hants, Dorset, Devon, Cornwall, Bute, Ireland, and the Channel Islands.

Distribution in Europe. Atlantic coasts.

2. P. FASTIGIATA Grev. Flora Edinensis, 1824, p. 308.
Hutchinsia fastigiata C. A. Agardh, Syn. Alg. Scan. 1817, p. 53.
Ceramium fastigiatum Roth, Catalecta Bot. iii. 1806, p. 157.
Conferva polymorpha Linn. Syst. Nat. ii. 1765, p. 721.
Grammita fastigiata Bonnem. Ess. d'une class. des Hydro. loc. 1822, p. 45.

References. Agardh (2) ii. pp. 67 & 1029; De Toni (22) iv. p. 946; Falkenberg (23) p. 149; Tobler-Wolff (55).

Icones. Harvey, Phyc. Brit. pl. 299. syn. 127. Kützing, Tab. Phyc. xiii. 1863, p. 14, tab. 44 (*a–d*). *Exsiccata*. Desmazières, exs. no. 254, 1842. Crouan, Alg. mar. Finist. no. 307, 1852. Lloyd, Alg. Ouest Fr. no. 104, 1854. Wyatt, Alg. Damnon. no. 177.

DESCRIPTION.—*Habit*. Plants about 7·5 cms. in height, perennial, forming dense tufts. Branching dichotomous, apices outspread. *Siphons*. 12–24 pericentral and large central. *Colour*. Dark reddish-brown. *Anatomy*. Articulations shorter than their breadth; contents of central siphon conspicuously dark in colour, shut down into a flattened mass by thickening of the wall in upper and lower parts of the siphon. *Attachment organ*.

Rhizoids, produced by the elongation of pericentral siphons, penetrate into the tissues of the host, the latter being almost invariably *Ascophyllum nodosum*. Procumbent branches creep along the thallus of the host, and send out rhizoids at intervals. Tips of the rhizoids swollen, with thin walls, closely applied to cells of the host which have become dark in colour. Dark cells also present in the thallus of the host in the area surrounding the path taken by the invading rhizoid. *Reproductive organs.* Tetraspores are borne in swollen terminal branches. Antheridia bright yellow in colour, borne in winter and spring in elongated clusters at the tips of the branches. Cystocarps sessile, egg-shaped, replacing one of the apical dichotomous branches.

The protoplasmic connections between the central and pericentral siphons are very well seen in young plants of *P. fastigiata*, although the maintenance of the connection between these siphons throughout the life of the plant has been the subject of much debate. Harvey Gibson (**27.** p. 129 *et seq.*) has shown that the continuity of the protoplasm is not maintained in the older parts of the plant. The pit between the siphons becomes closed by the development of a cellulose plate, and, although fine granular striæ are visible, maceration shows that these are due to a fringe of fine threads which arise along the margin of the plate. They are quite independent of the protoplasmic contents of the canal.

Polysiphonia usually attacks its host in the depression from which a new shoot will arise. This crevice forms a suitable substratum for the early stages of development of the plant, and rhizoids are soon produced by the elongation of single siphons which penetrate into the tissue of the host-plant. Tobler-Wolff (**55**) suggests that the reason *P. fastigiata* selects *Ascophyllum* as its host is the fact that the outer cells occur in chains in this species, and penetration is thus made more simple. This, however, seems an inadequate explanation of the phenomenon, as the epiphyte has been recorded on other Fuci. The cells which have been attacked by the *Polysiphonia* are dark in colour, and do not re-act when treated with vanillin in concentrated HCl. The ordinary *Ascophyllum* cells contain food-store, which turns red in the presence of the vanillin, and the failure of the dark cells to react shows that food must have been extracted from them.

Tobler-Wolff (**55**) in describing the dark cells says:—"Es war von vornherein anzunehmen, dass eine so tief eingreifende Befestigung—die wohl in dieser Weise für keinen anderen Fall bekannt ist—nicht ohne Schädigung des Substrates vor sich gehen kann. Tatsächlich sieht man auf entsprechenden Schnitten in der unmittelbaren Umgebung der Rhizoiden fast immer eine Anzahl Zellen mit auffallendem Inhalt. Er ist glasig, von einem rötlichen Braun, das von dem hellen gelbbraunen Ton der anderen Zellen stark absticht. Zudem sind diese Zellen meist aus dem Gewebeverband losgelöst; sie sind abgestorben."

It is evident that the *Polysiphonia* has obtained food from the dark cells, and also there seems no other explanation of the need for the swollen thin-walled tip of the rhizoid, which applies itself so closely to the host cells (see page 277 *et seq.*).

It is not absolutely necessary for the life of the *Polysiphonia* that it should be fixed to any host, but on the rare occasions when it occurs on a rocky substratum its vegetative growth is less perfect, although external conditions are similar with respect to depth and general environment. This shows that a direct advantage is gained by an epiphytic habit, and the statement is amplified by an examination of the anatomy.

There is frequently a slight local modification of the cells of the host in the immediate vicinity of the penetration of the *Polysiphonia*. Sometimes a little swelling occurs, and very frequently the cortical cells are displaced so that they no longer occur in chains.

Habitat. Occurring chiefly on *Ascophyllum nodosum*, but occasionally found on *Fucus serratus* and *Fucus vesiculosus*. It rarely occurs on a rocky substratum. Common.

British Records. Very common on the shores of the British Islands wherever its host-plant, *Ascophyllum nodosum*, grows.

Distribution in Europe. Atlantic shores and Baltic Sea.

3. P. FURCELLATA Hook. in Smith's English Flora, v. 1833, p. 332.
P. forcipata J. G. Ag. Alg. Med. 1842, p. 127.

Reference. Agardh (2) ii. p. 1025.

Icones. Harvey, Phyc. Brit. pl. 7. syn. 126. Johnstone & Croall, Nat. print. Brit. Seaweeds, pl. 22½. 1859. Kützing, Tab. Phyc. xiii. p. 25, tab. 79, 1863. *Exsiccata.* Crouan, Alg. mar. Finist. no. 306, 1852. Lloyd, Alg. Ouest Fr. no. 230, 1854.

DESCRIPTION.—*Habit.* Plants 12–14 cms. in length, with a well-marked central axis and numerous lateral branches. Main branches arising alternately with very wide axils, smaller branches and ramuli showing marked pseudo-dichotomy, apices being eventually clad with clusters of fibrillæ. *Siphons.* 8 or 9 pericentral round small central. *Colour.* Brick-red when fresh, becoming much darker in the herbarium. *Anatomy.* Length of articulations 3–5 times their breadth in the main branches, diminishing in the smaller branches, and only equal to their breadth in the ramuli. *Reproductive organs.* Tetraspores are intercalary in development, and are borne in distorted ramuli. Cystocarps are ovate and sessile. Antheridia are borne in clusters at the tips of the ramuli.

P. ceramiaeformis Crouan appears to have been assigned to a young form of *P. furcellata*, which is perhaps nearest to *P. furcellata* α. *forcipata* Ag. (2) ii. p. 1025. The articulations in this form are shorter than those of *P. furcellata*, and the siphons number eleven or twelve.

Habitat. Usually recorded either dredged or floating. Rare.

British Records. Norfolk coast (*fide* Geldart), Studland, Weymouth, Sidmouth, Torquay, Plymouth, Falmouth, Carrickfergus, Roundstone, and Jersey.

Distribution in Europe. Atlantic shores of France.

4. P. OBSCURA J. G. Ag. Alg. Med. 1842, p. 123.

Conferva intertexta Roth, Catalecta Bot. i. 1797, p. 188, tab. 2. fig. 5; ii. 1800, p. 214.

P. adunca Kütz. Tab. Phyc. xiii. 1863, p. 13, tab. 40 (*c–e*).

P. reptabunda Kütz. *l. c.* xiii. 1863, p. 12, tab. 34 (*d–g*).

References. Agardh (**2**) ii. p. 943; Falkenberg (**24**) p. 500; Hauck (**31**) p. 244.

Icones. Harvey, Phyc. Brit. pl. 102. A. syn. 120. Kützing, Tab. Phyc. *l. c.*

DESCRIPTION.—*Habit.* Forming low tufts 1–3 cms. in height, branched from the base, branches being monopodial in origin. Not adhering to paper. *Siphons.* 12–18 pericentral and a large central one. *Colour.* Dark brown. *Anatomy.* Articulations as long as broad, or sometimes rather shorter. *Attachment organ.* Rhizoids developed in abundance by lateral proliferation of pericentral siphons. Well-developed discs formed at the extremities when a firm substratum is encountered. *Reproductive organs.* Tetraspores are intercalary in development; formed spirally in much-branched filaments, only one group of tetraspores occurring in an articulation. Antheridia and cystocarps unknown.

P. obscura is distinguishable as having the most diminutive habit among British species with so large a number of siphons. The attachment organ is very similar to that of *P. macrocarpa* when the latter creeps in the sand.

Habitat. Occurring in tufts on sheltered rocks, on the attachment organs of Fuci, and on smaller algæ. Very rare.

British Records. Weymouth, Ladran Bay, Sidmouth, Mount Edgcumbe, Penzance, Pridmouth, Jersey, and Guernsey.

Distribution in Europe. Coast of Spain, Adriatic Sea.

5. P. OPACA Zanard. Syn. Alg. in Mari Adriat. 1842, p. 63.

Hutchinsia opaca C. A. Ag. Syn. Alg. Scandin. 1817, p. 148.

P. repens Kütz. Tab. Phyc. xiii. 1863, p. 13, tab. 39 (*d–f*).

P. virens Kütz. *l. c.* p. 14, tab. 41 (*a–c*).

P. condensata Kütz. *l. c.* p. 14, tab. 41 (*d–g*).

P. erythrocoma Kütz. *l. c.* p. 14, tab. 43 (*a*, *b*).

P. fasciculata Kütz. *l. c.* p. 15, tab. 44 (*d*, *e*).

P. umbellifera Kütz. *l. c.* p. 15, tab. 45 (*a*, *b*).

P. ophiocarpa Kütz. *l. c.* p. 15, tab. 47 (*c–f*).

P. tripinnata Kütz. (non Ag.) *l. c.* p. 16, tab. 48 (*a*, *b*).

P. macrocephala Zanard. ex Kütz. *op. cit.* xiv. 1864, p. 19, tab. 53 (*e–g*).

P. spiculifera Zanard. ex Kütz. *op. cit.* xiv. 1864, p. 17, tab. 49 (*a–c*).

References. Agardh (2) ii. p. 1055 ; De Toni (22) iv. p. 942; Falkenberg (24) p. 120 *et seq.* ; Hauck (31) p. 246.

Icones. Kützing, Tab. Phyc. xiii. & xiv. *l. c.*

Description.—*Habit.* Plants from 1–9 cms. high. Branching alternate or pseudo-dichotomous in the principal branches, irregularly alternate in the smaller branches and ramuli, the ramuli being short and spine-like, and closely set on the shorter branches. *Siphons.* 20 or more pericentral round central one of diameter roughly equal to the radius of the filament. *Colour.* Brownish, becoming black in drying. *Anatomy.* Articulations usually about as long as broad, sometimes attaining a length of $1\frac{1}{2}$ times their breadth. During summer, tips of branches and ramuli clothed with colourless multi-cellular dichotomising filaments. *Attachment organ.* Young plant attached at the base by rhizoids developed longitudinally from the pericentral siphons. Procumbent branches produce new rhizoids later, each having a disc at its extremity. *Reproductive organs.* Tetraspores intercalary in development, not always occupying successive articulations of the ramulus. Antheridia occurring in tufts on the terminal dichotomising fibrillæ, replacing some of the branches. Cystocarps ovate in form, sessile on the ramuli.

Habitat. Occurring between the tide-marks. Rare.

British Records. Petit Port, Guernsey.

Distribution in Europe. Adriatic Sea.

6. P. Richardsoni Hook. in Smith's English Flora, v. 1833, p. 333.

Reference. De Toni (22) iv. p. 920.

Icones. Harvey, Phyc. Brit. pl. 10. syn. 111.

Description.—*Habit.* Plants attaining a length of 8–10 cms. Main axis much branched and zigzag in form, with lateral branches arising at an angle of nearly 90°. Ramuli slender and like the branches, alternate in origin. *Siphons.* 5 round a smaller central. *Colour.* Reddish-brown, becoming darker in drying. *Anatomy.* Articulations three or four times as long as broad in the middle parts of the plant, where the pericentral siphons are spirally twisted. Articulations shorter and siphons parallel to the long axis in the upper parts. *Attachment organ.* Examination of Richardson's specimen in the Herbarium Hookerianum at Kew shows a disc-like attachment organ comparable to that of *P. elongella.* *Reproductive organs.* Cystocarps borne near the tips of the branches, globose and sessile with a wide ostiole.

De Toni (22. iv. p. 920) suggests the possibility of *P. Richardsoni* Hook. being synonymous with *P. rhunensis* Thur., but this is not practical, owing to the anatomy of the plant, the total difference of attachment organ, and the difference of habit. *P. Richardsoni* Hook. is probably near to *P. collabens*

Ag. (2) ii. p. 1022, to which it bears considerable resemblance anatomically. The specimen in the Herbarium Hookerianum at the Royal Botanic Gardens, Kew, was collected by Richardson. Harvey (28. p. 111) noticed the striking similarity between the branching of *P. Richardsoni* Hook. and *P. elongella* Harv., but remarks that there is no resemblance to any other character, evidently having omitted to examine the attachment organ.

Habitat. Detailed habitat unknown.

British Records. Colvend, Kirkcudbright (Richardson).

Distribution in Europe. Nil.

7. P. SIMULANS Harv. Man. Brit. Mar. Alg. ed. ii. 1849, p. 89.
P. spinulosa Harv. Man. Brit. Mar. Alg. ed. i. 1841, p. 87 (non Grev.).
P. divergens γ. *Grevilleana* Kütz. Sp. Alg. 1849, p. 822.

References. Agardh (2) ii. p. 1051 ; De Toni (22) iv. p. 935.

Icones. Harvey, Phyc. Brit. pl. 278. syn. 121. *Exsiccatæ*. Crouan, Alg. mar. Finist. no. 304, 1852. Lloyd, Alg. Ouest Fr. no. 279, 1854.

DESCRIPTION.—*Habit*. Plants tufted from the base; branches arising alternately, sparsely clothed with irregularly pinnate ramuli, the latter tapering sharply at the apex. *Siphons*. 12 pericentral round a central one of diameter equal to about $\frac{1}{3}$–$\frac{2}{5}$ times the radius of the whole filament. *Colour*. Reddish-brown. *Anatomy*. Articulations about one and a half times as long as broad in the main branches, but shorter than their breadth in the ramuli and at the extreme base of the plant. *Attachment organ*. Numerous rhizoids are developed by the proliferation of pericentral siphons, each rhizoid bearing a well-formed disc at its distal end. The main branches creep along the substratum for a short distance, producing an aggregation of discs. *Reproductive organs*. Tetraspores intercalary in development, borne in distorted ramuli. Cystocarps sessile, ovate in form, borne on the smaller branches.

P. simulans is rigid when fresh, but adheres to paper after immersion in fresh water. It is much darker in colour than *P. subulifera*. Should any confusion occur between some forms of this species and *P. nigrescens*, a transverse section at the extreme base of one of the main branches is often a decisive factor in determination. *P. simulans* is ecorticate throughout, while at the base of *P. nigrescens* there is frequently a row of corticating cells. The serrate appearance due to the remains of old branches so frequently to be observed in *P. nigrescens* does not occur in *P. simulans*. The aggregation of attachment discs is similar in the two species.

Habitat. Occurring near low-water mark. Most often found on thin-bedded and eroded schists. Rare.

British Records. Skaill, Studland, Swanage, Torbay, Plymouth, Mount Edgcumbe, Falmouth, Mount's Bay, Arran, Cumbrae, Valentia, and Kerry.

Distribution in Europe. Unknown.

8. P. SUBULIFERA (Ag.) Harv. in Hooker's Journal of Botany, vol. i. 1834, p. 301.

Hutchinsia subulifera C. A. Ag. in Bot. Zeit. 1827, p. 638.
P. armata J. G. Ag. Alg. Mar. Medit. et Adriat. 1842, p. 810.
P. pantophlœa Kütz. Tab. Phyc. xiv. 1864, p. 5, tab. 13 (*a–c*).
P. ramellosa Kütz. *l. c.* p. 9, tab. 26 (*a–b*).

References.—Agardh (**2**) ii. p. 1052; Cotton (**16**) p. 139; Crouan (**17**) ii. p. 311; De Toni (**22**) iv. p. 936: Harvey (**28**) pl. 228.; Kützing (**37**) iv. p. 936.

Icones. Harvey, Phyc. Brit. pl. 227. syn. **124**; Kützing, Tab. Phyc. *l. c.*
Exsiccatæ. Crouan, Alg. mar. Finist. no. 311, 1852. Lloyd, Ouest Fr. no. 278, 1854. Wyatt, Alg. Damnon. no. 178.

DESCRIPTION.—*Habit.* The species is an annual, appearing in summer and growing to a length of 8 inches under favourable conditions. Occurring in tufts, branched from the base and beset with alternate short spine-like ramuli, the tips clothed with clusters of almost colourless filaments when the plant is young. *Siphons.* 12–13 pericentral round a central one of diameter equal to about $\frac{1}{4}$ of the radius of the filament. *Colour.* Deep red when fresh, but becoming dark when gathered. *Anatomy.* Articulations varying in length from 2–3 times their breadth in the main branches to a length equal to their breadth in the smaller branches and ramuli. *Attachment organ.* Attached by rhizoids developed from pericentral siphons of procumbent branches. *Reproductive organs.* Tetraspores borne in distorted ramuli. Antheridia and cystocarps unknown.

The species is rigid when fresh, but soon becomes flaccid when gathered. It is usually only obtainable by dredging in from 4–10 fathoms of water, and examination of *complete* attachment organs proved impossible. It is a characteristic feature that the ramuli are short and spine-like, comparable to those of *P. fruticulosa*, from which it differs in the ecorticate form of the main axis. From *P. simulans* it is distinguished by larger size and lighter colour and difference in habitat, as it is rarely, if ever, found in the tide-pools at low water.

Habitat. Occurring in deep water, generally on Nullipore banks. Recorded from Jersey attached to *Rytiphlœa pinastroides* and *Polyides rotundus*, and from Roundstone (Cotton, Sept. 1911) on the *Lithothamnion* banks.

British Records. Weymouth, Torbay, Lamlash, Arran, Belfast, Carrickfergus, Roundstone Bay, Jersey, and Guernsey. Very rare.

Distribution in Europe. Adriatic Sea and coast of France.

II. CORTICATE SPECIES.

A. Four primary pericentral siphons.

1. P. ELONGATA (Huds.) Harv. in Smith's Engl. Flora, v. 1833, p. 333.
P. Ruchingeri Kütz. Tab. Phyc. xiv. 1864, p. 2, tab. 6 (*a–d*).
Hutchinsia strictoides Lyngb. Tent. Hydrophyt. Danicæ, 1819, p. 114.
P. trichodes Kütz. Tab. Phyc. xiv. 1864, p. 4, tab. 10 (*e–g*).
P. robusta Kütz. *l. c.* p. 4, tab. 11 (*a–c*).
P. stenocarpa Kütz. *l. c.* tab. 11 (*d–f*).
P. arborescens Kütz. *l. c.* p. 4, tab. 12 (*a–c*).
P. chalarophlœa Kütz. *l. c.* p. 5, tab. 12 (*d–f*).
P. macroclonia Kütz. *l. c.* p. 5, tab. 13 (*d*, *e*).
P. rosea Grev. Fl. Edin. 1824, p. 310.
P. clavigera Kütz. *l. c.* p. 5, tab. 14 (*a–d*).
Hutchinsia elongata C. A. Ag. Syn. Alg. Scandin. 1817, p. 54.
Ceramium elongatum Grev. Fl. Edin. 1824, p. 310.
Ceramium brachygonium Lyngb. Tent. Hydr. Dan. p. 118.
Conferva elongata Huds. Fl. Angl. ed. II. ii. 1778, p. 599.

References. Agardh (**2**) ii. p. 1004; De Toni (**22**) iv. p. 903; Falkenberg (**24**) p. 126 *et seq.*; Hauck (**31**) p. 227 *et seq.*

Icones. Harvey, Phyc. Brit. pls. 292 & 293. syn. 114. Kützing, Tab. Phyc. xiv. *l. c.* *Exsiccatæ.* Desmazières, exs. no. 1210, 1842. Crouan, Alg. mar. Finist. no. 301, 1852. Lloyd, Alg. Ouest Fr. nos. 55 & 305, 1854. Wyatt, Alg. Damnon. no. 40.

DESCRIPTION.—*Habit.* Plants usually solitary, 15–30 cms. long. Branches naked during the winter, clothed in spring with dense mass of ramuli. Branching alternate with sometimes a tendency to pseudo-dichotomy. Ramuli attenuate at base and apex. Main branches cartilaginous in texture, ramuli gelatinous. *Siphons.* 4 primary pericentral, alternating with which on the outside are 4 secondary. Surrounding these in the older parts eight tertiary siphons occur, bounded by a zone of corticating cells. *Colour.* Reddish-brown, very dark in the older parts; ramuli crimson. *Anatomy.* Articulations obscured in the older parts of the main axis by the dense band of peripheral corticating cells. In the smaller branches and ramuli articulations $1\frac{1}{2}$ to twice as long as broad. Protoplasmic continuity maintained throughout the thallus, fibrillæ passing through pits in the contiguous walls. *Attachment organ.* Base of main axis expanding into a disc formed by the activity of the siphons and corticating cells. Each of the cells and siphons at the base becomes elongated into a thick-walled rhizoid, the extreme base of which flattens out and attaches itself to the substratum. *Reproductive organs.* Tetraspores borne in lateral and terminal ramuli, which are swollen and distorted. Cystocarps borne on small branches, sessile or very slightly stalked, ovate in form but tending to be elongated.

The fact that the ramuli are attenuate at the base and apex is one of the distinguishing features of the species. *P. elongata* has been described as being either biennial or perennial, but close observation of individual plants has shown that it is perennial. According to Falkenberg (**24**. p. 126), the older plants may show a secondary development in which the cavities of the siphons become filled with small cells, comparable to those forming the corticcation, although the wall of the original siphon is still visible. The attachment organ is one of the most elaborate found in the genus. Its development can doubtless be correlated with the corticate anatomy of the plant and its solitary habit. There are no procumbent branches present which can aid in the attachment, but the large number of siphons and corticating cells make it possible to develop a strong organ of attachment from the main axis alone. At the extreme base the corticating cells spread out in a more or less horizontal direction, so giving an increased surface for the development of rhizoids. In the greater part of the large expanded disc the walls of the rhizoids cohere mechanically, forming a pseudo-tissue (see p. 279 *et seq.*).

Habitat. Attached to stones and shells in pools and muddy bays between the tide-levels and in from 5–10 fathoms of water. Common.

British Records. Scotland, Northumberland, Durham, Yorkshire, Norfolk, Essex, Kent, Sussex, Hants, Dorset, Devon, Cornwall, Hilbre Island, Wales, Ireland, and Jersey.

Distribution in Europe. Atlantic and Mediterranean shores.

2. P. ELONGELLA Harv. in Smith's Engl. Flora, v. 1833, p. 334.

P. lophuroides Kütz. Tab. Phyc. xiii. 1863, p. 28, tab. 91 (*a–b*).

References. Agardh (**2**) ii., iii. p. 1002; De Toni (**22**) iv. p. 910; Hauck (**31**) p. 228.

Icones. Kützing, Tab. Phyc. xiii. 1863, tab. 91 (*a–b*). Harvey, Phyc. Brit. pl. 146. syn. 113. *Exsiccata*. Wyatt, Alg. Damnon. no. 84.

DESCRIPTION.—*Habit*. Plants as much as 13 cms. in height, usually solitary. Branching pseudo-dichotomous with wide angle of divergence, in the main branches, alternate in the smaller branches, which are densely clothed with ramuli during the spring and summer. Upper parts gelatinous in substance, basal parts cartilaginous. *Siphons*. 4 primary pericentral, alternating with which 4 secondary occur bounded by a band of corticating cells. *Colour*. Bright red in the ramuli, darker in the lower parts of the plant. *Anatomy*. Articulations rather shorter than their breadth at the base, about equal to their breadth in the main branches, and in the ramuli very short near the apices, increasing in length proximally. *Attachment organ*. Very similar in form to that of *P. elongata*, the siphons and corticating cells elongating longitudinally into thick-walled rhizoids which cohere mechanically with each other, forming a pseudo-tissue. *Reproductive organs*. Tetraspores

intercalary in development, borne in the tips of the branches and ramuli. Cystocarps large, stalked, ovate in form, with a tendency to elongate near the ostiole.

P. elongella often resembles *P. elongata*, but may be distinguished by the visibility of the articulations in all parts of the plant except the extreme base, cortication being less well developed in the former species. Also, the ramuli of *P. elongella* are not attenuate at the base as in *P. elongata*. According to Harvey (*l. c.* p. 113), Hauck (*l. c.* p. 228), and De Toni (*l. c.* p. 910), there are 4 pericentral siphons in each articulation, surrounded by a band of "cellules." It is evident, however, that 4 secondary siphons alternate on the outside with the 4 primary ones, before the corticating cells begin, these siphons differing from the cells in the fact that they occupy the whole length of an articulation.

Habitat. On rocks, stones, and smaller algæ near low-water mark and at greater depth. Rare, though widely distributed.

British Records. Kirkwall Bay, Peterhead, Elie, Brighton, Bognor, Isle of Wight, Swanage, Weymouth, Sidmouth, Torbay, Plymouth, Torpoint, Talland Bay, Falmouth, Padstow, Anglesea, Isle of Man, Saltcoats, Seamill, Ardrossan, Arran, Cumbrae, Kirn, Larne, Belfast Lough, Malahide, Howth, Killiney, Bantry, and Jersey.

Distribution in Europe. Coast of France and Adriatic Sea.

3. P. FIBRATA Harv. in Smith's Engl. Flora, v. 1833, p. 329.

Hutchinsia allochroa β. fibrata C. A. Ag. Syst. Alg. 1824, p. 154.

Grammita decipiens Bonnem. Hydroph. loc. 1822, p. 37.

References. Agardh (2) ii. p. 965; De Toni (22) iv. p. 893.

Icones. Harvey, Phyc. Brit. 1846–51, pl. 208. syn. 109. *Exsiccatæ*. Crouan, Alg. mar. Finist. no. 294, 1852. Lloyd, Alg. Ouest Fr. no. 193, 1854. Wyatt, Alg. Damnon. no. 39.

DESCRIPTION.—*Habit*. Occurring in tufts 20–23 cms. in length. Branching either alternate or pseudo-dichotomous, main branches being clothed with numerous ramuli, frequently bearing delicate fibrillæ at their tips. *Siphons*. 4 pericentral round a minute central one, a row of corticating cells frequently occurring at the extreme base. *Colour*. Red when fresh, become very dark on drying. *Anatomy*. Articulations variable in length, as much as eight times their breadth in the main branches, becoming shorter in the upper parts and scarcely twice as long as broad in the ramuli. Filaments slightly swollen at the junction of the articulations with each other. *Attachment organ*. Young plant attached by two or more rhizoids developed by longitudinal proliferation of pericentral siphons; other rhizoids occur later on the main axis and on procumbent branches, being formed by lateral proliferation of the siphons. A tendency to deep lobing of the expanded portion of the rhizoid frequently visible. *Reproductive organs*. Tetraspores intercalary in development, borne in distorted ramuli. Antheridia elongated

in form, and borne on apical fibrillæ at the tips of branches. Cystocarps stalked, ovate, with large open ostiole, borne on upper parts of branches and ramuli.

P. fibrata is usually darker in colour than *P. urceolata*, and it may also be distinguished from that species by its gelatinous nature. According to a note by Moore on a specimen from the Antrim coast preserved in the Herbarium of the Royal Botanic Gardens, Kew, the arrangement of the siphons is frequently spiral in this species. Material obtained from Torquay in April 1920 exhibited this phenomenon, the amount of twist being about equal to that which is typical for *P. atro-rubescens*.

Habitat. On rocks, stones, and shells at extreme low-water mark. Frequent.

British Records. Scotland, Northumberland, Kent, Sussex, Hants, Dorset, Devon, Cornwall, Hilbre Island, Wales, Isle of Man, Ireland, and the Channel Islands.

Distribution in Europe. Atlantic shores of Europe.

4. P. FIBRILLOSA Grev. in Smith's Engl. Flora, v. 1833, p. 334.
Hutchinsia fibrillosa C. A. Ag. Sp. Alg. vol. ii. 1828, p. 78.
H. lubrica C. A. Ag. *l. c.* p. 94.
P. lasiotricha Kütz. Tab. Phyc. xiii. 1863, p. 23, tab. 72 (*e–h*).

References. Agardh (2) ii. p. 991; De Toni (22) p. 919; Hauck (31) p. 230.

Icones. Harvey, Phyc. Brit. pl. 302. syn. 117. Kützing, Tab. Phyc. xiii. *l. c.* *Exsiccatæ.* Crouan, Alg. mar. Finist. no. 296, 1852. Lloyd, Alg. Ouest Fr. no. 136, 1854. Wyatt, Alg. Damnon. no. 136.

DESCRIPTION.—*Habit.* Plants solitary, as much as 15 cms. in length. Branching alternate, lowest ones longer than the upper, giving conical appearance. Branches clothed with numerous ramuli; substance cartilaginous except in the smaller branches and ramuli, where it is gelatinous. *Siphons.* 4 primary pericentral, with which the four secondary alternate on the outside, the diameter of the central one being about $\frac{1}{3}$ the radius of the filament. A band of corticating cells present at the base. *Colour.* Brownish or straw-coloured when growing in sunny pools, darker in deeper water. *Anatomy.* Articulations obscured in the lower parts of the plant; from $1\frac{1}{2}$ to twice as long as broad in the smaller branches and ramuli, the tips of the latter being clothed during summer with multicellular dichotomous hairs. *Attachment organ.* Plant attached by an expanded disc of the same type as *P. elongata.* Length of the rhizoids very variable when the plant is epiphytic, *e. g.* on *Rytiphlæa pinastroides* Ag., the outer ones being longer and enabling the attachment disc to grasp the thallus of the host. *Reproductive organs.* Tetraspores intercalary in development in swollen ramuli. Antheridia borne on filamentous hairs at the apices

of the ramuli. Cystocarps sessile, ovate in form, borne on the smaller branches.

Antheridia are not recorded by Harvey (*l. c.*), Agardh (*l. c.*), or De Toni (*l. c.*), but were observed in a specimen in the Batters collection in the Natural History Museum, South Kensington.

Habitat. Occurring on rocks, stones, and other algæ, such as *Rytiphlæa pinastroides*, in clear sunny tide-pools and also in deep water. Rare, but occurring in considerable quantity at uncertain intervals.

British Records. Orkney Islands, Stonehaven, Earlsferry, Dunbar, Berwick, Whitley, Roker, Cromer, Brighton, Shoreham, Isle of Wight, Swanage, Weymouth, Seaton, Sidmouth, Torquay, Plymouth, Looe, Falmouth, Mount's Bay, St. Minver, Isle of Man, Anglesea, Saltcoats, Isles of Arran, Bute and Cumbrae, Loch Coil, Bangor (Co. Down), Howth, Bantry, Miltown Malbay, Roundstone, and the Channel Islands.

Distribution in Europe. Atlantic shores, Baltic and Mediterranean Seas.

5. P. SPINULOSA Grev. Scottish Cryptogamic Flora, vol. ii. 1824, p. 90.

Reference. Agardh (2) ii. p. 999.

Icones. Greville, Scottish Crypt. Fl. ii. 1824, pl. 90. Harvey, Phyc. Brit. 1846–1851, pl. 320. syn. 110.

DESCRIPTION.—*Habit.* Plant about 5 cms. in height. Branched from the base, branches arising alternately, clothed with short spine-like ramuli, each bearing a cluster of dichotomising fibrillæ at the tip. *Siphons.* 4 primary pericentral, alternating with which are 4 secondary, bounded by a row of corticating cells. *Colour.* Dark red. *Anatomy.* Articulations visible throughout the plant, their length being about equal to their breadth. *Reproductive organs.* Cystocarps sessile and ovate in form, occurring on the branches and ramuli.

P. SPINULOSA var. β. MAJOR, J. G. Ag. Spec. Alg. ii. 1863, p. 999.
=*P. Carmichaeliana* Harv. in Smith's Engl. Flora, v. 1833, p. 328.

Reference. Harvey (28) pl. 319. syn. 116.

This variety occurs on *Desmarestia aculeata*, and has been recorded by Captain Carmichael from Appin, and records have also been made from Little Cumbrae and Skaill, although the plant is very rare. The growth is more lax than that of *P. spinulosa*. There is a central axis from which the branches arise, rather similar to that of *P. fibrillosa*, but the branching is more delicate. A wider band of corticating cells occurs than is present in *P. spinulosa*.

Habitat. Probably in tide-pools. Rare.

British Records. Appin, Argyll (Carmichael's spec. in Herb. Hook., Kew).

Distribution in Europe, Nil.

6. P. VIOLACEA Harv. Man. Brit. Alg. ed. i. 1841, p. 92.
P. subulata J. G. Ag. Spec. Alg. ii. 1863, p. 985 (nec Kütz.).
Hutchinsia violacea C. A. Ag. Syn. Alg. Scan. 1817, p. 54.

References. De Toni (**22**) iv. p. 900 ; Falkenberg (**24**) p. 115 ; Hauck (**31**) p. 225.

Icones. Harvey, Phyc. Brit. 1846–51, pl. 209. syn. 115. *Exsiccata.* Wyatt, Alg. Damnon. no. 176.

DESCRIPTION.—*Habit.* Plants consisting of a main axis, conspicuous at the base, but soon becoming alternately branched, the branches being densely clothed with alternate ramuli. Length usually about 12–15 cms., occasionally attaining a length of 25 cms. *Siphons.* 4 primary pericentral alternating with 4 secondary, bounded on the outside by a band of corticating cells. *Colour.* Brownish-purple. *Anatomy.* Articulations obscured at the base by the corticating cells, 2 to 4 times as long as broad in the smaller branches and ramuli. *Attachment organ.* Young plant attached by 2 or 3 rhizoids developed by longitudinal proliferation of the pericentral siphons. Later, the siphons and external cells at the base all develop rhizoids, and form an attachment organ similar in type to that of *P. elongata*. *Reproductive organs.* Tetraspores borne in swollen ramuli. Cystocarps ovate, usually shortly stalked, with no elongation in the region of the ostiole.

There seems to have been confusion between *P. violacea* and *P. nigrescens*, although the anatomy is so dissimilar. The confusion was probably due to a variety of *P. nigrescens*, which was brighter and purple in colour with greater delicacy of ramification, being described as *P. violacea* by Harvey in Smith's English Flora (p. 332). The *P. violacea* Harv. has been ascertained by Agardh to be identical with the *P. riolacea* of Continental authors, which has only four primary siphons.

P. subulata Ag. differs from *P. violacea* Harv. only in the degree of corticcation, which seems insufficient ground for a specific distinction.

P. VIOLACEA var. GRIFFITHSIANA, var. nov.
P. Griffithsiana Harv. Manual, 1841, p. 91 ; Phyc. Brit. 1846–51, pl. 228. syn. 112.

Pyramidal in form, attaining a length of as much as 25 cms. Axis consisting in the lower parts of 4 primary siphons and 4 secondary arranged round a central siphon. In the upper parts the four secondary are absent. Occasionally a few small corticating cells are present at the extreme base of the plant. Branches arising alternately, clothed with numerous ramuli which are sometimes dichotomously branched.

P. VIOLACEA var. TENUISSIMA Hauck, Meeresalg. 1885, p. 227.
P. divaricata Kütz. Tab. Phyc. xiii. 1863, p. 26, tab. 84 (*a–c*) [*fide* Hauck].

Plants délicate with lax growth, corticate at the base. Articulations 4 to 8 times as long as broad, branching showing marked pseudo-dichotomy.

The various species of *Polysiphonia* exhibit such diversity of form dependent on the conditions under which they are growing that it seems unnecessary to create new species for these forms until they have been shown to possess some stability.

Habitat. Occurring on rocks, stones, and on other algæ such as *Chordaſilum* near low-water mark. Rather rare.

British Records. Orkney Islands, Peterhead, Elie, Earlsferry, Berwick, Whitley, Roker, Kent, Sussex, Hants, Dorset, Devon, Cornwall, Carnarvon, Isle of Man, Arran, Bute, Cumbrae, Howth, Bantry, Ferriter's Cove, Roundstone, and the Channel Islands.

Distribution in Europe. Generally distributed over the coasts of Northern Europe.

B. More than four primary pericentral siphons.

1. P. Brodiæi Grev. in Smith's Engl. Flora, v. 1833, p. 328.
   Grammita Brodiæi Bonnem. Hydroph. loc. 1822, p. 31.
   P. penicillata Kütz. Spec. Alg. 1849, p. 827.
   P. polycarpa Kütz. Tab. Phyc. xiv. 1864, p. 1, tab. 2 (*e–g*).
   P. callitricha Kütz. *l. c.* tab. 2 (*a–d*).

References. Agardh (**2**) ii. p. 993 ; De Toni (**22**) iv. p. 947 ; Hauck (**31**) p. 237.

Icones. Harvey, Phyc. Brit. 1846–51, pl. 195. syn. 118. Kützing, Tab. Phyc. *l. c.* *Exsiccata.* Wyatt, Alg. Damnon. no. 83.

Description.—*Habit.* Plants branched from the base, frequently showing a distinct main axis. Branching irregular or pseudo-dichotomous, densely clothed with tufted ramuli. Substance cartilaginous, but flaccid in the ramuli. *Siphons.* 6–8 primary pericentral siphons, alternating with which occur the same number of secondary siphons bounded by a band of corticating cells. *Colour.* Dark purplish-red, becoming much darker in drying. *Anatomy.* Articulations of the main axis and principal branches entirely obscured by the cortication ; articulations of the ramuli about as long as broad. *Attachment organ.* Young plant attached to the substratum by a number of rhizoids formed by the longitudinal proliferation of the siphons and by the elongation of the corticating cells, a certain amount of mechanical coherence resulting in the formation of a disc as in *P. elongata*, although the individual rhizoids are looser. Later, certain of the procumbent branches form rhizoids by the lateral elongation of the corticating cells, thus giving additional strength to the organ. The form of the attachment organ thus comes intermediate between the *P. nigrescens* and *P. elongata* types. *Reproductive organs.* Tetraspores intercalary in development, borne in swollen ramuli. Cystocarps ovate in form and shortly stalked, developed in large numbers on the ramuli.

P. Brodiæi Grev. differs anatomically from *P. Brodiæi* Aresch., the latter having as many as 16 siphons in the main thallus and 12 in the ramuli. The ramuli are very numerous, giving the plant a distinctive tufted appearance.

Habitat. Occurring near low-water mark and at greater depth on rocks, corallines, and shells. Flourishes where conditions are turbulent. Common.

British Records. Orkney Islands, Forres, Peterhead, Arbroath, Elie, Earlsferry, Dunbar, Berwick, Alnmouth, Whitley, Folkestone, Brighton, Isle of Wight, Swanage, Weymouth, Sidmouth, Torbay, Plymouth, Torpoint, Falmouth, Penzance, Isle of Man, Portincross, Arran, Cumbrae, Bute, South and West coasts of Ireland, and the Channel Islands.

Distribution in Europe. Atlantic shores of Europe as far south as France.

2. P. FŒTIDISSIMA Cocks, Alg. Fasc. Coll. Brit. Seaweeds, 1855, no. xxix [nomen].

P. stuposa Zanard. ex Kützing, Tab. Phyc. xiv. 1864, p. 18 (diagnosis); Ralfs in Penzance Nat. Hist. Soc. Trans. 1884, p. 325 [nomen].

References. De Toni (**22**) iv. p. 924; Hauck (**31**) p. 240 *et seq.*; Bornet (**10**) p. 154 [314].

Icones. Kützing, Tab. Phyc. xiv. 1864, p. 18, tab. 49 (*d–g*). *Exsiccata*. Cocks, Alg. Fasc. Coll. Brit. Seaweeds, 1855, no. xxix.

DESCRIPTION.—*Habit*. Occurring in tufts from 3–10 cms. in length. Branching alternate or pseudo-dichotomous, branches being clothed with numerous ramuli, especially in the upper parts. Substance gelatinous. *Siphons*. 8–10 pericentral sometimes bounded by a row of corticating cells at the base. *Colour*. Brownish-red. *Anatomy*. Articulations from 1–2 or seldom three times longer than their breadth in the upright parts of the plant, and about equal to their breadth in the prostrate portions near the attachment organ. *Attachment organ*. Numerous rhizoids formed from the pericentral siphons or the corticating cells when the latter are present, the rhizoids developing disc-like expansions at the tips when they encounter a firm substratum. *Reproductive organs*. Tetraspores intercalary in development, borne in swollen ramuli. Cystocarps ovate in form, with a conical elongation towards the ostiole.

According to Hauck (**31**. p. 240), the species is ecorticate, but in the lower parts of the main branches a row of corticating cells sometimes occurs, the individual cells of which alternate with the pericentral siphons. The ramuli are described by De Toni (**22**. p. 924) as having "apice non penicilliferis," but in a specimen obtained from Swanage, April 1919, there were clusters of filamentous hairs at the tips of the ramuli. The error is probably due to the previous examination of the plant having taken place at a different time of the year. When the plant grows on another alga, e. g. *Codium adhærens* (Durlston Head, Swanage), attachment discs are not developed at the tips of the rhizoids; a holdfast is obtained by the latter ramifying among the cells of the host.

Habitat. On rocks, stones, and on other algæ such as *Codium adhærens* between the tide-levels. Very rare.

British Records. Brighton, Swanage (Batten, 1919), Plymouth, Falmouth, and Newlyn West.

Distribution in Europe. Adriatic Sea.

3. P. FRUTICULOSA Sprengel, Syst. veg. vol. iv. 1825, p. 350.
Rytiphlœa fruticulosa Harv. Phyc. Brit. pl. 220. syn. 105.
Hutchinsia Wulfeni C. A. Ag. Sp. Alg. vol. ii. 1828, p. 95.
Grammita Wulfeni Bonnem. Hydroph. loc. 1822, p. 27.
P. Martensiana Kütz. Tab. Phyc. xiv. 1864, p. 10, tab. 29 (*a–c*).
P. pycnophlœa Kütz. *l. c.* p. 10, tab. 30 (*e–g*).
P. comatula Kütz. *l. c.* p. 10, tab. 31 (*a–c*).

References. Agardh (2) ii. p. 1028 ; De Toni (22) iv. p. 950.

Icones. Harvey, Phyc. Brit. *l. c.* Kützing, Tab. Phyc. *l. c.* Falkenberg, Die Rhodomel. 1901, pl. 21 (1–5). *Exsiccata.* Wyatt, Alg. Damnon. no. 132.

DESCRIPTION.—*Habit.* Occurring in tufts from 10–15 cms. in height. Branching roughly pseudo-dichotomous in the main branches, with wide angle of divergence causing characteristically angular appearance. Smaller branches bi-pinnate, the whole plant being clothed with short spine-like ramuli set at a wide angle. Perennial species, cartilaginous in nature. *Siphons.* 8–12 pericentral, surrounded by a wide band of corticating cells. *Colour.* Dark brownish-purple. *Anatomy.* Articulations almost completely obscured throughout the plant by the corticating cells. When visible they are about as long as broad, except in the small branches and ramuli where their length is less than their breadth. *Attachment organ.* Rhizoids developed from siphons and corticating cells at the base of the original axis. Later, branches arising near the base creep along the substratum and bear laterals alternately, those on the upper side forming 'shoots,' the lower ones being modified to form attachment organs. The modified branches bear rhizoids profusely, frequently strengthening the holdfast by twisting round a portion of the coralline host. *Reproductive organs.* Tetraspores borne in swollen and distorted ramuli. Cystocarps rare, sessile and ovate in form when present, crowded on the ramuli.

The attachment organ of this species is of especial interest, resembling that of *Pterosiphonia* rather than *Polysiphonia.* It is the only British member of the latter genus which has branches specially modified to form attachment organs.

Habitat. Occurring in tide-pools on the rocky bottom, and particularly in warm shallow pools on *Corallina officinalis* and other coralline algæ. Occurring also in the low littoral zone when the *Fucus serratus* vegetation is not too dense. Common on the shores of the South of England, Ireland, and the Channel Islands, rare in Scotland and northern England.

British Records. Isle of Wight, Swanage, Weymouth, Sidmouth, Torbay, Plymouth, Looe (Batten, 1921), Falmouth, Penzance, Mount's Bay, Trevone, Hilbre Island, Isles of Man and Anglesea, Arran, Cumbrae, Ballantrae, Portincross, Portrush, Bantry Bay, Miltown Malbay, Roundstone Bay, and the Channel Islands.

Distribution in Europe. Atlantic and Mediterranean shores.

4. P. NIGRESCENS Grev. in Smith's Engl. Flora, v. 1833, p. 332.
Conferva nigrescens Dillw. Brit. Conf. 1809, pl. 155.
P. violascens Kütz. Spec. Alg. 1849, p. 813.
P. regularis Kütz. Tab. Phyc. xiii. 1863, p. 16, tab. 51 (*a*, *b*).
P. sentosa Kütz. Tab. Phyc. xiii. 1863, p. 16, tab. 51 (*c*, *d*).
P. lophura Kütz. Tab. Phyc. xiii. 1863, p. 17, tab. 52 (*c*, *d*).

References. Agardh (2) ii. p. 1057 ; De Toni (22) iv. p. 940 ; Falkenberg (24) p. 129 ; Hauck (31) p. 244.

Icones. Dillwyn, Brit. Conf. 1809, pl. 155. Harvey, Phyc. Brit. 1846–51, pl. 277. syn. 122. Kützing, Tab. Phyc. *l. c.* pls. 51, 52 (*c*, *d*), 56 (*f*–*i*). *Exsiccata.* Wyatt, Alg. Damnon. no. 135.

DESCRIPTION.—*Habit.* A perennial, occurring in tufts as much as 5 cms. in diameter, and varying from a slender plant about 7 cms. in length to a coarse form attaining a length of 30 cms. and having the lower parts clad with the broken remains of old ramuli. Branching variable but typically alternate, the branches subdividing and ultimately bearing large numbers of closely pinnate ramuli, which are themselves again doubly-pinnate and bear dichotomous fibrillæ at their tips. During the winter the ramuli disappear, leaving the plant with a serrate appearance. The substance is rigid except in the ramuli, which are flaccid and adhere to paper. *Siphons.* 12–20 pericentral, round a central one with diameter equal to about one-third of the diameter of the filament. At the extreme base a row of small cells frequently bounds the pericentral siphons on the outside. *Colour.* Brownish-purple. *Anatomy.* Articulations about as long as broad in the older parts, but attaining a length of 1½ times their breadth in the smaller branches. *Attachment organ.* At the base of the main axis a number of rhizoids occur, formed from the longitudinal elongation of pericentral siphons. Later, when cortication develops, external cells aid in the formation of the attachment organ, and procumbent branches send off rhizoids from their creeping portions. The discs at the apices of the rhizoids are well developed, affording additional resistance to the force of the waves by their mechanical interlocking, the part actually coming in contact with the substratum being comparable to the base of the attachment in complex forms like *P. elongata.* *Reproductive organs.* Tetraspores borne in the ramuli and uppermost branches, frequently intercalary in development. Antheridia formed in yellow clusters at the tips of the ramuli, usually among clusters of multicellular hairs. Cystocarps broadly egg-shaped and almost sessile.

This species often bears a strong outward resemblance to *Pterosiphonia thuyoides* Sch., although the branching is not so regular. It may be distinguished with a hand-lens by means of the attachment organ, the tiny branches specially modified for attachment which are present in *Pterosiphonia thuyoides* being absent in *P. nigrescens.*

P. atro-purpurea Moore in Harv. Man. ed. i. p. 89, appears to be a variety of *P. nigrescens* with a more slender habit and corymbose ramuli. A variety which was brighter and more purple in colour with greater delicacy of ramification was described by Carmichael (**28**. p. 115) as *P. violacea*. This no doubt accounts for the one-time confusion between two species which are so distinct anatomically. A form with 16 siphons and long articulations has been separated by Moore as *P. affinis* in Ord. Surv. Londonderry, App. p. 11, t. 7, and figured by Harvey (**28**) t. 303. The siphons are somewhat twisted, but the twisting is very slight and variable. The plant shows lax growth, and combines corymbose branching with unusually long articulations and about 16 siphons. *P. dichocephala*, figured by Kützing (**37**) xiii. pl. 53, appears to be the same plant as that which Harvey describes as *P. affinis* Moore.

Material dredged in Plymouth Sound showed the antherida of *P. nigrescens* growing directly on short stalks on the ramuli and not on dichotomising fibrillæ. Under these circumstances the multicellular axes of the antheridia frequently protruded from their tips.

Habitat. Attached to larger algæ, and on rocks and stones between the tide-levels. Common.

British Records. Common almost everywhere on the shores of the British Isles. Var. *P. affinis* Moore (=var. *ε. affinis* J. Ag.) : Mouth of R. Deben, Ramsgate, Eastbourne, Torbay, Carnlough near Glenarm, Cushendall, and the Channel Islands. Rather rare.

Distribution in Europe. Atlantic shores.

5. P. VARIEGATA J. G. Ag. Alg. Medit. 1842, p. 129.
   Grammita Bonnem. in Journ. Phys. xciv. (1822) p. 186.
   G. denudata Crouan, in Desmaz. exs. no. 1208, 1842 (excl. syn.).
   P. leptura Kütz. Tab. Phyc. xiii. 1863, p. 28, tab. 89 (*f–i*).
   P. denudata (fide Hauck) Kütz. Tab. Phyc. xiii. 1863, p. 28, tab. 90.

References. Agardh (**2**) ii. p. 1030; De Toni (**22**) iv. p. 922 ; Falkenberg (**24**) p. 119 *et seq.* ; Hauck (**31**) p. 236.

Icones. Harvey, Phyc. Brit. 1846–51, pl. 155. syn. 119. Kützing, Tab. Phyc. *l. c.* Thuret et Bornet, Études Phyc. 1878, fig. 42. *Exsiccata.* Desmaz. exs. no. 1208, 1842 (excl. syn.).

DESCRIPTION.—*Habit.* An annual, cæspitose, tufts attaining a length of 25 cms. Branching pseudo-dichotomous, widely divergent, main axis flexuose. *Siphons.* 6 pericentral, surrounded by a band of corticating cells in the lower parts of the plant. *Colour.* Purplish-brown, with frequently a greenish tint in the principal branches. *Anatomy.* Articulations shorter than their breadth near the base of the plant, twice as long as broad in the principal branches, gradually becoming shorter upwards. *Attachment organ.* Plants attached by a disc at the base of the main axis, subsequently strengthened by rhizoids formed from the siphons and corticating cells of

small branches, arising near the original attachment organ. A disc-like expansion develops by the mechanical interlocking of the expanded bases of the rhizoids. *Reproductive organs.* Tetraspores small, intercalary. Antheridia occurring in large numbers near the tips of the branches. Cystocarps occurring on the smaller branches and ramuli, broadly ovate at the base and shortly stalked.

A floating species found in September (Cotton) in the lake of Poole Park exhibited marked dichotomy in the lower branches, and the articulations consisted of six pericentral siphons and a central one. No cortication was present. The mud-loving estuarine habit of the plant confirms the decision that the plants found were floating forms of *P. variegata.*

Habitat. A mud-loving estuarine species occurring on rocks, stones, and on smaller algæ such as *Chorda filum* and on the leaves of *Zostera.* Very rare.

British Records. Brighton, Isle of Wight, Studland (Batten), Swanage (Batten), Weymouth, Plymouth, Torpoint, and St. Minver.

Distribution in Europe. Atlantic shores of France and Spain, Mediterranean and Adriatic Seas.

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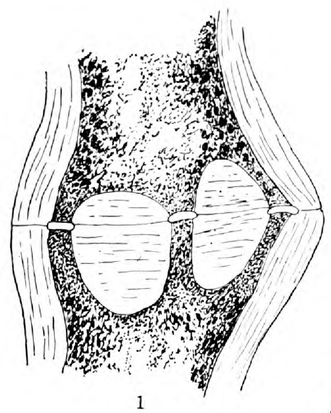
EXPLANATION OF THE PLATES.

Plate 22.

Fig. 1. Protoplasmic connections of the central siphon in *P. elongata*.
2. Attachment disc of *P. fruticulosa*, seen from below.
3. Tip of lateral branch of *P. urceolata*.
4. Central siphon of *P. fastigiata*, showing protoplasmic connections and thickened walls.
5. Development of rhizoids from the pericentral siphons of *P. macrocarpa*.
6. Formation of rhizoids from the corticating cells in *P. nigrescens*.
7. Transverse section of thallus of *Ascophyllum nodosum*, showing penetration by the rhizoids of *P. fastigiata* (constructed from a number of sections).
8. T. S. of thallus of *Ascophyllum nodosum* at the point of penetration of *P. fastigiata*, showing decolorised cells which have been attacked. Cam. luc.
9. T. S. of thallus of *P. fastigiata* in region bearing tetraspores.
10. *P. insidiosa*. T. S. of thallus.
11. „ Habit drawing.
12. *P. macrocarpa*. Portion of thallus showing attachment organs.
13. „ Habit drawing.
14. „ T. S. of thallus.
15. *P. rhunensis*. Habit drawing.
16. *P. spiralis*, spec. nov. Plan showing relative positions of twisted and untwisted portions.
17. „ Branch bearing tetraspores.
18. „ T. S. of thallus.
19. „ Portion of thallus showing spiral twisting of the siphons.
20. „ Habit drawing.
21. „ Portion of thallus showing attachment organ.
22. „ Branch bearing tetraspores.
23. *P. urceolata*. Habit drawing.

Plate 23.

Fig. 24. *P. urceolata*. Portion of thallus bearing attachment organs.
25. „ T. S. of thallus.
26. *P. atro-rubescens*. Portion of thallus showing spiral twisting of the siphons.
27. „ Portion of thallus showing attachment organs.
28. „ T. S. of thallus.
29. „ Habit drawing.
30. *P. fastigiata*. T. S. of thallus.
31. „ Habit drawing showing various stages in the development of the Polysiphonia on *Ascophyllum nodosum*.
32. *P. furcellata*. Habit drawing.



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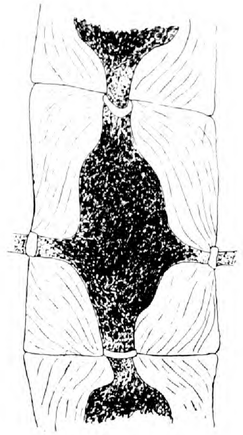

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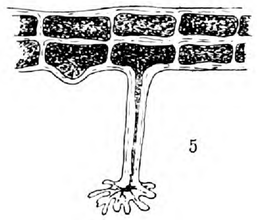

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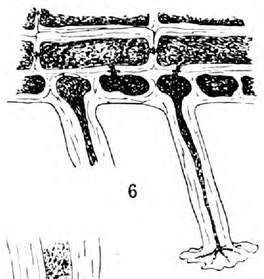

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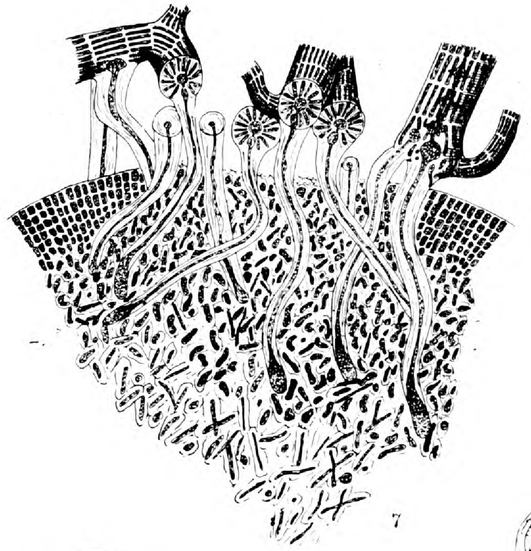

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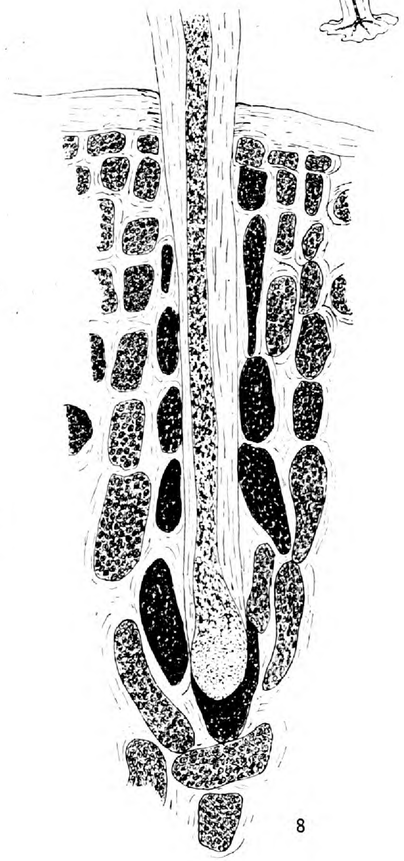

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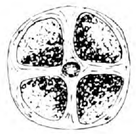

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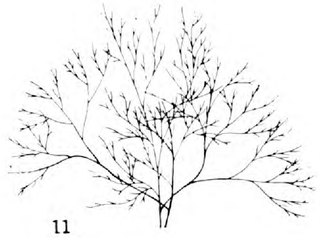

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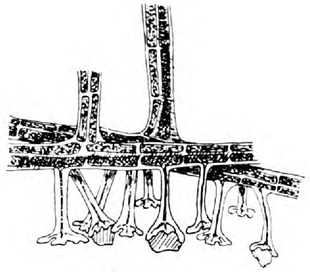

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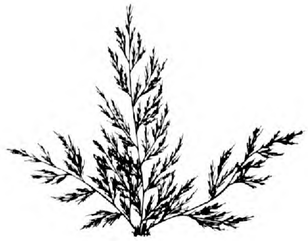

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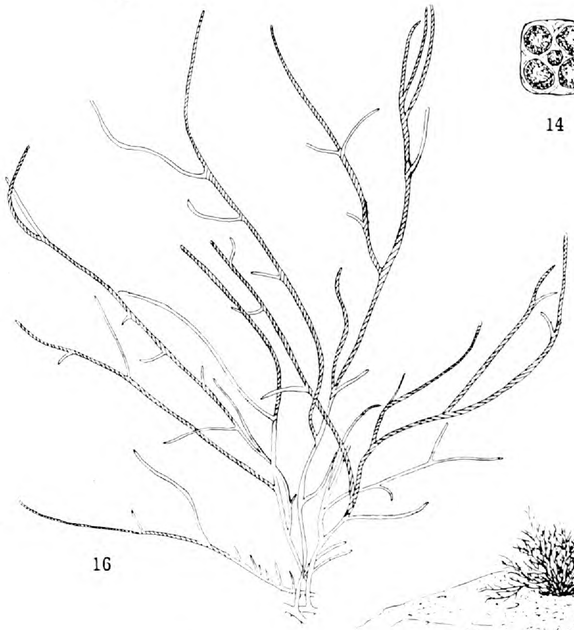

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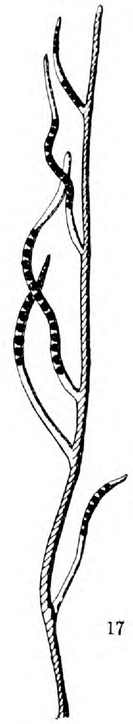

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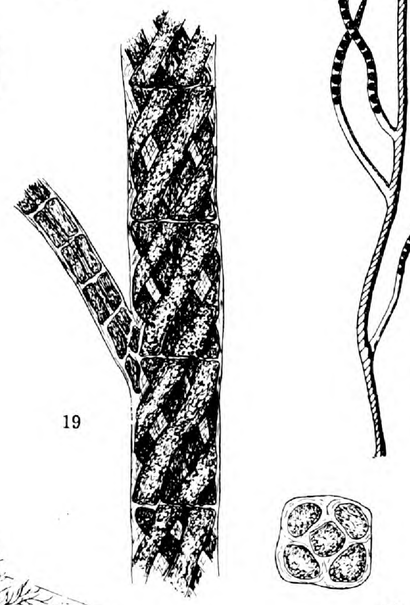

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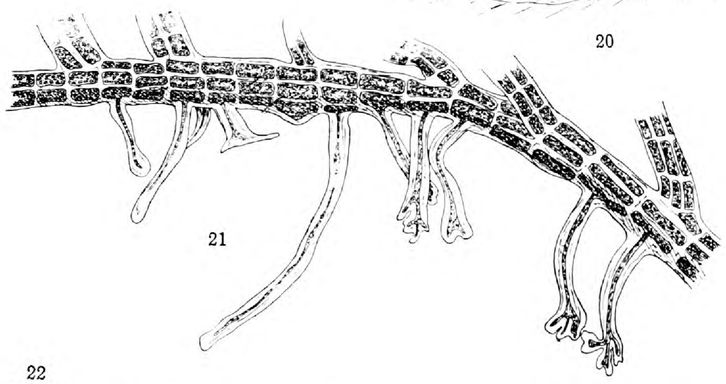

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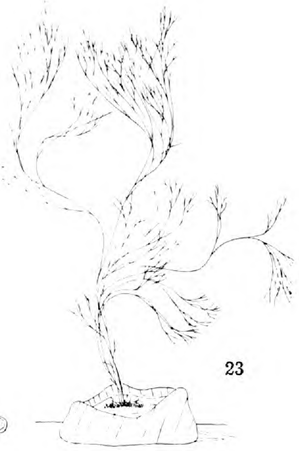

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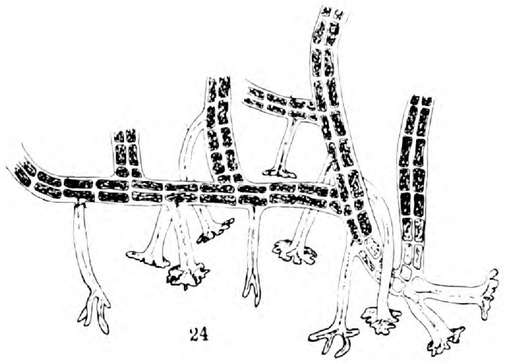

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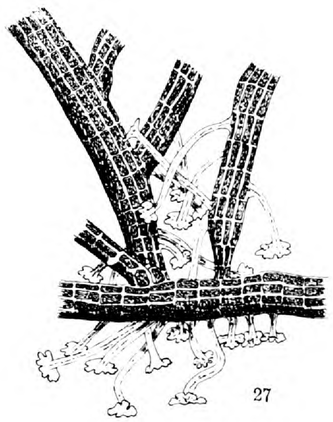

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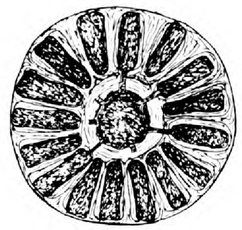

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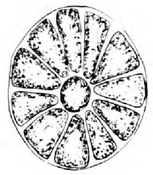

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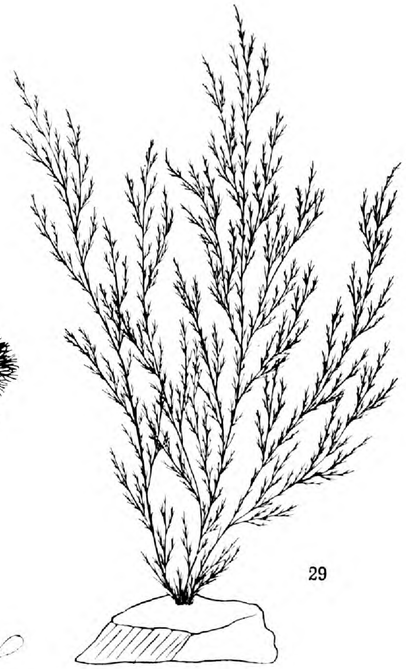

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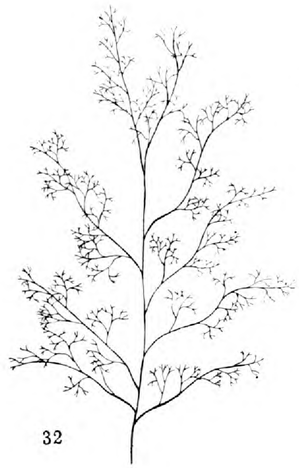

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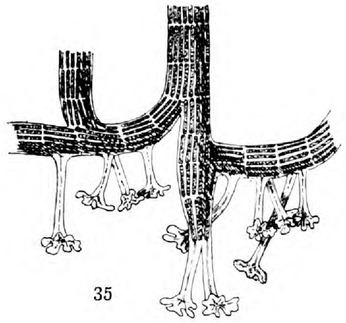

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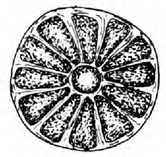

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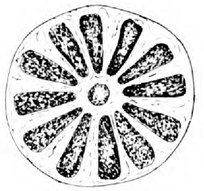

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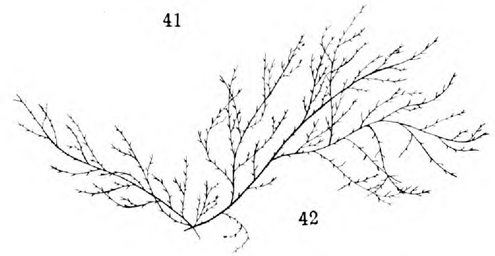

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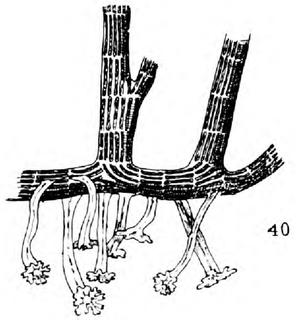

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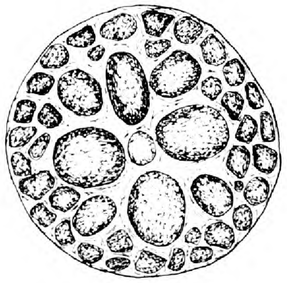

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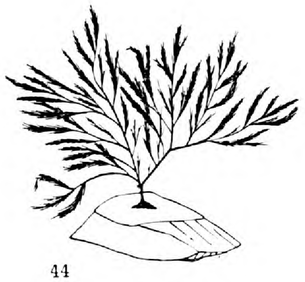

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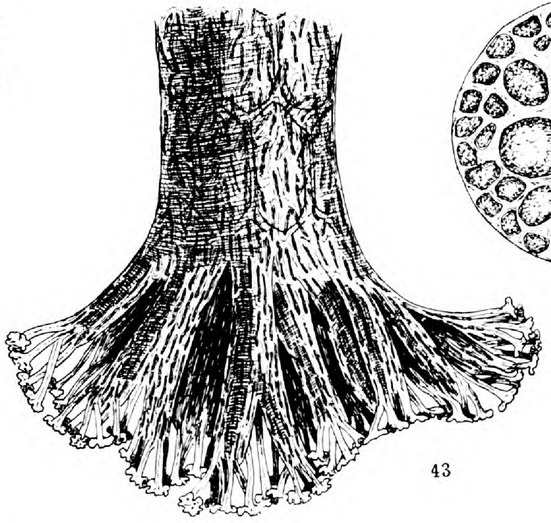

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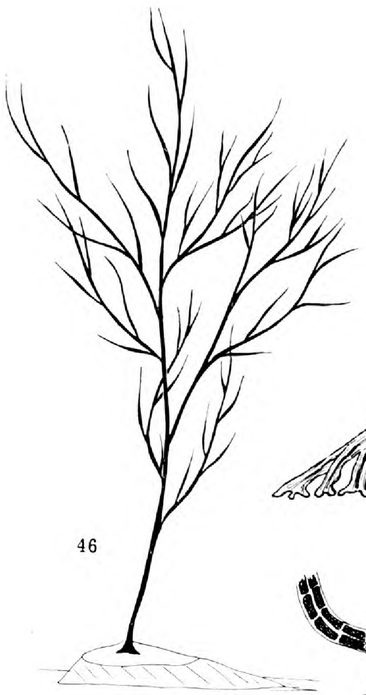

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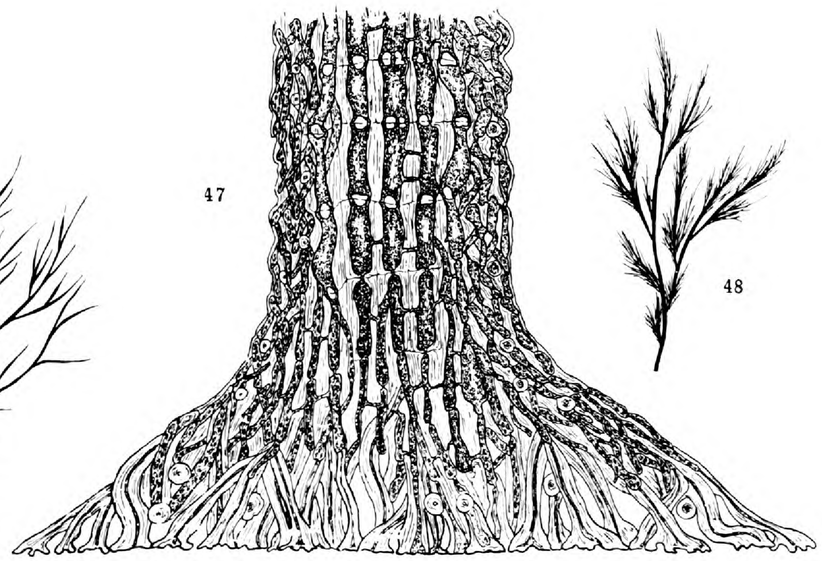

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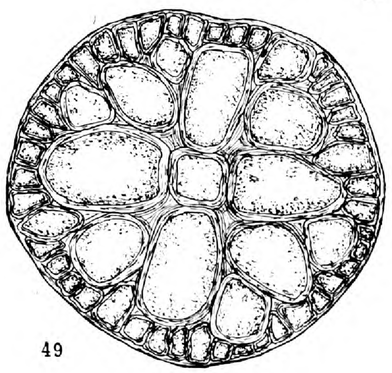

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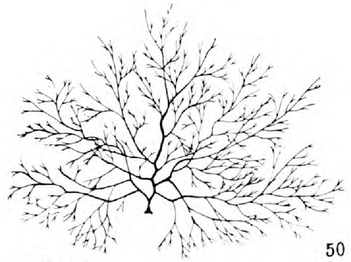

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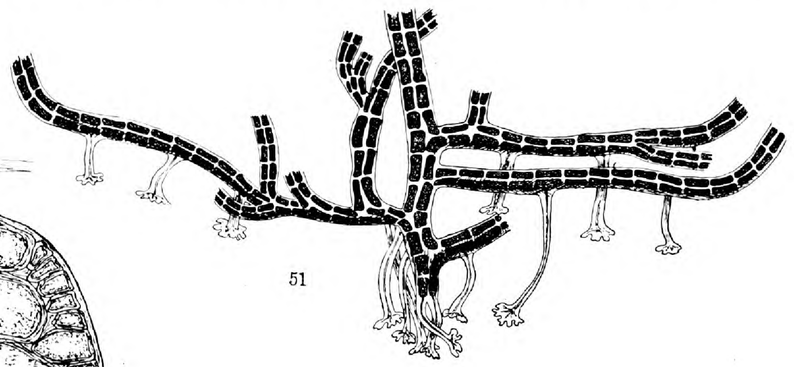

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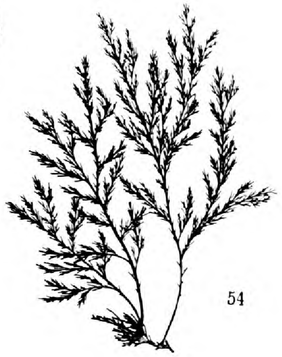

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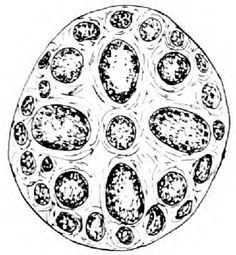

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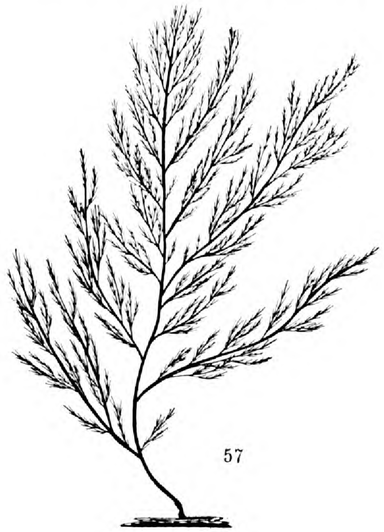

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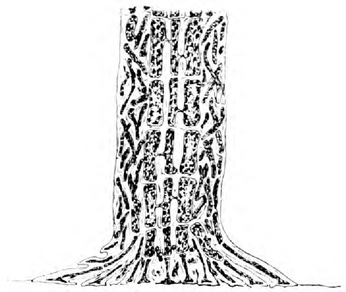

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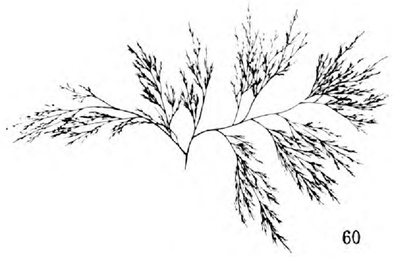

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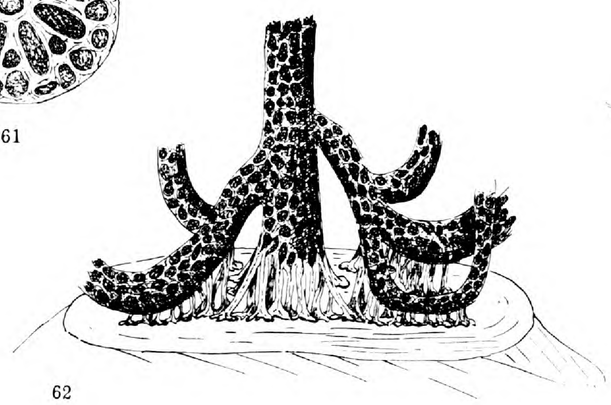

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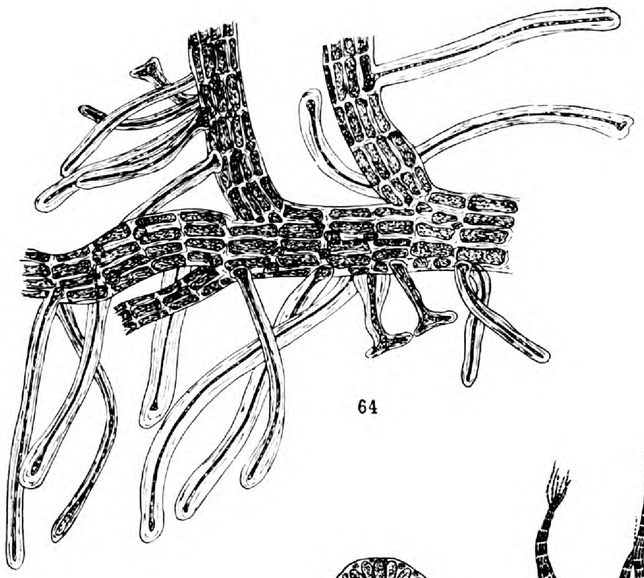

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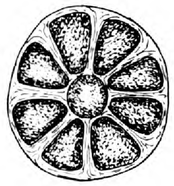

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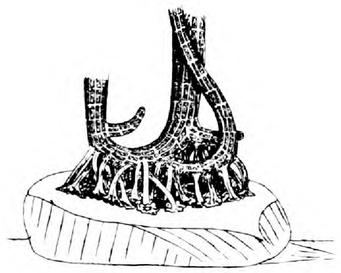

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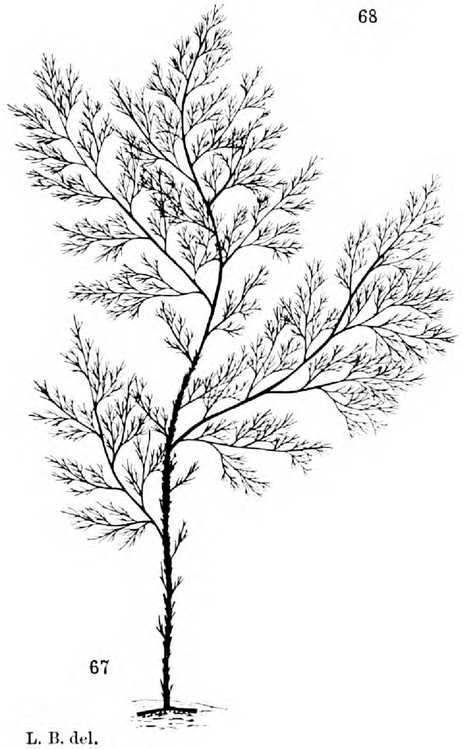

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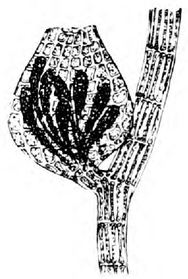

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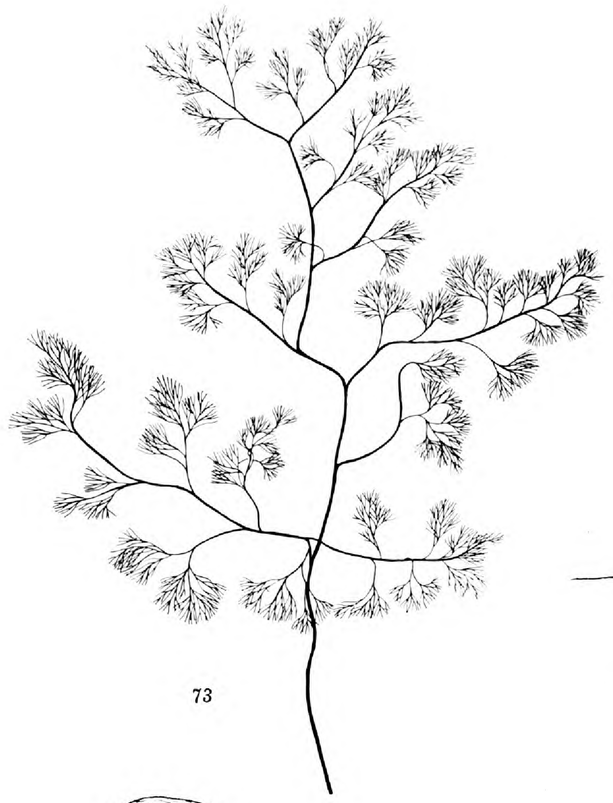

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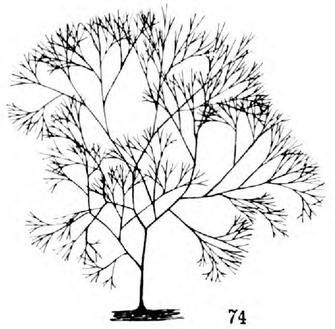

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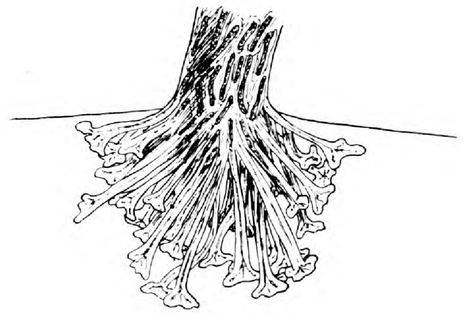

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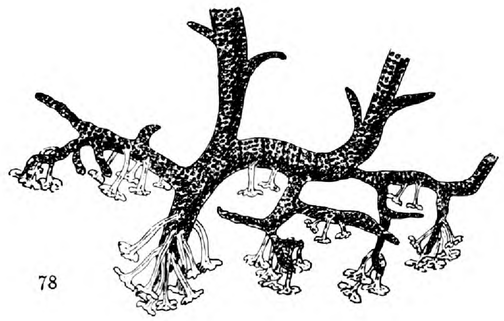

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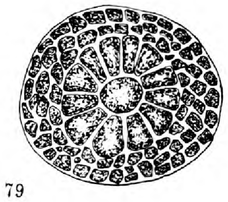

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Fig. 33. *P. obscura.* Habit drawing.
34. „ T. S. of thallus.
35. „ Portion of thallus bearing attachment organs.
36. *P. opaca.* Habit drawing. (Herb. spec.)
37. „ T. S. of thallus.
38. *P. simulans.* Habit drawing.
39. „ T. S. of thallus.
40. „ Portion of thallus showing attachment organs.
41. *P. subulifera.* T. S. of thallus.
42. „ Habit drawing.
43. *P. elongella.* Habit drawing.
44. „ Exterior view of attachment organ.
45. „ T. S. of thallus.

Plate 24.

Fig. 46. *P. elongata.* Habit drawing. (Winter state.)
47. „ Longitudinal section of thallus showing attachment organ.
48. „ Portion showing ramuli. (Summer state.)
49. „ T. S. of thallus.
50. *P. Richardsoni.* (From Dr. Richardson's specimen, Nat. Hist. Mus.)
51. *P. fibrata.* Portion of thallus showing attachment organs.
52. „ Habit drawing.
53. „ T. S. of thallus.
54. *P. fibrillosa.* Habit drawing of plant on *Rytiphlæa pinastroides.*
55. „ L. S. of attachment organ grasping thallus of *Rytiphlæa pinastroides.*
56. „ T. S. of thallus.
57. *P. violacea.* Habit drawing of plant on *Chorda filum.*
58. „ T. S. of thallus.
59. „ L. S. of thallus showing attachment organ.
60. *P. spinulosa.* (From herb. spec. Nat. Hist. Mus.)
61. *P. Brodiæi.* T. S. of thallus.
62. „ Portion showing attachment organ.
63. „ Habit drawing.

Plate 25.

Fig. 64. *P. fœtidissima.* Attachment organs when growing on *Codium adhærens.*
65. „ Habit drawing.
66. „ T. S. of thallus.
67. *P. nigrescens.* Habit drawing.
68. „ T. S. of thallus.
69. „ Branch bearing tetraspores.
70. „ Portion showing attachment organ.
71. „ Cystocarp with carpospores.
72. „ Interlocking attachment discs seen from below.
73. *P. nigrescens* var. *affinis.* Habit drawing.
74. *P. variegata.* Habit drawing from herbarium specimen of Rev. W. S. Hore.
75. „ Portion showing attachment organ.
76. „ T. S. of thallus.
77. *P. fruticulosa.* Habit drawing of plant on *Corallina officinalis.*
78. „ Portion showing attachment organs.
79. „ T. S. of thallus.