ART. XXXVII.—*Observations on* Salicornia australis.

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Communicated by Professor H. B. Kirk.

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INTRODUCTION.

Salicornia australis is a small halophyte which grows abundantly in New Zealand, Tasmania, and Australia, along the sea-shores, and especially at the mouths of tidal rivers.

The genus consists of about eight species, found on most temperate and tropical shores, and occasionally in saline places inland (5).

"In central and northern Europe the first settler in littoral swamps is *Salicornia herbacea*, a succulent herb, and by the Mediterranean shrubby species of *Salicornia* (*S. fruticosa, S. macrostachya, S. sarmentosa*) occur in such habitats" (4, *c*).

I append notes under two headings—(1) Plant-habits; (2) Structure.

(1.) PLANT-HABITS.

From April to June underneath the plants of *S. australis* are seen a large number of seedlings in which the plumule has made no appearance. Seedlings were only found where the plant was growing in the sand. (For the development of seedlings, see fig. 1.)

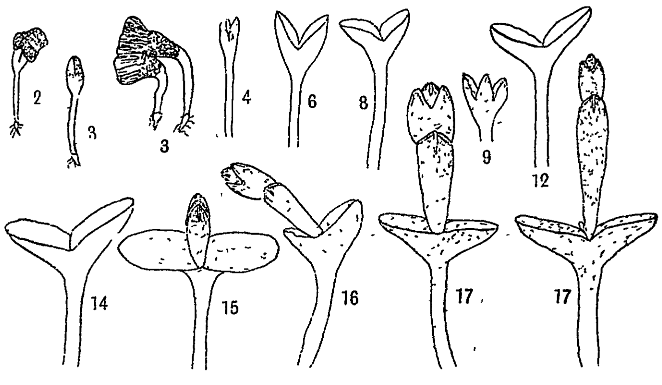

FIG. 1.—Seedlings of *Salicornia* grown in laboratory. (The numbers 2, 3, &c., denote the age of the plant in weeks. The one numbered 9 has three cotyledons.)

In autumn many plants in exposed positions die down and appear to be dead, but sprout up again from the base in July and August. In other plants the branches have a withered appearance, but from them fresh branches arise, so that the plant remains green. When the coast is rocky *S. australis* is found nearer the sea than any other vegetation. The conditions for life for these plants growing on rocks seem almost impossible, for there appears to be neither soil nor water, except from the sea. Plants growing on low rocks washed by the sea are found on the tops of them, the action of the waves being too strong for them to get a footing at the base.

These plants have a stellate appearance, owing to the complete drying-up of old branches, the new ones all arising from the base. The roots are closely pressed against the rocks, and are matted together to collect any particles of soil.

The stems of many plants growing on loose shingle are long, thick, and woody, and are continued some distance below the surface, giving rise at the nodes to thick, long, adventitious roots.

A curious feature is shown in some stems, especially in those on which an inflorescence has been borne. The internode nearest the stem is withered and brown, several adjoining it are green and succulent, then again there are several brown and withered internodes, then either the succulent apex or the withered remains of the inflorescence (see fig. 9, *a*).

Plants growing on rocks almost in the sea become red, and wither very soon. The more exposed and drier, both physically and physiologically, a situation is, the more is the plant inclined to turn red.

Colouring always begins in the internode at the base of a branch, and proceeds upwards to the apex. The internode does not long remain coloured, but soon turns brown; thus there are never more than two or three internodes on the same branch coloured at the same time. It would seem that the plant turning red is an indication that the chlorenchyma is about to disappear. This is further borne out by the fact that the cotyledons of the seedlings growing on a small salt meadow at Paremata turn red before withering. That plants that die down early do not usually turn red shows that the withering is not necessarily preceded by the plant turning red. The red colouring is dissolved in the cell-sap, which gives an acid reaction. It is therefore probably anthocyanin. It is purple in reflected and red in transmitted light.

At Oriental Bay *S. australis* grows on cliffs 40 ft. above the sea-level, and with it large quantities of *Mesembryanthemum australe* and *Aciphylla squarrosa*. It also grows at the edge of the water, but is not immersed even at high tide, although in some other places it is.

At Napier the salt meadow covered with *S. australis* and plants mentioned above extends for several miles. This is one of the few extensive salt meadows in New Zealand. Most of the meadow is in the process of draining, so that each year it becomes drier. The whole meadow in autumn has a reddish tinge. The finest specimens I found at the edge of a lagoon which receives each day fresh supplies of salt, and is sheltered by a shingle-bank. The branches remain succulent for twelve months, and secondary wood is well developed in them while still succulent. They are duller in colour owing to a coating of wax, which serves to check transpiration. These plants contain much salt, and remain succulent for a long time when picked, showing that transpiration is greatly restricted, and that the water tissue has not given up its water to the atmosphere, but to the green tissues.

At Plimmerton, along the railway embankment, *Salicornia* forms a thick mat several feet wide and extending for some 50 yards. In some places the plants are very shrubby.

Salicornia australis is a frutescent or shrubby perennial. The stems are upright or procumbent; the usual height is 4–8 in. In a sheltered position at the edge of a lagoon the plants are 1½–2 ft. in height, and the branches are very long and thick. Sometimes when the stems are procumbent they are as much as 3 ft. long, and give off adventitious roots at the nodes. Short procumbent branches often become very thick and woody, being sometimes over ½ in. in diameter. The young branches are cylindrical, green, and succulent, owing to the succulent leaves and leaf-bases which surround them.

The branching is opposite. In some plants the branches appear to be given off from the main axis, just below the insertion of a branch. These are, in the cases I examined, branches given off from the lowest node of that branch, the node being almost indistinguishable. Sometimes two branches arise together, and are surrounded by leaves (with only slightly developed bases), in the form of a spiral (see fig. 9; *c*).

(2.) Structure.

Leaves.

Thomson, Cheeseman, Laing and Blackwell, and Miss Cross, all following Sir Joseph Hooker, describe *Salicornia australis* as "leafless," but I find that as long as green tissue remains on the plant leaves persist, and are short and connate—the free portions like decussate scales. At the apex they are only a few cells in thickness, but lower down abundant water tissue is present. The veins are not visible till a section is made. It is the greatly developed leaf-base which forms the "cortex" referred to by writers on *Salicornia*.

A longitudinal section of the growing-point shows an apical cone surrounded by leaves. Those near the apex have the base only slightly enlarged. Apical growth of the leaves soon ceases, and intercalary growth takes place at the base, as in the majority of leaves. This is recognizable by the fact that all the mitotic nuclei are there. The cells containing these nuclei are small and isodiametrical in shape (fig. 3, *b*). In leaves further down the stem the mitotic nuclei are still observable at the base. Thus this intercalary growing-point proceeds downwards, and gives rise to all the chlorenchyma, as well as all the water tissue of the leaf-base.

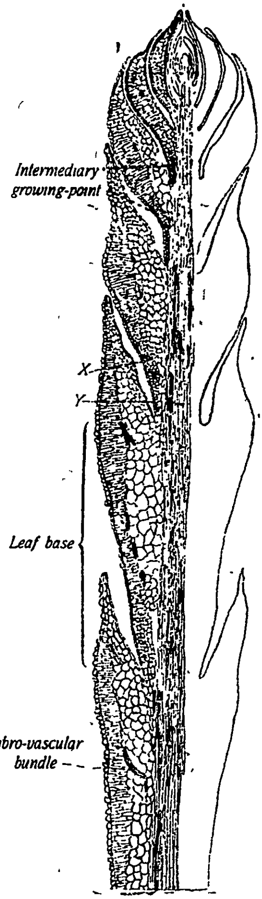

Fig. 2.—Longitudinal section of bud, ×16.

Running down the middle of the dorsal surface of the leaf is a white line, due to the absence of chlorophyll in the underlying tissue. The lower termination of the line marks off the free portion of the leaf from the beginning of the leaf-base. As each whorl of leaves overlaps the bases of the whorl above, the stem is never visible till the leaves have fallen.

The dorsal surface of the leaf is concave, the ventral convex. The leaf-margins are colourless, since, being only two cells in width, there is no palisade tissue developed between the dorsal and ventral epidermis.

The vascular system is well developed. I found no bundle-sheath present.

The following references show that the structure of the so-called cortex is constant throughout the genus:—

Ganong (3, *b*) describes *Salicornia herbacea* as having "a branching, succulent, practically leafless stem . . . possessing a compact stele (with cortical system of bundles replacing those of abandoned leaves), thick water-storing cortex."

Warming (2) says that in *Salicornia ambigua* the leaves stand out like collars round the older parts of the branches, which are shrivelled and thin, and in structure it differs little from *Salicornia herbacea,* described by De Bary.

De Bary (1, *b*) says *Salicornia herbacea* has chlorophyll tissue in palisade form in the cortex of the stem, and has short scaly leaves arranged in decussate pairs.

Reasons for calling Leaf-base what appears to be and has been described as "Cortex."

1. The vascular-bundle system in the cortex-like portion resembles that of a leaf. The leaf-trace divides, the middle branch behaving normally; the two lateral branches are directed upwards for a short distance,

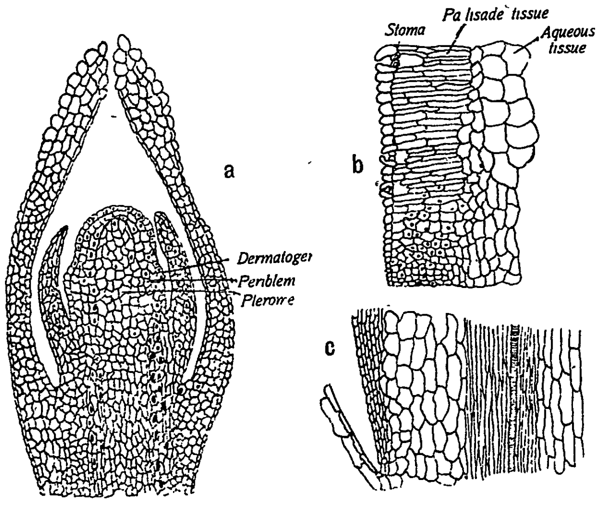

FIG. 3.—*a*, Longitudinal section of growing-point; *b*, *c*, x and y of fig. 2 under higher power.

and then run downwards in the aqueous tissue, anastomosing freely, and forming a network. This position of the vascular bundles is comparable to that in the basal portion of peltate leaves.

2. Except for the median branch, the network has no connection with the stem.

3. The bundles end blindly in mesophyll.

4. There is no difference between the palisade-cells in the leaf and leaf-base, and there is no break in continuity, they being developed in both on the ventral side.

5. The water tissue of the leaf-base (cortex) is in all parts similar to the mesophyll of the leaf, when this does not consist of palisade-cells.

6. Below what I regard as the leaf-base the stem loses its palisade tissue (see fig. 3, *c*). This is a very short portion of each internode, just the part covered by the leaves of the next node below.

7. A longitudinal section through the growing-point shows the leaf-base of the usual kind, with a very extensive growing-point (see fig. 2).

Cross-section of the internode before leaf-base disappears shows:—

(1.) Epidermis, a single layer of cells, the outer walls of which have developed a cuticle.

(2.) Palisade parenchyma and scattered tracheides.

(3.) Aqueous tissue, the internal limit of which is the endodermis.

(4.) Portions of fibro-vascular bundles scattered about in the aqueous tissue. These I regard as the vascular bundles of the leaf-bases.

(5.) Central cylinder or stele with a well-marked pericycle. This is the only portion in this section which can be called "stem." In this are embedded the collateral fibro-vascular bundles, which in this section are seven in number.

Cross-section of stem below the leaf-base shows:—

(1.) A thin-walled epidermis of cells much smaller than those of the leaf.

(2.) Hypodermis, two cells deep.

(3.) Cortex of thin-walled parenchymatous cells resembling those of water tissue, only much smaller. Chloroplasts are few in number in comparison with those of the chlorenchyma in the leaf and leaf-base.

(4.) Central cylinder.

There is no cuticle, no stomata, no palisade tissue, no scattered tracheides, and no fibro-vascular bundles except in central cylinder.

Epidermis of Leaf and Leaf-base.

The epidermis consists of a single layer of thin-walled cells whose outer walls present cuticular thickenings. The cells of the dorsal differ considerably from those of the ventral side of the leaf, the radial walls being short and the tangential long. The outer wall is quite flat, and there are no stomata. On the ventral side a longitudinal section shows the epidermal cells have the vertical diameter about the width of the radial, and the outer walls are raised into small papillae. Surface view shows that the cells are—(*a*) hexagonal, with sharp corners; (*b*) elongated transversely. This transverse extension, according to De Bary (1, *d*), occurs only in the leaves of several plants or in the stems when palisade tissue is developed in the cortex. It occurs also in the leaves and leaf-bases of *Salicornia australis*. The nucleus of epidermal cell is large, and when treated with alcohol turns yellow and becomes very obvious.

As usual in the case of the epidermal cells, there are no chloroplasts except in the guard-cells of the stomata. If, however, the plant is grown under a bell jar, and is watered often, chloroplasts, few in number, may be found in the epidermal cells. Under these conditions the epidermal cells are not elongated transversely, and are wavy in outline.

The cells of the epidermis of the hypocotyl are very much longer than they are wide, but the elongation this time is longitudinal. Cross-section of hypocotyl shows a number of the epidermal cells dividing periclinally (see fig. 4, *e*).

Stomata.—Stomata are numerous on the ventral surface, but absent on the dorsal. Development, as far as I have made out, takes place in the usual way, and the first stomata are formed about the 4th leaf from the apex. The guard-cells are long, and are comparatively narrow. Their walls are thick, and at the top and bottom the thickened portion of the wall bounding the pore projects in the form of a ridge. Midway between these ridges the walls are not thickened, and when turgid jut out into the pore, and thus facilitate its closing. The guard-cells are half the epidermal cells in height, and are sunk beneath the epidermis, the inner walls being in the same plane as the inner walls of the epidermal cells.

Warming (2) and Miss Cross (7) describe stomata as not being sunk. I found that they were sunk in every case, except in the cotyledons, which are not referred to by either of these writers.

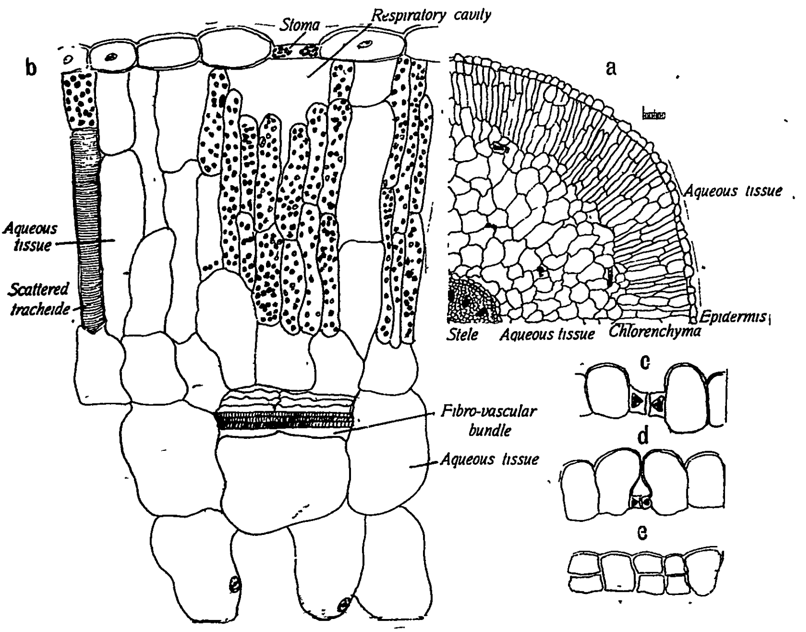

FIG. 4.—*a*, Transverse section of stem surrounded by leaf and leaf-bases; *b*, transverse section of tracheides; *c*, longitudinal section of stoma at 9.30 a.m.; *d*, longitudinal section of stoma at 6 p.m.; *e*, transverse section of epidermis of cotyledon, showing cells dividing.

If a longitudinal section of leaf or leaf-base is taken at the end of the day, after transpiration has been going on freely, it is seen that the cells which abut on the guard-cells curve over them. If a section is taken late that night or early the next morning, these cells are no longer curved. Thus when turgidity is reduced the cells curve over the stoma, and the amount of transpiration is diminished (see fig. 4, *c*, *d*).

The stomata are situated above the palisade tissue. This is not usual in ordinary leaves, but occurs in plants having much the same structure as *Salicornia*. The guard-cells are at right angles to the axis of the stem.

Aqueous Tissue.—The cells are large, thin-walled, and colourless, and have a delicate lining of protoplasm. The nucleus is large and well marked, and the remainder of the cell is filled with water.

In a plant whose cells have remained succulent all the winter the water has much salt dissolved in it, and chloroplasts are found in the protoplasm. Starch-grains are present, and are often aggregated round the periphery of the nucleus.

In plants grown under a bell jar through the winter all the aqueous tissue contained chloroplasts. It may be inferred that the aqueous tissue is modified chlorenchymatous tissue.

Palisade tissue is developed on the ventral side of the leaf and leaf-base. The tissue is two or three cells deep. The cells are thin-walled, elongated at right angles to the epidermis, have rounded ends, and are separated by numerous small intercellular spaces. Large intercellular spaces, respiratory cavities, lie beneath the stomata.

Palisade-cells contain numerous chloroplasts, and, with the exception of the guard-cells and aqueous tissue in the case mentioned above, they are the only cells containing chlorophyll.

The chlorenchyma is interrupted at intervals by small patches of water tissue two or three cells wide, and in these patches are sometimes found the scattered tracheides.

Palisade tissue is not found in the stem itself.

A longitudinal section of the growing-point shows palisade tissue well developed about the 6th or 8th leaf down. Further down it is to be seen developing from an intercalary growing-point.

Scattered Tracheides.—These are present in the palisade tissue of both leaf and leaf-base. Their length is perpendicular to the epidermis, but they do not reach out to it, ending one short cell from it. There are a number of these short palisade-cells, but they do not form a layer. The other end of the tracheides abuts on the water tissue, but there is no connection with the vascular bundles there. According to De Bary (1, *c*), these tracheides occur close to one of the numerous air-cavities of the stomata. I also found them in the water-containing palisade tissue in the leaf, and in such cases they were two or three cells from the epidermis. The tracheides are cylindrical in shape, the ends being sometimes oblique. The walls are thicker than those of the adjoining cells. Thickening takes the form of a close fine delicate spiral. The function is that of air-storage. Similar air-storing tracheides are referred to in *Salicornia herbacea* by Ganong (3, *a*), and by Duval Jouve in *Salicornia emerici* (see fig. 4, *a*).

Apical Growth.—A longitudinal section through the apex of the stem shows an apical cone surrounded by leaves. It appeared as if the opposite character of the leaves was a secondary consideration, since the leaves were at the very apex alternate. This was probably due to the twisting of the young stem, since cross-sections did not bear out this theory.

The meristem at the apex is differentiated into three layers—(1) the outer dermatogen, a layer of cells all the same size with mitotic nuclei; (2) periblem, two or three cells wide; (3) plerome (see fig. 3, *a*).

There is a slight bulging in the apical cone where the next leaf will arise. The leaves overarching the growing-point are wider at the apex; the other leaves taper to a point (see fig. 2).

There is a depression in the leaves on the lower side, and in this depression the apex of the leaf next below lodges.

Stomata do not appear to be formed till the 4th leaf down.

There is a clear indication that the leaf-trace bundles are sent inwards.

The Root.—The stele is diarch; the bundles of phloem are quite distinct and easily distinguished from the xylem. As in the majority of roots, the medulla becomes obliterated.

In old roots the structure resembles that of the stems, in that secondary xylem and phloem are developed from an extra-fascicular cambium. It differs in that phloem islands in the root are slightly larger than those in the stem, and the fibrous cells round them have thinner walls. The distinction between one season's growth and the next is more apparent.

A cross-section of the hypocotyl shows two groups of xylem which converge to form, in the root, the plate, on each side of which is the phloem group (see fig. 5, *a*).

The development of the root takes place as usual.

Seedlings have numerous long delicate hairs, the outline of which is often crinkled and wavy. They present a curious resemblance to fungal

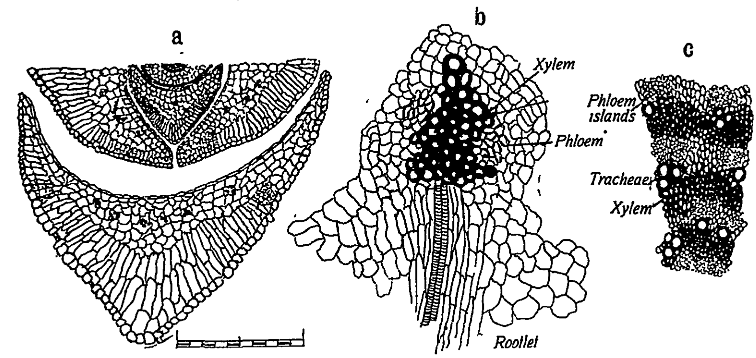

FIG. 5.—*a*, Transverse section of root of an old plant; *b*, transverse section of young branch, near tip; *c*, transverse section of part of internal structure of root of a seedling.

hyphae, and portions of them are often swollen, especially the tip. Some of them are as much as 2 mm. in length, while the root is only 0·25 mm. in diameter. They extend along the root, from just behind the growing-point to the base of the hypocotyl.

Cotyledons.—Stomata occur on the upper and lower surfaces, and are placed as in leaf and leaf-base, but are not sunk beneath the epidermis. The guard-cells are short and wide, so that in surface view the stomata appear circular.

Epidermis.—Surface view of epidermal cells shows that they are wavy in outline. In a cross-section the radial walls are shorter than the tangential, and the outer walls are flat. Seedlings grown in a greenhouse showed chloroplasts, few in number, in some of the epidermal cells.

In cotyledons palisade tissue is developed beneath the upper epidermis only.

Secondary Growth.

Stems of *Salicornia* increase greatly in thickness owing to secondary growth, some of the older ones being $\frac{1}{2}$ in. in diameter.

The cambium in the original collateral fibro-vascular bundles soon becomes exhausted, causing the secondary phloem and xylem to have an unusual origin. As a rule, with the exceptions noted below, interfascicular cambium is not formed.

A cross-section of a branch six months old shows just outside the phloem a layer of cells divided usually by tangential and occasionally by radial walls. Thus a complete extra-fascicular cambium ring is formed (see fig. 6). This has been recorded by De Bary for *Salicornia herbacea* (1, *e*). The xylem formed from this cambium consists of thick-walled fibrous cells, among which are situated, in irregular rings, the vessels, with very large lumens. The phloem consists of thin-walled cells, forming, as usual, a cylinder outside the cambium. No sieve-tubes could be detected among these cells, which in *Salicornia australis* always contain chlorophyll, and are densely packed with starch-grains. Some of these cells disintegrate, those remaining being arranged in radial rows, between which are large intercellular spaces.

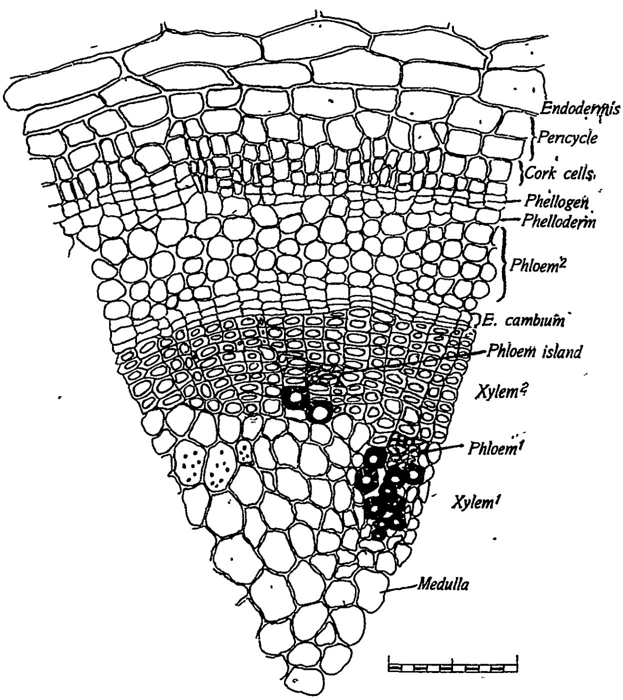

FIG. 6.—Transverse section of stem, showing extra-fascicular cambium ring (E. cambium).

In addition to the phloem cylinder, there are phloem islands scattered about in the fibrous cells of the xylem, in each case lying just outside the large vessels, from which they are separated by only a few fibrous cells.

A theory which might account for these phloem islands is this: The formation of the large vessels consumes time; while these are forming, the cells each side of the group of vessels, growing more quickly, grow over, enclosing a small patch of cambium. This gives rise to the phloem and several small fibrous cells, the latter separating the phloem from the vessels.

The phloem islands consist of thin-walled cells, which show great uniformity in length. When stained with saffranin they are easily distinguished, since they turn an orange colour, the cells of the xylem turning red. Particles in the cells of the phloem islands exhibit Brownian movements. The phloem islands were at first thought to be either phloem or xylem parenchyma cells. Careful investigation showed that in some cases undoubted sieve-tubes are present, although none were found in the phloem cylinder. The walls of the sieve-tubes, as usual, are thin and colourless, and the sieve-plates slightly oblique. I could not with certainty observe any pits in the sieve-plates, or any callus.

The Tracheae.—In this plant, as usual, the protoxylem vessels are spiral, the spiral being here from right to left. The xylem of the leaf-traces consists entirely of spiral vessels. In addition to these, there are the large vessels mentioned above. In many cases they are observable in the course of formation. They usually occur in groups of two or three, but there may be as many as six. They are the only cells of the xylem which do not

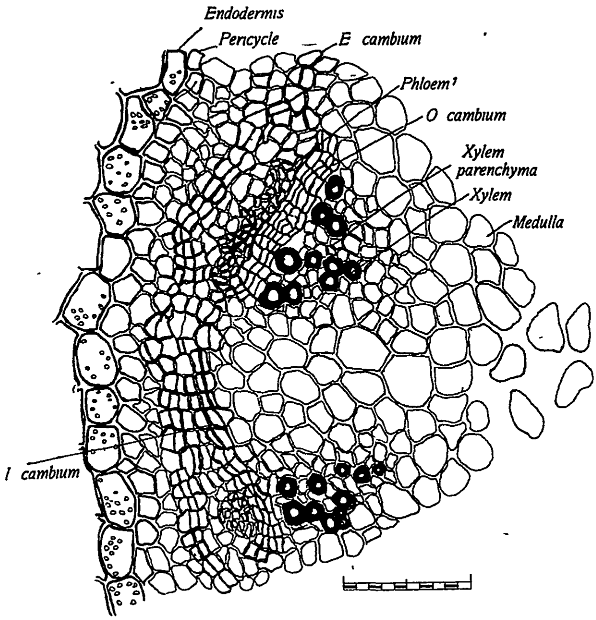

FIG. 7.—Transverse section of stem, showing extra-fascicular, interfascicular, and original cambium.

contain starch. Their walls are greatly thickened and pitted, the pits differing from the simple pits of fibrous cells, although in the walls of the vessels bordering the fibrous cells they are simple. The pits differ from ordinary bordered pits in that their walls, instead of being dome-shaped, are perpendicular to the middle lamella (see fig. 8, *a*, *b*).

Fibrous Cells.—In this plant the secondary wood consists chiefly of fibrous cells. These have greatly thickened walls, and resemble woody fibres more or less closely in form. There is no stratification or striation observable. A few are septate. The fibrous cells always contain abundance of starch-grains, which are large and closely packed. In places a few chloroplasts are present. The cells are all about the same length.

The nuclei are large, those of the adjoining cells being in a straight line, showing there has been practically no displacement of the cells due to elongation. There are numerous pits, simple, both in radial and oblique walls.

As the cells always remain living, there is no differentiation into heart and sap wood.

No sclerenchymatous fibres were found anywhere.

Medullary Rays.—Primary medullary rays are not continued through the secondary wood, and, as a rule, no clearly distinguished secondary medullary rays are formed; nor is there any necessity for them, seeing that most of the xylem-cells are living and are connected by pits. Occasionally I found a distinct medullary ray, the cells of which were elongated radially, being three times as long as they were broad, and narrower than the fibrous cells. There occur also a number of bands of cells one or two wide, the cells having then radial diameters slightly longer than the tangential. These resemble the medullary rays in *Mahonia* given by Schleiden, where they are very thick-walled, and scarcely to be distinguished from the fibrous cells of the wood. In *Salicornia* they are packed with starch-grains.

The result of this slight development of medullary rays is that they are not observable in longitudinal section.

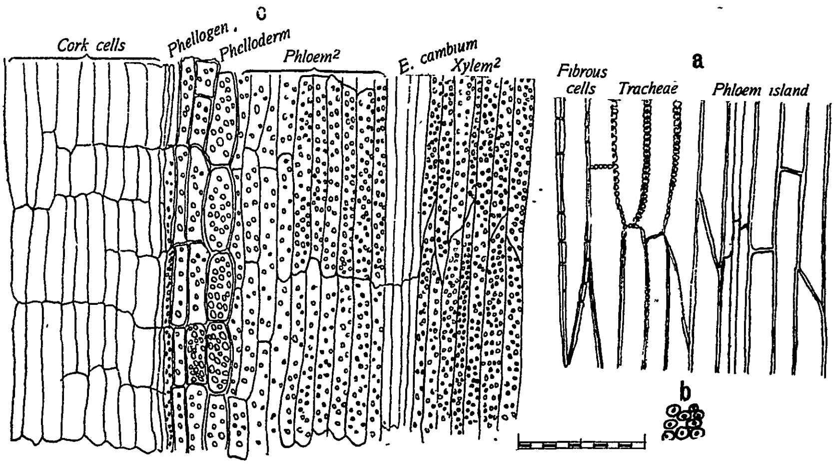

FIG. 8.—*a*, Longitudinal section of stem of secondary growth; *b*, pits in trachea; *c*, longitudinal section showing periderm.

A cross-section of a branch which has remained succulent all the winter shows not only the fascicular cambium dividing and increasing in size, but cells are dividing between the bundles to form interfascicular cambium (fig. 7). When the bundles are close to each other the dividing cells reach right across, but when far apart the line of the dividing cells curves outwards and joins on to the extra-fasicular cambium, forming a complete ring round the phloem.

The interfasicular cambium does not long remain functional, and the majority of secondary tissues are formed from the extra-fascicular cambium, as usual.

The Formation of Cork.—As winter advances, as a rule, all the branches formed in spring assume a different appearance. The succulent tissue becomes withered and turns brown, the free portion of the leaves of each internode surrounding the base of the internode above like a collar. This brown portion finally falls off, or, if the plant is at the water's edge, is soon washed off, and the branches appear green again. They are, however, much smaller, having lost all palisade and aqueous tissue. The green colour is due to chloroplasts in the phelloderm and the phloem cylinder. Chloroplasts are also present, although to a less extent, in the fibrous cells of the wood and in the outer portion of the medulla. The development of chlorophyll corresponds to that in several desert-plants mentioned by Austin (9) (see fig. 8, *c*).

This withering of tissue is due to the formation of cork. The inner layer of pericycle, which is now several cells thick, gives rise to phellogen. Cork tissue and phelloderm are formed in the usual way. The phelloderm in this plant even more than usual shows great uniformity in the length of cells. Chloroplasts are present, and starch, which is never found to be exhausted. The granules are larger than those of the phloem cylinder.

Flowers.

Salicornia australis flowers from December to March. The flowers are wind-pollinated. All the branches may be fertile, and bear small

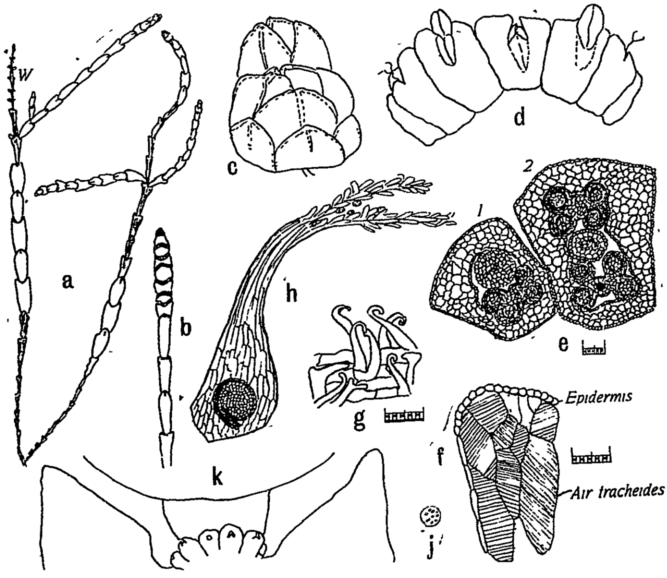

Fig. 9.—*a*, Branch showing withered inflorescence, two-fifths natural size; *b*, flowering-branch, two-fifths natural size; *c*, bud, × 3; *d*, flowers, × 6; *e*, transverse section of flower—(1) with one stamen, (2) with two; *f*, persistent perianth; *g*, hooked hairs on testa; *h*, pistil; *j*, pollen-grain; *k*, longitudinal section of flowering-branch taken in July, five months before flowers are mature.

insignificant flowers at their apex; these flowers are placed side by side in the axils of the leaves, and form an almost complete ring. The leaf-bases in the flowering-branches are developed only to a comparatively small extent.

The number of flowers in each axil, as a rule, varies from five to ten; occasionally there are as many as sixteen, and then they form a double row round the branch.

The flowering-branches are thicker than the ordinary branches, and do not taper to a point like those of *Salicornia herbacea*, shown by Schimper (4, *a*).

A very young flowering-shoot does not differ in appearance from an ordinary one. When the internodes of the ordinary branch lengthen, the difference becomes apparent, since those of the flowering-branch always remain short.

If a longitudinal section is made (see fig. 9, *k*) the flowers are seen sessile in the axils of the leaves. The section was made five months before the plant flowers, and even then the perianth was little different from that of a mature flower.

Flowers are hermaphrodite or polygamous. Several whorls of flowers were examined in order to find some regular arrangement, but none was observable.

An examination of a large number of flowers shows that the stamens are usually two in number, occasionally one, rarely wanting the pistil of one carpel.

The perianth is monochlamydeous, fleshy, broad, flat, and quadrangular at the top. The lobes, three in number, fit together, almost closing the mouth. On this quadrangular portion the epidermal cells are very thick-walled and isodiametrical, and there are a number of stomata. Beneath this lies a little chlorenchyma, and then the aqueous tissue. The flowers are narrower at the immersed base, and the epidermis of the perianth here is very thin-walled, and the cells are elongated longitudinally, as in the hypocotyl.

When the seed is ripe the fleshy perianth persists, the cell-contents disappear, and the cell-walls become thickened by regular bands which run in different directions in different cells (see fig. 9, *f*), and the cells are filled with air. This is evidently an adaptation for dispersal, for by means of this persistent perianth the seeds float on the top of the water for a long time. Seeds were placed in fresh water, and at the end of a week only 3 per cent. of them had sunk. The perianth remains attached to the cotyledons even when the seedling is several months old.

Androecium.

Stamens are perigynous, two or one, occasionally there is only one staminode. In the young flower the filament is short, but it is later elongated so that the stamen hangs out of the mouth. When there are two fertile stamens they are protruded successively. There are two large anther-lobes attached to the filament for about half their length. Development takes place as usual. Each lobe consists of two compartments when the anther is young, but when mature of one only. Dehiscence is by a longitudinal crack coinciding with the partition between the two pollen-sacs. The pollen-grains are developed in the usual way. Each has a thickened wall in which there are numerous round pits (see fig. 9, *j*).

Gynoecium.

Ovary is superior, of one carpel, and ovoid, containing one basal anatropous ovule.

Styles, two in number, are papillose, long and narrow, and tapering to a point.

Flower is protogynous, and the styles hang out of the mouth before the stamens.

Utricle is ovoid, consisting of a thin loose pericarp enclosing the seed. It is itself surrounded by the persistent perianth.

Testa is brown, coriaceous, and covered with hooked hairs of different shapes (see fig. 9, *g*). The inner coat of the seed is thin and membranous.

There is no endosperm.

Embryo has thick fleshy cotyledons, and an incumbent, terete, radicle.

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