JOURNAL OF THE COLLEGE OF SCIENCE, IMPERIAL UNIVERSITY
TOKYO, JAPAN.

VOL. XVIII., ARTICLE 4.

On the Comparative Anatomy of the Cucurbitaceæ, Wild and Cultivated, in Japan.[1]

By

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With Plates I.-V.

Introductory and Historical.

The anatomical characters of the Cucurbitaceæ having long attracted the attention of botanists, and the special structures of various organs having been investigated and described by them, I shall begin this essay by giving a brief *résumé* of the work that has thus far been done. LESTIBONDOIS[2] investigated the arrangement and distribution of the fibro-vascular bundles in the root of *Cucurbita Pepo* and in the stem of *Cucumis Melo,* describing at the same time the relation of the bundles in the stem to those of the leaf in the latter plant. VAN TIEGHEM[3] made an anatomical study of the roots of *Luffa, Lagenaria,* and *Cucurbita.* DUTAILLY[4] observed the course of the fibro-vascular bundles in the

1) Compare A. YASUDA. Preliminary Note on the Comparative Anatomy of Cucurbitaceæ, Wild and Cultivated in Japan. Botanical Magazine, Tokyo. 1901. Vol. XV. No. 173.

2) TH. LESTIBONDOIS. Étude sur l'anatomie et la physiologie des végétaux. Lille 1840.

3) PH. VAN TIEGHEM. Mémoir sur la racine. Paris 1872.

4) G. DUTAILLY. Recherches anatomiques et organogéniques sur les Cucurbitacées. Congrès de Montpier. 1879.

Cucurbitaceæ, including that of the leaf-traces and of the bundles in the leaves themselves. A further investigation was conducted by LOTAR,[1] who compared the structures of the stems, hpyocotyls, leaves, tendrils, roots, and seeds of many genera in this family, such as *Citrullus*, *Lagenaria*, *Luffa*, *Coccinea*, *Cucumis*, *Cucurbita*, *Cyclanthera*, *Sicyos*, *Momordica*, *Abobra*, *Rhynchocarpa*, *Bryonia*, *Ecballium*, and *Thladiantha*. In his essay he described in great detail the distribution of the fibro-vascular bundles, with accompanying diagrammatic figures. FISCHER[2] examined the arrangement of the sieve-tubes in the stems of several genera, and classified them under four heads: (a) vascular-bundle sieve-tubes, (b) ectocyclic sieve-tubes, (c) entocyclic sieve-tubes, and (d) commissural sieve-tubes.

He also referred to the mode of distribution of the sieve-tube system, and described six distinct types: (i.) *Alsomitra* type, (ii.) *Luffa* type, (iii.) *Bryonia* type, (iv.) *Cyclanthera* type, (v.) *Lagenaria* type, and (vi.) *Cucurbita* type. PENZIG[3] observed in the epidermal cells on the under surface of the leaves of *Momordica echinata* and *M. Charantia*, globular cystoliths which, he found, occurred in groups, radiating from a common centre. In regard to tendrils WARMING,[4] DUTAILLY,[5] COGNIAUX,[6] MÜLLER,[7] and

1) HENRI-AIMÉ LOTAR. Essai sur l'anatomie comparée des organes végétatifs et des téguments séminaux des Cucurbitacées. Lille 1881.

2) A. FISCHER. Untersuchungen über das Siebröhrensystem der Cucurbitaceen. Bot. Centralbl. 1885. Bd. XXI. No. 4.

3) O. PENZIG. Zur Verbreitung der Cystolithen im Pflanzenreich. Bot. centralbl. 1881. Bd. VIII. No. 13.

4) E. WARMING. Verzweigungsverhältnisse der Phanerogamen. König. deutsch. Acad. der Wissenschaft. 1877.

5) G. DUTAILLY. Recherches organogéniques sur les formations axillaires ches les Cucurbitacées. Association français pour l'avancement des sciences. Congrès de Harure. 1877.

6) A. COGNIAUX. Cucurbitaceen in DE CANDOLLE'S Monographiæ Phanerogamarum. 1881. Vol. III.

7) E. G. O. MÜLLER. Untersuchungen über die Ranken der Cucurbitaceen. COHN'S Beiträge zur Biologie der Pflanzen. 1886. Bd. IV. Heft 2.

others came to the conclusion, that the main axis of the tendril corresponds to a branch, which carries several leaves. The testa has been investigated by BISCHOFF,[1] STRANDMARK,[2] HÖHNEL,[3] FICKEL,[4] GODFRIN,[5] HARTWICH,[6] and HARZ.[7] According to HÖHNEL the testa consists of ten layers of cells, of which the first layer arises from the epidermis of the carpel; the second, the swollen epidermis, is made up of prismatic cells with thickened-ridges on their walls, and together with the following three layers is derived from the outer integument of the ovule; the third consists of irregular cells, abounding in intercellular spaces; the fourth, of large stone-cells; the fifth, of reticulate cells with many intercellular spaces; the sixth, of compressed cells derived from the inner integument of the ovule; the seventh originates from the epidermis of the nucellus; the eighth, from the perisperm; the ninth and the tenth, from the endosperm.

So far the chief results of investigations hitherto made concerning the anatomy of the Cucurbitaceæ; for my part, I have tried to examine and compare the internal structures of various organs of those Cucurbitaceæ which are found wild or are cultivated in Japan. The number of our known genera belonging to this family is fifteen: namely, *Actinostemma*, *Melothria* *Mukia*,[8]

1) G. W. BISCHOFF. Handbuch der botanischen Terminologie und Systemkunde. Nürnberg 1833. Bd. I.

2) J. E. STRANDMARK. Bau der Samenschale. JUST's Bot. Jahresber. 1874. Bd. II.

3) F. v. HÖHNEL. Morphologische Untersuchungen über die Samenschale der Cucurbitaceen. Wien 1876.

4) J. F. FICKEL. Ueber die Anatomie und Entwicklungsgeschichte der Samenschalen einiger Cucurbitaceen. Bot. Ztg., 1876. Bd. XXXIV. Nr. 47-50.

5) J. GODFRIN. Étude histologique sur les téguments séminaux des Angiospermes. Paris 1880.

6) C. HARTWICH. Ueber die Samenschale der Coloquinthe. Archiv. der Pharm. 1882. Bd. CCXX.

7) C. D. HARZ. Landwirthschaftliche Samenkunde. 1885. Bd. II.

8) H. KUROIWA. A List of Phanerogams collected in the Southern Part of Okinawa, an island of the Loochoo Chain. Botanical Magazine, Tokyo. 1900. Vol. XIV. No. 163. p. 123.

Zehneria,[1] *Schizopepon*, *Momordica*, *Luffa*, *Citrullus*, *Cucumis*, *Bryonopsis*,[2] *Benincasa*, *Lagenaria*, *Trichosanthes*, *Cucurbita*, and *Gymnostemma*. Of these I have examined twelve genera, leaving for a future occasion the study of *Mukia*, *Zehneria*, and *Bryonopsis*, which are at present unfortunately inaccessible to me.

I have studied the anatomical characters of the stems, hypocotyls, blades, petioles, cotyledons, tendrils, roots, fruits, and seeds of the following sixteen species: *Actinostemma racemosum* Maxim., *Melothria japonica* Maxim., *Schizopepon bryoniæfolius Maxim.*, *var. japonicus* Cogn., *Momordica charantia* L., *Luffa cylindrica* (L.) Roem., *L. acutangula* (L.) Roxb., *Citrullus vulgaris* Schrad., *Cucumis sativus* L., *C. Melo* L., *Benincasa cerifera* Savi., *Lagenaria vulgaris* Ser., *Trichosanthes cucumeroides* Maxim., *T. japonica* Regel., *T. multiloba* Miq., *Cucurbita Pepo* L., and *Gymnostemma cissoides* Fr. et Sav. Whenever it has appeared necessary, old as well as young specimens have been examined and compared. In the present paper I shall treat the subject in nine chapters, to be followed with a summary of the chief results of my investigation. Here I wish to express my hearty thanks to Prof. Dr. J. MASTUMURA of the Imperial University, of Tokyo, under whose care my investigations have been conducted. My thanks are due also to Mr. Y. TANAKA, Dr. K. MIYABE, Mr. T. MAKINO and Mr. T. YOSHINAGA, all of whom have kindly supplied me with valuable materials for study.

1) H. KUROIWA. *loc. cit.* p. 123.
2) Ditto. p. 123.

CHAPTER I.

THE STEM.

Contour. In the Cucurbitaceæ the contour of a transverse section through the stem differs considerably in different species and varies even in one and the same individual according to its age. When young the outline of the stem is pentagonal, but becomes more or less roundish as the stems grows older. The stems of *Benincasa cerifera* and *Lagenaria vulgaris* are especially remarkable for a secondarily produced process in the furrows. Generally speaking, young stems are solid, but in advanced age some stems acquire a wide lumen in the centre, and the formation of a narrow compressed cavity is common in the very old stems of many species. In *Benincasa cerifera* (Pl. I. fig. 1–4), *Lagenaria vulgaris,* and *Cucurbita Pepo,* when the stems are still young, a remarkable roundish hollow is already formed in the centre by a gradual splitting of the central tissue.

The full-grown stems of *Luffa cylindrica* and *L. acutangula* as well as the old stems of *Momordica charantia* and *Actinostemma racemosum* have sharply ridged angles. Microscopical examination shows that the ridges of *Luffa cylindrica* (Pl. II. Fig. 35) and *L. acutangula* consist only of outgrowths of the collenchyma, while those of *Momordica charantia* (Pl. II. Fig. 36) and *Actinostemma racemosum,* in spite of their resemblance to the former in external appearance, are formed by newly developed secondary fibro-vascular bundles, which have originated from the

secondary meristem outside of the outer ring[1] of the vascular bundles.

Stomata. The stomata on the stems generally lie in the same plane with the adjoining epidermal cells, but they are sometimes elevated with the epidermis above the surface of the latter, appearing as if they were supported by a short thick hair. *Cucurbita Pepo*, *Benincasa cerifera*, *Lagenaria vulgaris* (Pl. II. Fig. 34), *Luffa cylindrica*, and *Trichosanthes cucumeroides* give good examples of the elevated stomata.

The average numbers of stomata on a square millimetre of the stems of the Cucurbitaceæ in question are as follows:

Trichosanthes cucumeroides	23
T. japonica	23
T. multiloba	22
Citrullus vulgaris	22
Cucurbita Pepo	21
Actinostemma racemosum	20
Lagenaria vulgaris	18
Cucumis Melo	18
Momordica charantia	17
Luffa cylindrica	16
L. acutangula	16
Benincasa cerifera	15
Cucumis sativus	14
Melothria japonica	12
Schizopepon bryoniæfolius var. japonicus	8
Gymnostemma cissoides	7

1) The fibro-vascular bundles in the stems of the Cucurbitaceæ are arranged in two circles, outer and inner, each of which contains five bundles.

Trichomes. The trichomes on the stems are multicellular in every case, and may be divided into four classes: (i.) sharp-pointed conical trichomes, (ii.) blunt-ended conical trichomes, (iii.) short-stalked glandular trichomes, and (iv.) long-stalked glandular trichomes. The first kind is found in *Melothria japonica* (Pl. I. Fig. 5), *Citrullus vulgaris*, *Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, *Lagenaria vulgaris*, and *Cucurbita Pepo;* the second, in *Actinostemma racemosum*, *Schizopepon bryoniæfolius*, *var. japonicus* (Pl. I. Fig. 6), *Momordica charantia*, *Luffa cylindrica*, *L. acutangula*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, and *Gymnostemma cissoides;* the third, which has an oval head composed of several cells, in all species without exception; the fourth, which has an oval head consisting of one or more cells, in *Momordica charantia*, *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Cucumis sativus* (Pl. I. Fig. 8), *C. Melo*, *Benincasa cerifera*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, and *Cucurbita Pepo.* Among these the trichome of *Benincasa cerifera* is especially characterized by having two processes at the apex (Pl. I. Fig. 9); that of *Trichosanthes cucumeroides*, by having a single enlarged terminal cell (Pl. I. Fig. 10), and that of *Cucurbtia Pepo*, by having the head consisting of two cells, one placed above the other (Pl. I. Fig. 11).

Cuticle. The cuticle on the stems is mostly thin and smooth. As exceptions, however, are to be noted *Actinostemma racemosum* and *Gymnostemma cissoides*, the former of which has the cuticle striated at the angled portions, while the latter has it so on all surfaces.

Collenchyma. The collenchyma is developed at the angles

of the stems, and often in the furrows between the angles. For example, *Actinostemma racemosum*, *Melothria japonica*, *Momordica charantia*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, and *Gymnostemma cissoides* have the collenchyma developed only at the angles; while *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, and *Cucurbita Pepo* have it at the angles as well as in the furrows. The number of groups of collenchymatous cells developed in the furrows varies from two to five. *Cucumis sativus* and *C. Melo* have only traces of this tissue in each furrow; *Luffa cylindrica* and *L. acutangula* have two masses of it; *Citrullus vulgaris* and *Benincasa cerifera*, three masses; and *Cucurbita Pepo*, five masses.

The layers of the collenchymatous cells are much thicker at the angles than in the furrows. Their maximum number (sixteen) is found in the angled portions of the stem of *Luffa cylindrica*, while their minimum number (one) is found in the furrowed portions of the stem of *Cucumis Melo*.

Sclerenchyma. In young stems the sclerenchyma forms a ring,[1] but when the stems become old the ring breaks up into several sections, so that the latter are placed outward of each fibro-vascular bundle. In some old stems the sclerenchyma is also formed inside of the inner phloëm. In other stems a secondarily formed sclerenchyma is developed within the primary one. The secondary sclerenchymatous cells are short and thick-walled, manifesting many pore-canals; while the primary ones are long and fibre-like.

1) E. G. O. MÜLLER. Cucurbitaceen in ENGLER und PRANTL's die natürlichen Pflanzenfamilien. 1894. Th. IV. Abt. 5. p. 3.

The old stems of some species have only one group of sclerenchymatous cells outside of each fibro-vascular bundle, as in *Actinostemma racemosum*, *Melothria japonica*, *Schizopepon bryoniæfolius, var. japonicus*, *Citrullus vulgaris*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, and *Gymnostemma cissoides;* some have two sclerenchyma masses tangentially arranged, which have been formed by a rupture of the original continuous ring, as in *Momordica Charantia*, *Luffa cylindrica*, *L. acutangula*, *Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, and *Cucurbita Pepo*. There is a remarkable development of secondary sclerenchyma in the very old stems of *Actinostemma racemosum*, *Melothria japonica*, *Momordica Charantia*, *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, and *Gymnostemma cissoides*. In *Momordica Charantia* and *Actinostemma racemosum* it is especially noticeable, that the sclerenchyma at the angled portions has a double arrangement, one mass lying just outside a primary fibro-vascular bundle of the outer ring, and the other lying outside a newly formed secondary bundle[1] which is placed externally to the primary one. In the old stems of *Trichosanthes cucumeroides*, *T. japonica*, and *T. multiloba* the secondary sclerenchymatous cells or stone-cells are developed in great masses and form an incomplete ring around the stem.

Fibro-vascular Bundles. The fibro-vascular bundles in the stems are arranged in two rings, the outer and the inner. Each ring contains five bundles, the members of one ring being situated alternately to those of the other. The fibro-vascular bundles of the outer ring are smaller and nearly equally-developed, but those

1) See below.

of the inner ring often grow irregularly, and in some cases one or two of them are wanting. The old stems of *Momordica Charantia* and *Actinostemma racemosum* present a characteristic arrangement of the fibro-vascular bundles. We may observe double bundles overlapping one another at the angled portions; i.e., the secondary bundles grow outside of the primary ones from a secondary meristem, so that the angled portions are raised into keels.

(a) *Phloëm.* The fibro-vascular bundles are of a bicollateral type, so they have two kinds of phloëm, the peripheral and the axial, of which the former is always better-developed than the latter.

Sieve-tubes occur not only in the phloëm but also outside of it. They are, according to FISCHER,[1] classified under four heads: (i.) vascular-bundle sieve-tubes, which are found in the phloëm; (ii.) ectocyclic sieve-tubes, between the epidermis and the sclerenchymatous ring; (iii.) entocyclic sieve-tubes, within sclerenchymatous ring; (iv.) commissural sieve-tubes, serving to connect the other kinds of sieve-tubes with one another.

In reference to the mode of distribution of these four kinds of sieve-tubes we may distinguish three types in the Cucurbitaceæ: the first type has the vascular-bundle and entocyclic sieve-tubes, but no ectocyclic or commissural ones; the second has the vascular-bundle, entocyclic and commissural sieve-tubes, but lacks the ectocyclic tubes; the third has the vascular-bundle, ectocyclic, entocyclic, and commissural sieve-tubes. To the first type belong *Luffa cylindrica* and *L. acutangula;* to the second, *Actinostemma racemosum, Melothria japonica, Schizopepon bryoniæfolius, var. japonicus, Momordica Charantia, Citrullus vulgaris, Cucumis sativus, C. Melo, Benincasa cerifera, Lagenaria vulgaris, Trichosanthes*

1) A. FISCHER. *loc. cit.* p. 104.

cucumeroides, *T. japonica*, *T. multiloba*, and *Gymnostemma cissoides*; to the third, *Cucurbita Pepo*.

The size of the sieve-tubes is so large that it serves as a distinctive character to the family. The following numbers denote the diameters of the large sieve-tubes in the stems of each species:

Luffa acutangula	0.088 mm.
Cucurbita Pepo	0.088 „
Luffa cylindrica	0.087 „
Trichosanthes japonica	0.085 „
Benincasa cerifera	0.080 „
Lagenaria vulgaris	0.075 „
Momordica Charantia	0.075 „
Trichosanthes multiloba	0.070 „
T. cucumeroides	0.070 „
Citrullus vulgaris	0.065 „
Cucumis Melo	0.065 „
C. sativus	0.065 „
Schizopepon bryoniæfolius, var. japonicus	0.054 „
Actinostemma racemosum	0.045 „
Gymnostemma cissoides	0.040 „
Melothria japonica	0.040 „

(b) *Xylem.* Among the characteristic features of the xylem vessels the following are to be noticed. They are very well-developed and become especially noticeable as the stems advance in age, when they can be easily perceived even with the naked eye. As a rule thyloses[1] are developed in old vessels. By comparing the diameters of the large vessels in each species the following average measurements were obtained:

1) H. A. LOTAR. *loc. cit.* p. 30.

Luffa acutangula	0.50 mm.
Lagenaria vulgaris	0.50 ,,
Cucurbita Pepo	0.48 ,,
Benincasa cerifera	0.48 ,,
Luffa cylindrica	0.46 ,,
Trichosanthes japonica	0.45 ,,
Momordica Charantia	0.43 ,,
Trichosanthes cucumeroides	0.32 ,,
Citrullus vulgaris	0.31 ,,
Trichosanthes multiloba	0.30 ,,
Cucumis Melo	0.25 ,,
C. sativus	0.24 ,,
Schizopepon bryoniæfolius, var. japonicus	0.23 ,,
Gymnostemma cissoides	0.22 ,,
Actinostemma racemosum	0.17 ,,
Melothria japonica	0.14 ,,

Periderm. In the very old stems of many species periderm is often formed, but in none is it so well developed as in *Trichosanthes cucumeroides*, *T. japonica*, and *T. multiloba*. The periderm originates from phellogen, which has been formed on the outside of the sclerenchymatous sheath.

Starch-grains and Crystals. Although some species contain reserve starch-grains in the full-grown stems, yet most species first accumulate them in the old stems, where they are reserved chiefly in the medullary rays. The stems ef *Gymnostemma cissoides* and *Actinostemma racemosum* contain reserve starch-grains from a comparatively early age.

The diameters of the large starch-grains stored in the stems of many species are as follows:

Gymnostemma cissoides	0.040 mm.
Melothria japonica	0.025 ,,
Trichosanthes multiloba	0.017 ,,
T. cucumeroides	0.017 ,,
Cucurbita Pepo	0.015 ,,
Luffa cylindrica	0.015 ,,
L. acutangula	0.015 ,,
Trichosanthes japonica	0.013 ,,
Actinostemma racemosum	0.013 ,,
Citrullus vulgaris	0.012 ,,
Cucumis Melo	0.012 ,,
C. sativus	0.012 ,,

The stems of *Schizopepon bryoniæfolius, var. japonicus, Momordica Charantia, Benincasa cerifera,* and *Lagenaria vulgaris* contain no reserve starch-grains that are appreciable.

Crystals of calcium oxalate are found in the old stems of *Momordica charantia, Trichosanthes cucumeroides, Luffa cylindrica, L. acutangula, Lagenaria vulgaris, Benincasa cerifera, Cucumis sativus, C. Melo, Schizopepon bryoniæfolius, var. japonicus,* etc. Of these *Momordica Charantia* has an abundance of the large crystals displaying various forms belonging to the quadratic system.

Rhizomes. Rhizomes occur in *Melothria japonica* and *Gymnostemma cissoides.* In both cases, they have scales at each node which, when completely developed, are three in number, and are to be anatomically distinguished as a shoot, a leaf, and a tendril: for, the first has ten fibro-vascular bundles; the second, five bundles with a semi-circular contour; and the third, three or four bundles

with a circular contour;—all which structures characterize the above organs of *Melothria japonica* and *Gymnostemma cissoides* as such respectively.[1] The rhizomes serve as a reservoir of food-materials, so that though other parts of the plants perish with the approach of winter they preserve their life till the next spring, when the young plants grow from the rudimentary scales destined to be the shoots; thus *Melothria japonica* (Pl. II. Fig. 37) and *Gymnostemma cissoides* lead a perennial life by means of their subterranean stems.

Generally speaking, the anatomical structures of the rhizomes follow the type of the terrestrial stems, but in particulars they differ widely from the latter. The collenchyma is reduced to a trace, or can be no longer distinguished as such. In *Melothria japonica* a very small group of the delicate sclerenchymatous cells is found only on the outside of each fibro-vascular bundle of the outer ring, while in *Gymnostemma cissoides* the degeneration is not so great as in *Melothria japonica;* the sclerenchymatous cells composed of 2–5 layers, extending outside of each fibro-vascular bundle of the outer as well as of the inner rings.

The fibro-vascular bundles in the rhizomes show great degeneration. The sieve-tubes and the vessels are much smaller than those of the terrestrial stems. The following are the diameters of the large sieve-tubes and vessels in the rhizomes of *Melothria japonica* and *Gymnostemma cissoides:*

	Sieve-tube.	Vessel.
Melothria japonica	0.032 mm.	0.07 mm.
Gymnostemma cissoides	0.031 „	0.12 „ ;

from which we see that the degeneration is much greater in *Melothria japonica* than in *Gymnostemma cissoides.*

1) Compare p. 9. p. 20, and p. 33.

The parenchymatous cells in the rhizomes are remarkably large as compared with those of the ordinary stems on account of their reserved starch-grains. On the epidermis of the rhizomes stomata and trichomes are also sometimes found.

The large starch-grains found in the rhizomes are of the following sizes:

	Diameter.
Gymnostemma cissoides	0.060 mm.
Melothria japonica	0.034 „

Those of the former plant (Pl. II. Fig. 38) are the largest among the starch-grains contained in any organs of the Cucurbitaceæ.

CHAPTER II.

THE HYPOCOTYL.

The germinating plantlets of the Cucurbitaceæ have long terrestrial hypocotyls or very short subterranean hypocotyls. *Actinostemma racemosum, Melothria japonica, Schizopepon bryoniæfolius, var. japonicus, Momordica Charantia, Luffa cylindrica, L. acutangula, Citrullus vulgaris, Cucumis sativus, C. Melo, Benincasa cerifera, Lagenaria vulgaris,* and *Cucurbita Pepo,* have the former kind; while *Trichosanthes cucumeroides, T. japonica, T. multiloba,* and *Gymnostemma cissoides,* have the latter.

Contour. As seen in a transverse section the contour of the

hypocotyl may be (a) roundish, (b) roundish with a central hollow, (c) square, and (d) square with a central hollow. The first is found in *Actinostemma racemosum*, *Melothria japonica*, *Momordica Charantia*, *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, and *Gymnostemma cissoides*; the second, in *Benincasa cerifera*, *Lagenaria vulgaris*, and *Cucurbita Pepo*; the third, in *Cucumis sativus*; and the fourth, in *Cucumis Melo*.

Stomata. The average numbers of the stomata on the surface of the hypocotyl are as follows. They are entirely wanting in the species having the under-ground hypocotyls.

Luffa cylindrica	36	per sq. mm.
L. acutangula	32	,,
Citrullus vulgaris	26	,,
Cucurbita Pepo	24	,,
Cucumis Melo	20	,,
Benincasa cerifera	19	,,
Lagenaria vulgaris	14	,,
Cucumis sativus	8	,,
Actinostemma racemosum	7	,,
Melothria japonica	6	,,
Momordica charantia	0	,,
Trichosanthes cucumeroides	0	,,
T. japonica	0	,,
T. multiloba	0	,,
Gymnostemma cissoides	0	,,

Trichomes. Some species bear many trichomes on the hypocotyl, while others have only a small number of them or none

at all. The hypocotyls of *Melothria japonica*, *Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, *Lagenaria vulgaris*, and *Cucurbita Pepo*, are hairy; those of *Actinostemma racemosum*, *Momordica Charantia*, *Luffa cylindrica*, *L. acutangula*, and *Citrullus vulgaris*, are nearly smooth; those of *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba* and *Gymnostemma cissoides*, are entirely naked. The trichomes on the hypocotyl may be divided into the same four classes as those on the stem.

Collenchyma. In all species the collenchyma is developed so as to entirely surround the hypocotyl without interruption.

Sclerenchyma. The sclerenchyma of the hypocotyl presents a characteristic arrangement; it forms a small mass on the outside of each fibro-vascular bundle.

Fibro-vascular Bundles. The number of the fibro-vascular bundles in the hypocotyl is generally smaller than that in the stem. The typical number is six, a median and two angular bundles[1] being symmetrically situated opposite each cotyledon. Exceptions are however found in *Citrullus vulgaris* and *Cucurbita Pepo*, the former of which has twelve bundles, while the latter has ten.

1) H. A. LOTAR. *loc. cit.* p. 14.

CHAPTER III.

THE BLADE.

Epidermis. When viewed from the surface the outlines of the epidermal cells of the blades are straight or wavy: the former is the case on the upper surface and the latter on the lower, except in *Schizopepon bryoniæfolius, var. japonicus, Momordica Charantia, Lagenaria vulgaris, Trichosanthes japonica, T. multiloba* and *Gymnostemma cissoides,* where the walls of the epidermal cells on the upper surface are also wavy.

The size of epidermal cells of the blades is greatest in *Gymnostemma cissoides,* the average diameter reaching 0.07 mm., while in those of the remaining species it is 0.03–0.04 mm.

The epidermal cells on the upper surface of the blade of *Trichosanthes cucumeroides* are very characteristic; they are raised into conical papillæ pointing outwards (Pl. III. Fig. 39).

In certain places on the under surface of the blade of *Cucurbita Pepo* the epidermal cells are two or three-layered, and these places consequently assume a somewhat etiolated appearance (Pl. III. Fig. 42).

The epidermis on the under-side of the blade of *Momordica Charantia* is characterized by having many enlarged cells, each of which contains a globular cystolith[1] (Pl. III. Fig. 40). *Momordica Charantia* is the only species among the plants we have studied, which contains cystoliths. They are fixed to a lateral wall; not, as we see in *Ficus, Morus* and *Zelkowa,* to the outer wall. The epidermal cells which contain the cystoliths are

1) O. PENZIG. *loc. cit.* p. 393.

united into groups, radiating from a common centre, as the surface view of the epidermis will clearly show. Each group of these enlarged epidermal cells consists of two or more cells with the cystoliths arranged head to head, as many as eleven of these having been counted. The diameter of a large cystolith is 0.065 mm.

Stomata. The number of stomata on the upper and lower surfaces of the blade differs remarkably in each species. The following are the average numbers of stomata found on the upper surface :

Cucumis sativus	160	per sq. mm.
C. Melo	156	,,
Cucurbita Pepo	146	,,
Benincasa cerifera	112	,,
Citrullus vulgaris	100	,,
Lagenaria vulgaris	84	,,
Luffa cylindrica	76	,,
L. acutangula	72	,,
Trichosanthes cucumeroides	66	,,
Actinostemma racemosum	59	,,
Melothria japonica	9	,,
Momordica Charantia	0†	,,
Trichosanthes japonica	0†	,,
T. multiloba	0†	,,
Schizopepon bryoniæfolius, var. japonicus	0	,,
Gymnostemma cissoides	0	,,

As can be seen from the above table *Momordica Charantia*

† Stomata rarely occur.

rarely has stomata on the upper surface of the blade ; *Trichosanthes japonica* and *T. multiloba* have them ; still more rarely, in the neighbourhood of the veins ; and *Schizopepon bryoniæfolius, var. japonicus* and *Gymnostemma cissoides* have none at all.

In all species the under-surface of the blades has greater number of stomata. The following show the average numbers of them on the under-surface :

Cucurbita Pepo	347	per sq. mm.
Benincasa cerifera	344	,,
Cucumis Melo	331	,,
C. sativus	324	,,
Trichosanthes cucumeroides	310	,,
Lagenaria vulgaris	298	,,
Citrullus vulgaris	297	,,
Trichosanthes japonica	288	,,
T. multiloba	276	,,
Luffa cylindrica	221	,,
L. acutangula	220	,,
Momordica Charantia	211	,,
Schizopepon bryoniæfolius, var. japonicus	200	,,
Melothria japonica	172	,,
Actinostemma racemosum	168	,,
Gymnostemma cissoides	91	,,

Trichomes. The trichomes on the blades follow the types of those on the stems. Their shapes are quite the same on the upper and lower surfaces. Their number on the lower surface is generally greater than that on the upper surface, except in *Melothria japonica, Schizopepon bryoniæfolius, var. japonicus, Momordica*

Charantia, Trichosanthes japonica, T. multiloba and *Gymnostemma cissoides,* in which the trichomes on the under-surface are borne only upon the veins. *Actinostemma racemosum* has them only upon the veins on both the upper and lower surfaces.

The following are the average numbers of the trichomes on the upper surface of the blades, omitting those species in which the trichomes grow only upon the veins:

Lagenaria vulgaris	36	per sq. mm.
Cucurbita Pepo	20	,,
Trichosanthes cucumeroides	16	,,
Luffa cylindrica	13	,,
Melothria japonica	12	,,
Cucumis sativus	12	,,
Benincasa cerifera	12	,,
Cucumis Melo	10	,,
Luffa acutangula	9	,,
Trichosanthes japonica	2	,,
T. multiloba	2	,,
Schizopepon bryoniæfolius, var. japonicus	2	,,
Citrullus vulgaris	2	,,
Momordica Charantia	18	in 5 sq. mm.
Gymnostemma cissoides	4	,,

The average numbers of the trichomes on the under-surface are as follows, again omitting the species in which they are borne only upon the veins:

Cucurbita Pepo	80	per sq. mm.
Lagenaria vulgaris	52	,,
Trichosanthes cucumeroides	52	,,
Benincasa cerifera	28	,,

Cucumis Melo	19	per sq. mm.
Luffa cylindrica	16	,,
L. acutangula	10	,,
Cucumis sativus	9	,,
Citrullus vulgaris	4	,,

Some of the trichomes are soft, while others are stiff, silicifying at the base centrifugally over the epidermal surface.[1] The trichomes on the upper surface of the blade of *Melothria japonica*, and on both surfaces of the blades of *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Cucumis sativus* and *C. Melo*, are good examples of the latter kind.

Thickness of Blades. The thickness of blades differs somewhat in each species. The average thickness of full-grown leaves is as follows:

Luffa acutangula	0.27	mm.
L. cylindrica	0.25	,,
Cucumis Melo	0.21	,,
Benincasa cerifera	0.20	,,
Cucumis sativus	0.20	,,
Momordica Charantia	0.18	,,
Citrullus vulgaris	0.18	,,
Trichosanthes cucumeroides	0.18	,,
T. japonica	0.18	,,
T. multiloba	0.17	,,
Lagenaria vulgaris	0.16	,,
Gymnostemma cissoides	0.16	,,
Actinostemma racemosum	0.14	,,

1) A. DE BARY. Comparative Anatomy of the Phanerogams and Ferns. Oxford 1884 p. 103.

Melothria japonica	0.14 mm.
Cucurbita Pepo	0.13 ,,
Schizopepon bryoniæfolius, var. japonicus	0.12 ,,

Pallisade Parenchyma. The thickness of the pallisade parenchyma is not uniform in all individuals. The results of microscopical measurements of it are given in the following table:

Luffa acutangula	0 120 mm.
L. cylindrica	0.095 ,,
Cucurbita Pepo	0.085 ,,
Cucumis Melo	0.075 ,,
Benincasa cerifera	0.070 ,,
Cucumis sativus	0.070 ,,
Lagenaria vulgaris	0.063 ,,
Melothria japonica	0.062 ,,
Momordica Charantia	0.062 ,,
Citrullus vulgaris	0.060 ,,
Trichosanthes cucumeroides	0.055 ,,
Gymnostemma cissoides	0.055 ,,
Trichosanthes japonica	0.052 ,,
T. multiloba	0.050 ,,
Actinostemma racemosum	0.050 ,,
Schizopepon bryoniæfolius, var. japonicus	0.050 ,,

The pallisade cells mostly occupy three- or four-tenths of the thickness of the blades, and sometimes even exceed six-tenths in *Cucurbita Pepo*, where the pallisade cells are at times arranged in double rows. The following will show these relations more clearly:

Cucurbita Pepo	0.085/0.13=0.65
Luffa acutangula	0.120/0.27=0.44
Melothria japonica	0.062/0.14=0.44
Shizopepon bryoniæfolius, var. japonicus	0.050/0.12=0.42
Lagenaria vulgaris	0.063/0.16=0.39
Luffa cylindrica	0.095/0.25=0.38
Cucumis Melo	0.075/0.21=0.36
Actinostemma racemosum	0.050/0.14=0.36
Cucumis sativus	0.070/0.20=0.35
Benincasa cerifera	0.070/0.20=0.35
Momordica Charantia	0.062/0.18=0.34
Gymnostemma cissoides	0.55/0.16=0.34
Citrullus vulgaris	0.60/0.18=0.33
Trichosanthes cucumeroides	0.55/0.18=0.31
T. multiloba	0.50/0.17=0.29
T. japonica	0.52/0.18=0.29

As to the breadth of the pallisade cells some have a large diameter, as in *Actinostemma racemosum* and *Gymnostemma cissoides*, in which the breadth is nearly equal to the length (Pl. III. Fig. 41), while others have a comparatively small diameter, those of *Cucurbita Pepo*, *Luffa cylindrica*, and *L. acutangula* being remarkably long and narrow.

Spongy Parenchyma. The spongy parenchyma consists of 2–6-layered cells. The spongy cells of *Gymnostemma cissoides* are characterized by being only 2–3-layered and by being far larger than those of other species.

Starch-grains. The chloroplasts in the mesophyll of *Actino-*

stemma racemosum Melothria japonica and *Gymnostemma cissoides* contain large spindle-shaped starch-grains as a product of assimilation (Pl. III. Fig. 41).

Mid-ribs. The median line of the upper surface of the mid-ribs is always raised into a ridge, where the collenchyma is well-developed, and of the species of the Cucurbitaceæ under consideration, the one having the highest and sharpest ridge is *Gymnostemma cissoides.*

The fibro-vascular bundles of the mid-ribs near the proximal portion are arranged in six ways: the first type has a single bundle situated at the centre of the mid-rib (Pl. III. Fig. 43); the second has two bundles one above the other (Pl. III. Fig. 44); the third has three bundles, a larger one at the centre, the other smaller two on each side and above (Pl. III. Fig. 45); the fourth also has three bundles, but they are arranged in a straight line drawn from above downwards, the uppermost bundle being the smallest, while the lowest is the largest (Pl. III. Fig. 46); the fifth has four bundles, and is distinguished from the third type by having one more small bundle at the upper part of the central one (Pl. III. Fig. 47); the sixth has seven bundles, the largest bundle being undermost, and the other smaller six on each side and above (Pl. III. Fig. 48). *Actinostemma racemosum* and *Schizopepon bryoniæfolius, var. japonicus* belong to the first; *Melothria japonica,* to the second; *Gymmostemma cissoides,* to the third; *Cucumis sativus, C. Melo, Benincasa cerifera, Lagenaria vulgaris,* to the fourth; *Momordica Charantia, Luffa cylindrica, L. acutangula, Trichosanthes cucumeroides, T. japonica* and *T. multiloba,* to the fifth; *Citrullus vulgaris* and *Cucurbita Pepo,* to the sixth.

In tracing the fibro-vascular bundlles of the mid-ribs from base to apex we find that the first type retains the single bundle to the last; the second loses the smaller upper bundle on the way, and is reduced to a single bundle; the third is also reduced to one bundle near the apex, the associated bundles on each side being out of sight; the fourth loses the uppermost bundle first, then the middle one, the lowest bundle remaining to the end; in the fifth, the lateral bundles first disappear and then the uppermost bundle, the lowest one being the survivor; in the sixth the lateral bundles disappear from above downwards till the lowest bundle remains isolated.

Collenchyma. The position of the collenchyma developed in the mid-ribs varies somewhat according to the above six types: in the first, second, third, fourth, and fifth it is developed only at the upper and lower margins, but in the sixth, besides the preceding places, collenchyma is also developed on both sides of the mid-ribs.

CHAPTER IV.

THE PETIOLE.

Contour. The contour of the petioles, as seen in a transverse section, is not of a constant shape in the proximal, middle, and distal portions even in one and the same species. Generally

speaking, a transverse section cut through the distal portion shows a deep groove on the upper surface, while that of the proximal portion appears roundish, the groove becoming extremely shallow. The middle portion has an intermediate character. Besides, though many of the petioles are solid some of them have a large central hollow throughout, this being the case in *Benincasa cerifera, Cucurbita Pepo* (Pl. I. Fig. 15–17), and *Luffa acutangula.*

Stomata. Stomata are not found on the epidermis, where the collenchyma is developed; they are present only in the intercollenchymatous portions. The following are the average numbers of the stomata on the petioles of each species:

Cucurbita Pepo	12	per sq. mm.
Trichosanthes multiloba	12	,,
T. cucumeroides	11	,,
Momordica Charantia	11	,,
Actinostemma racemosum	11	,,
Cucumis Melo	11	,,
Citrullus vulgaris	10	,,
Lagenaria vulgaris	10	,,
Benincasa cerifera	8	,,
Cucumis sativus	8	,,
Trichosanthes japonica	7	,,
Luffa cylindrica	7	,,
L. acutangula	7	,,
Gymnostemma cissoides	6	,,
Melothria japonica	4	,,
Schizopepon bryoniæfolius, var. japonicus	3	,,

Trichomes. The petioles may bear several kinds of trichomes or they may be nearly smooth. *Momordica Charantia, Luffa cylindrica, L. acutangula, Citrullus vulgaris, Cucumis sativus, C. Melo, Benincasa cerifera, Lagenaria vulgaris, Trichosanthes cucumeroides* and *Cucurbita Pepo,* belong to the first group; *Actinostemma racemosum, Melothria japonica, Schizopepon bryoniæfolius, var. japonicus, Trichosanthes japonica, T. multiloba* and *Gymnostemma cissoides,* to the second.

Collenchyma. In the middle portion of the petioles the collenchyma is developed outside of each fibro-vascular bundle. The number of the collenchyma groups varies from five to thirteen, the extremes being represented respectively by *Gymnostemma cissoides* and *Cucurbita Pepo.* In the distal as well as the proximal portions of the petioles several isolated collenchyma groups are united with one another, and in an extreme case all the groups of the collenchyma are entirely fused together.

Sclerenchyma. On the outside of each fibro-vascular bundle several-layered sclerenchymatous cells are formed, which are particularly well-developed in *Luffa cylindrica* and *L. acutangula.*

Fibro-vascular Bundles. The fibro-vascular bundles of the petioles have a circular arrangement. They are always in pairs laterally, while the undermost bundle is unpaired. Sometimes there appears a small bundle in the fundamental tissue under the groove. The undermost unpaired bundle is the largest of all and towards the upper portion of the petioles the paired bundles gradually decrease in size. The uppermost pair, when the upper surface of the petioles is deeply grooved, enters into

the ridges raised on both sides of the groove (Pl. I. Fig. 12–13). The number of the fibro-vascular bundles varies from five to thirteen. *Actinostemma racemosum*, *Melothria japonica* and *Gymnostemma cissoides* have five bundles; *Schizopepon bryoniæfolius, var. japonicus*, seven; *Momordica Charantia*,[1] *Citrullus vulgaris*,[2] *Cucumis sativus*, *C. Melo*,[3] *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica* and *T. multiloba*, nine; *Luffa cylindrica*, *L. acutangula* and *Benincasa cerifera*, eleven; *Cucurbita Pepo*, thirteen.

CHAPTER V.

THE COTYLEDON.

The cotyledons are above the ground or underneath it. Those of *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, and *Gymnostemma cissoides*, are entirely buried in the soil. The anatomical structure of the cotyledons differs from that of the foliage-leaves.

Epidermis. When observed in a surface view the contour of the epidermal cells of the cotyledons is either straight or wavy as in the case of the foliage-leaves. On the upper surface

1) H. A. LOTAR. *loc. cit.* p. 103.
2) Ditto. p. 95.
3) Ditto. p. 96.

of the cotyledons of *Momordica Charantia, Luffa cylindrica, L. acutangula, Citrullus vulgaris, Cucumis sativus, C. Melo, Trichosanthes cucumeroides, T. japonica, T. multiloba, Cucurbita Pepo,* and *Gymnostemma cissoides,* as well as on the under surface of those of *Momordica Charantia, Trichosanthes cucumeroides, T. japonica, T. multiloba* and *Gymnostemma cissoides,* the walls of the epidermal cells are straight; while they are wavy on the upper surface of those of *Actinostemma racemosum, Melothria japonica, Benincasa cerifera* and *Lagenaria vulgaris,* as well as on the under surface of those of *Actinostemma racemosum, Melothria japonica, Luffa cylindrica, L. acutangula, Citrullus vulgaris, Cucumis sativus, C. Melo, Benincasa cerifera, Lagenaria vulgaris* and *Cucurbita Pepo.*

Stomata. In nearly all of the species, as far as we have seen, stomata are found on both the upper and under surfaces of the cotyledons. Exceptions are however to be found in some species, where they are either almost exclusively on the upper side or only on the under. For example, in *Momordica Charantia, Trichosanthes japonica* and *T. multiloba,* they are chiefly on the upper, very rarely on the lower surface, while in *Gymnostemma cissoides* they are exclusively on the lower.

The numbers of the stomata found on the upper surface of the cotyledons of each species average as follows to a square millimetre:

Citrullus vulgaris	270
Luffa cylindrica	268
L. acutangula	260
Cucurbita Pepo	224
Lagenaria vulgaris	164

Cucumis Melo	142
Benincasa cerifera	125
Actinostemma racemosum	115
Cucumis sativus	93
Melothria japonica	43
Momordica Charantia	40
Trichosanthes cucumeroides	28
T. japonica	10
T. multiloba	4
Gymnostemma cissoides	0

Those on the under surface:

Luffa cylindrica	368	per sq. mm.
L. acutangula	360	,,
Cucumis Melo	314	,,
C. sativus	270	,,
Cucurbita Pepo	253	,,
Citrullus vulgaris	228	,,
Benincasa cerifera	177	,,
Lagenaria vulgaris	153	,,
Melothria japonica	135	,,
Actinostemma racemosum	118	,,
Gymnostemma cissoides	15	,,
Trichosanthes cucumeroides	11	,,
Momordica Charantia	0†	,,
Trichosanthes japonica	0†	,,
T. multiloba	0†	,,

Trichomes. Some cotyledons are furnished with trichomes on both the upper and the lower surfaces; others only on the

† Stomata rarely occur.

upper, and yet others have none on either surface. Thus in *Luffa cylindrica*, *L. acutangula*, *Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, *Lagenaria vulgaris* and *Cucurbita Pepo*, they are present on both surfaces; in *Melothria japonica* and *Citrullus vulgaris*, only on the upper; in *Actinostemma racemosum*, *Momordica Charantia*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba* and *Gymnostemma cissoides*, they are entirely absent.

Pallisade Parenchyma. The pallisade parenchyma of the cotyledons is generally many-layered; but there are some exceptional cases, in which the pallisade parenchyma can be scarcely recognised. The commonest type of the pallisade parenchyma consists of two or three-layered cells: e.g. *Actinostemma racemosum* *Melothria japonica*, *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, *Lagenaria vulgaris*, and *Cucurbita Pepo*. In *Momordica Charantia*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba* and *Gymnostemma cissoides* the pallisade cells are indistinct.

Spongy Parenchyma. The layers of the spongy parenchyma-cells of the cotyledons are much more numerous than those of the foliage-leaves. A very peculiar structure of the spongy parenchyma appears in the cotyledons of *Actinostemma racemosum* where it presents a reticulate appearance, the cells radiating from a fibro-vascular bundle and thus leaving very large intercellular spaces among them, a character which reminds us of the inner structures of water-plants (Pl. IV. Fig. 49). The spongy parenchyma-cells of the cotyledons of *Momordica Charantia*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba* and *Gymnostemma cissoides*, are not well differentiated, and possess no marked intercellular spaces.

CHAPTER VI.

THE TENDRIL.

Contour. The contour of a transverse section through the proximal portion of a tendril is nearly circular. In the more remote portions it takes a more or less polygonal shape, and at the distal portion it becomes flattened. Especially in *Luffa acutangula* and *Benincasa cerifera* the surface of the main axis of the tendrils is elevated into noticeable longitudinal ridges. In *Benincasa cerifera* (Pl. IV. Fig. 50), *Cucurbata Pepo*, *Luffa acutangula* and *Schizopepon bryoniæfolius, var. japonicus* a central hollow is formed in the main axis of the tendrils.

Stomata. The average numbers of the stomata on the tendrils are not widely different in each species, as may be seen from the following table:

Trichosanthes cucumeroides	24	per sq. mm.
T. japonica	24	,,
T. multiloba	24	,,
Gymnostemma cissoides	24	,,
Actinostemma racemosum	20	,,
Melothria japonica	20	,,
Luffa cylindrica	20	,,
L. acutangula	20	,,
Benincasa cerifera	20	,,
Momordica Charantia	16	,,
Citrullus vulgaris	16	,,

Cucumis sativus	16 per sq. mm.
C. Melo	16 „
Lagenaria vulgaris	16 „
Cucurbita Pepo	16 „
Schizopepon bryoniæfolius, var. japonicus	16 „

Collenchyma. At the proximal portion of the tendrils we may distinguish three varieties of collenchyma according as it is developed: (i.) on all sides of the tendrils, (ii.) on the outside of each fibro-vascular bundle, and (iii.) outside of each fibro-vascular bundle as well as of each medullary ray. The first variety is found in *Melothria japonica, Cucumis sativus, C. Melo, Trichosanthes cucumeroides, T. japonica, T. multiloba, Gymnostemma cissoides;* the second, in *Actinostemma racemosum, Schizopepon bryoniæfolius, var. japonicus, Momordica Charantia, Luffa cylindrica, L. acutangula, Citrullus vulgaris* and *Lagenaria vulgaris;* the third, in *Benincasa cerifera* and *Cucurbita Pepo.* In the distal portion, the collenchyma masses on the under side of the tendrils fuse into one another.

Sclerenchyma. At the proximal portion of the tendrils the sclerenchyma forms a continuous ring.[1] At the distal portion, however, it is developed only on the ventral side of the tendrils.[2] In *Benincasa cerifera* and *Lagenaria vulgaris* the sclerenchyma masses occur separately outside of each fibro-vascular bundle near the base of the tendrils, and those masses which are on the ventral side of the tendrils at the distal portion towards their apex, are united.

1) H. A. LOTAR. *loc. cit.* p. 139.
2) Ditto. p. 138.

Fibro-vascular Bundles. At the proximal portion of the tendrils the number of the fibro-vascular bundles varies from four to ten, gradually decreasing towards the distal portion. The maximum number of the bundles occurs in *Luffa cylindrica*, while the minimum is found in *Actinostemma racemosum* and *Gymnostemma cissoides*. *Luffa acutangula*, *Citrullus vulgaris*, *Benincasa cerifera*, *Momordica charantia*, *Cucurbita Pepo*, *Cucumis Melo*, *C. sativus*, *Lagenaria vulgaris*, *Trichosanthes multiloba*, *T. cucumeroides*, *T. japonica*, *Schizopepon bryoniæfolius*, *var. japonicus* and *Melothria japonica* have numbers intermediate between the extremes in a descending order.

CHAPTER VII.

THE ROOT.

Besides ordinary roots, tubers are met with in some species. They are, however, limited to one genus only, *Trichosanthes* which thus leads a perennial life, just as *Melothria japonica* and *Gymnostemma cissoides* preserve their vitality through the winter by means of rhizomes.

I shall now first take up the investigation of the anatomical structure of the ordinary roots, and then that of the tubers.

Contour. The contour of the root is not diversified like

that of the stem. It is mostly roundish, and in some cases it is more or less triangular or square, according to the number of fibro-vasculer bundles present.

Periderm. Although the formation of periderm is common in old roots yet none have it so well-developed as that observed in the roots of *Trichosanthes cucumeroides*, *T. japonica*, and *T. multiloba*.

Sclerenchyma. When the roots are young, sclerenchyma is developed on the outside of each fibro-vascular bundle, but when they become old it breaks up into several parts, often forming two or three tangential parallel rows. When still further advanced in age numerous masses of sclerenchyma are found scattered in the cortex outside of each bundle as well as of each medullary ray. The degree of development of the sclerenchyma varies according to the species: some have well-developed and numerous sclerenchyma groups, while in others they are delicate and reduced. In *Melothria japonica*, *Trichosanthes cucumeroides*, and *Gymnostemma cissoides* the well-developed sclerenchyma forms a nearly continuous ring, but in *Schizopepon bryoniæfolius, var. japonicus*, *Benincasa cerifera*, and *Cucurbita Pepo* it is greatly reduced. At the angled portions of old roots of *Momordica Charantia* the sclerenchyma shows a charateristic double arrangement like that seen in the old stem, a mass of it being developed outside of each of the double fibro-vascular bundles heaped one upon the other.

Fibro-vascular Bundles. Most of the fibro-vascular bundles

in the main roots are tetrarch.[1] In the lateral roots, however, di-, tri- or polyarch bundles are found especially in the adventitious roots: thus, for example, the pentarch occur in those of *Actinostemma racemosum*, *Melothria japonica*, *Luffa cylindrica*, *L. acutangula* and *Benincasa cerifera*; the hexarch, in those of *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, and *Gymnostemma cissoides*; the octarch, in those of *Cucurbita Pepo*.[2] In old roots of *Momordica Charantia* the fibro-vascular bundles are arranged in double rows at the angled portions as in the old stem, one small secondary bundle, or occasionally two, being newly formed outside of the primary one.

(a) *Phloëm*. The sieve-tubes found in the roots are of smaller sizes than those of the stems. The diameters of the large sieve-tubes under consideration are shown in the following table:

Lagenaria vulgaris	0.075 mm.
Benincasa cerifera	0.070 ,,
Momordica Charantia	00.70 ,,
Luffa cylindrica	0.068 ,,
L. acutangula	0.067 ,,
Cucurbita Pepo	0.067 ,,
Trichosanthes japonica	0.060 ,,
T. multiloba	0.058 ,,
Citrullus vulgaris	0.057 ,,
Trichosanthes cucumeroides	0.055 ,,
Cucumis sativus	0.055 ,,
C. Melo	0.054 ,,
Schizopepon bryoniæfolius, var. japonicus	0.040 ,,

1) H. A. LOTAR. *loc. cit.* p. 155.
2) Ditto. p. 170.

Actinostemma racemosum	0.040 mm.
Melothria japonica	0.030 ,,
Gymnostemma cissoides	0.025 ,,

(b) *Xylem.* The xylem in the roots is well-developed and occupies the greater part of them. The sizes of the vessels in the roots are somewhat smaller than those of the stems.

	Diameter of the large vessel.
Benincasa cerifera	0.50 mm.
Luffa cylindrica	0.44 ,,
L. acutangula	0.43 ,,
Lagenaria vulgaris	0.43 ,,
Cucurbita Pepo	0.35 ,,
Momordica Charantia	0.33 ,,
Citrullus vulgaris	0.29 ,,
Trichosanthes multiloba	0.28 ,,
T. cucumeroides	0.25 ,,
T. japonica	0.24 ,,
Cucumis Melo	0.22 ,,
C. sativus	0.20 ,,
Schizopepon bryoniæfolius, var. japonicus	0.17 ,,
Actinostemma racemosum	0.15 ,,
Gymnostemma cissoides	0.14 ,,
Melothria japonica	0.09 ,,

Thyloses[1] within the vessels occur most commonly in old roots as they do in the old stems.

Intercellular Spaces. The intercellular spaces in the cortex of young roots are numerous and large. Those found in the roots of *Actinostemma racemosum* are exceptionally large, a trans-

1) H. A. LOTAR. *loc. cit.* p. 152.

verse section presenting an appearance like that of a water-plant (Pl. IV. Fig. 55). This peculiar character of the root of *Actinostemma racemosum* is not to be wondered at, when we consider that this plant always grows in the neighbourhood of a stream or in moist places, it having evidently acquired the character of a water-plant in order to adapt itself to its surroundings.

Starch-grains and Crystals. Reserve starch-grains of appreciable size are contained in old roots of the following species:

	Diameter of the large starch-grains.
Gymnostemma cissoides	0.023 mm.
Trichosanthes multiloba	0.020 „
T. japonica	0.020 „
T. cucumeroides	0.018 „
Melothria japonica	0.017 „
Luffa cylindrica	0.016 „
L. acutangula	0.014 „
Actinostemma racemosum	0.010 „
Citrullus vulgaris	0.009 „
Cucurbita Pepo	0.008 „

Crystals of calcium oxalate are met with in the old roots of *Momordica Charantia, Luffa cylindrica, L. acutangula, Lagenaria vulgaris, Benincasa cerifera, Cucumis sativus, C. Melo,* &c., those of *Momordica Charantia* being the most remarkable in size and quantity.

Tubers. Tubers are found only in *Trichosanthes cucumeroides, T. japonica* and *T. multiloba.* They occur in simple or grouped forms and attain an enormous size. A transverse section of a tuber shows a great degeneration of fibro-vascular bundles, the parenchyma itself being much increased so as to serve as a reserve tissue.

The periderm is well-developed and forms a thick layer around the tubers.

The sclerenchyma of the tubers is best developed in *Trichosanthes cucumeroides*, where it forms an almost continuous ring. In *Trichosanthes multiloba* the development of the sclerenchyma is somewhat checked and in *Trichosanthes japonica* it is very much retarded. The size of the sclerenchymatous cells and the thickness of their walls are much greater in the first two species than in the last. For the sake of a comparison I give the following numbers obtained from the measurements of the large sclerenchymatous cells in the tubers of the above three species:

	Diameter.	Thickness of the wall.
Trichosanthes multiloba	0.080 mm.	0.020 mm.
T. cucumeroides	0.050 „	0.020 „
T. japonica	0.030 „	0.008 „

The fibro-vascular bundles are most reduced in *Trichosanthes cucumeroides*, where many of the vessels are separated from each other. The following are the diameters of the large sieve-tubes in each species:

Trichosanthes multiloba	0.070 mm.
T. japonica	0.050 „
T. cucumeroides	0.045 „

Diameters of the large vessels:

Trichosanthes multiloba	0.42 mm.
T. japonica	0.35 „
T. cucumeroides	0.30 „

The starch-grains contained in the tubers attain their maximum size in *Trichosanthes multiloba*, those of *Trichosanthes japonica* coming next, and then those of *Trichosanthes cucumeroides*. In point of size the starch-grains from the tubers of *Trichosanthes multiloba*, however, stand second among those contained in the

various organs of the Cucurbitaceæ, the first place being held by those from the rhizome of *Gymnostemma cissoides.*[1] The diameters of the large starch-grains from the tubers of *Trichosanthes* are as follows:

Trichosanthes multiloba	0.042 mm.
T. japonica	0.027 „
T. cucumeroides	0.018 „

CHAPTER VIII.

THE FRUIT.

The surface of the fruit of the Cucurbitaceæ is mostly smooth, except in *Actinostemma racemosum, Momordica Charantia* and *Cucumis sativus,* where it is raised into tubercles. The nature of the tubercles varies, for an examination of their anatomical structure shows that those of *Actinostemma racemosum* (Pl. IV. Fig. 58) and *Momordica Charantia* are only parenchymatous outgrowths, while those of *Cucumis sativus* are the large protuberant bases of trichomes, on which the latter have formerly rested (Pl. IV. Fig. 57).

Epidermis. The epidermal cells of the fruit have several distinct characters in the different species. To begin with, the shapes of the epidermal cells may be (a) radially flattened, (b)

1) See p. 15.

cubical, or (c) radially elongated. To the first belong *Actinostemma racemosum, Schizopepon bryoniæfolius, var. japonicus, Momordica Charantia* and *Gymnostemma cissoides;* to the second, *Melothria japonica, Luffa cylindrica, L. acutangula, Citrullus vulgaris, Lagenaria vulgaris, Trichosanthes cucumeroides, T. japonica* and *T. multiloba;* to the third, *Cucumis sativus, C. Melo, Benincasa cerifera* and *Cucurbita Pepo,* the epidermal cells of *Cucumis sativus* being the longest of all the radial diameter exceeding four times the tangential (Pl. V. Fig. 60); those of *Benincasa cerifera* are also characteristic, many of the cells having a tangential septum (Pl. V. Fig. 61).

A superficial view of the epidermal cells shows some variation n size, their diameters measuring 0.006–0.055 mm. *Actinostemma racemosum, Momordica Charantia, Gymnostemma cissoides* and *Citrullus vulgaris,* for example, being of the maximum size, while *Cucurbita Pepo* and *Cucumis sativus* are of the minimum size.

The walls of the epidermal cells of the fruit may be especially thick on the outer side or on the lateral sides, the outer half particularly manifesting an unusual thickening. *Melothria japonica, Cucumis sativus, C. Melo, Benincasa cerifera, Trichosanthes cucumeroides, T. japonica,* and *T. multiloba* belong to the latter; the remaining species to the former.

Stomata. The numbers of the stomata on the fruit may be shown by the following mean values in a square millimetre:

Luffa cylindrica	60
L. acutangula	50
Cucurbita Pepo	44
Citrullus vulgaris	37
Cucumis Melo	31

C. sativus	27
Benincasa cerifera	20
Trichosanthes multiloba	16
Lagenaria vulgaris	14
Momordica Charantia	12
Actinostemma racemosum	10
Gymnostemma cissoides	10
Trichosanthes cucumeroides	9
T. japonica	8
Melothria japonica	8
Schizopepon bryoniæfolius, var. japonicus	5

Trichomes. When young, the fruit bears several kinds of trichomes on its surface, but when they become old almost all of the trichomes have become detached from their bases, which then remain as traces of the once existing trichomes. We may distinguish four kinds of trichomes on the surface of the fruit: sharp-pointed conical hairs, blunt-ended conical hairs, short-stalked glandular hairs, and long-stalked glandular hairs, the details of which are quite the same as those of the stem.

Cuticle. The cuticle on the fruit-surface may be smooth or striated. In *Luffa cylindrica, L. acutangula, Actinostemma racemosum, Schizopepon bryoniæfolius, var. japonicus, Cucurbita Pepo, Momordica Charantia* and *Citrullus vulgaris* it is striated, that of *Luffa cylindrica* and *L. acutangula* being the most marked, the striations running out radially from the bases of the trichomes or from the stomata. In the remaining species it is smooth.

Wax. The fruit, when matured, has a greater or less deposit of wax on its surface. This wax covering is best developed on

the fruit of *Benincasa cerifera*, *Citrullus vulgaris* and *Cucurbita Pepo*. In *Benincasa cerifera* it consists of bundles of rods crossing one another like a trellis, and presenting a reticular appearance.[1)]

Pericarp-tissue within the Epidermis. The structure of the pericarp-tissue within the epidermis is not uniform in all species. Some fruits have a hardened ring in the outer tissue of the pericarp (Pl. V. Fig. 61), while in others this is lacking (Pl. V. Fig. 60). In *Actinostemma racemosum*, *Melothria japonica*, *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Benincasa cerifera*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba* and *Gymnostemma cissoides* the hardened ring is developed, that of *Actinostemma racemosum* and *Melothria japonica* being incomplete and interrupted in many places (Pl. IV. Fig. 58); in *Schizopepon bryoniæfolius, var. japonicus*, *Momordica Charantia*, *Cucumis sativus*, *C. Melo* and *Cucurbita Pepo* the mechanical sheath is entirely wanting.

The sclerenchymatous cells constituting the hardened ring may be thin-walled with numerous pits, as in *Actinostemma racemosum*, *Melothria japonica* and *Benincasa cerifera*, or may be thick-walled with distinct pore-canals, as in *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba* and *Gymnostemma cissoides*.

The hypodermal cells lying outside of the hardened ring are rather smaller than those of the deeper fundamental tissue, and when no hardened ring is present the parenchymatous cells of the outer part of the pericarp under the epidermis act as such. In *Lagenaria vulgaris* and *Benincasa cerifera* the hypodermal

1) A DE BARY. *loc. cit.* p. 86.

cells are remarkably small, but in *Actinostemma racemosum* and *Momordica Charantia* they are exceptionally large.

The number of the layers of the hypodermal cells outside of the hardened ring should also be noticed. While usually they are many-layered in *Melothria japonica* and *Gymnostemma cissoides* they are reduced to the minimum; that is, in the former the hypodermal cells are one- or two-layered, but in the latter only one-layered.

Fibro-vascular Bundles. As a rule the fibro-vascular bundles in the fruit are weakly developed, and most of them have no sclerenchymatous sheath. Exceptions are found, however, in the fruit of *Luffa cylindrica* and *L. acutangula.* The fibres constituting the net-work of the *Luffa*-fruit are really the fibro-vascular bundles surrounded by the thick layers of the sclerenchymatous cells, which give a roundish shape to the fibres, and make them extremely elastic, the circumscribed bundles themselves remaining merely rudimentary (Pl. V. Fig. 59).

A peculiar arrangement of the fibro-vascular bundles is observed in the tubercles on the surface of the fruit of *Momordica Charantia.* A bundle enters into the tubercle perpendicular to the surface of the fruit, branching out near the top of the tubercle (Pl. IV. Fig. 56).

The sieve-tubes show a characteristic distribution in the fruit-tissue. Besides those found in the phloëm, there occur isolated sieve-tubes in the tissue of the pericarp within the epidermis (Pl. V. Fig. 61). In the species which have the hardened ring such as *Benincasa cerifera, Trichosanthes cucumeroides, T. japonica* and *T. multiloba,* they occur in the hypoderma on the outside of the ring, and in *Schizopepon bryoniæfolius, var. japonicus, Cucumis*

sativus, *C. Melo* and *Cucurbita Pepo*, where the sclerenchymatous sheath is wanting, they are found in the outer part of the pericarp-tissue (Pl. V. Fig. 60).

Parenchyma of the inner Part. The parenchymatous cells which fill up the intervascular spaces are of enormous size, and the intercellular spaces among them are also remarkable. Especially, as we proceed to the inner part of the fruit do we find larger parenchymatous cells touching each other very slightly. In *Melothria japonica* the parenchymatous cells are transversely and tangentially elongated, and in *Momordica Charantia* they are transversely and radially elongated.

The structure of the innermost part of the fruit is often different from that of the other parts. In *Actinostemma racemosum*, *Schizopepon bryoniæfolius*, *var. japonicus* and *Gymnostemma cissoides* the innermost part of the fruit contains large intercellular spaces, which are most marked in *Actinostemma racemosum*, where the parenchyma presents a reticulate appearance.

Starch-grains and Crystals. Starch-grains are contained in the fruit of *Actinostemma racemosum*, *Melothria japonica*, *Schizopepon bryoniæfolius*, *var. japonicus*, *Momordica Charantia*, *Luffa cylindrica*, *L. acutangula*, *Benincasa cerifera*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba*, *Cucurbita Pepo* and *Gymnostemma cissoides*, those of *Gymnostemma cissoides* being the largest (the major axis being 0.022 mm. long and the minor axis, 0.017 mm.), showing an irregular shape and a tubercular surface, while those of the other species are round and smooth. The quantity of the starch-grains in the fruit attains its maximum in *Melothria japonica* and *Gymnostemma cissoides*.

Crystals of calcium oxalate are found in the fruit of many species. Especially *Momordica Charantia* and *Benincasa cerifera* contain large quantities of them.

CHAPTER IX.

THE SEED.

Contour. The contour of a transverse section through the seed shows interesting forms in each species (Pl. I. Fig. 18–33). In *Luffa cylindrica*, *L. acutangula*, *Cucumis sativus*, *C. Melo*, *Lagenaria vulgaris*, *Trichosanthes japonica*, *T. multiloba* and *Cucurbita Pepo* it is of a spindle shape; in *Actinostemma racemosum*, *Schizopepon bryoniæfolius*, *var. japonicus*, *Memordica Charantia*, *Trichosanthes cucumeroides* and *Gymnostemma cissoides* it is barrel-shaped, that of *Trichosanthes cucumeroides* having two processes on both truncated ends; and in *Melothria japonica*, *Citrullus vulgaris* and *Benincasa cerifera*, it is flattened, that of *Benincasa cerifera* being also noticeable for having three processes on both edges.

Testa. The testa of the Cucurbitaceæ consists, according to FICKEL,[1] of the following seven layers: (i.) epidermis, (ii.) pitted

1) J. F. FICKEL. *loc. cit.*

cells, mostly thick-walled, (iii.) stone-cells, (iv.) irregular thin-walled cells, which abound in intercellular spaces, (v.) thin-walled compressed cells, (vi.) the remnant of the nucellus, and (vii.) the remnant of the endosperm.

The epidermal cells constituting the first layer of the testa, when immersed in water, swell greatly. Their forms are very characteristic, being entirely different from the epidermal cells found in other parts of the plants. They are divided into three classes: (a) the flattened or cubical form, (b) the prismatic form, and (c) the prismatic form with thickened-ridges on the cell-wall. The first is found in *Actinostemma racemosum, Schizopepon bryoniæfolius, var. japonicus* and *Gymnostemma cissoides,* and among these the lateral walls of the epidermal cells of the seed-coat of *Schizopepon bryoniæfolius, var. japonicus* deserve special notice, for they become thinckened inwards, pointing gradually outwards. The second is found in *Momordica Charantia,*[1] *Trichosanthes cucumeroides, T. japonica* and *T. multiloba;* and the third, in *Melothria japonica, Luffa cylindrica,*[2] *L. acutangula, Citrullus vulgaris,* [3]*Cucumis sativus, C. Melo, Benincasa cerifera, Lagenaria vulgaris* and *Cucurbita Pepo,* and the thickened-ridges of *Cucurbita Pepo,*[4] *Lagenaria vugaris*[5] and *Benincasa cerifera* ramify dendritically at the apex, while those of *Melothria japonica, Cucumis sativus*[6] and *C. Melo*[7] point towards the apex and extend towards the base (Pl. V. Fig. 64–65).

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1) H. A. LOTAR. *loc. cit.* p. 221.
2) J. F. FICKEL. *loc. cit.* p. 771. and H. A. LOTAR. *loc. cit.* p. 218.
3) J. F. FICKEL. *loc. cit.* p. 757.
4) Ditto. p. 769. and H. A. LOTAR. *loc. cit.* p. 216.
5) J. F. FICKEL. *loc. cit.* p. 742.
6) C. D. HARZ. *loc. cit.* p. 777.
7) H. A. LOTAR. *loc. cit.* p. 216.

The cuticle on the epidermis is mostly thin, except in *Citrullus vulgaris*, *Trichosanthes cucumeroides*, *T. japonica* and *T. multiloba*, where it is much thickened.

The thick-walled, irregular, pitted cells constituting the second layer of the testa have some intercellular spaces, and often attain a great thickness in, *Actinostemma racemosum*, *Schizopepon bryoniæfolius*, *var. japonicus*, *Momordica Charantia*, *Citrullus vulgaris*, *Benincasa cerifera*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica* and *T. multiloba*.

In *Melothria japonica*, *Luffa cylindrica*, *L. acutangula*, *Cucumis sativus*, *C. Melo*, *Cucurbita Pepo* and *Gymnostemma cissoides* this layer occupies a comparatively small portion of the testa. That of *Cucurbita Pepo*[1] and *Gymnostemma cissoides* is composed of thin-walled cells, furnished with reticulate thickenings. In some cases the second layer passes over gradationally to the third layer.

The stone-cells of the third layer of the testa are especially large, and polyhedral or roundish. They are characterized by the considerable thickness of their walls, and by the presence of a greatly reduced cavity as well as numerous branched pore-canals. This layer is made up of one or more rows of cells, which sometimes have small intercellular spaces. In *Luffa cylindrica*[2] and *L. acutangula*[3] it consists of rather large prismatic stone-cells (200 μ long and 37 μ wide), which are placed radially parallel; while in *Gymnostemma cissoides* it is made up of large reticulate cells.

The parenchymatous cells of the fourth layer are thin-walled

1) H. A. LOTAR. *loc. cit.* p. 213.

2) Ditto. p. 221.

3) A. YASUDA. On the Anatomy of *Luffa acutangula* (L.) Roxb. Botanical Magazine, Tokyo. 1896. vol. x. No. 108. p. 37.

and pitted or reticulate. They are mostly irregular-shaped and often stellate, with many remarkable intercellular spaces. The reticulate cells occur in *Actinostemma racemosum* and *Cucurbita Pepo*,[1] those of the former being especially large and noticeable (Pl. V. Fig. 63).

The tangentially compressed cells of the fifth layer are also thin-walled. They are gradually transferred over from the cells of the fourth layer.

The remnant of the nucellus coming under the fifth layer is a strongly refractive tissue, which is made up of the epidermis of the nucellus and several rows of compressed cells. Then follows the remnant of the endodermis, under which are laid the cotyledons (Pl. V. Fig. 62–66).

SUMMARY.

1. The old stems of *Luffa cylindrica*, *L. acutangula*, *Momordica Charantia* and *Actinostemma racemosum* are very characteristic. They have a sharp keel along the angled portions. Microscopical examination shows that the ridges of *Luffa cylindrica* and *L. acutangula* consist only of outgrowths of the collenchyma, while those of *Momordica Charantia* and *Actinostemma racemosum* are formed by newly developed secondary fibro-vascular bundles.

2. Stomata on the stems of the Cucurbitaceæ may be

1) J. F. Fickel *loc. cit.* p. 757. and H. A. Lotar. *loc. cit.* p. 214.

sometimes elevated with the epidermis above the surface of the latter, as if they were supported by short thick hairs.

3. Trichomes on the stems are of four kinds: (i.) sharp-pointed conical trichomes, (ii.) blunt-ended conical trichomes, (iii.) short-stalked glandular trichomes and (iv.) long-stalked glandular trichomes. The glandular trichome of *Trichosanthes cucumeroides* is especially characterized by having a single enlarged terminal cell; that of *Benincasa cerifera*, by having two processes at the apex; and that of *Cucurbita Pepo* by having the head consisting of two cells one overlying the other.

4. There are four types of the distribution of the sieve-tubes in the stems: (a) vascular-bundle sieve-tubes, (b) ectocyclic sieve-tubes, (c) entocyclic sieve-tubes, and (d) commissural sieve-tubes. *Luffa cylindrica* and *L. acutangula* have those of the first and third types; *Actinostemma racemosum*, *Melothria japonica*, *Schizopepon bryoniæfolius, var. japonicus*, *Momordica Charantia*, *Citrullus vulgaris*, *Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, *Lagenaria vulgaris*, *Trichosanthes cucumeroides*, *T. japonica*, *T. multiloba* and *Gymnostemma cissoides*, those of the first, third and fourth; and *Cucurbita Pepo*, all four types.

5. Rhizomes occur in *Melothria japonica* and *Gymnostemma cissoides*. They are long and thick, having at several nodes three scales, which are anatomically distinguished as a shoot, a leaf and a tendril. They are full of starch-grains, those of *Gymnostemma cissoides* being the largest (0.06 mm. in diameter) contained in any of the organs of the Cucurbitaceæ.

6. In the rhizomes the collenchyma, sclerenchyma and fibro-vascular bundles are considerably reduced. Their degeneration is much greater in *Melothria japonica* than in *Gymnostemma cissoides*.

7. The number of fibro-vascular bundles in the hypocotyls is generally six, except in *Citrullus vulgaris* and *Cucurbita Pepo*, the former of which has twelve, and the latter ten.

8. The epidermal cells on the upper surface of the blade of *Trichosanthes cucumeroides* are raised into conical papillæ pointing outwards.

9. The epidermis of the blades may be many-layered as in *Cucurbita Pepo*, a character which is limited to this species. *Momordica Charantia* contains globular cystoliths (0.065 mm. in diameter) in the greatly enlarged epidermal cells on the lower surface of the blade. They are united into groups.

10. Stomata on the upper surface of the blades are rarely found in *Momordica Charantia*, *Trichosanthes japonica* and *T. multiloba*, while they are entirely wanting in *Schizopepon bryoniæfolius, var. japonicus* and *Gymnostemma cissoides*.

11. The pallisade parenchyma is usually confined to three- or four-tenths of the thickness of the blades, but sometimes exceeds six-tenths in *Cucurbita Pepo*, where the pallisade cells may be arranged in double rows.

12. The fibro-vascular bundles of the mid-ribs near the proximal portion of the blades are arranged in six ways: the first type has a single bundle situated at the centre of the mid-ribs (*Actinostemma racemosum*, *Schizopepon bryoniæfolius, var. japonicus*); the second has two bundles overlapping each other (*Melothria japonica*); the third has three bundles, a larger one at the centre, the other smaller two on each side and above (*Gymnostemma cissoides*); the fourth also has three bundles, but they are arranged perpendicularly (*Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, *Lagenaria vulgaris*); the fifth has four bundles, and is distinguished from the third by having one more

small bundle on the upper part of the central one (*Momordica Charantia, Luffa cylindrica, L. acutangula, Trichosanthes cucumeroides, T. japonica, T. multiloba*); the sixth has seven bundles, the largest bundle undermost, the other six on each side and above (*Citrullus vulgaris, Cucurbita Pepo*).

13. The petioles are solid in general, except in *Cucurbita Pepo, Benincasa cerifera* and *Luffa acutangula*, in which they are hollow. The number of fibro-vascular bundles varies from five (*Actinostemma racemosum, Melothria japonica* and *Gymnostemma cissoides*) to thirteen (*Cucurbita Pepo*).

14. Stomata on the cotyledons are in many cases present on both the upper and lower surfaces. *Momordica Charantia, Trichosanthes japonica, T. multiloba* and *Gymnostemma cissoides* form an exception to this rule, the former three having the stomata on the lower surface, very rarely on the upper; while the last has them exclusively on the under side.

15. The pallisade parenchyma of the cotyledons is commonly several-layered, while the spongy parenchyma is many-layered. The mesophyll of the cotyledons of *Momordica Charantia, Trichosanthes cucumeroides, T. japonica, T. multiloba* and *Gymnostemma cissoides* is, however, scarcely differentiated into the pallisade and spongy tissues.

16. The spongy parenchyma of the cotyledons of *Actinostemma racemosum* shows a reticulate appearance, the cells radiating from a fibro-vascular bundle and thus leaving very large intercellular spaces, so that it reminds one of the leaf-tissue of water-plants.

17. Unlike the common solid types, the stems of *Cucurbita Pepo, Benincasa cerifera, Lagenaria vulgaris,* the hypocotyls of *Cucurbita Pepo, Benincasa cerifera, Lagenaria vulgaris, Cucumis*

Melo, and the main axis of the tendrils of *Cucurbita Pepo*, *Benincasa cerifera*, *Luffa acutangula*, *Schizopepon bryoniæfolius*, *var. japonicus* are equally furnished with a central hollow.

18. The number of stomata found on the tendrils is nearly the same in all species. The number of fibro-vascular bundles varies from four (*Actinostemma racemosum*, *Gymnostemma cissoides*) to ten (*Luffa cylindrica*).

19. In the old roots of *Momordica Charantia* the fibro-vascular bundles have a double arrangement at the angled portions, as in the old stems.

20. The young roots of *Actinostemma racemosum* have remarkably wide intercellular spaces, the cause of which is to be found in the habitus of the plant.

21. Tubers are confined to *Trichosanthes cucumeroides*, *T. japonica* and *T. multiloba*. The largest starch-grains contained in the roots are those of the tuber of *Trichosanthes multiloba* (0.042 mm. in diameter).

22. The epidermal cells of the fruit may be radially flattened, cubical, or radially elongated. *Cucumis sativus* is characterized by having the epidermal cells four times longer radially than tangentially; and *Benincasa cerifera*, by having a tangential septum in many of them.

23. In the pericarp-tissue a sclerenchymatous ring, either complete or incomplete, is generally formed. In *Schizopepon bryoniæfolius*, *var. japonicus*, *Cucumis sativus*, *C. Melo* and *Cucurbita Pepo*, however, it is entirely absent.

24. The surface of the fruit of *Actinostemma racemosum*, *Momordica Charantia* and *Cucumis sativus* is raised into tubercles. The origin of the tubercles varies; for those of *Actinostemma racemosum* and *Momordica Charantia* are anatomically proved to be

parenchymatous outgrowths, while those of *Cucumis sativus* are the large protuberant bases of trichomes, which have become detached.

25. Sieve-tubes have a characteristic distribution in the fruits. Besides those found in the phloëm there are isolated sieve-tubes in the tissue of the pericarp. These extra-phloëm sieve-tubes occur in the hypoderma outside of the hardened ring. And when no hardened ring is present they are found in the outer part of the pericarp-tissue.

26. Into the tubercles on the surface of the fruit of *Momordica Charantia* a fibro-vascular bundle enters, and runs perpendicularly to the surface branching out near the top of the tubercle. Nothing of this kind is observed in other genera.

27. The anatomical structure of the fibro-vascular bundles in the fruit of *Luffa cylindrica* and *L. acutangula* deserves notice because of the fact that the well-developed sclerenchyma surrounds the remaining weakly-developed portion of the bundle, the whole forming a spongy mass.

28. We may distinguish three kinds of epidermal cells in the seeds: a) flattened or cubical cells, b) prismatic cells, and c) prismatic cells with thickened-ridges on their walls. To the first class belong *Actinostemma racemosum*, *Schizopepon bryoniæfolius, var. japonicus* and *Gymnostemma cissoides;* to the second, *Momordica Charantia*, *Trichosanthes cucumeroides*, *T. japonica* and *T. multiloba;* and to the third, *Melothria japonica*, *Luffa cylindrica*, *L. acutangula*, *Citrullus vulgaris*, *Cucumis sativus*, *C. Melo*, *Benincasa cerifera*, *Lagenaria vulgaris* and *Cucurbita Pepo*. The thickened-ridges of *Benincasa cerifera*, *Lagenaria vulgaris* and *Cucurbita Pepo* ramify dendritically at the apex, while those of *Melothria japonica*, *Cucumis sativus*, *C. Melo* are pointed towards the apex and widen towards the base.

Contents.

A. YASUDA.

ON THE COMPARATIVE ANATOMY OF THE CUCURBITACEÆ, WILD AND CULTIVATED, IN JAPAN.

PLATE I.

Plate I.

Fig. 1–4. Diagrammatic representation of transverse sections through the stem of *Benincasa cerifera* in various stages. Fig. 1. A young stem; Fig. 2. A growing stem; Fig. 3. A full-grown stem; Fig. 4. An old stem. *a*, fibro-vascular bundle of the outer ring; *b*, fibro-vascular bundle of the inner ring; *c*, central hollow.

Fig. 5. Sharp-pointed conical trichome of *Melothria japonica*. Zeiss, 2 × D.

Fig. 6. Blunt-ended conical trichome of *Schizopepon bryoniæfolius, var. japonicus.* Zeiss, 2 × D.

Fig. 7. Short-stalked glandular trichome of *Cucumis sativus.* Zeiss, 2 × D.

Fig. 8. Long-stalked glandular trichome of *Cucumis sativus.* Zeiss, 2 × D.

Fig. 9. The same of *Benincasa cerifera.* Zeiss, 2 × D.

Fig. 10. „ „ „ *Trichosanthes cucumeroides.* Zeiss, 2 × D.

Fig. 11. „ „ „ *Cucurbita Pepo.* Zeiss, 2 × D.

Fig. 12–14. Diagrammatic representation of transverse sections through various portions of the petiole of *Momordica Charantia.* Fig. 12. The distal portion; Fig. 13. The middle portion; Fig. 14. The proximal portion. *f'*, fibro-vascular bundle; *f*, fibro-vascular bundle entering the ridges, which are raised on both sides of the groove.

Fig. 15–17. Diagrammatic representation of transverse sections through various portions of a petiole of *Cucurbita Pepo.* Fig. 15. The distal portion; Fig. 16. The middle portion; Fig. 17. The proximal portion. *f*, fibro-vascular bundle; *h*, central hollow.

Fig. 18. Scheme of the median transverse section through the testa of *Actinostemma racemosum.*

Fig. 19. The same of *Melothria japonica.*

Fig. 20. „ „ „ *Schizopepon bryoniæfolius, var. japonicus.*

Fig. 21. „ „ „ *Momordica Charantia.*

Fig. 22. „ „ „ *Luffa cylindrica.*

Fig. 23. „ „ „ *L. acutangula.*

Fig. 24. „ „ „ *Citrullus vulgaris.*

Fig. 25. „ „ „ *Cucumis sativus.*

Fig. 26. „ „ „ *C. Melo.*

Fig. 27. „ „ „ *Benincasa cerifera.*

Fig. 28. „ „ „ *Lagenaria vulgaris.*

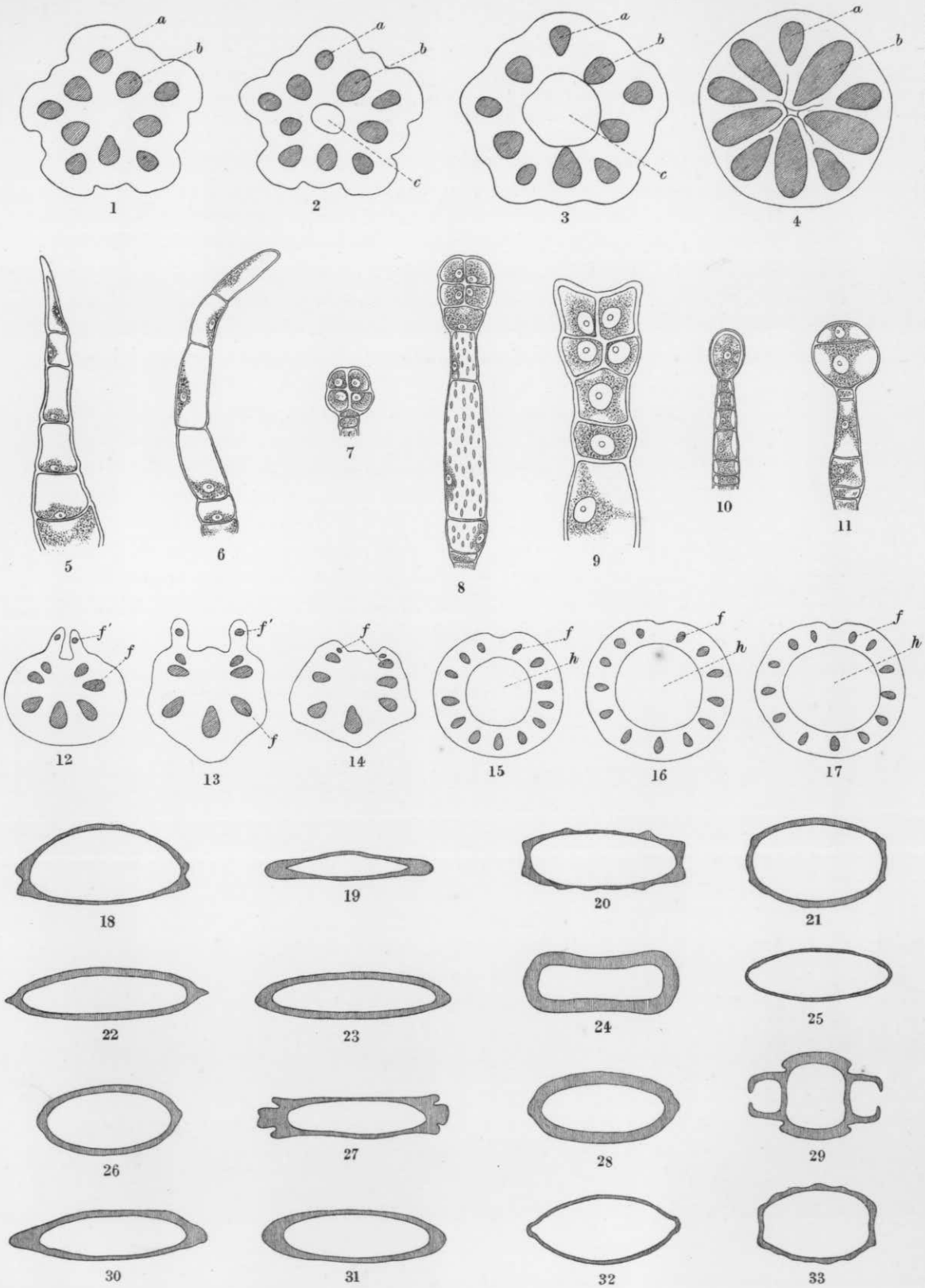
Fig. 29. „ „ „ *Trichosanthes cucumeroides.*

Fig. 30. „ „ „ *T. japonica.*

Fig. 31. „ „ „ *T. multiloba*

Fig. 32. „ „ „ *Cucurbita Pepo.*

Fig. 33. „ „ „ *Gymnostemma cissoides.*



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A. YASUDA.

ON THE COMPARATIVE ANATOMY OF THE CUCURBITACEÆ, WILD AND CULTIVATED, IN JAPAN.

PLATE II.

Plate II.

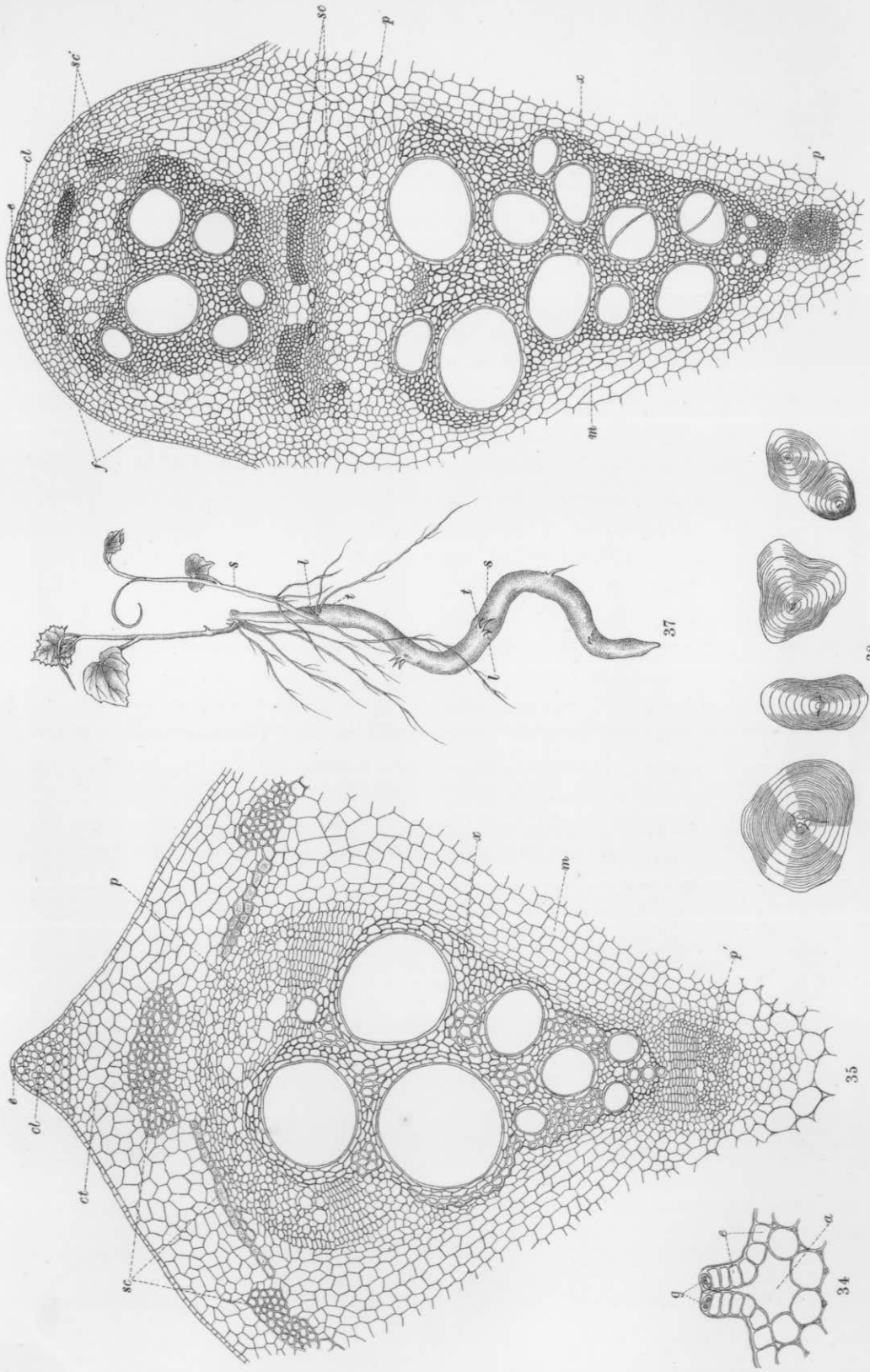
Fig. 34. Elevated stoma from the stem of *Lagenaria vulgaris*. *g*, guard-cells; *e*, epidermal cells; *a*, respiratory cavity. Zeiss, 4 × D.

Fig. 35. Transverse section through an angled portion of an old stem of *Luffa cylindrica*, showing the sharp ridge consisting of collenchyma. *e*, epidermis; *cl*, collenchyma; *ct*, cortex; *sc*, sclerenchyma; *p*, peripheral phloëm; *p'*, axial phloëm; *x*, xylem; *m*, medullary ray. Zeiss, 2 × B.

Fig. 36. Transverse section through a keeled portion of an old stem of *Momordica Charantia*, showing the sharp ridge consisting of a newly formed secondary fibro-vascular bundle. *e*, epidermis; *cl*, collenchyma; *f*, newly formed secondary fibro-vascular bundle; *p*, peripheral phloëm; *p*, axial phloëm; *x*, xylem of the primary bundle; *sc*, sclerenchyma of the primary bundle; *sc'*, sclerenchyma of the secondary bundle; *m*, medullary ray. Zeiss, 1 × B.

Fig. 37. Rhizome of *Melothria japonica* gathered in May. At each node three scales are developed, which are destined respectively to be a shoot (*s*), a leaf (*l*), and a tendril (*t*). Natural size.

Fig. 38. Starch-grains from the rhizome of *Gymnostemma cissoides*. Zeiss, 4 × D.



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A. YASUDA.

ON THE COMPARATIVE ANATOMY OF THE CUCURBITACEÆ, WILD AND CULTIVATED, IN JAPAN.

PLATE III.

Plate III.

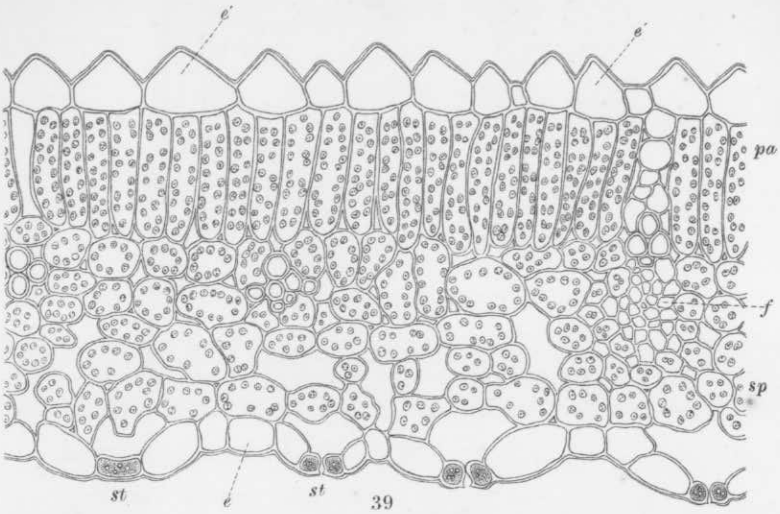
Fig. 39. Transverse section of the blade of *Trichosanthes cucumeroides.* *e*, epidermal cell on the under surface raised into conical papillae outwards; *st*, stoma; *pa*, pallisade parenchyma; *sp*, spongy parenchyma; *f*, fibro-vascular bundle. Zeiss, 4 × D.

Fig. 40. Transverse section of the blade of *Momordica Charantia.* *c*, cystoliths; *e*, epidermis; *st*, stoma; *pa*, pallisade parenchyma; *sp*, spongy parenchyma. Zeiss, 4 × D.

Fig. 41. Transverse section of the blade of *Gymnostemma cissoides.* *ch*, chloroplasts containing large spindle shaped starch-grains; *e*, epidermis; *st*, stoma; *pa*, pallisade parenchyma; *sp*, spongy parenchyma. Zeiss, 4 × D.

Fig. 42. Transverse section of the blade of *Cucurbita Pepo* through the etiolated portion. *e*, epidermis; *e'*, many-layered epidermis; *pa*, pallisade parenchyma; *sp*, spongy parenchyma. Zeiss, 4 × D.

Fig. 43–48. Diagrammatic representation of six types of the mid-ribs of the leaves in reference to the manner of development of fibro-vascular bundles. Cross sections. Fig. 43. *Actinostemma racemosum;* Fig. 44. *Melothria japonica;* Fig. 45. *Gymnostemma cissoides;* Fig. 46. *Cucumis sativus;* Fig. 47. *Momordica Charantia;* Fig. 48. *Cucurbita Pepo.* f, fibro-vascular bundle.



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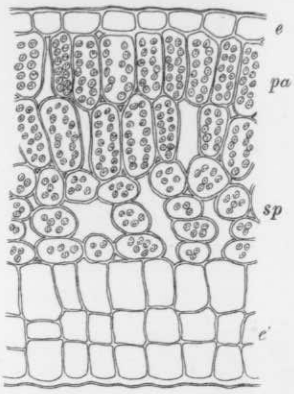

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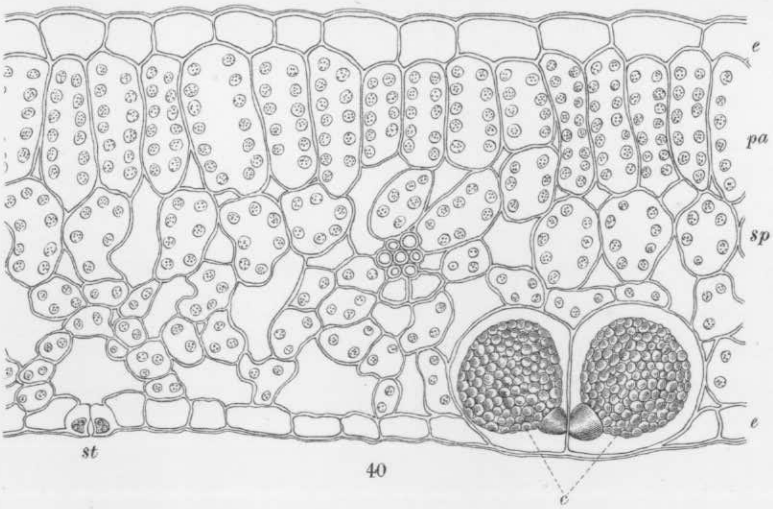

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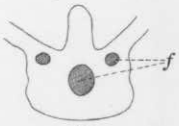

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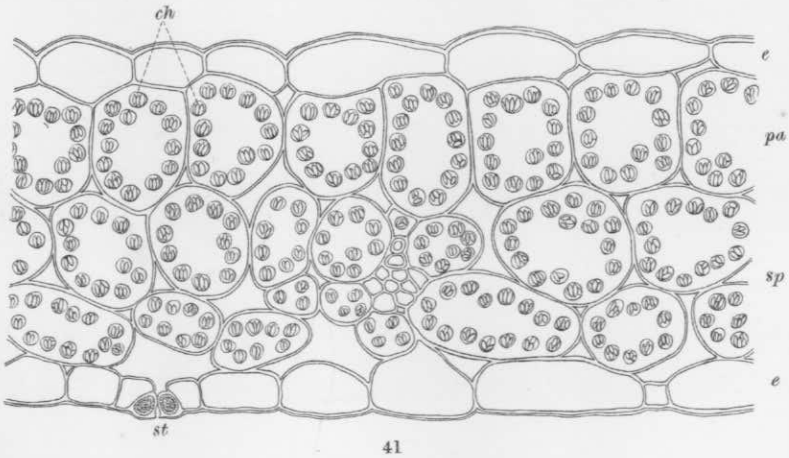

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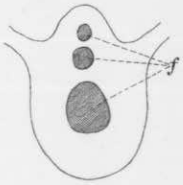

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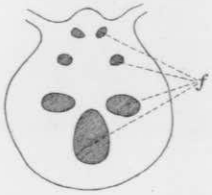

48

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PLATE IV.

Plate IV.

Fig. 49. Transverse section of a cotyledon of *Actinostemma racemosum*. *e*, epidermis; *st*, stoma; *pa*, pallisade parenchyma; *sp*, spongy parenchyma; *f*, fibro-vascular bundle; *i*, intercellular space. Zeiss, 2 × B.

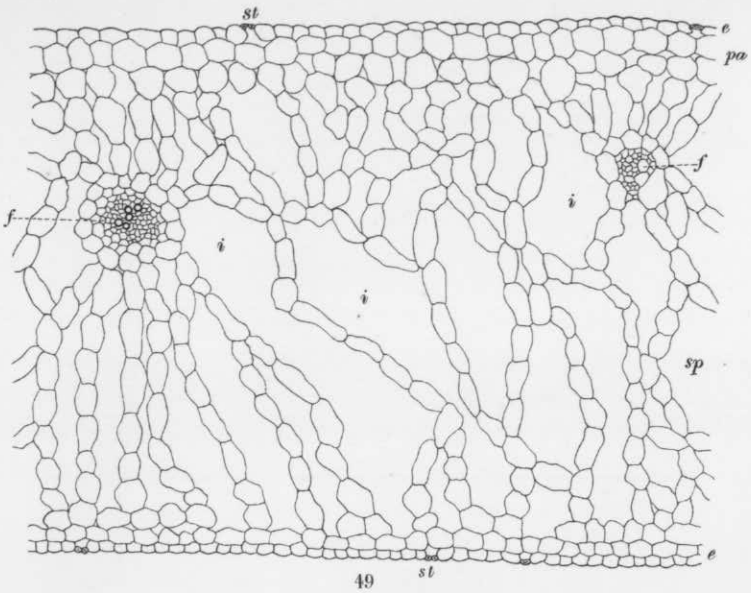
Fig. 50–54. Diagrams of transverse sections of a tendril of *Benincasa cerifera* through various portions. Fig. 50. The proximal portion; Fig. 51. A farther portion; Fig. 52 and Fig. 53. Still farther portions; Fig. 54. The distal portion. *f*, fibro-vascular bundle; *h*, central hollow.

Fig. 55. Transverse section of a young root of *Actinostemma racemosum*. *e*, epidermis; *i*, intercellular space; *en*, endodermis; *pc*, pericambium; *x*, tetrarch bundle. Zeiss, 4 × B.

Fig. 56. Scheme of a longitudinal section through a tubercle on the surface of the fruit of *Momordica Charantia*. *f*, fibro-vascular bundle; *t*, tubercle.

Fig. 57. Trichome from the surface of a young fruit of *Cucumis sativus*, supported on a protuberant parenchymatous base. *a*, trichome; *e*, epidermis; *b*, protuberant parenchymatous base. Zeiss, 2 × B.

Fig. 58. Longitudinal section through a tubercle on the surface of the fruit of *Actinostemma racemosum*. *t*, tubercle composed of parenchyma; *e*, epidermis; *p*, parenchyma; *sc*, a portion of sclerenchyma forming an incomplete ring around the pericarp; *f*, reduced fibro-vascular bundle. Zeiss, 3 × B.



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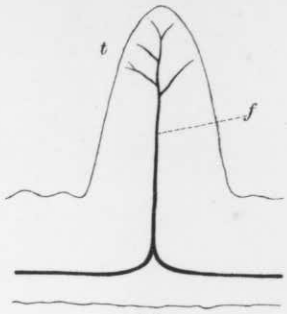
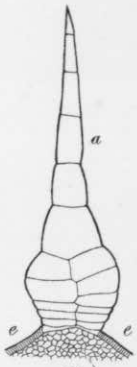


56



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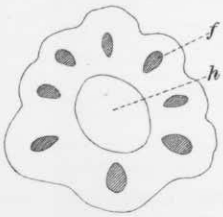

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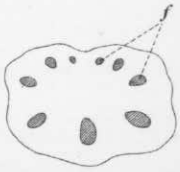

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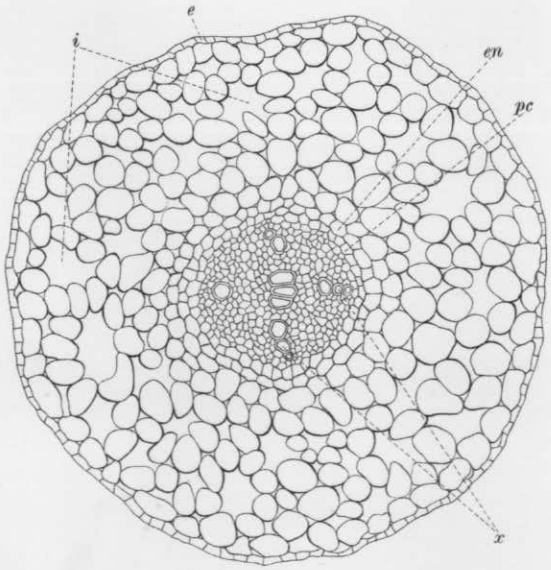

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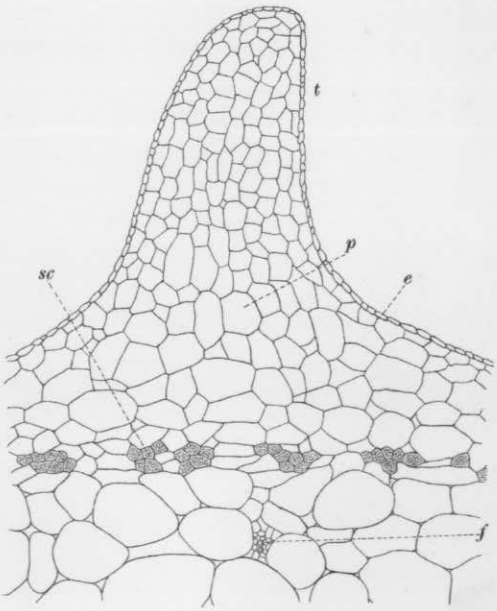

58

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PLATE V.

Plate V.

Fig. 59. Transverse section of a fibro-vascular bundle in the fruit-tissue of *Luffa cylindrica*. *sc*, well-developed sclerenchymatous sheath; *f*, enclosed rudimentary bundle; *p*, parenchymatous cell. Zeiss, 4 × B.

Fig. 60. Transverse section through the pericarp of *Cucumis sativus*. *e*, prismatic epidermal cell; *st*, stoma; *sb*, extra-phloëm sieve-tube; *p*, parenchymatous cell. Zeiss, 4 × B.

Fig. 61. Transverse section through the pericarp of *Benincasa cerifera*. *w*, wax; *e*, epidermal cell having a tangential septum; *h*, trichome; *st*, stoma; *sb*, extra-phloëm sieve-tube; *sc*, sclerenchymatous ring; *p*, parenchyma; *f*, fibro-vascular bundle; *k*, crystal. Zeiss, 4 × B.

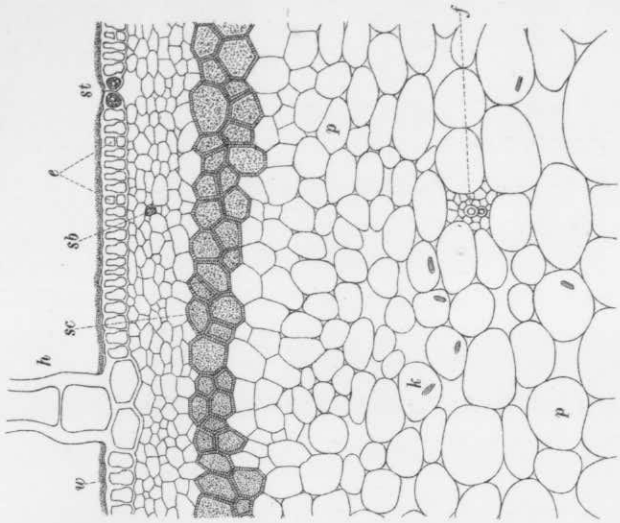
Fig. 62. Transverse section through the testa of *Luffa acutangula*. 1, first layer: prismatic epidermal cells with thickened-ridges; 2, second layer: small thick-walled pitted cells; 3, third layer: one row of characteristic large prismatic stone-cells; 4, fourth layer: thin-walled stellate pitted cells; 5, fifth layer: thin-walled compressed cells; 6, sixth layer: the remnant of the nucellus; 7, seventh layer: the remnant of the endosperm. *r*, thickening-ridge. Zeiss, 2 × D.

Fig. 63. Transverse section through the testa of *Actinostemma racemosum*. 1, first layer: flattened epidermal cells; 2, second layer: thick-walled reticulate and pitted cells; 3, third layer: several-layered stone-cells; 4, fourth layer: remarkably large reticulate cells; 5, 6, and 7, fifth, sixth, and seventh layers, like those in fig. 62.

Fig. 64. Transverse section through the testa of *Melothria japonica*. 1, first layer: prismatic epidermal cells with pointed, thickened-ridges; 2, second layer: thick-walled pitted cells; 3, third layer: stone-cells; 4, fourth layer: slightly pitted thin-walled cells; 5, 6, and 7, fifth, sixth, and seventh layers, like those in fig. 63. *r*, thickened-ridge. Zeiss, 2 × D.

Fig. 65. Tangential section through the epidermis of the testa of *Melothria japonica*. *e*, epidermal cell; *r*, thickened-ridges. Zeiss, 2 × D.

Fig. 66. Transverse section through the testa of *Schizopepon bryoniæfolius, var. japonicus*. 1, first layer: cubical epidermal cells with the thickened lateral walls; 2, second layer: thick-walled pitted cells; 3, third layer: large stone-cells; 4, fourth layer: stellate thin-walled pitted cells; 5, 6, and 7, fifth, sixth, and seventh layers, like those in fig. 64. Zeiss, 2 × D.



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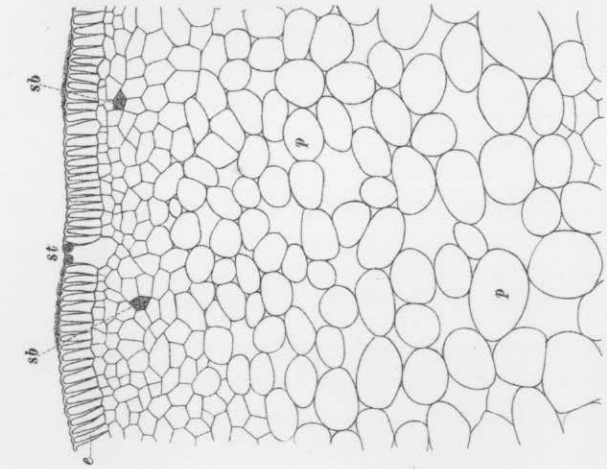

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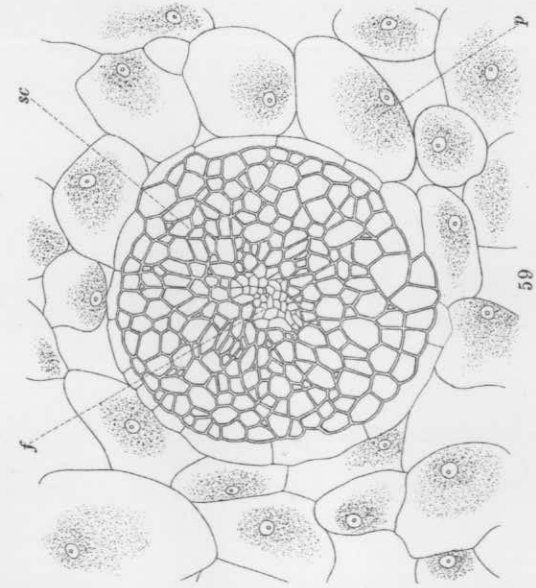

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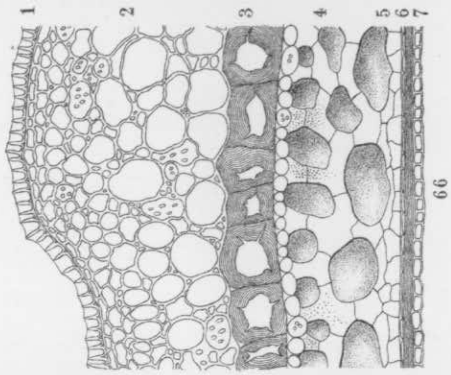

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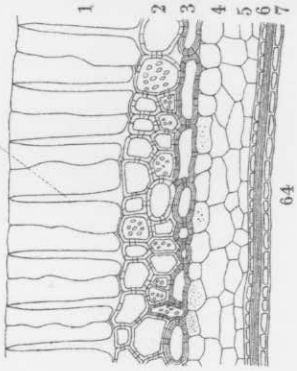

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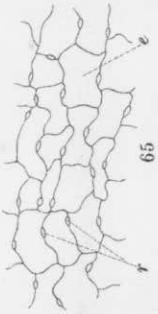

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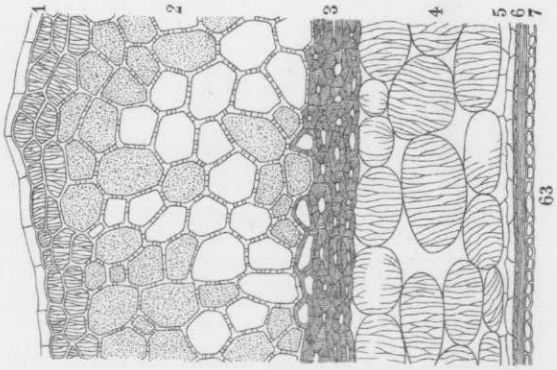

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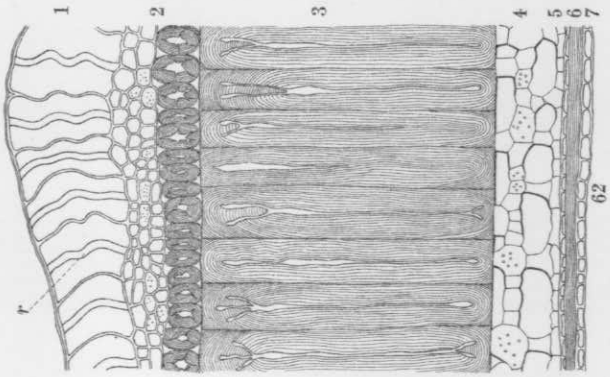

62

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