Notes on Avocado Anatomy

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The following notes are excerpts from an unpublished paper covering an investigation made by me while a student at Northwestern University. Avocado seeds were secured in California and a large number of seedlings were grown in the greenhouse. These were used in connection with several investigations, only one of which is reported on here.

I greatly appreciate the kind assistance given me by Dr. Carlson, my instructor in this work at Northwestern.

ROOT

The cortex of the root consists wholly of unspecialized parenchyma cells (Pigs 1, 2). The cortex is considerably thicker than that of the stem, a condition brought about as an adaptation to the function of storage. This cortex is, however, a temporary tissue, since the formation of a periderm layer, when secondary thickening takes place, does away with any need for it. Limiting the cortex on the inside is a layer of endodermis cells (Pig. 1). The endodermis is also a temporary tissue and disappears with the formation of secondary growth.

The pericycle is not very evident in the primary structure of the root but is of great importance and will be taken up under secondary growth.

In the primary vascular tissue of the root, the xylem occurs as four radially extending groups of cells with the first formed protoxylem situated at the outer ends of the rows of cells (Fig. 1). Thus in the development of the strands of primary xylem the first cells of the procambium strand to mature into xylem are those located near the pericycle region next to the endodermis. Prom this point, xylem cells are matured progressively towards the center of the stele. Instead of the xylem arms meeting in the center of the steele, there is a mass of parenchymatous tissue, forming a pith.

As already mentioned, there are four xylem arms to the vascular tissue and hence it is known as a tetrarch root.

When secondary growth begins, cabium originates as bands of meristems between the groups of primary phloem and the center of the stele. Here initials are formed that produce xylem cells towards the inside and phloem towards the outside, as is the regular procedure. In this matter, the primary phloem is crushed and the endodermis ruptured. The crushed cells are absorbed, a process that is little understood. After persistent secondary growth, a complete vascular cylinder is formed as is shown in Fig. 2. This tissue is fundamentally the same as that found in the stem.

The next important development to take place is the formation of periderm in the outer layers of the pericycle (Fig. 2). After this layer has been formed and considerable expanding has taken place, the cortex and endodermis is ruptured and soon decay. A smooth brownish covering of cork cells, broken only by lenticels, is the resulting outer tissue of the root.

STEM

The transition from root to stem is very difficult to observe in the avocado. Following the stem down to the point of attachment at the cotyledons, the regular arrangement of vascular tissue is observed. The cylinder here branches out, leaving cotyledon traces. Below the point of attachment, the vascular tissue begins in the arrangement of the root. It is evident that some sort of inversion must take place as the traces leave the cotyledons.

In the primary cylinder of the stem, there is very little difference from the secondary. There is a continuous cylinder of primary xylem, cambium, and phloem (Fig. 3).

As the vascular tissue develops, the relation of the position of the primary and secondary xylem is just the reverse of the root. The xylem in the root being exarch and that of the stem, endarch.

Just outside of the secondary phloem, perhaps in the pericycle, a narrow band of thick walled sclerenchyma cells originate. These cells (Fig. 5) are an adaptation to the function of the stem. Since the fruit that the stem must bear is very heavy in proportion to the thickness and structure of this organ, it can readily be seen that a cylinder of strengthening cells is much needed.

The lenticel as seen in Fig. 5 is especially prominent in the young seedling. They are spaced at intervals of about one-half inch wherever there is periderm to produce them. As the tree matures, the lenticels disappear and are almost entirely done away with.

The formation of cork (Fig. 6) is very clearly illustrated in the Avocado. When the epidermis of the primary stem ceases to function, a new protective layer, the periderm, is formed. The periderm consists of three layers of tissue: the initiating layer of meristem, known as the phellogen, or cork cambium; the layer of cells formed towards the outside by this meristem, the phellem, or cork; and the layer formed toward the inside, the phelloderm. The phellogen acts as a secondary meristem. It produces fairly equal amounts of cells on either side of itself. Bark taken from the mature trunk, however, does not have a very heavy layer of cork cells, as can be seen in the last drawing of Fig. 6.

LEAF

The vascular skeleton of the avocado leaf may be classified as net veined. The vein islets are very small but of a definite type.

The xylem and phloem elements of the leaf are arranged in the same manner as the other vascular tissue of the plant (Fig. 8). The same type of vessels, tracheids, fibres,

and parenchyma, both primary and secondary, occur, and in much the same proportion and relation to one another as found in the stele itself; this holds true for xylem and phloem.
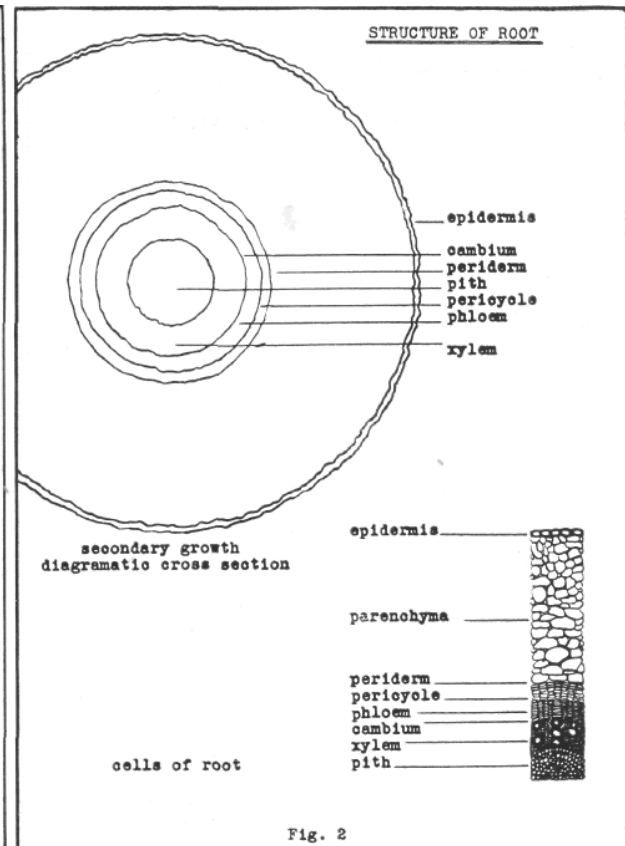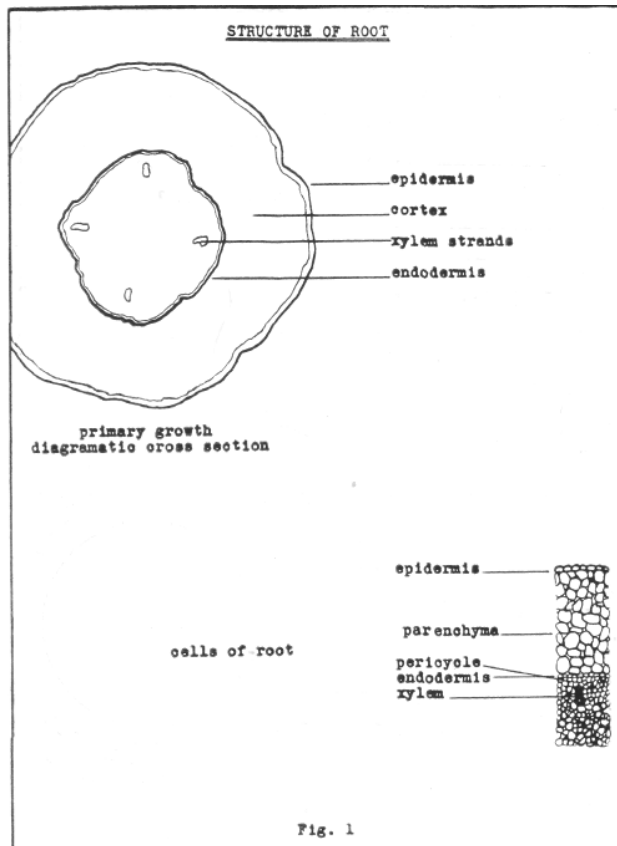
The epidermis is cutinized and the lower part is covered with hairs. These hairs are most abundant on young leaves.
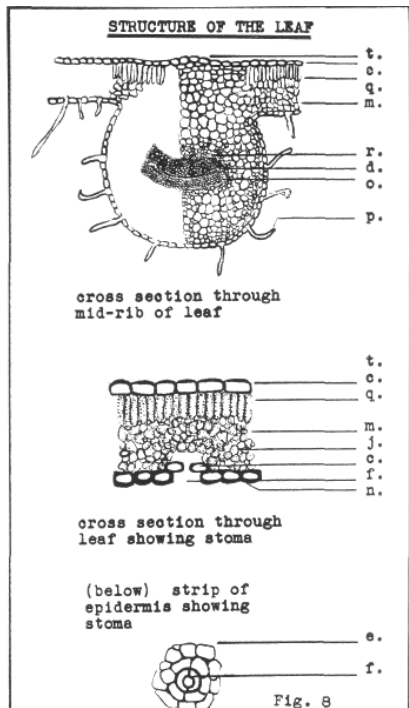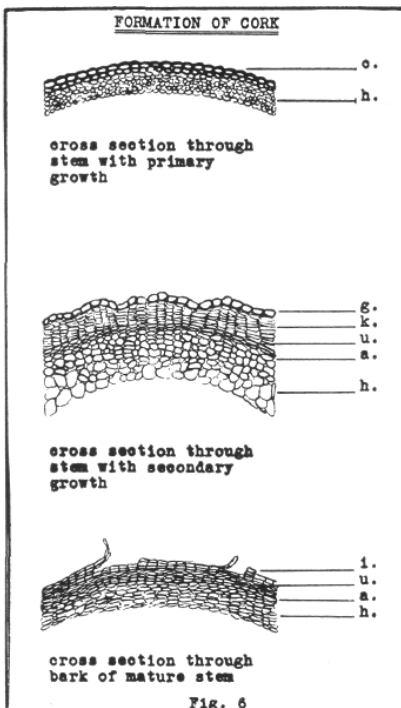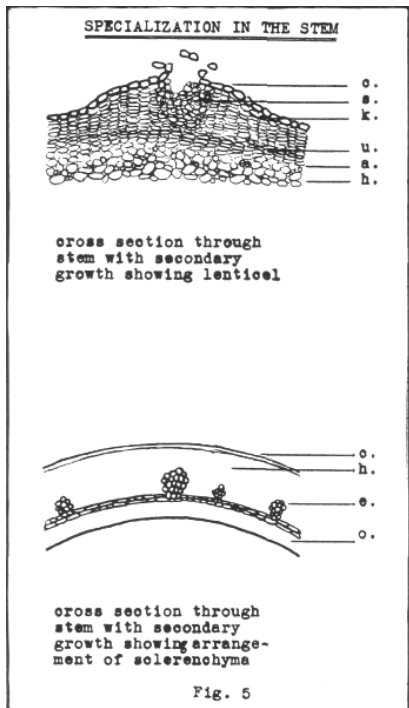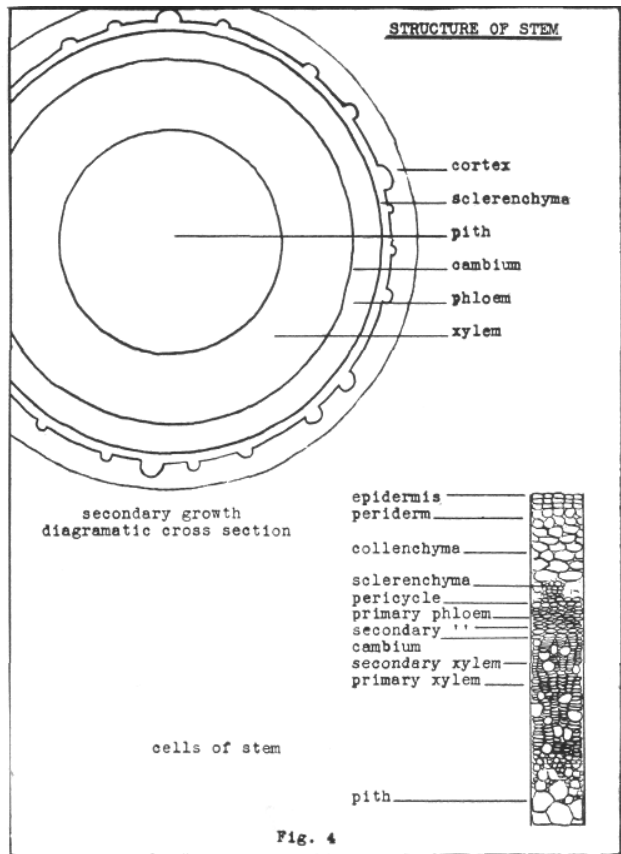
The palisade layer is arranged in a single layer of elongated, cylindrical cells. They are extremely close packed. The spongy layer is also close packed, a condition that is different from most leaves, although there are a few intercellular spaces (Fig. 8).

The stomata are found only on the dorsal side of the leaf and are relatively few in number. The guard cells are sunk below the lower epidermis and often there is an abundance of hairs growing immediately around this region.

PETIOLES

As the traces pass out of the stele and enter the petiole, the xylem and phloem maintain their relative positions. Thus we have xylem on the dorsal side and phloem on the ventral. Aside from the fact that the vascular tissue is in a crescent there is no difference in the stem and the petiole.

STRUCTURE OF ROOT

epidermis
cortex
xylem strands
endodermis

primary growth
diagramatic cross section

cells of root

epidermis
parenchyma
pericycle
endodermis
xylem

Fig. 1

STRUCTURE OF ROOT

epidermis
cambium
periderm
pith
pericycle
phloem

xylem

secondary growth
diagramatic cross section

epidermis

parenchyma

periderm
pericycle
phloem
cambium
xylem
cells of root   pith

Fig. 2

STRUCTURE OF STEM

phloem
cambium
xylem
pith
cortex
epidermis

primary growth
diagramatic cross section

cells of stem

epidermis
collenchyma
phloem
cambium
xylem

pith

Fig. 3

STRUCTURE OF STEM

cortex
sclerenchyma
pith
cambium
phloem
xylem

secondary growth
diagramatic cross section

cells of stem

epidermis
periderm
collenchyma
sclerenchyma
pericycle
primary phloem
secondary ''
cambium
secondary xylem
primary xylem

pith

Fig. 4

SPECIALIZATION IN THE STEM

o.
s.
k.
u.
a.
h.

cross section through
stem with secondary
growth showing lenticel

o.
h.
e.
o.

cross section through
stem with secondary
growth showing arrange-
ment of sclerenchyma

Fig. 5

FORMATION OF CORK

o.
h.

cross section through
stem with primary
growth

g.
k.
u.
a.
h.

cross section through
stem with secondary
growth

i.
u.
a.
h.

cross section through
bark of mature stem

Fig. 6

STRUCTURE OF THE LEAF

t.
c.
q.
m.

r.
d.
o.

p.

cross section through
mid-rib of leaf

t.
c.
q.
m.
j.
c.
f.
n.

cross section through
leaf showing stoma

(below) strip of
epidermis showing
stoma

e.
f.

Fig. 8

(a) Phelloderm; (c) Epidermis; (d) Cambium; (e) In Fig. 8 Epidermal cells, in Fig 5. Schlerenchyma; (f) Stoma; (g) Corky epidermis; (h) Collenchyma; (i) Cork; (j) air spaces (intercellular); (k) phellem; (m) Spongy tissue; (n) Lower epidermis; (o) Phloem; (p) Hairs; (q) Palisade tissue; (r) Xylem; (s) Complimentary cells; (t) Cutin;....(u) Phellogen.