

Plant Anatomy and Morphology

A horticulturist who does not know the basic anatomy of plants is like a nurse that does not know basic human anatomy. It could turn out to be down right uncomfortable where he/she sticks that thermometer! So we are going to take a tour of plant structure. A working knowledge of plant anatomy is absolutely essential in:

- plant propagation: grafting, budding, division, cuttings, layering, tissue culture
- pruning
- making crosses in plant breeding
- diagnosing plant disorders

Anatomy is very simply. Anatomists simply look at the outside and inside of plants and when they see distinctive structures they give them a name. At the whole plant level, plants are divided into **four organs**: The root, stem and leaf are vegetative organs, and the flower, and resultant fruit, is a reproductive organ.

Plant Organs

- root
- stem
- leaf
- flower

Each organ is composed of **three tissue systems**:

Tissue Systems

- dermal tissue system
- vascular tissue system
- ground or fundamental tissue system

Each tissue system is composed of distinctive **tissues** (epidermis, periderm, xylem, phloem, cortex, pith and mesophyll), and tissues are in-turn composed of **cells** (parenchyma, collenchyma, sclerenchyma, and specialized cells such as trichomes, vessels, companion cells, laticifers, etc.).

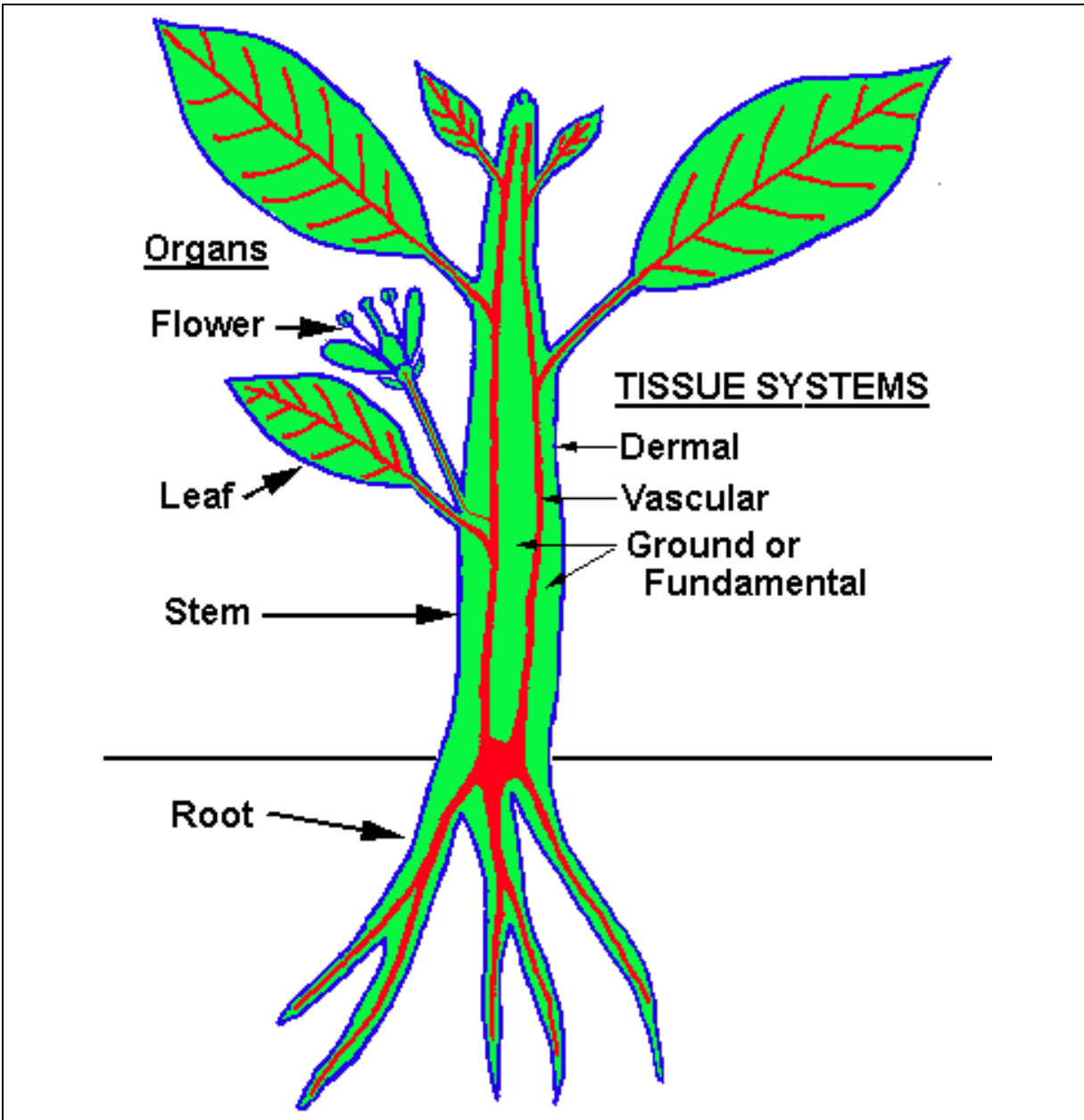
Plants produce all these structures by growing from discrete clusters of dividing cells called **meristems**. Herbaceous tissue is growth in length from: 1) **apical meristems**, which occur at the end of every shoot and root, and 2) **intercalary meristem** at the base of grass leaves. Woody tissue is due to growth in diameter from: 1) **vascular cambium**, which produce secondary xylem (wood) and phloem, and 2) **phellogen**, which produces the **periderm** (bark).

Virtually all of the crops we grow in horticulture are monocots (linear leaves, ex. grasses, corn, dracaena, and palm), **dicots** (broad-leaved plants, ex. oak, lettuce, apple) or **gymnosperms** (leaves as needles and scales, ex. pine, juniper). The internal anatomy of monocots, dicots and gymnosperms are sometimes similar and sometimes different. Different types of plants are not like animals - all the tissues and organs are not always in the same location. Thus, one must know the basic anatomical similarities and differences of each, or else you are not going to know where to insert that thermometer - ouch!

ORGANS AND TISSUE SYSTEMS

Plants are composed of 3 vegetative organs and 1 reproductive organ.

Three tissue systems comprise each organ and are contiguous between each of the four organs.



HOW DO PLANTS GROW?

Meristems and Growth

Primary Growth - growth in length that gives rise to primary (herbaceous) tissues called the primary plant body.

2 -Types

apical meristem or **apex** - the growing points located at the tips of stems and roots

intercalary meristem - the growth region at the base of grass leaves which causes leaves to elongate.

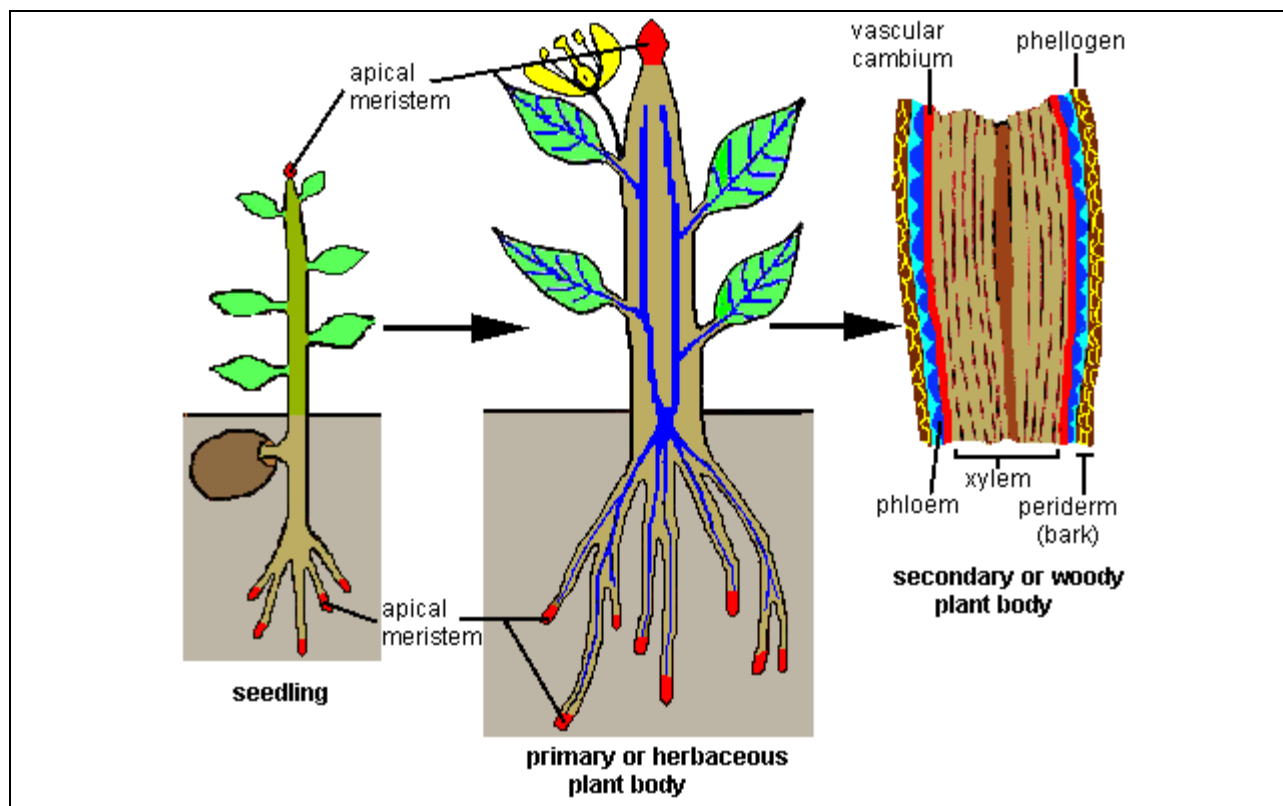
Secondary Growth - growth in width or diameter which gives rise to secondary (woody or corky) tissues called the secondary plant body.

lateral meristem - meristematic regions along the sides of stems and roots.

2 Types

vascular cambium or **cambium** - gives rise to secondary xylem (wood) on the inside and phloem on the outside.

cork cambium or **phellogen** - gives rise to the **periderm** (bark).



STEM ANATOMY

Herbaceous Dicot or Gymnosperm - Primary Growth

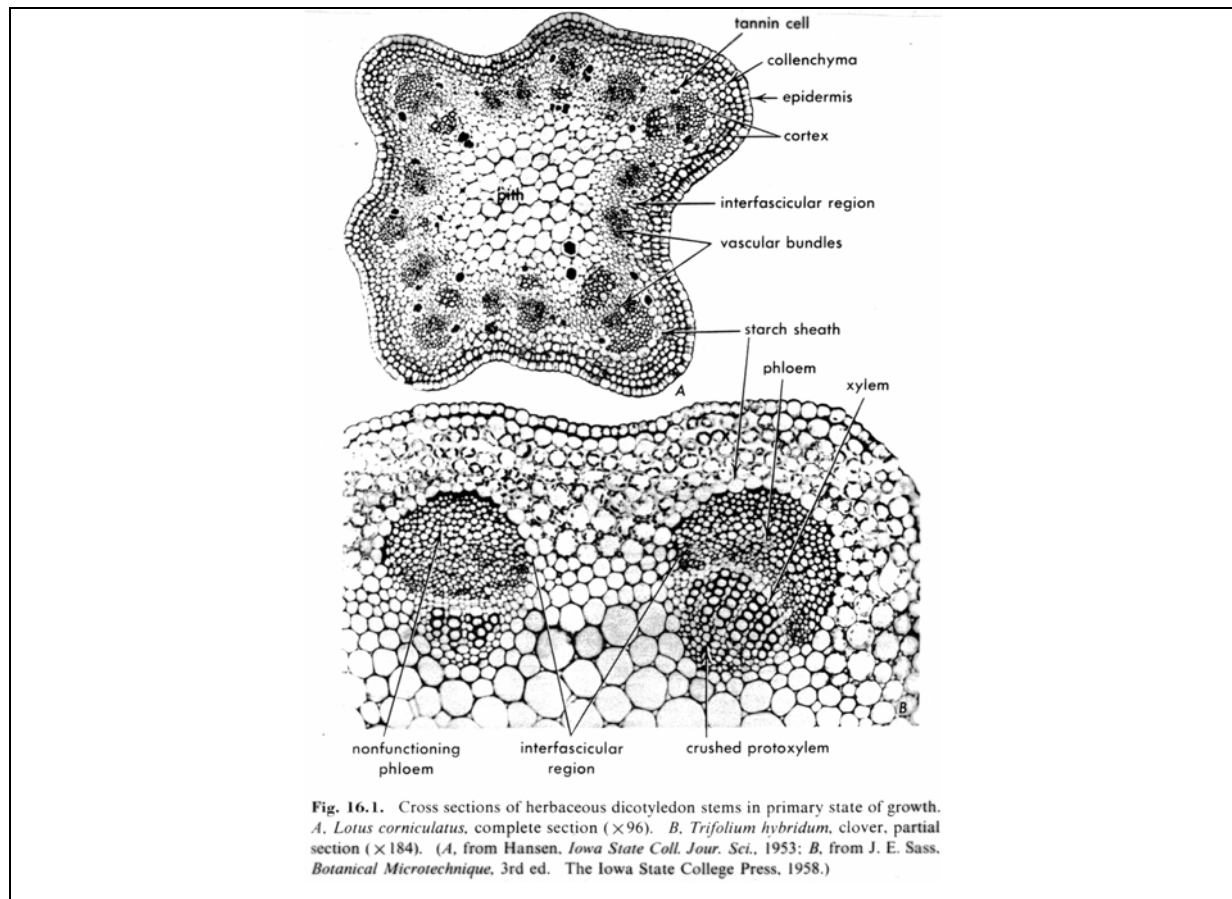
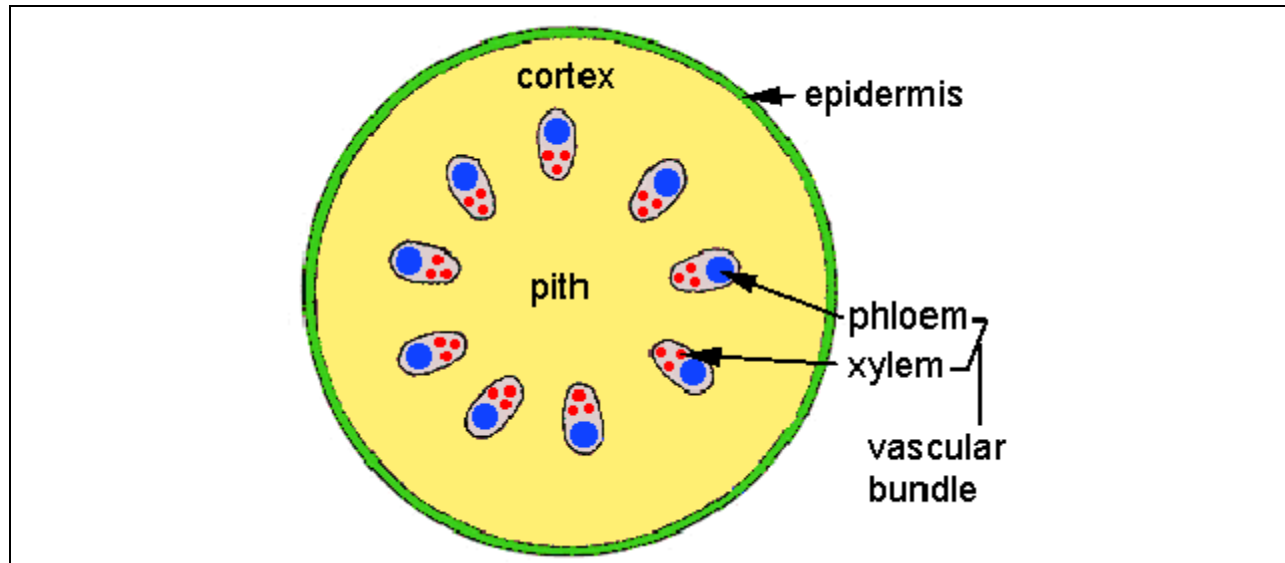
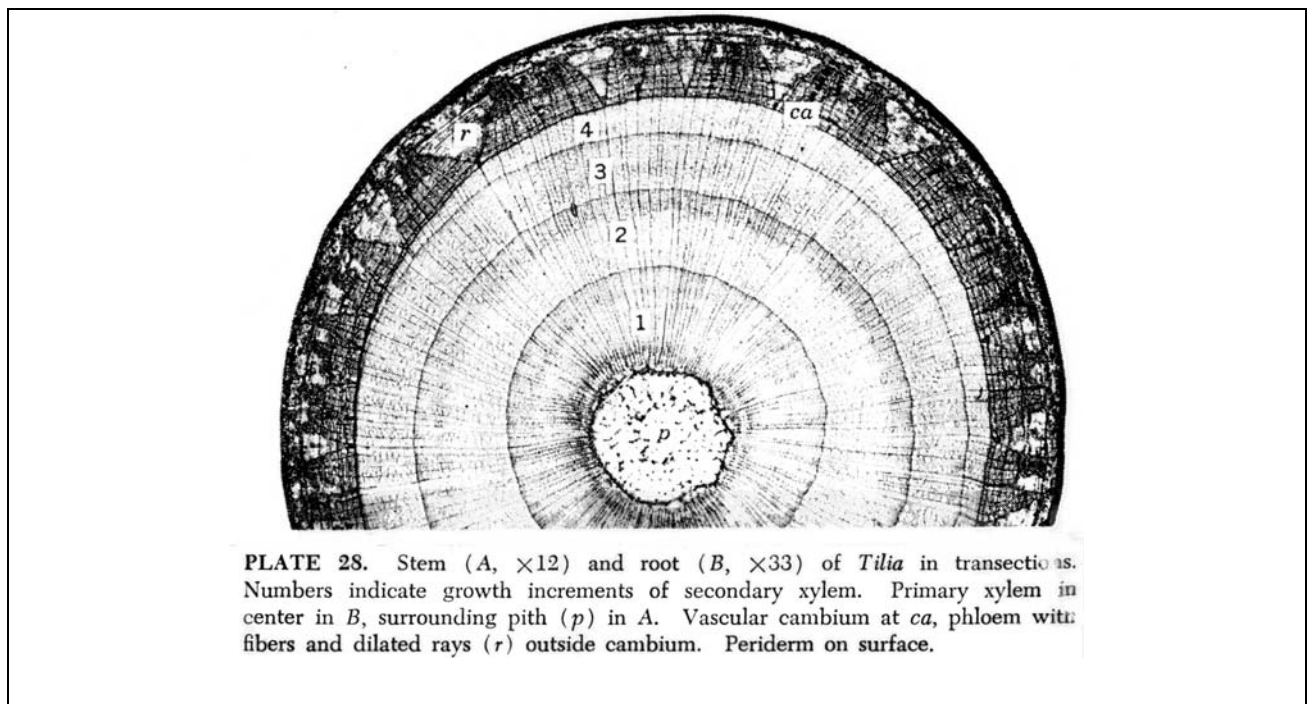
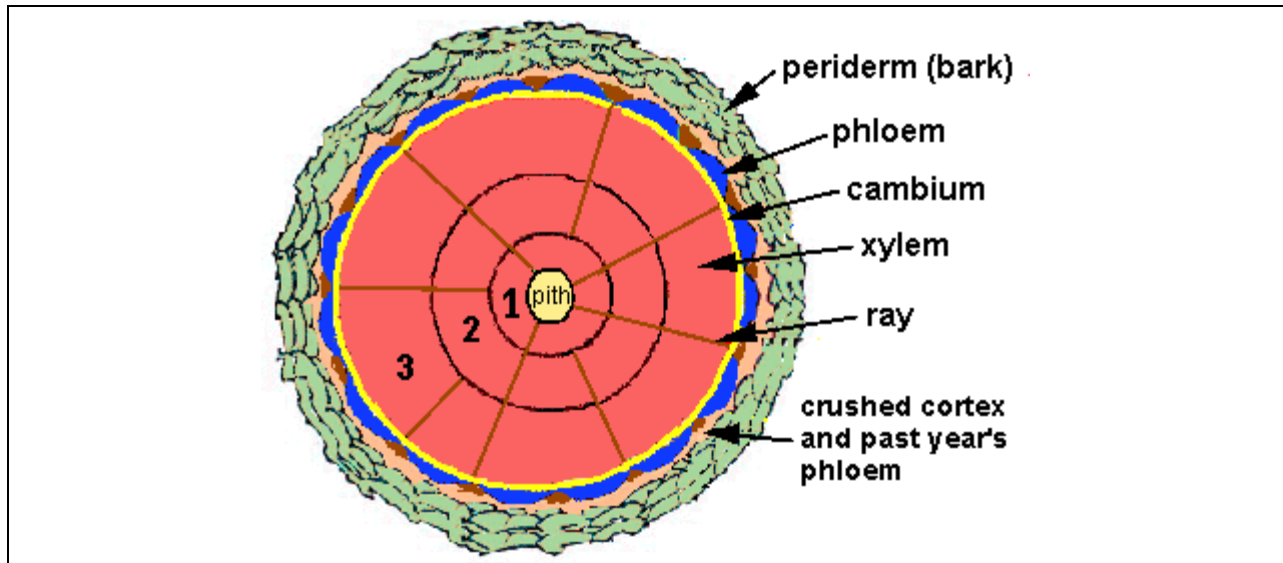


Fig. 16.1. Cross sections of herbaceous dicotyledon stems in primary state of growth. *A.* *Lotus corniculatus*, complete section ($\times 96$). *B.* *Trifolium hybridum*, clover, partial section ($\times 184$). (*A.* from Hansen, *Iowa State Coll. Jour. Sci.*, 1953; *B.* from J. E. Sass, *Botanical Microtechnique*, 3rd ed. The Iowa State College Press, 1958.)

(Fig. 16.1 from Esau 1960)

STEM ANATOMY

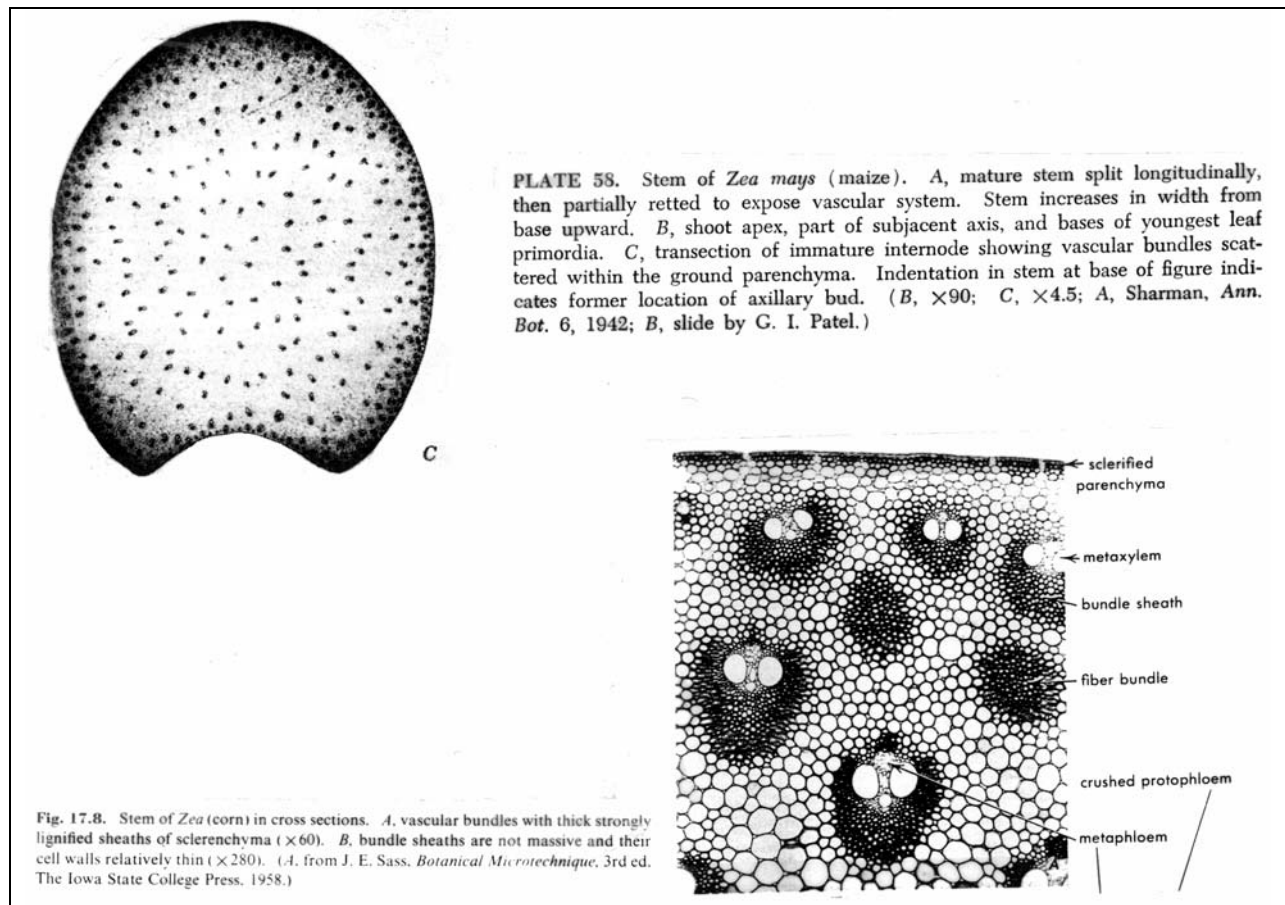
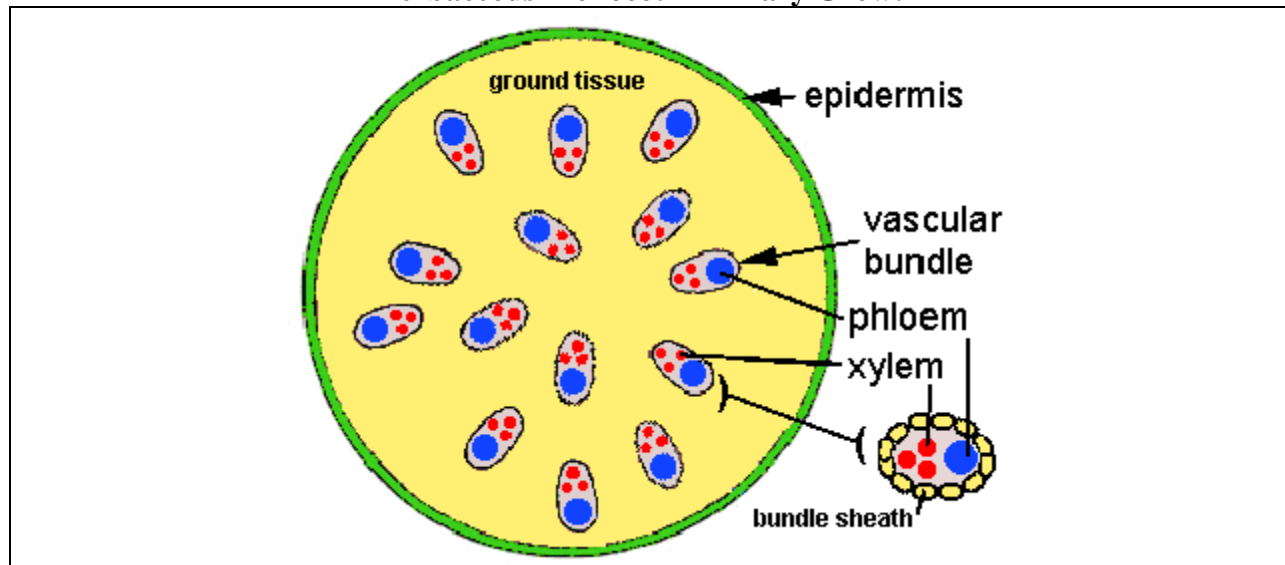
Woody Dicot or Gymnosperm - Secondary Growth



(Plate 28 from Esau 1965)

STEM ANATOMY

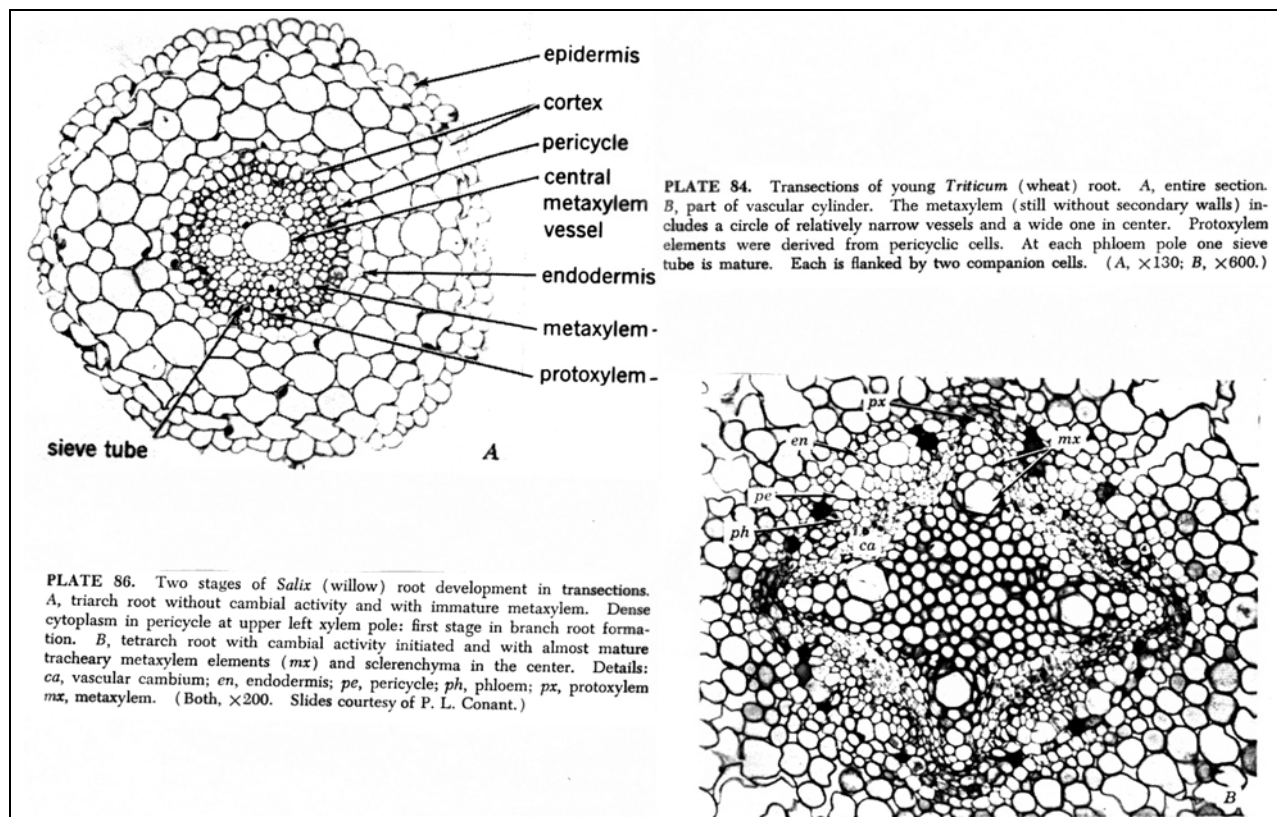
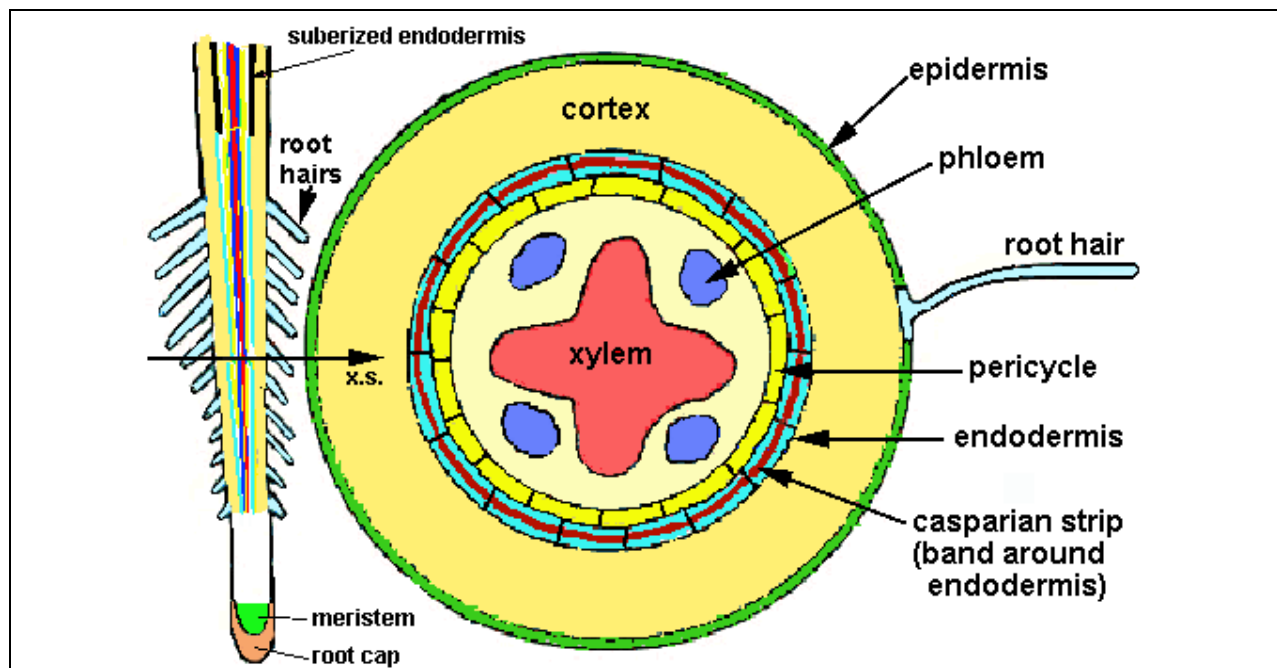
Herbaceous Monocot - Primary Growth



(Plate 58 from Esau 1965, Fig. 17.8 from Esau 1960)

ROOT ANATOMY

Herbaceous Dicot, Gymnosperm or Monocot - Primary Growth

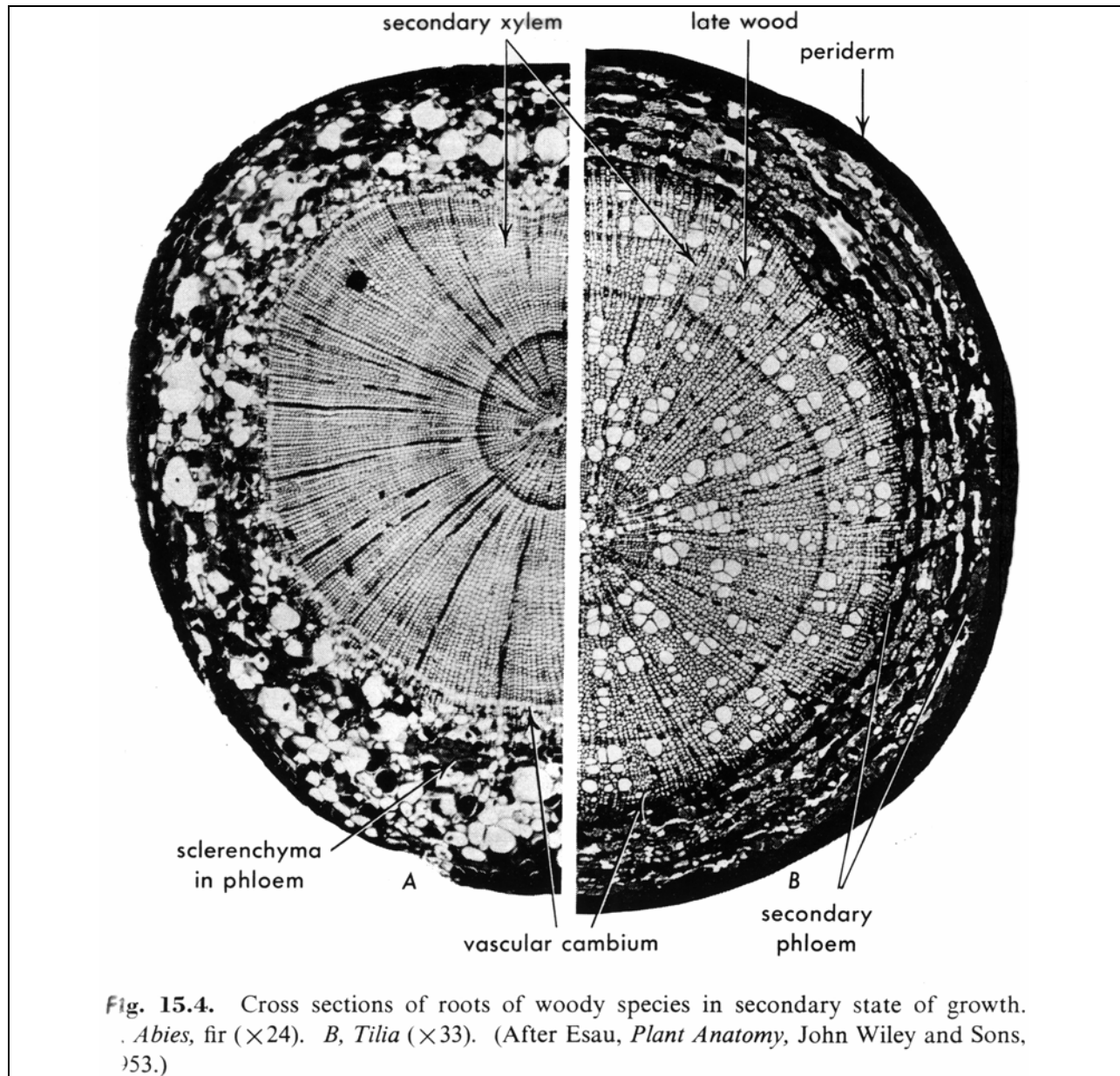


(Plate 84 & 86 from Esau 1965)

ROOT ANATOMY

Woody Dicot or Gymnosperm - Secondary Growth

A woody dicot or gymnosperm root in secondary growth looks very similar to a stem in secondary growth. The tissue is more porous and less dense, and the periderm is thinner. Rings of xylem growth may not be as distinctive as occurs in stems. This is because roots of temperate plants do not possess a distinctive “rest” or “physiological dormancy” period during the winter as do buds and shoots. Root growth may occur whenever the soil moisture, fertility and temperature are favorable.



(Fig.15.4 from Esau 1960)

LEAF ANATOMY

Dicot

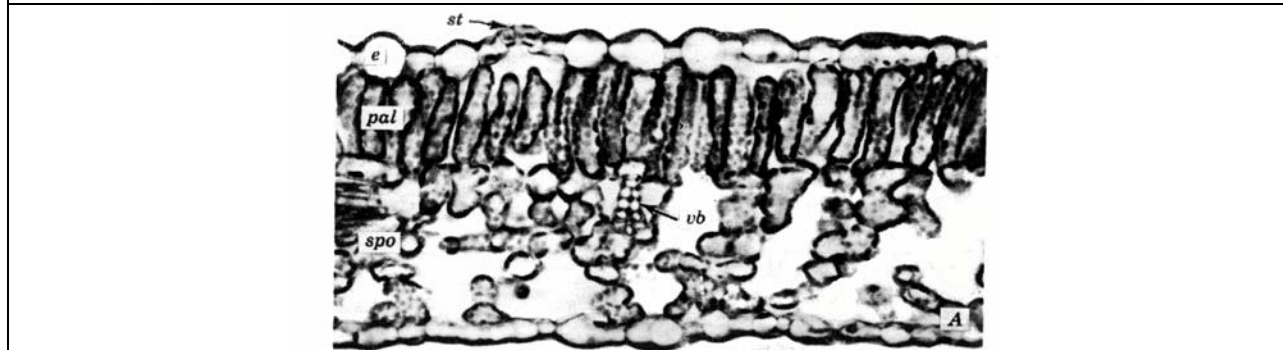
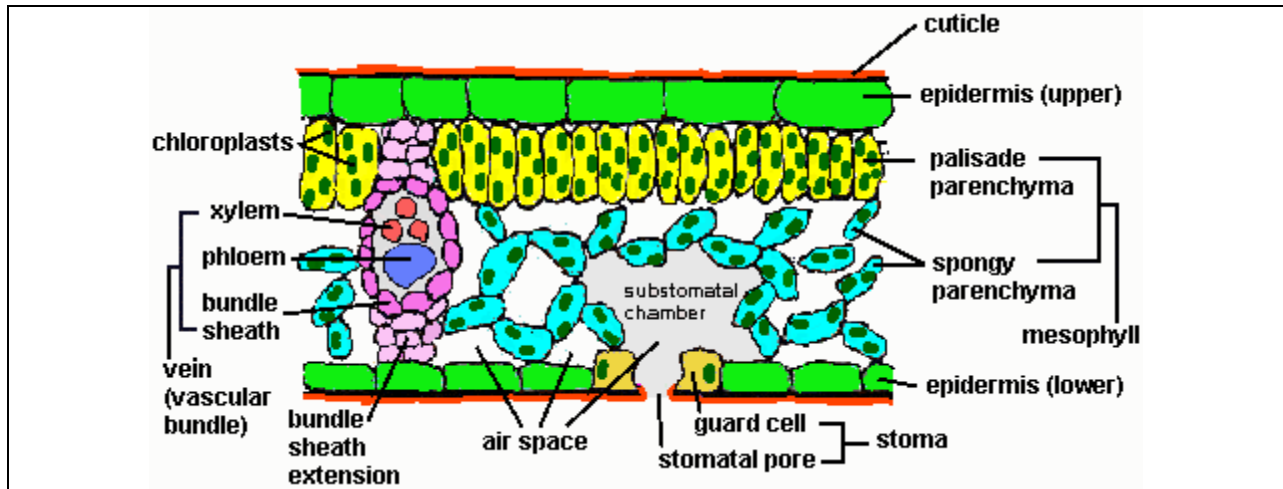


PLATE 73. A, transection of leaf of *Nicotiana tabacum*. Details: e, epidermis; pal, palisade parenchyma; spo, spongy parenchyma; st, stoma; vb, vascula bundle. B, cleared *Boronia* leaf. Sclereids (sc) at bundle ends (be). (A $\times 280$; B, Foster, *Amer. Jour. Bot.* 42, 1955, $\times 93$.)

(Plate 73 from Esau 1965)

Monocot

(Similar to dicot, except no palisade, mesophyll is all spongy parenchyma)

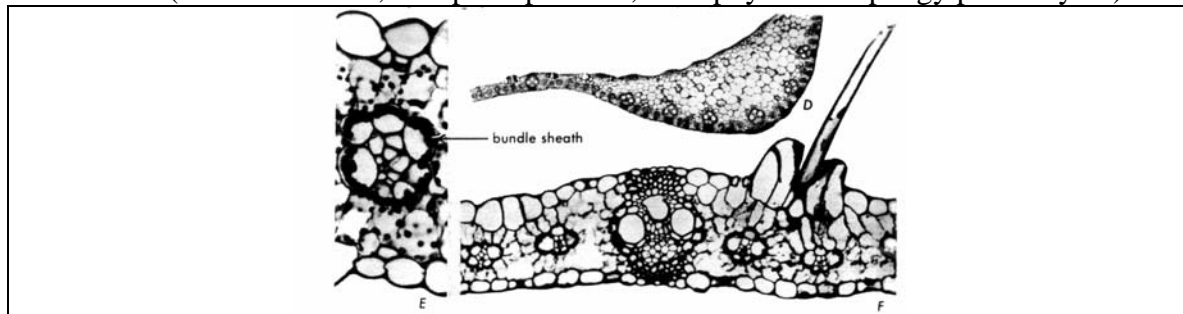


Fig. 19.6. Leaves of grasses in cross sections. A, margin of *Bromus* blade. B, midvein of *Poa* blade. C, blade of *Saccharum* (sugar cane). D, midvein of *Zea* (corn) leaf. E, F, blade of *Zea*. (A-C, $\times 150$; D, $\times 14$; E, $\times 320$; F, $\times 98$. A-C, slides courtesy of J. E. Sassi; D, F, from J. E. Sassi, *Botanical Microtechnique*, 3rd ed. The Iowa State College Press, 1958.)

(Fig. 19.6 from Esau 1960)

LEAF ANATOMY

Gymnosperm

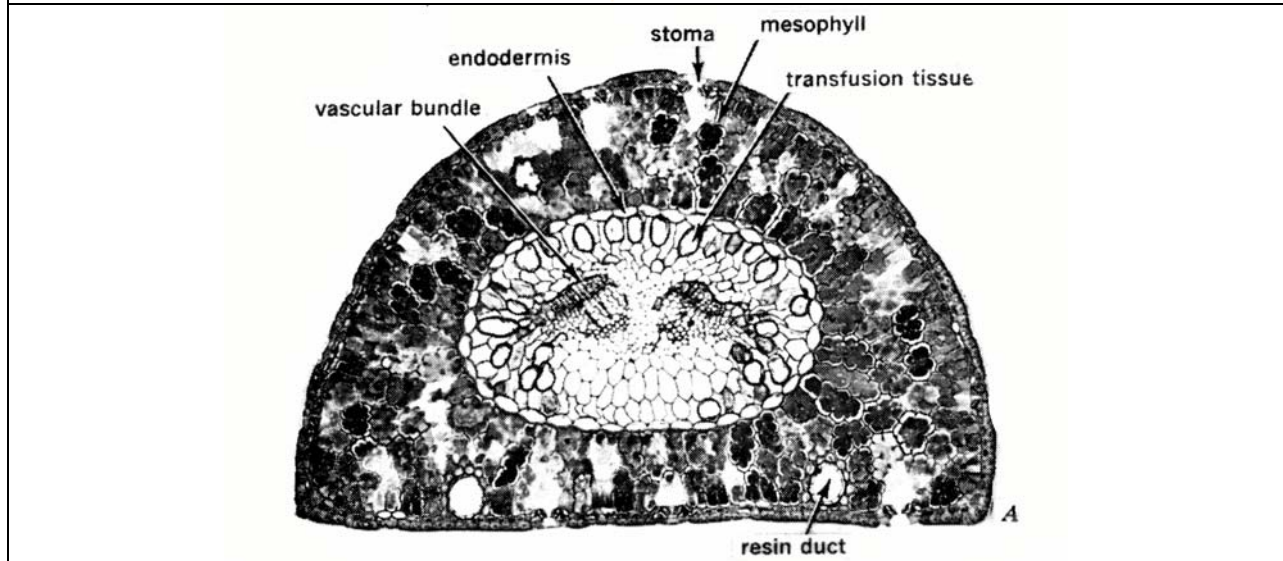
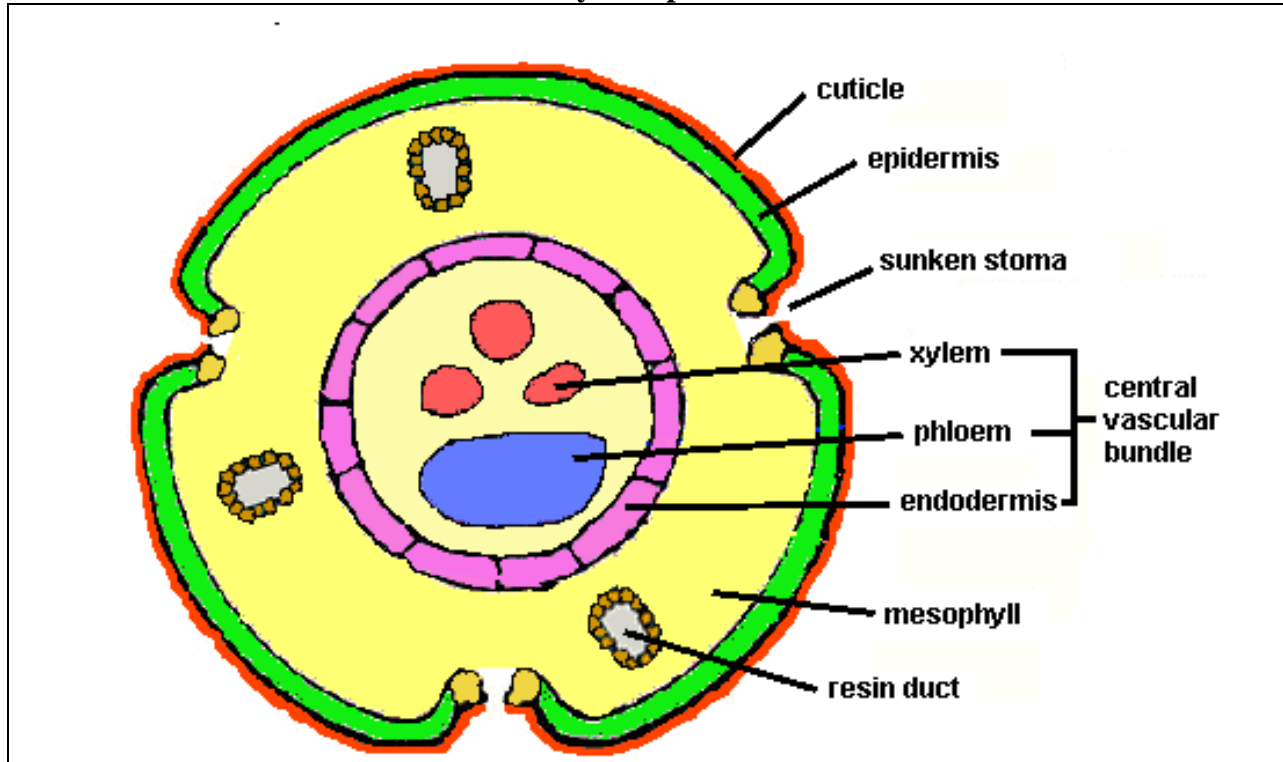
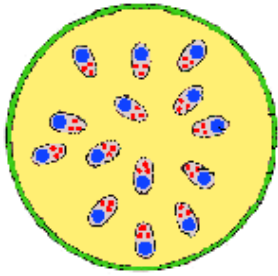
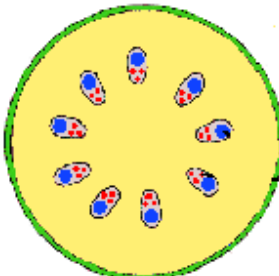
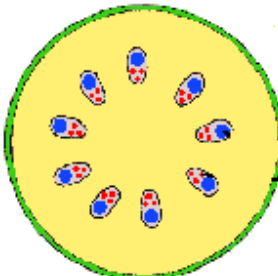
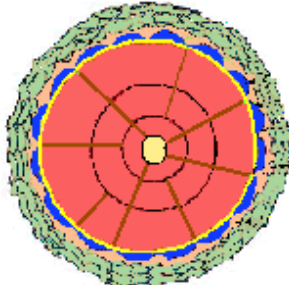
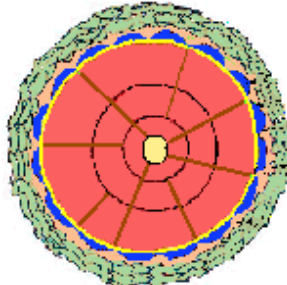
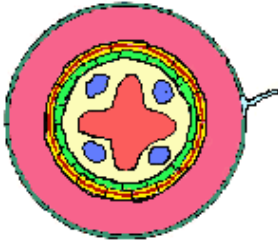
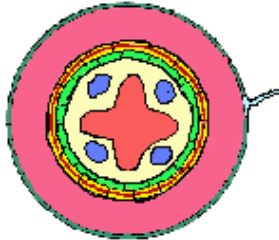
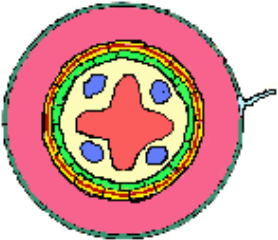
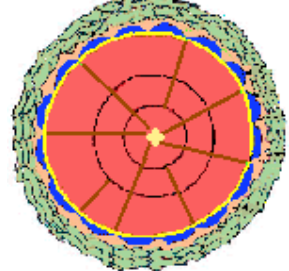
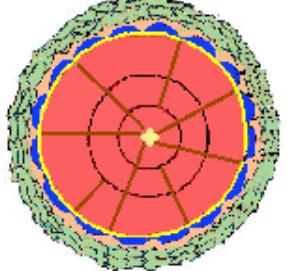


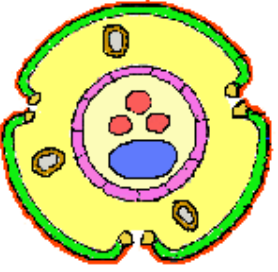


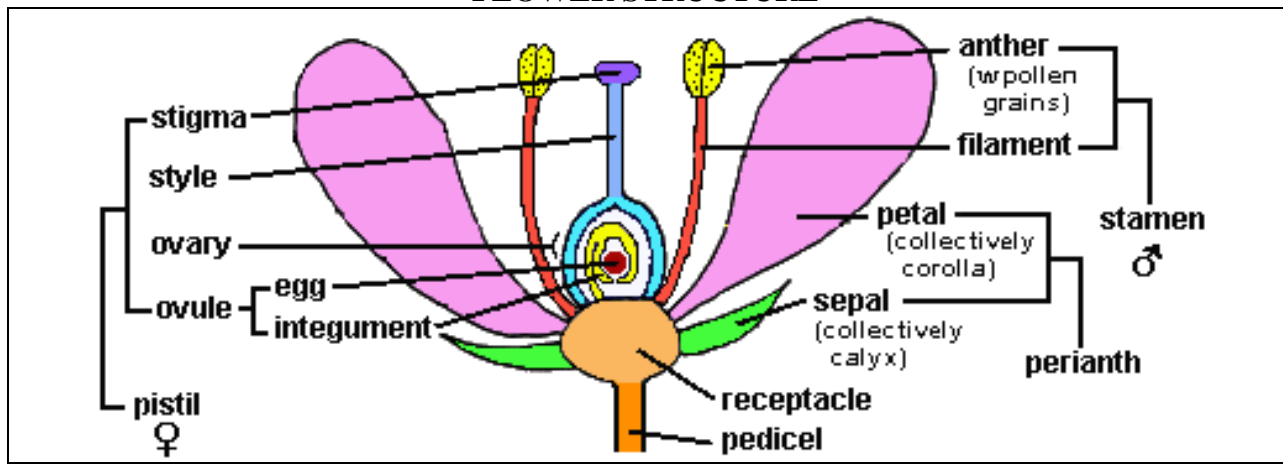
PLATE 78. Conifer leaf, *Pinus resinosa*. Transections. A, entire section; B, parts of vascular bundle (left), transfusion tissue (middle), and endodermis (right). (A, $\times 78$; B, $\times 490$.)

(Plate 78 from Esau 1965)

SUMMARY OF ANATOMY – VEGETATIVE STRUCTURES

		MONOCOT	DICOT	GYMNOSPERM
STEM	PRIMARY (herbaceous) GROWTH			
	SECONDARY (woody) GROWTH	none		
ROOT	PRIMARY (herbaceous) GROWTH			
	SECONDARY (woody) GROWTH	none		
LEAF	PRIMARY (herbaceous) GROWTH			
	SECONDARY (woody) GROWTH	none	none	none

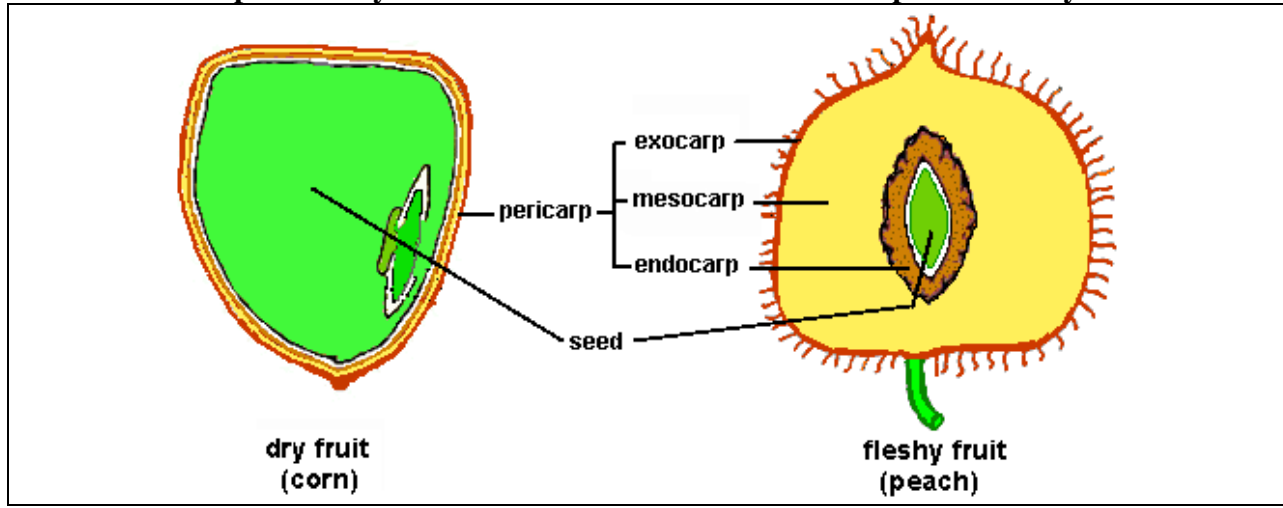
FLOWER STRUCTURE



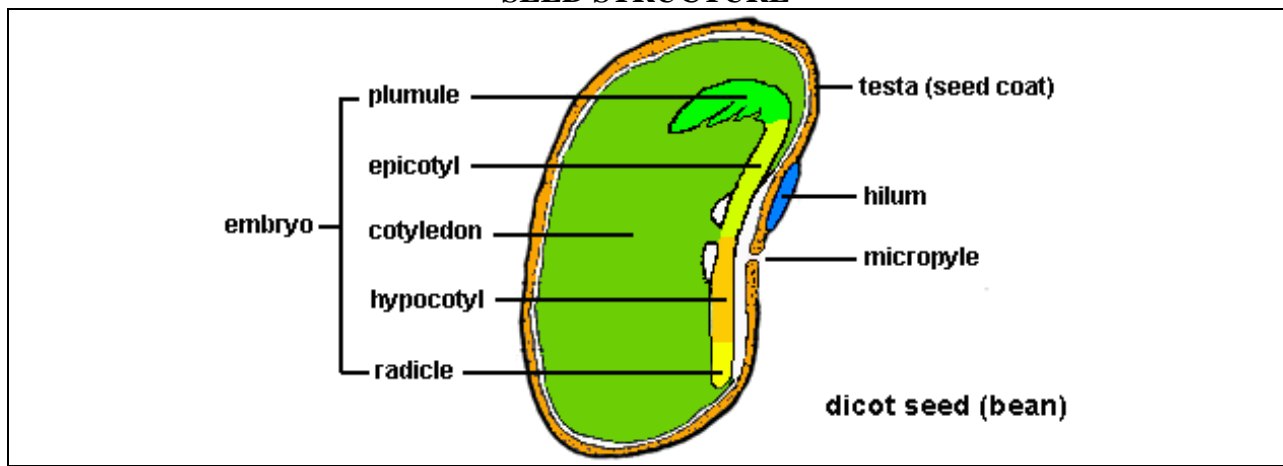
FRUIT STRUCTURE

Example of a dry fruit

Example of a fleshy fruit



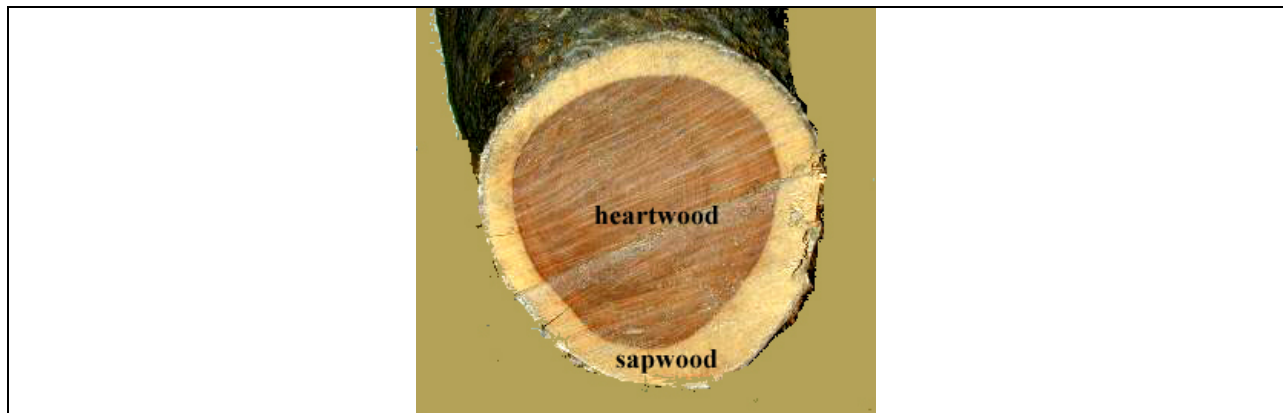
SEED STRUCTURE



Anatomical Structure and Function

"Structure and function" is a term used when the anatomy of a plant part explains how it functions. Structure and function brings anatomy to the real world, and it is what makes anatomy exciting. We are going to take a close look at one of the most important structure function relationships in plants - **translocation**. The tissues responsible for long distance translocation in plants are **xylem** and **phloem**.

Xylem is composed dead, hollow cells with perforated walls. The xylem cells are called vessel elements or tracheids. . They are connected end to end and clustered side by side. They are like a cluster of leaky pipes with holes on all sides. If you took sewer drain field pipe and connected them end to end, and bundled many of them together side by side, you would have a perfect model of xylem. Xylem only flows up. All xylem is dead and the water is "passively" pulled up stems by transpiration of water from the leaves. It is like sucking water up a straw. In young tissue, these bundles of xylem cells occur inside the vascular bundles, which are the stringy tissue in herbaceous tissue (ex. veins in leaves). In woody plants, xylem is the **wood**. The **sapwood** is functional because the hollow xylem cells are open and water easily flows up the tubes. All the water flows up the sapwood. The **heartwood** is old clogged xylem, and does not translocate water, and thus is not functional. The heartwood is clogged with resins and tannins and this makes the heartwood both waterproof and prevents it from rotting.



Phloem is composed of specialized cells that remain alive and "actively" translocate solutes (salts, sugars, metabolites, hormones, etc.) around plants. The phloem tissue is very concentrated in sugars, amino acids, and many nutrients. It is the phloem that sucking insect, such as aphids, puncture in order to feed on the sugar and nutrients... This is similar to a mosquito piercing your veins and arteries as a food source.

Phloem flows both up and down and all around. It is commonly stated that phloem flows down, but this is wrong. Phloem flows to where it is needed. Phloem flows from **sources** to **sinks**, which will be discussed next.