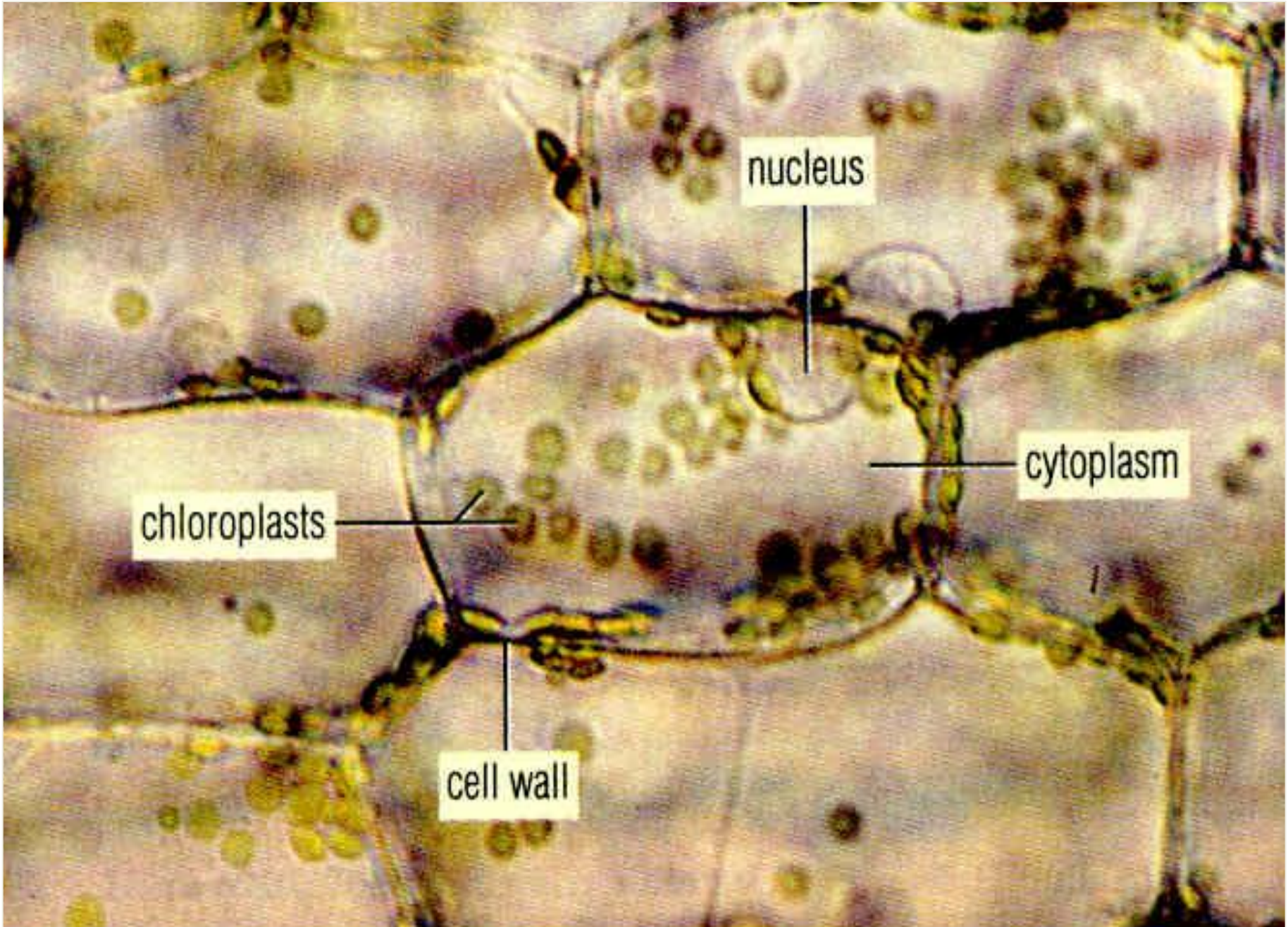
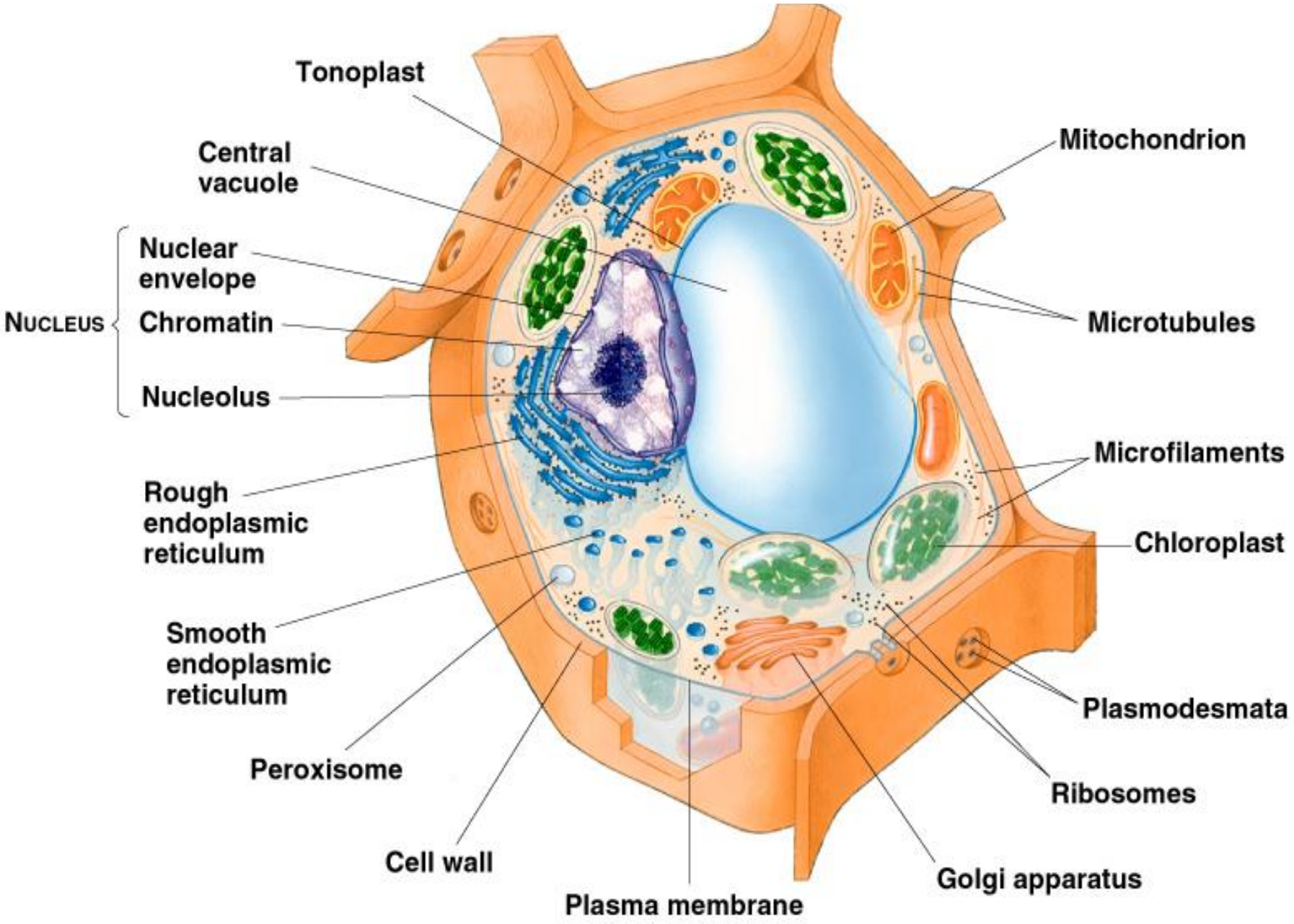
Anatomy and Morphology of Plants

Typical Plant Cell



Composition of plant cell



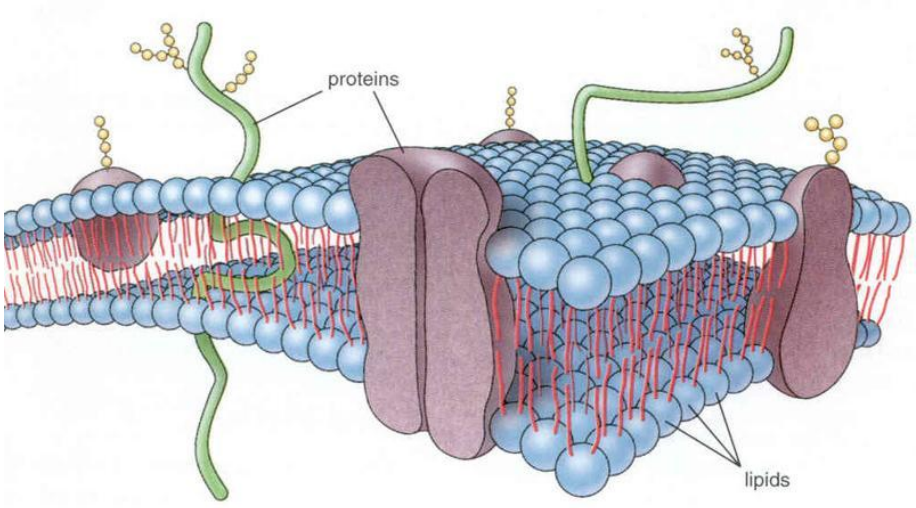
The Plant Cell

- The Plant Cell consists of a more or less rigid cell wall and the protoplast - the contents of the cell
- The protoplast consists of the cytoplasm and a nucleus
- The cytoplasm includes distinct membrane-bound organelles such as plastids and mitochondria; systems of membranes (endoplasmic reticulum and dictyosomes); nonmembranous entities such as ribosomes, actin filaments and microtubules
- The rest of the cytoplasm is a liquid matrix in which the nucleus, various entities and membrane systems are suspended - it is typically referred to as the cytosol or ground substance

Plasma Membrane

The plasma membrane has several functions:

1. it mediates the transport of substances into and out of the protoplasm
2. it coordinates the synthesis and assembly of cellulose microfibrils
3. it relays hormonal and environmental signals involved in the control of cell growth and differentiation



Cell Walls

- Found in plants (mostly cellulose) and fungi (contain chitin).
- Surrounds plasma membrane

Cell Walls

- Cellulose cell walls help distinguish plants from other organisms
- The main component of a cell wall is cellulose arranged in microfibers
- The cellulose framework is interpenetrated by a cross-linked matrix of noncellulose molecules - primarily hemicelluloses and pectins
- Cell walls are layered - there is a primary cell wall, a middle lamella between two cells and sometimes a secondary cell wall

Cell Wall Structure

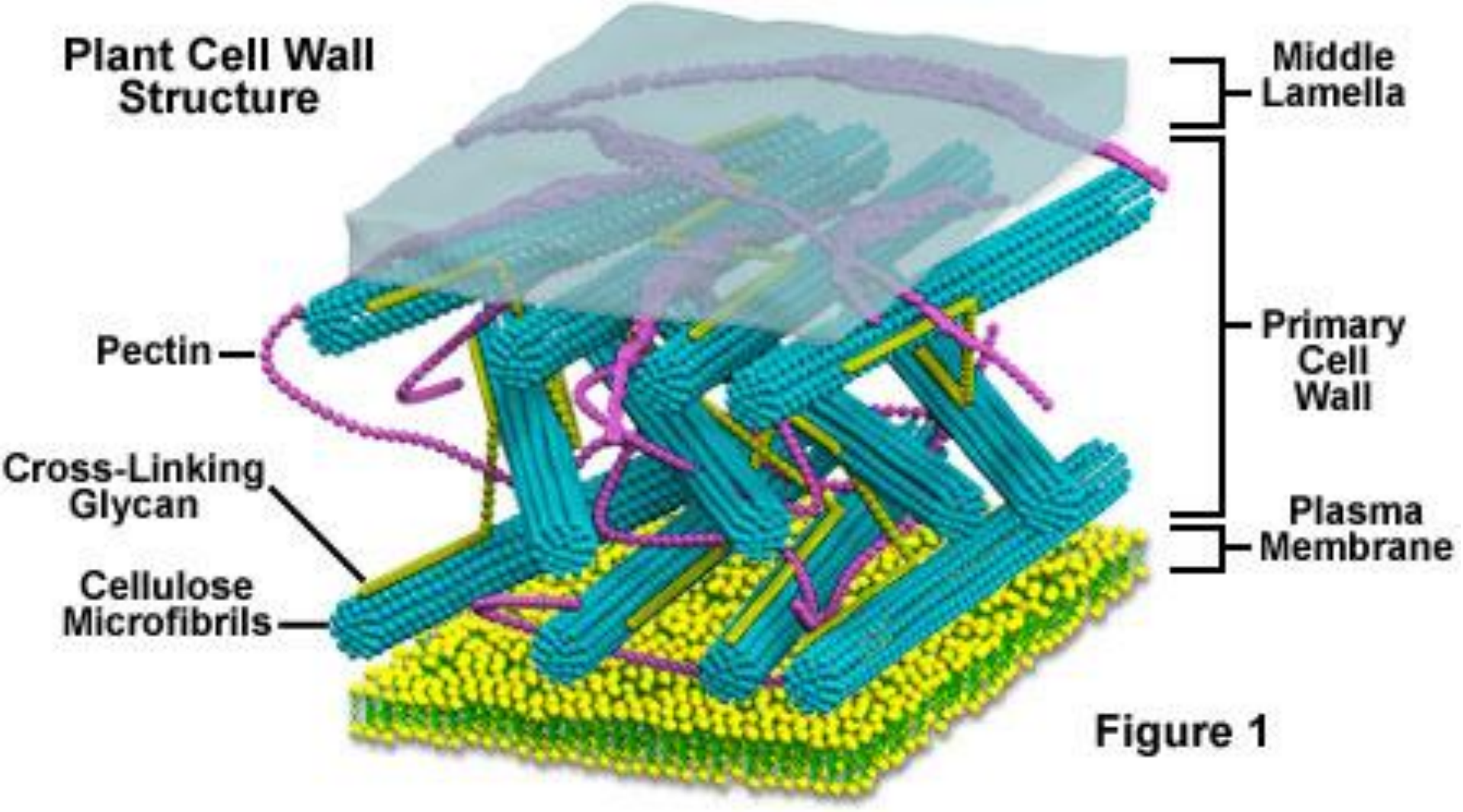
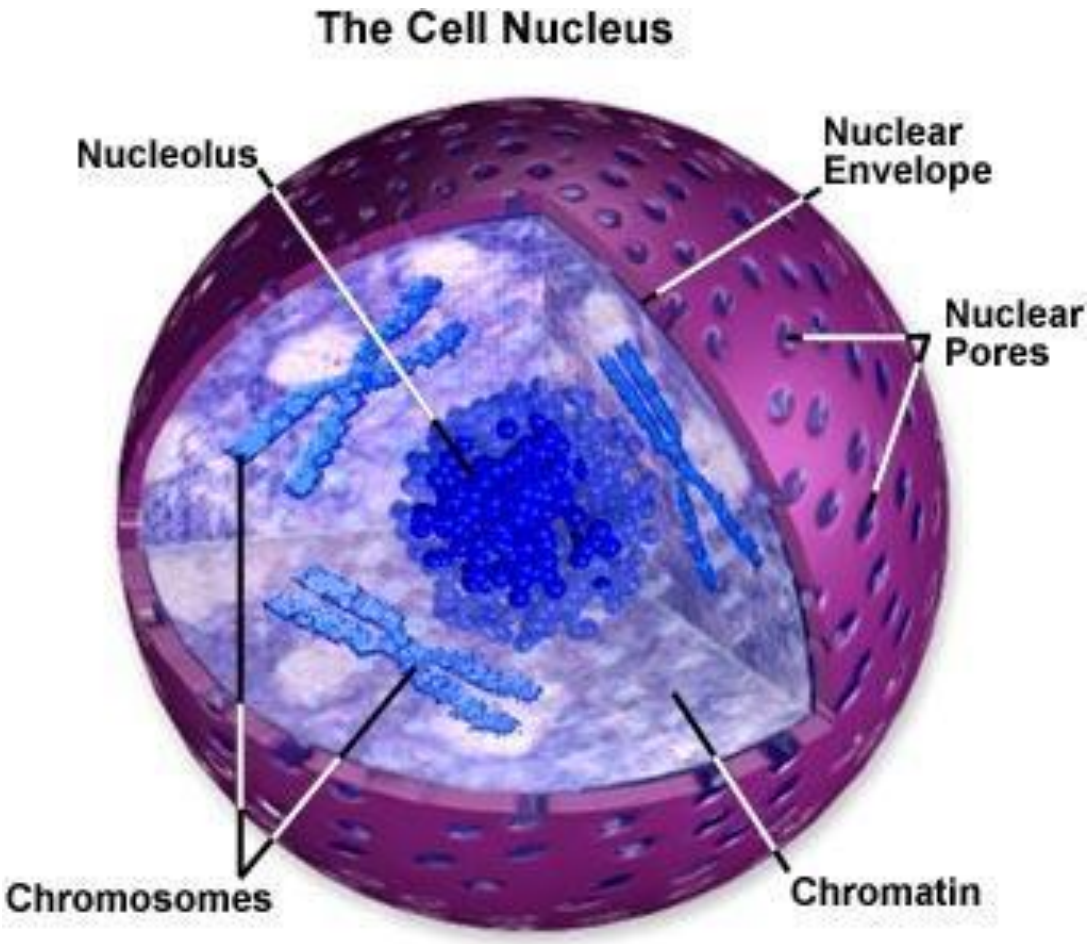


Figure 1

Cell Nucleus

The nucleus is usually the most prominent structure in the protoplast of eukaryote cells

1. it controls the ongoing activities of the cell by determining which protein molecules are produced by the cell and when they are produced
2. it stores genetic information, passing it onto daughter cells during cell division

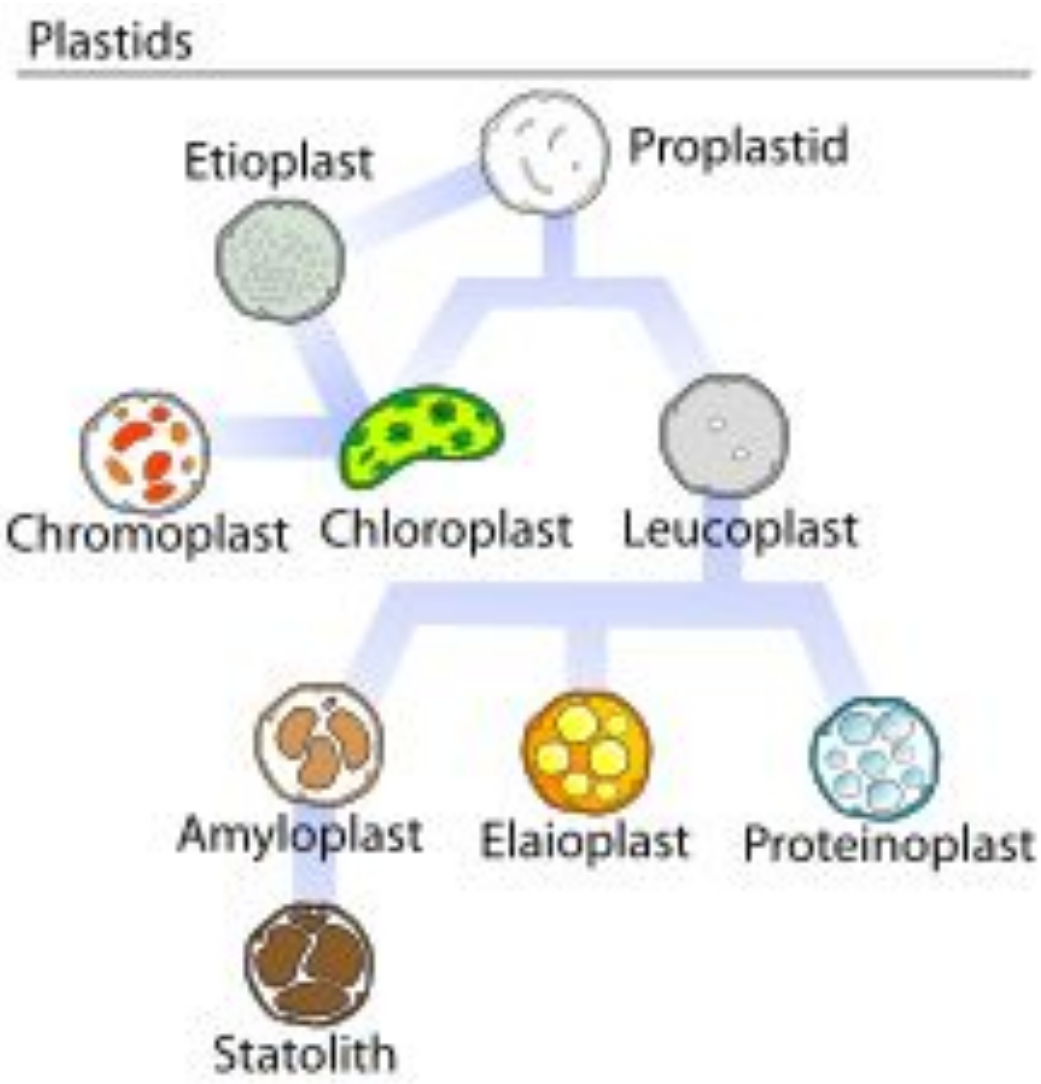


Plastids

- Plastids are a characteristic component of plant cells
- Plastids are classified and named based on the kinds of pigments they contain
- Each plastid is surrounded by two membranes and internally the plastid has a system of membranes which form flattened sacs called thylakoids and a ground (fluid) substance called stroma

Proplastids

- Proplastids are small, colorless or pale green undifferentiated plastids that occur in meristematic cells of roots and shoots - they will eventually develop into other, differentiated plastids such as the chloroplasts, chromoplasts or leucoplasts



Chloroplasts

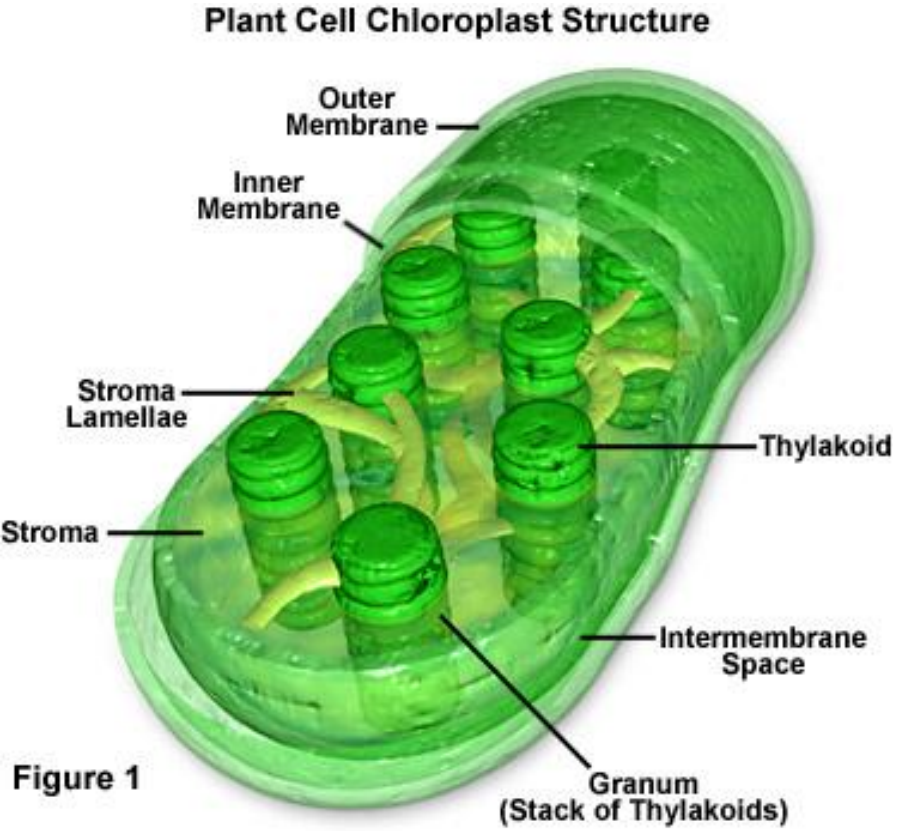
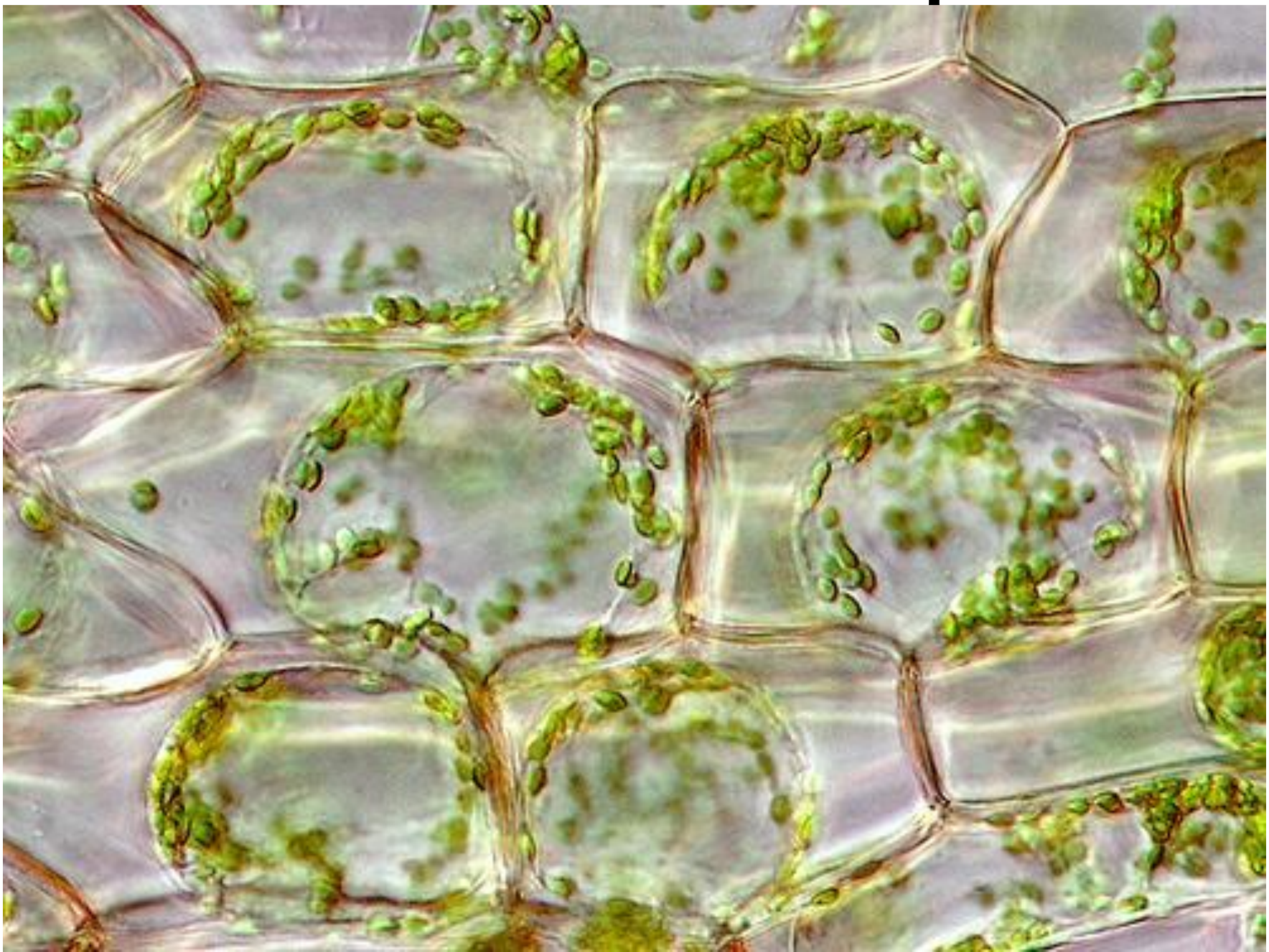


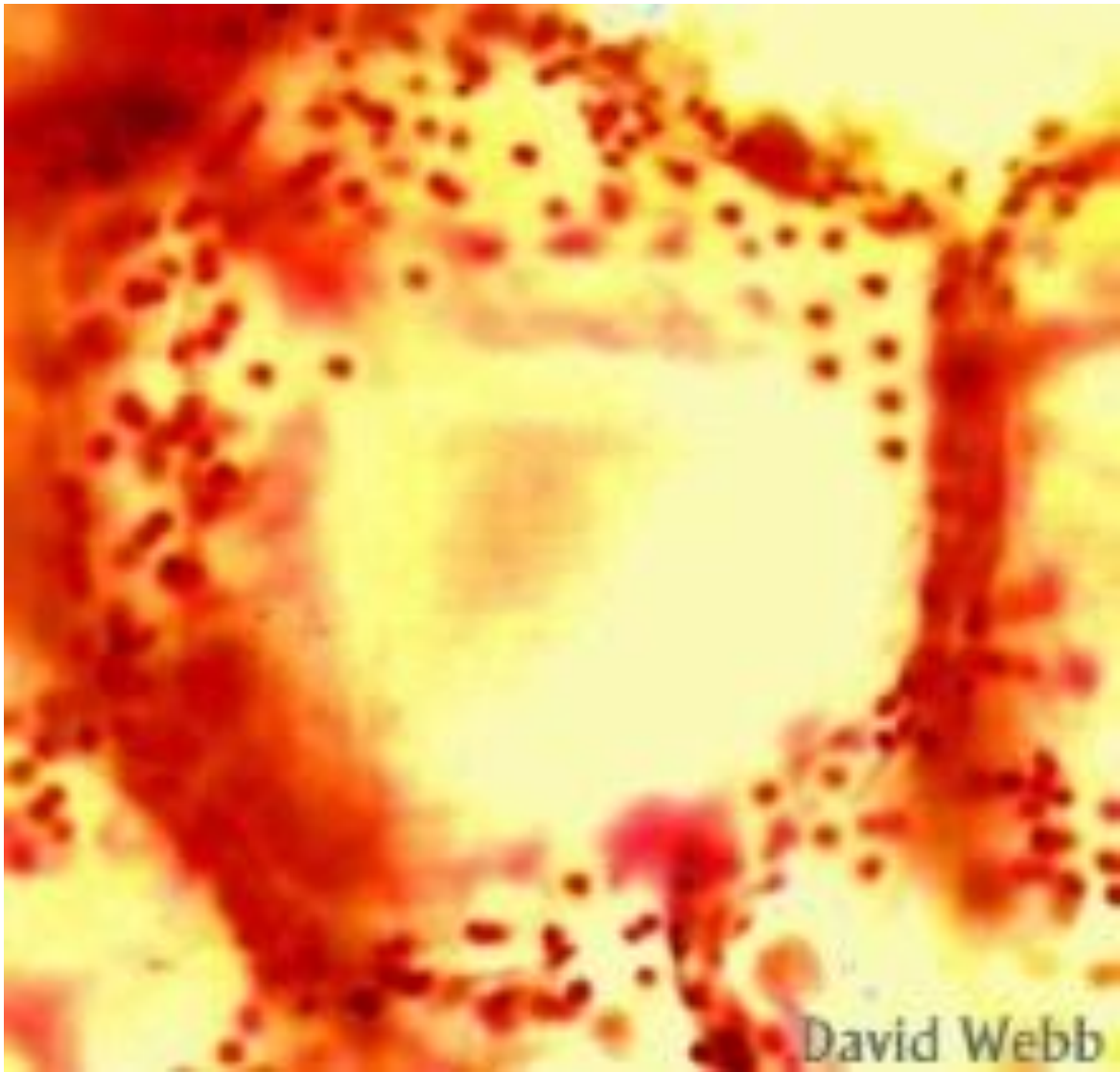
Figure 1

Plant Cells with Chloroplasts



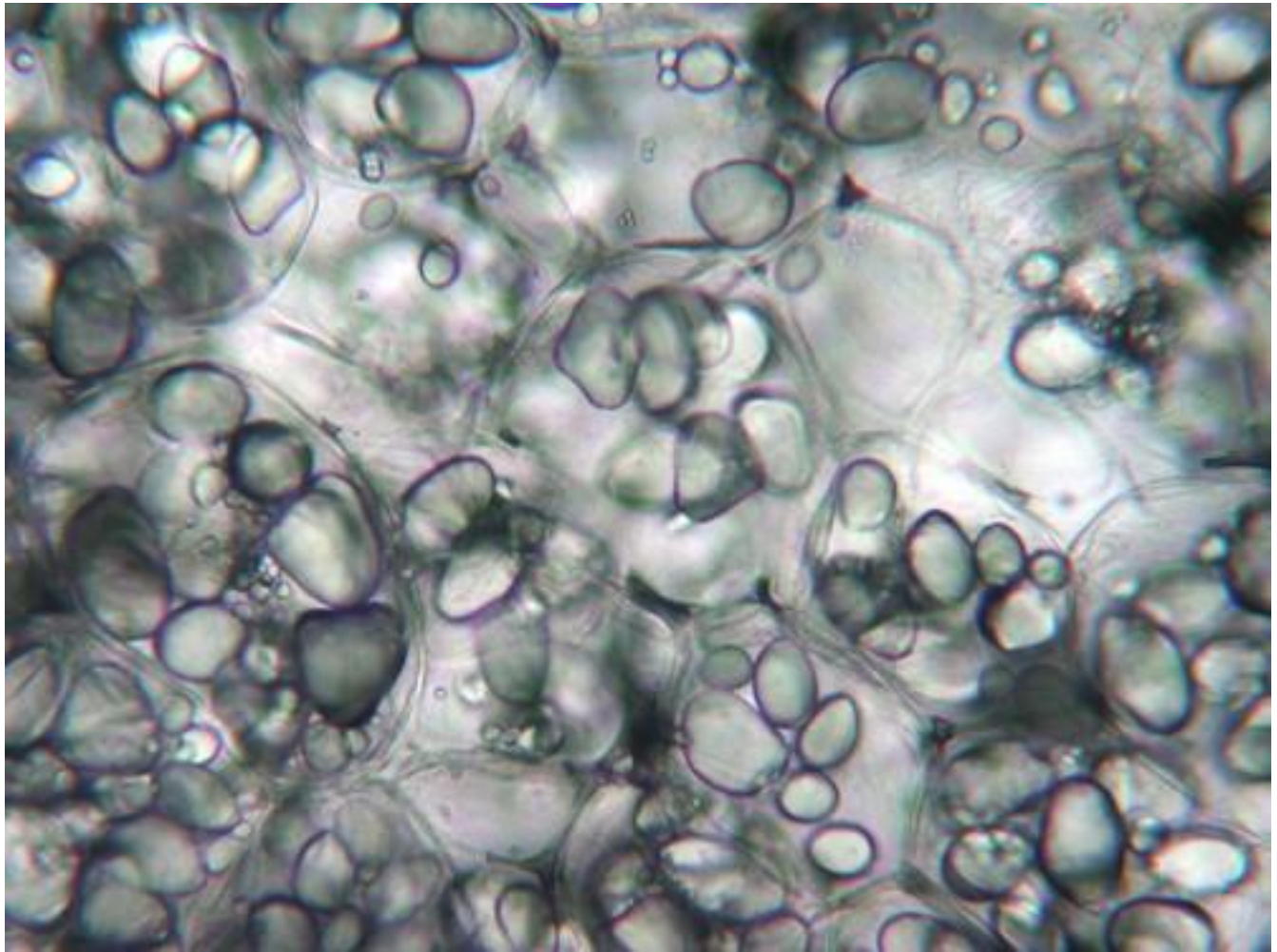
Chromoplasts

Chromoplasts lack chlorophyll but synthesize and retain carotenoid pigments which are responsible for the yellow, orange or red colors of many flowers, old leaves, some fruits and some roots



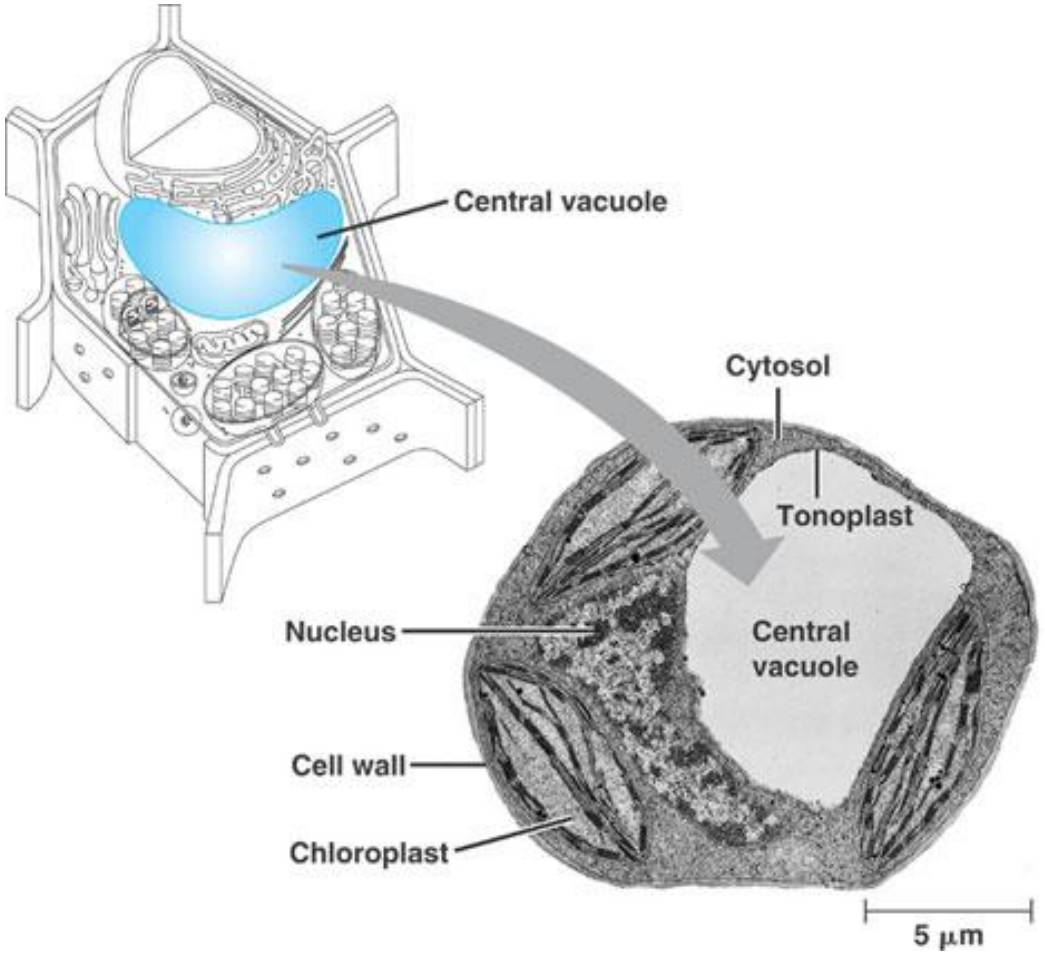
Leucoplasts

- Leucoplasts are non-pigmented plastids some of which synthesize starch while others produce oils or proteins
- Upon exposure to light they may develop into chloroplasts

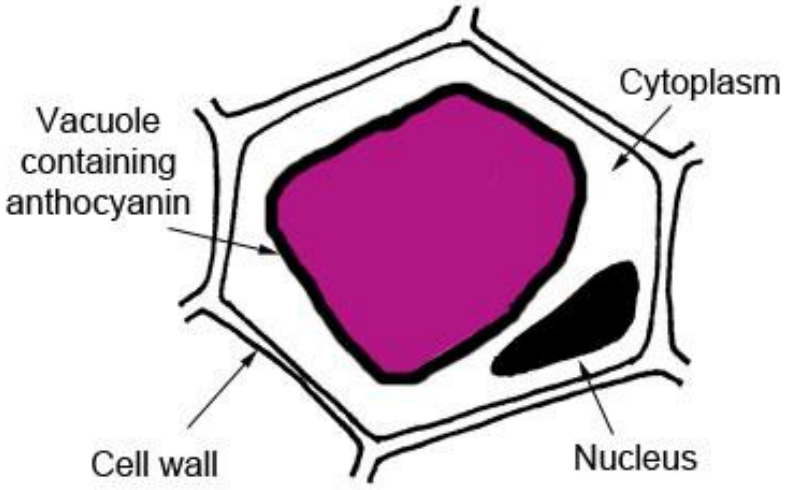


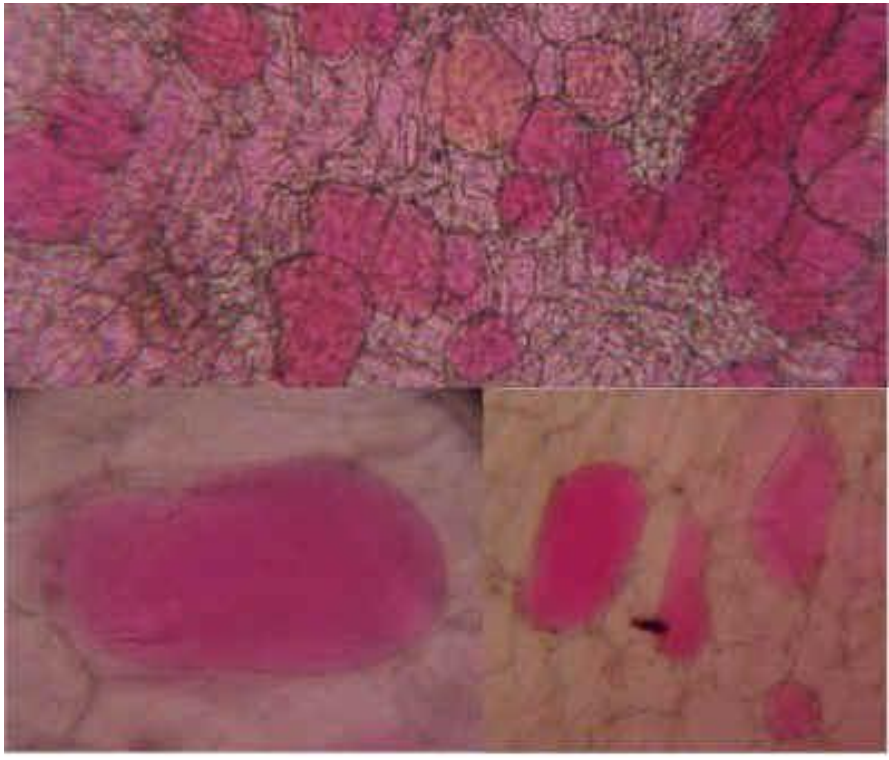
Vacuoles

- Vacuoles are membrane bound organelles filled with cell sap
- The membrane is referred to as the tonoplast
- Different kinds of vacuoles may have different functions within the same cell
- Along with water based cell sap, vacuoles typically contain salts, sugars and some dissolved proteins

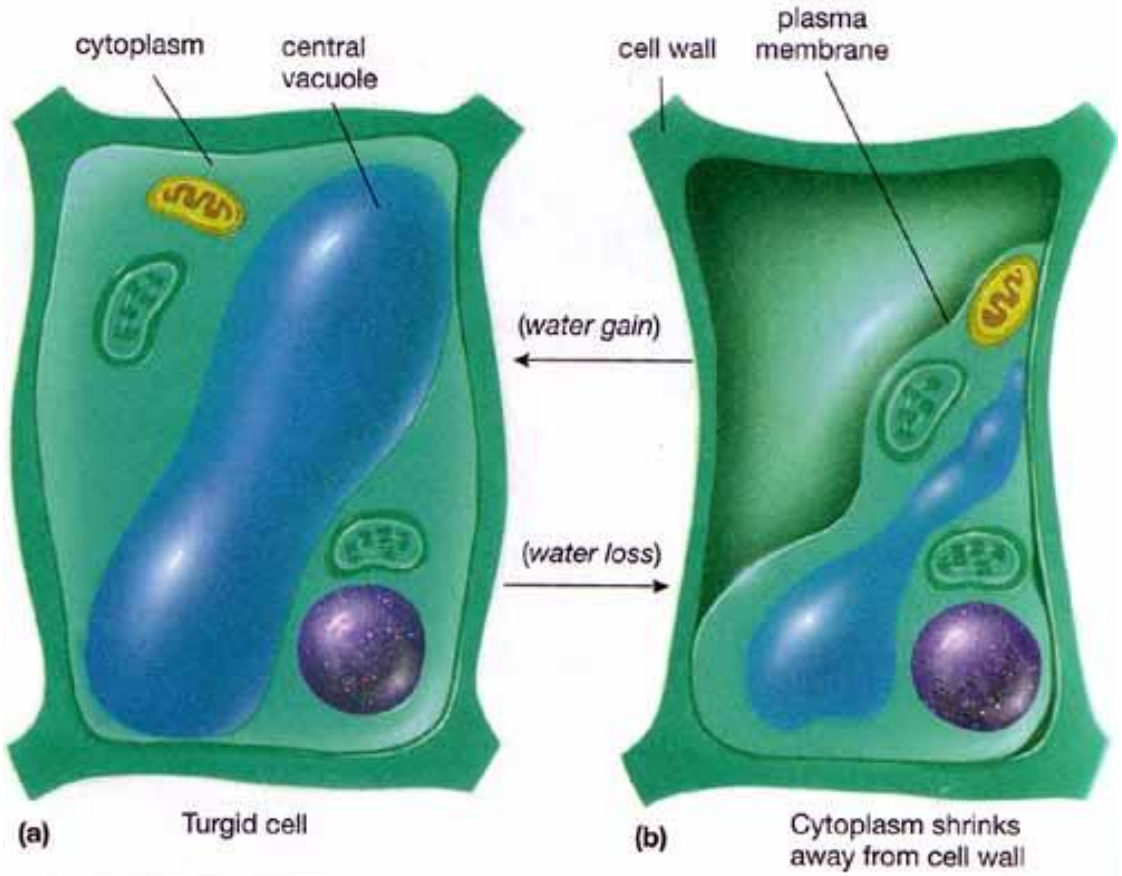


Beetroot cell vacuoles



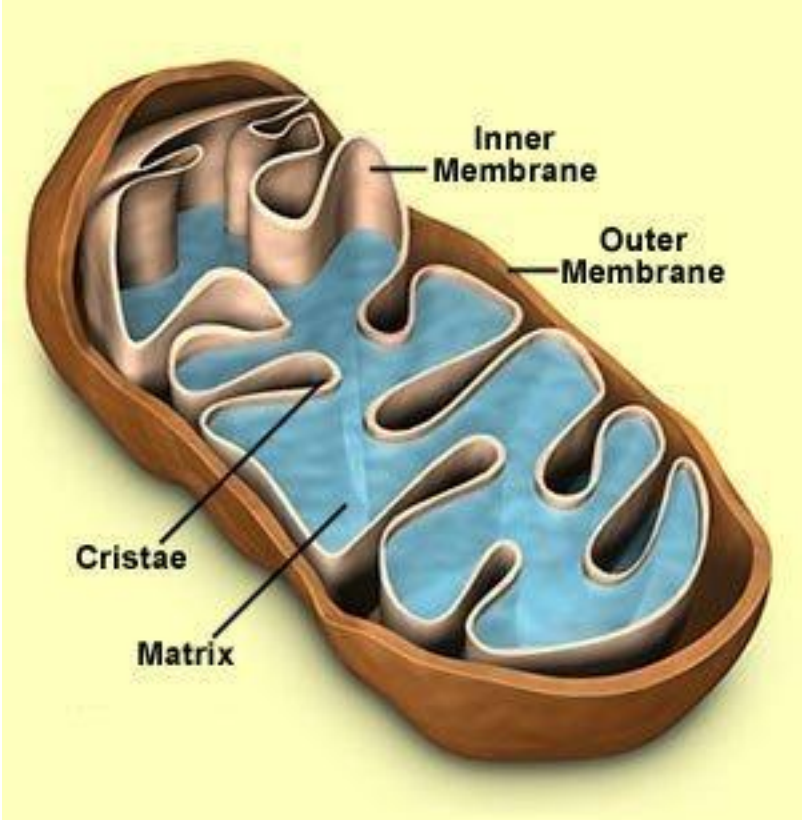


Vacuole and Turgor Pressure



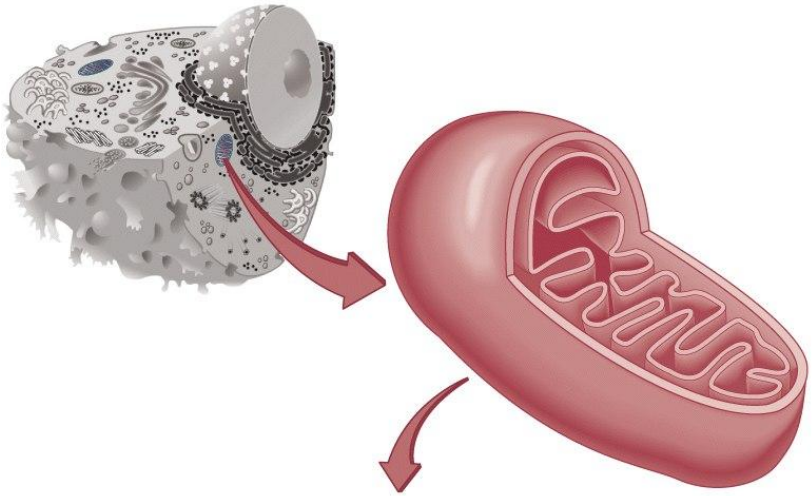
Mitochondria

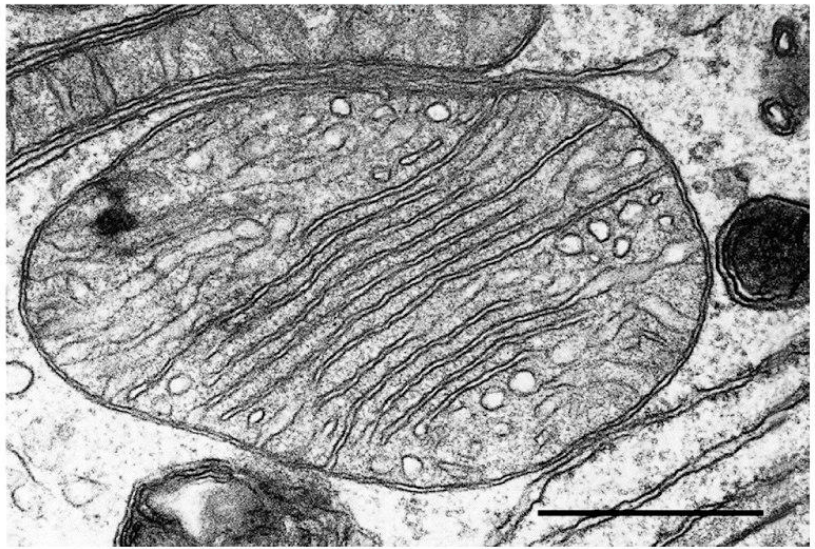
- Mitochondria are another organelle bounded by two membranes
- The inner membrane is folded into many pleats called cristae
- Mitochondria are the sites of cellular respiration - converting organic molecules to ATP the main immediate energy source for living eukaryote cells - plant cells may have hundreds to thousands of mitochondria



Mitochondria

- Break down fuel molecules (cellular respiration)
  - Glucose
  - Fatty acids
- Release energy
  - ATP
- Have their own DNA
- Bound by double membrane



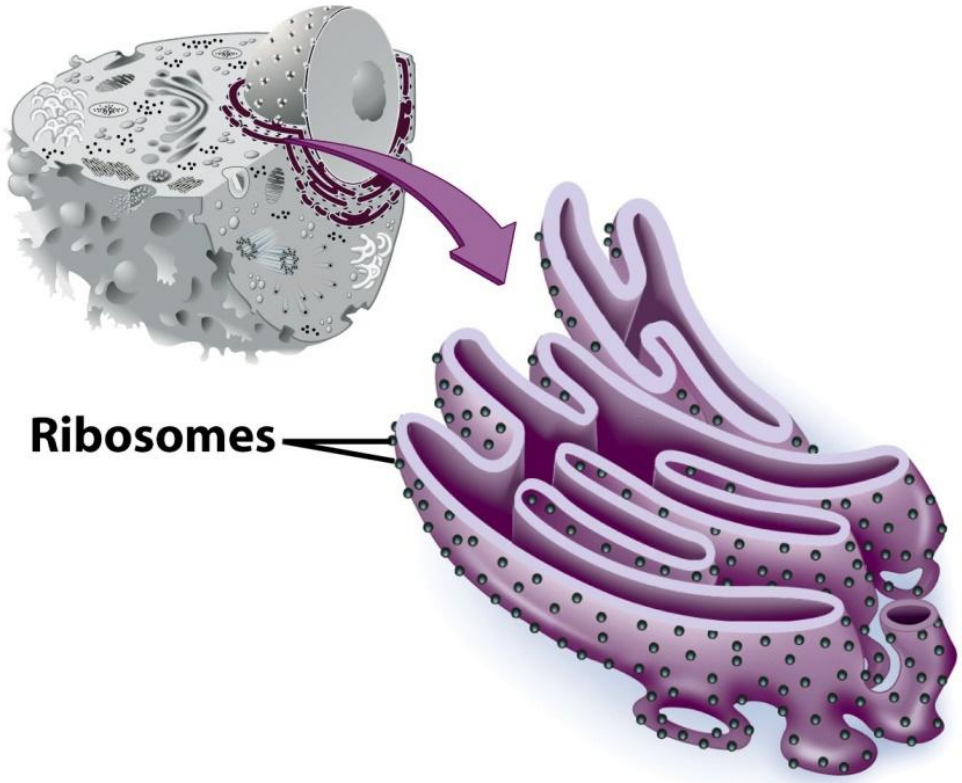


Endoplasmic Reticulum

- Helps move substances within cells
- Network of interconnected membranes
- Two types
  - Rough endoplasmic reticulum
  - Smooth endoplasmic reticulum

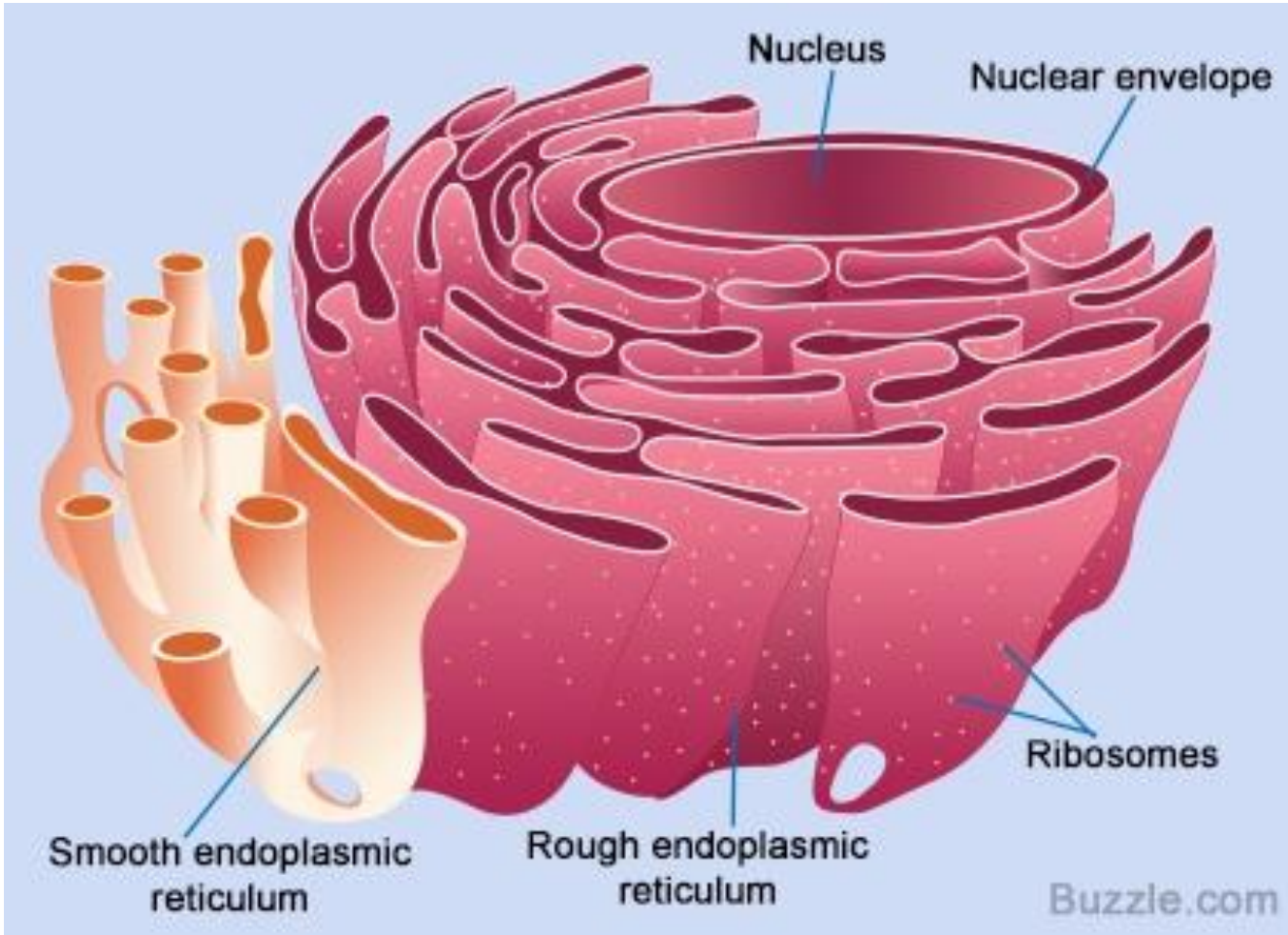
Rough Endoplasmic Reticulum

- Ribosomes attached to surface
  - Manufacture proteins
  - Not all ribosomes attached to rough ER
- May modify proteins from ribosomes



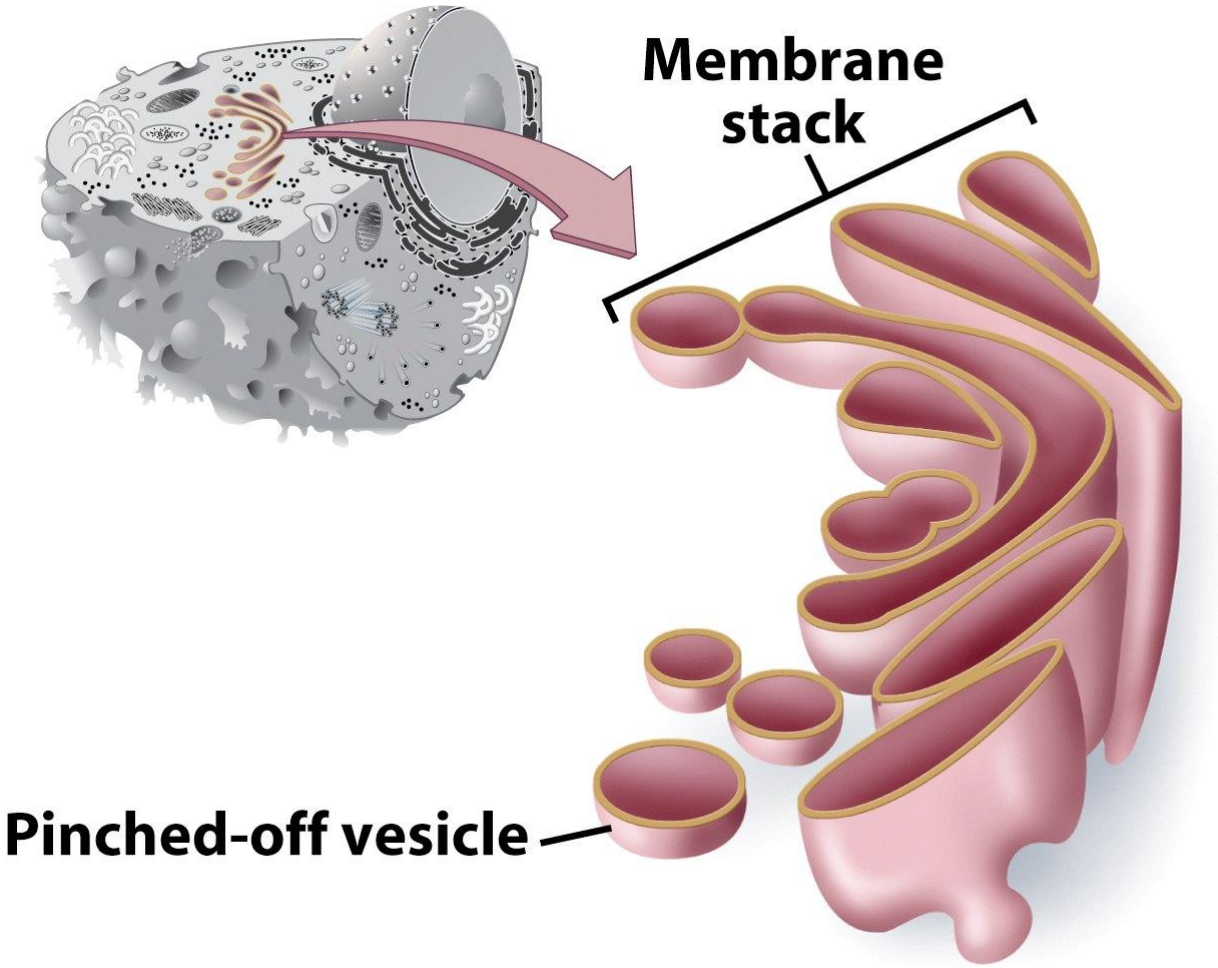
Smooth Endoplasmic Reticulum

- No attached ribosomes
- Has enzymes that help build molecules
  - Carbohydrates
  - Lipids



Golgi Apparatus

- Involved in synthesis of plant cell wall
- Packaging & shipping station of cell



Golgi Apparatus Functions

1. Molecules come in vesicles

2. Vesicles fuse with Golgi membrane

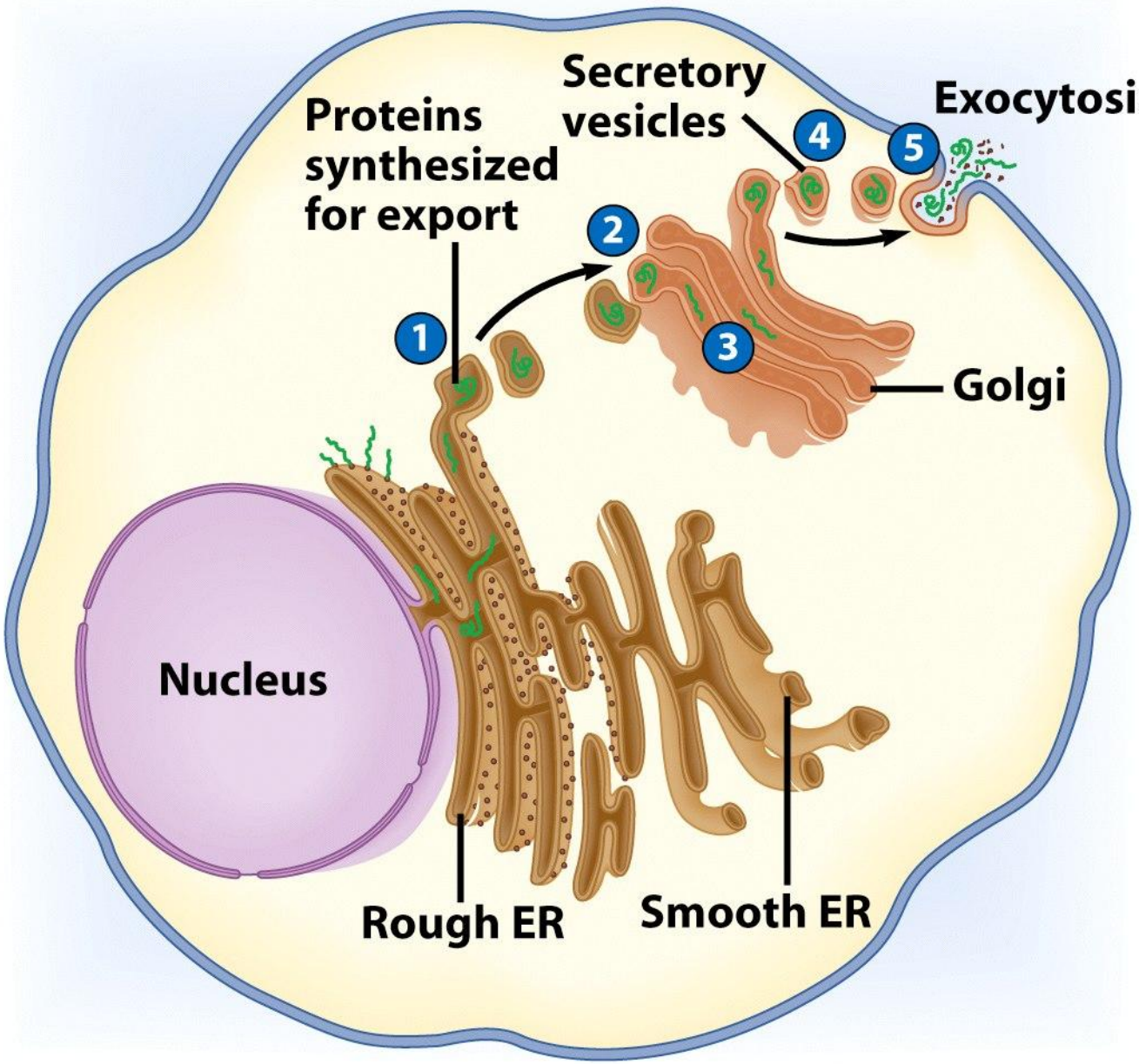
3. Molecules may be modified by Golgi

4. Molecules pinched-off in separate vesicle

5. Vesicle leaves Golgi apparatus

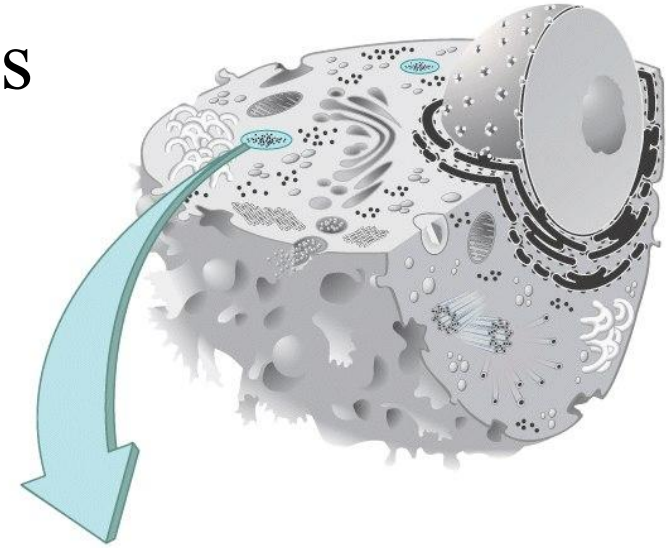
6. Vesicles may combine with plasma membrane to secrete contents

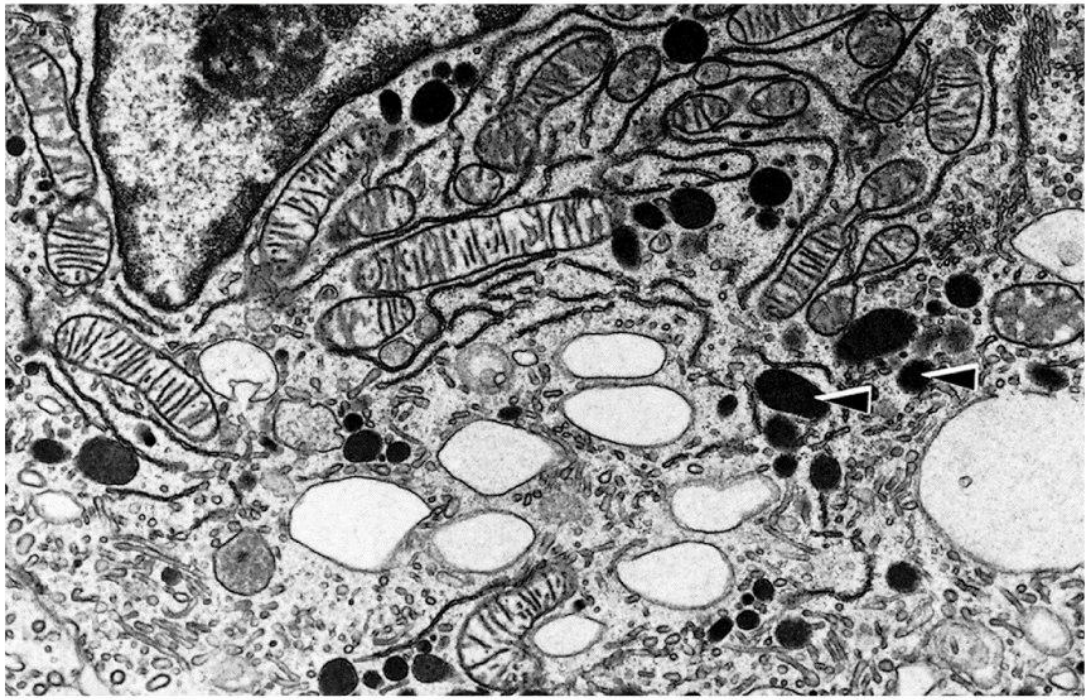
Golgi Apparatus Function: Exocytosis



Lysosomes

- Contain digestive enzymes
- Functions
  - Aid in cell renewal
  - Break down old cell parts
  - Digests invaders





Plant Tissues Types

All plant organs (roots, stems, leaves) are composed of the same tissue types.

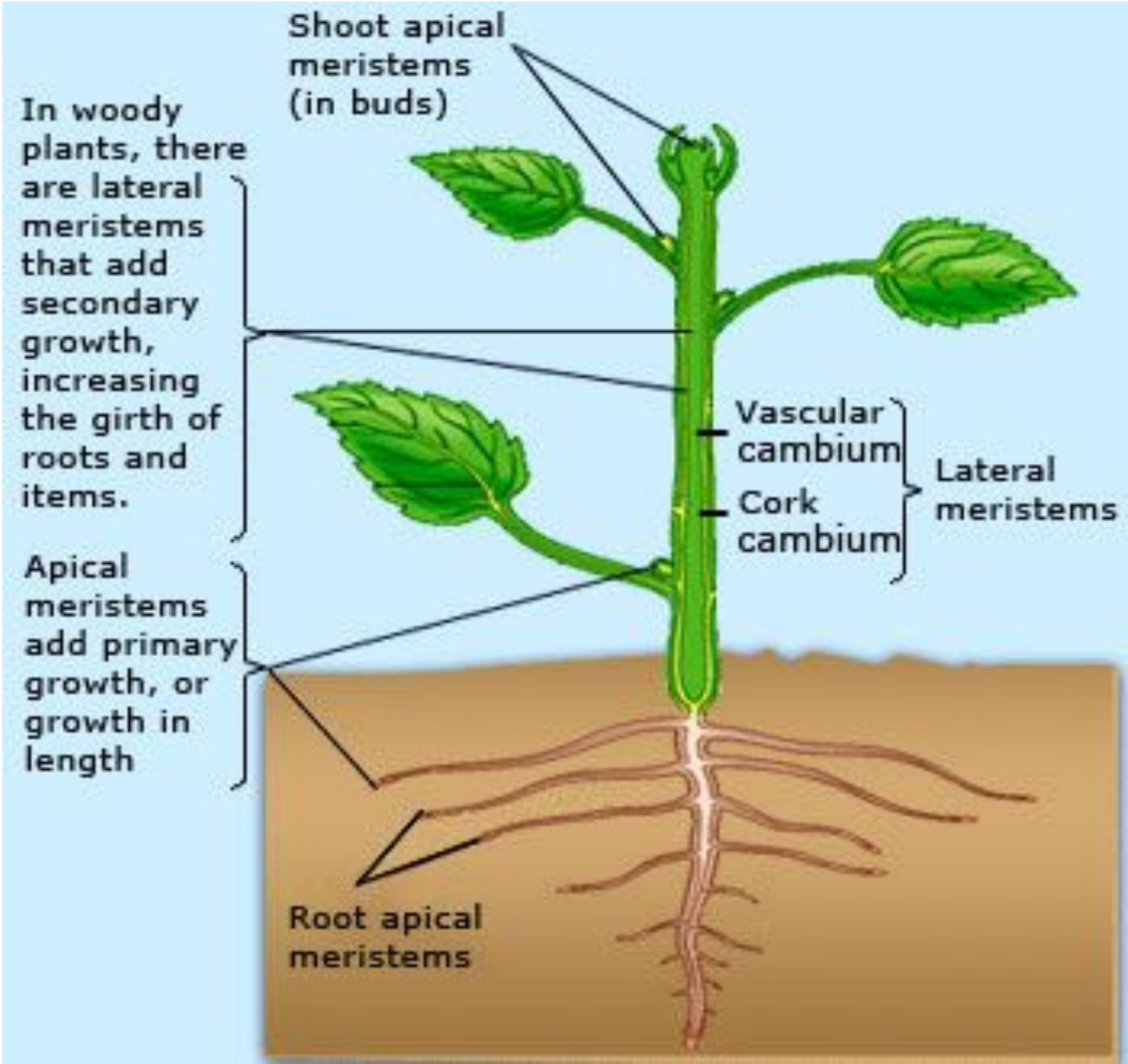
There are four types of tissues:

- **0. Meristems**.
- **1. Dermal** – outermost layer. Dermal tissue includes:
  - Epidermis
- **2. Vascular** – conducting tissue, transport. Vascular tissue includes:
  - Xylem tissue
  - Phloem tissue
- **3. Ground** – bulk of inner layers. Ground tissue includes:
  - Parenchyma tissue
    - Chlorenchyma
  - Collenchyma tissue
  - Sclerenchyma tissue

Meristems generate cells for new organs

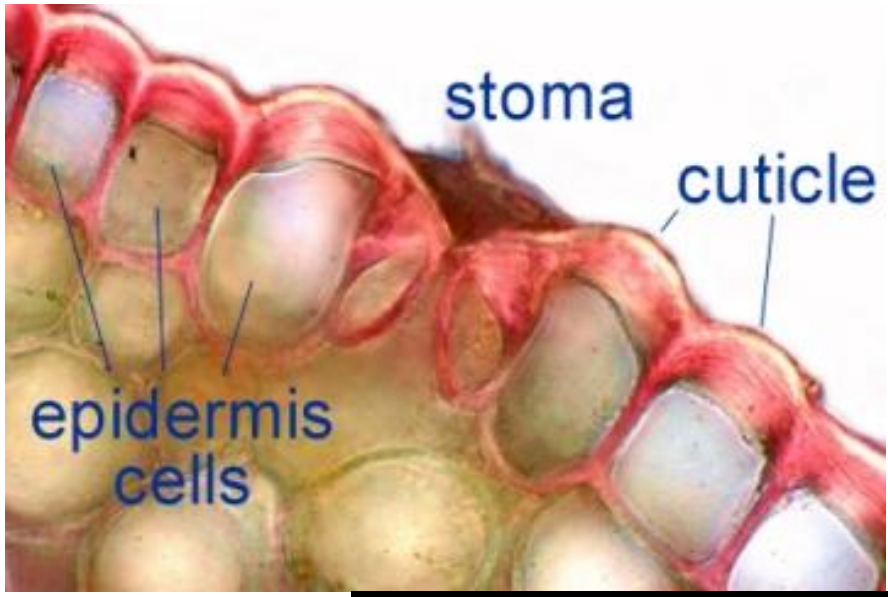
- **Apical meristem**
  - It is located at the apices or growing points of root and shoot and bring about increase in length.
  - It includes both pro-meristem as well as primary meristem.
- **Intercalary meristem**
  - It lies between the region of permanent tissues and is considered as a part of primary meristem which has become detached due to formation of intermediate permanent tissues.
  - It is found either at the base of leaf e.g. Pinus or at the base of internodes e.g. grasses.
- **Lateral Meristem**
  - It arranged parallel to the sides of origin and normally divide periclinally or radially and give rise to secondary permanent tissues.
  - It increases the thickness of the plant part.

MERYSTEM TOPOGRAPHY

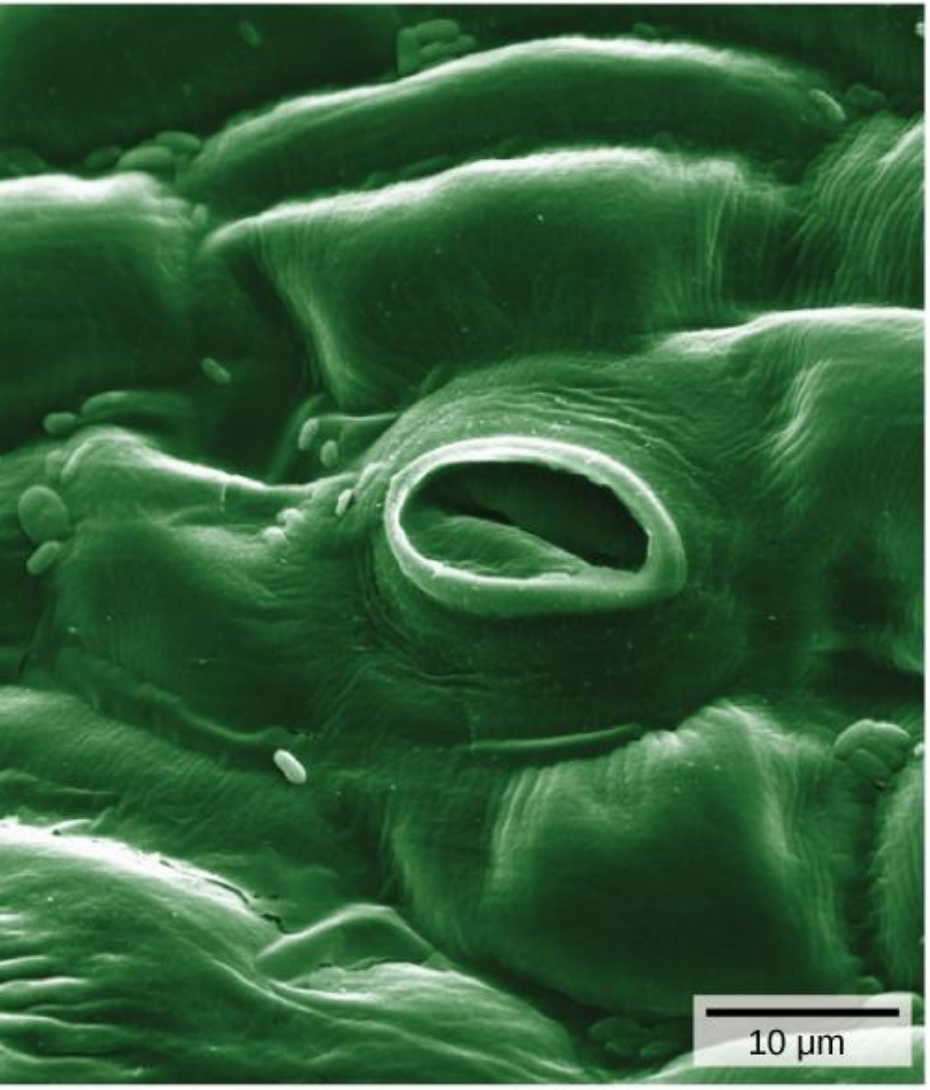


Dermal tissue

- **Epidermis** is the outermost layer of cells
- Like the "skin" of animals
- In stems and leaves, epidermis has **cuticle**, a waxy layer that prevents water loss.
- Some have **trichomes,** hairs.
- Root epidermis has **root hairs,** for water and nutrient absorption



Structure of plant epidermis



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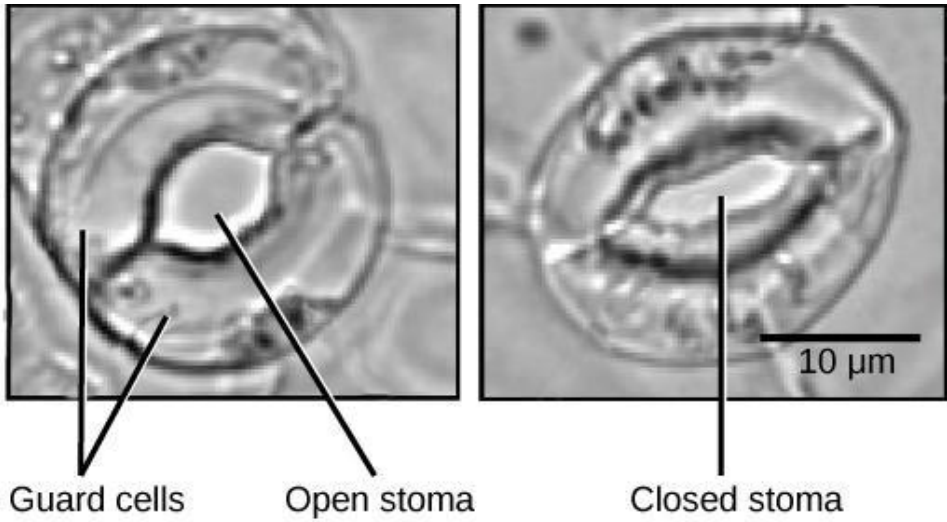

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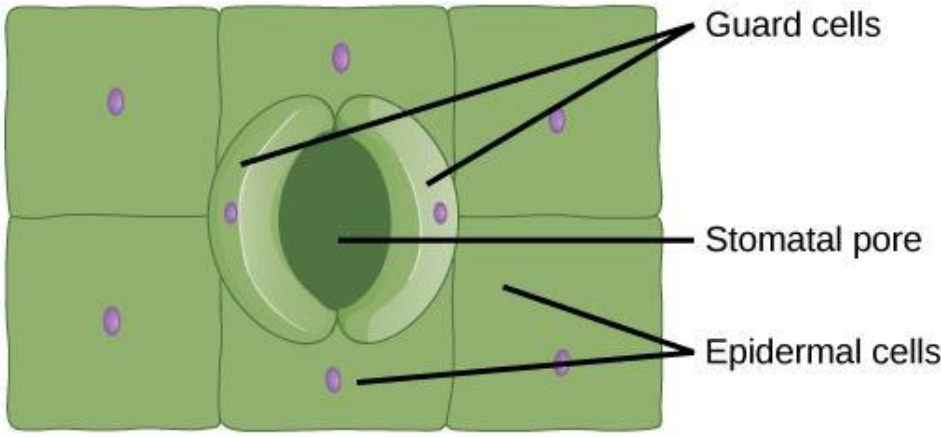
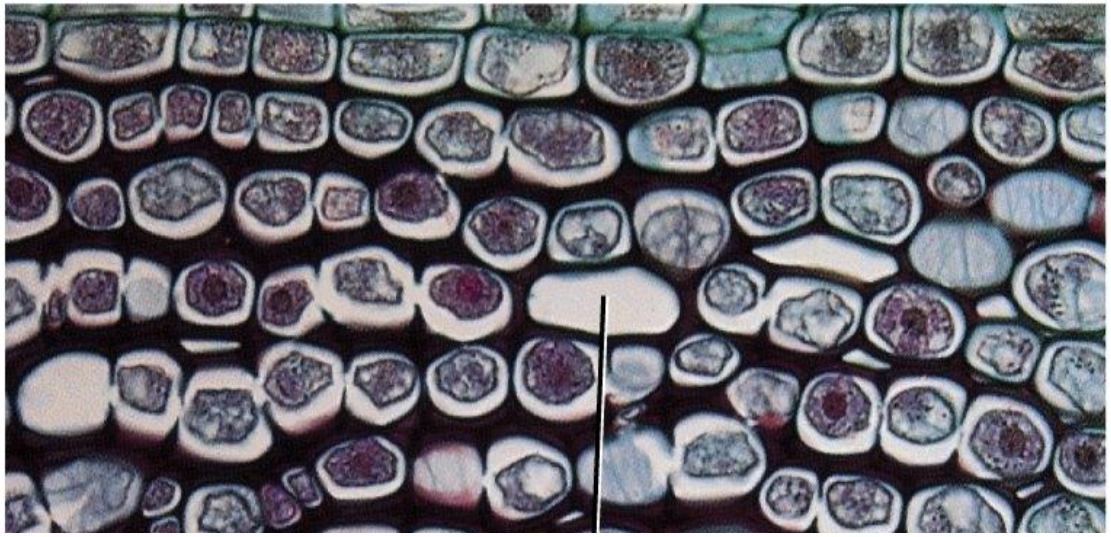
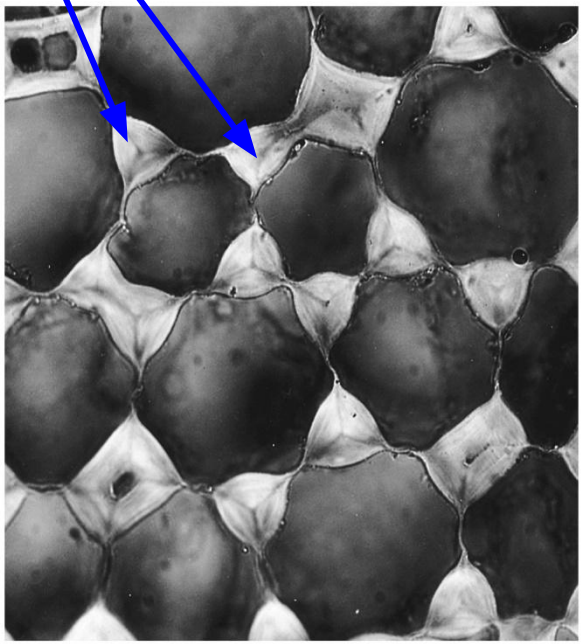


(c)

Ground tissues

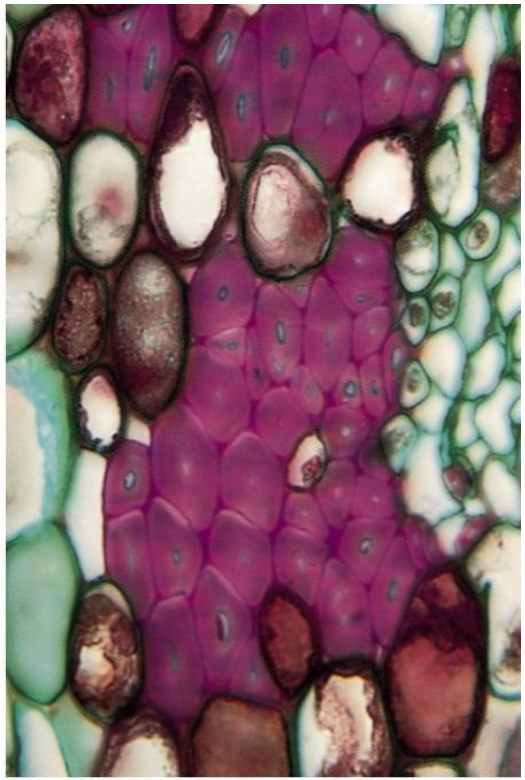
- Collenchyma tissue:
  - SIMPLE
  - Cells are ALIVE at maturity
  - Contain unevenly thickened walls
  - Support young growing stems and organs





Ground tissues

- Sclerenchyma tissue:
  - SIMPLE
  - Cells are dead at maturity
  - Typically lack protoplasts
  - Posses secondary walls with lignin
  - Strong polymer
  - Support stems and organs that have stopped growing



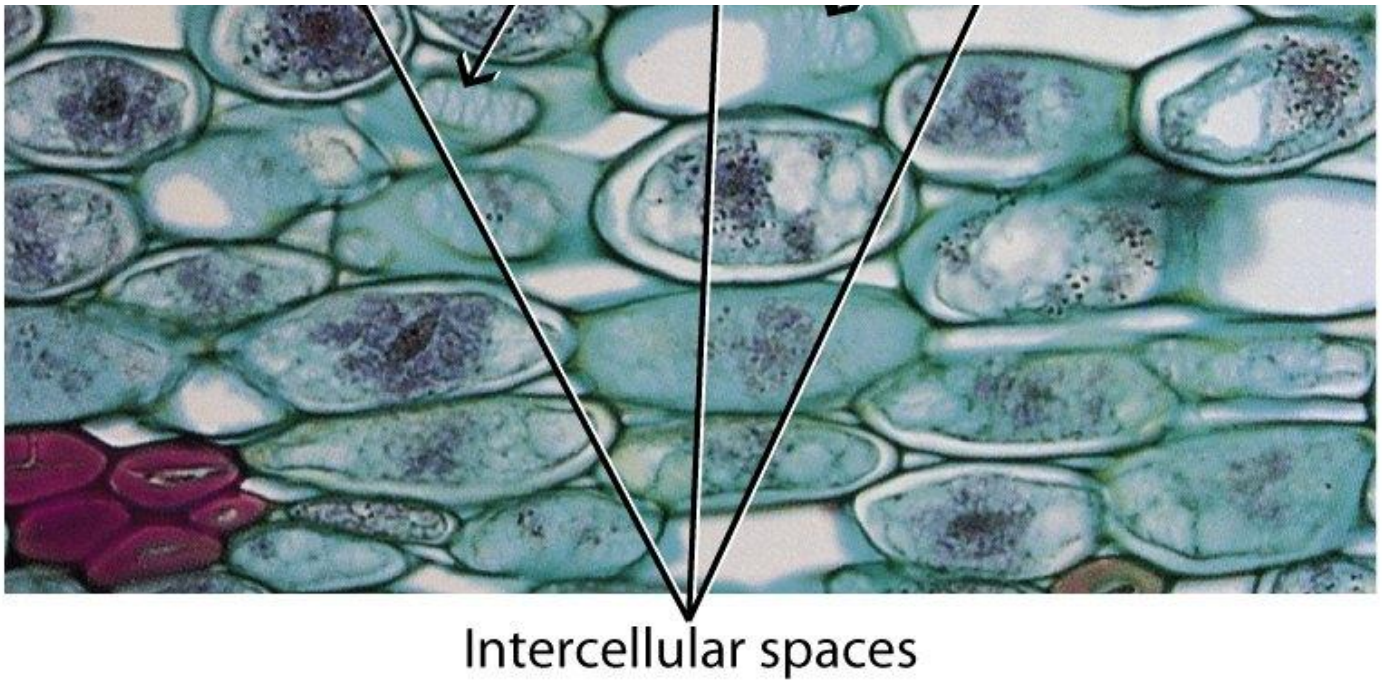
fibres

sclereid

Economically important tissue.
e.g. Hemp fibres

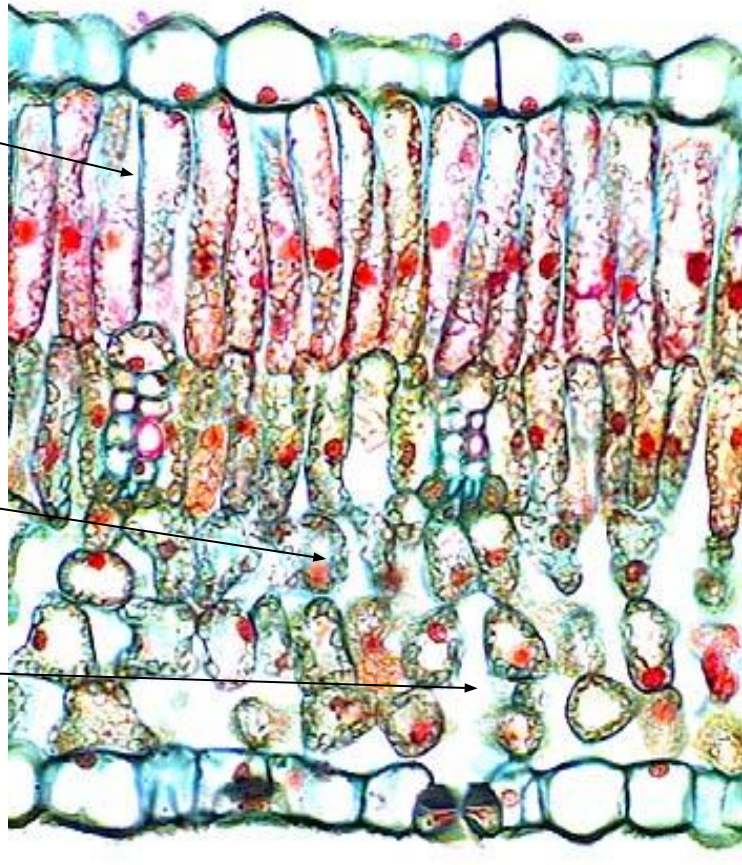
Ground tissues

- Parenchyma tissue:
  - SIMPLE
    - Made up of a single cell type
  - Cells are ALIVE at maturity
  - Capable of dividing
    - TOTIPOTENT
  - Involved in wound regeneration and range of metabolic functions



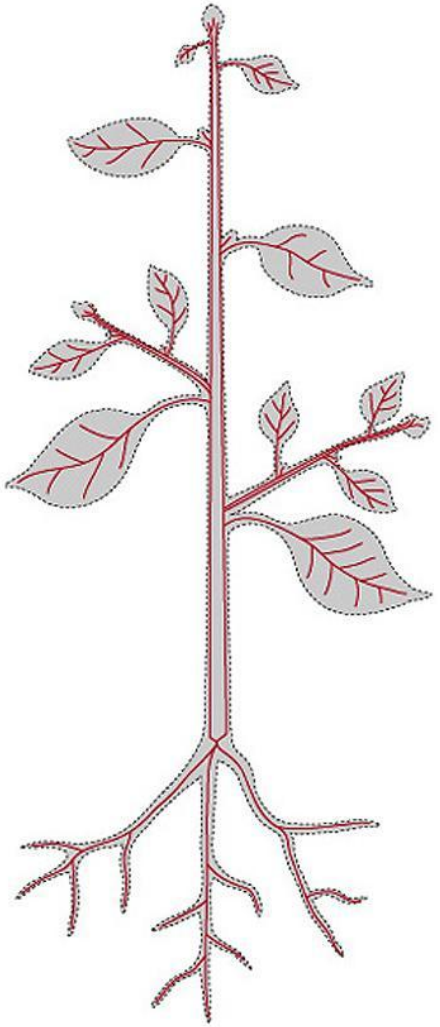
Leaf Mesophyll

- Middle of the leaf (meso-phyll)
- Composed of photosynthetic ground cells:
- **Palisade** parenchyma (long columns below epidermis; have lots chloroplasts for photosynthesis)
- **Spongy** parenchyma (spherical cells) with **air spaces** around, (for gas exchange)



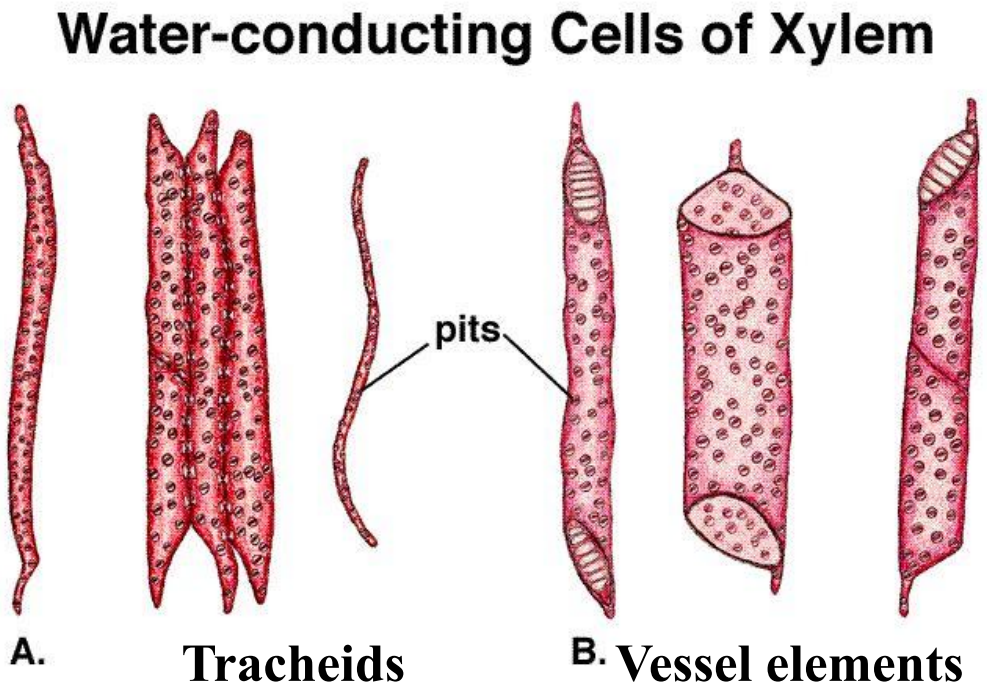
Vascular tissues

- Transports water and organic materials (sugars) throughout the plant
- **Xylem** – transports water and dissolved ions from the root to the stem and leaves.
- **Phloem** – carries dissolved sugars from leaves to rest of the plant



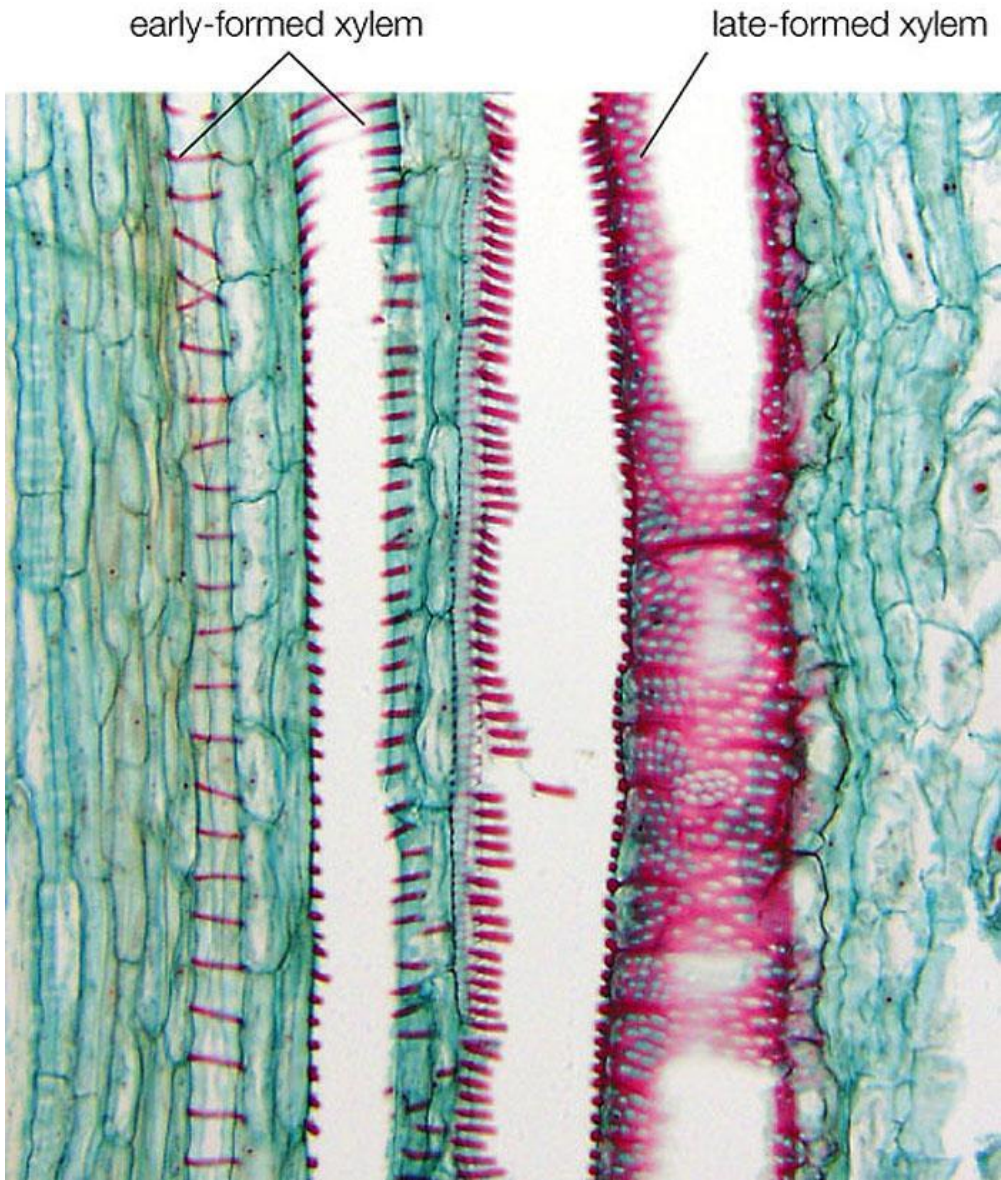
Xylem

- Transports water and dissolved minerals
- **Tracheids**: long, thin tube like structures without perforations at the ends
- **Vessel elements**: short, wide tubes perforated at the ends (together form a pipe, called vessel).
- Both cells have **pits** (thin sections) on the walls



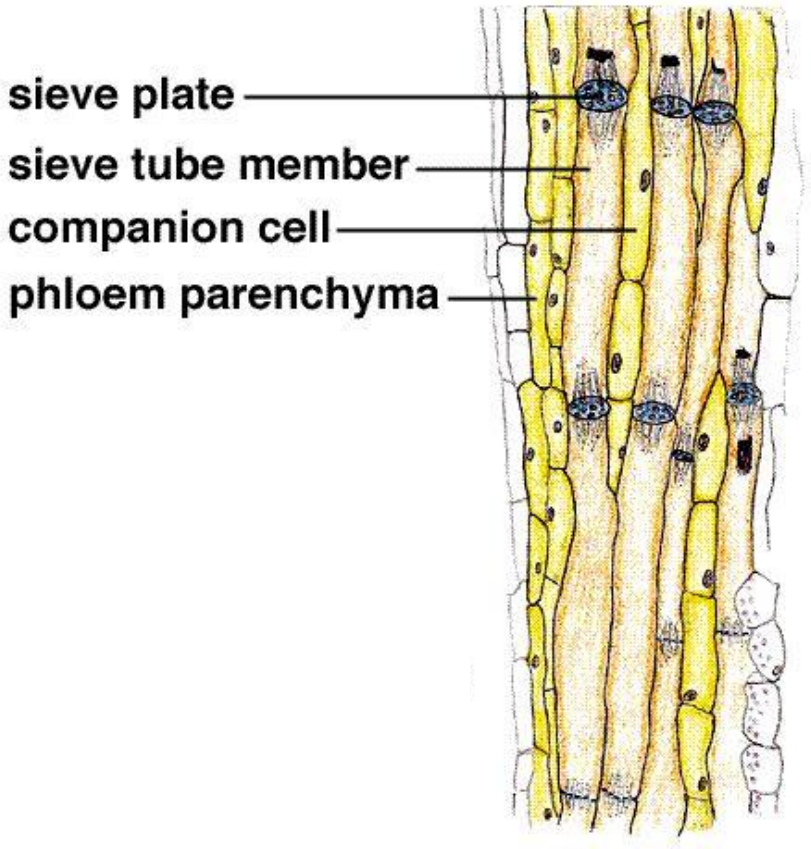
Xylem cells

- **Xylem** cells are dead!
- They are hollow cells and consist only of <u>cell wall</u>



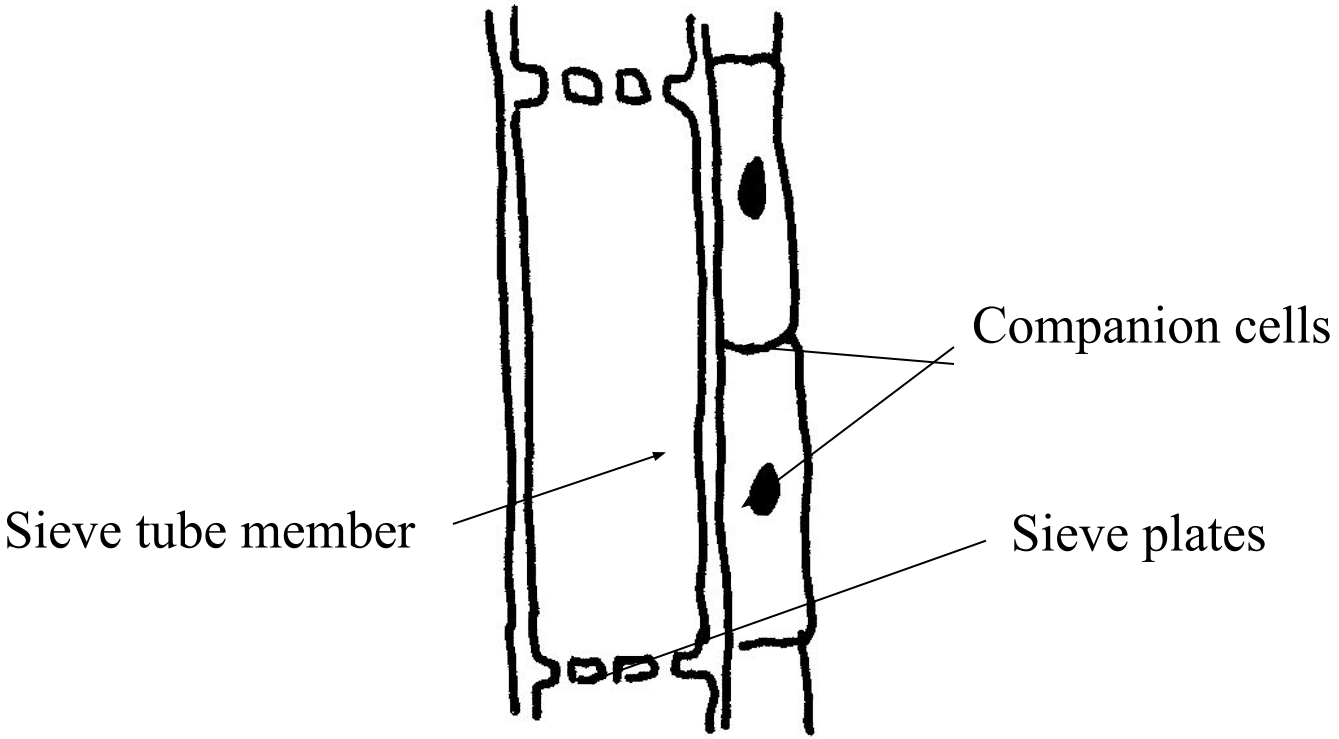
Phloem

- Cells that transport organic materials (sugars)
- Phloem cells are **ALIVE** (unlike xylem).
- However, they lack nucleus and organelles

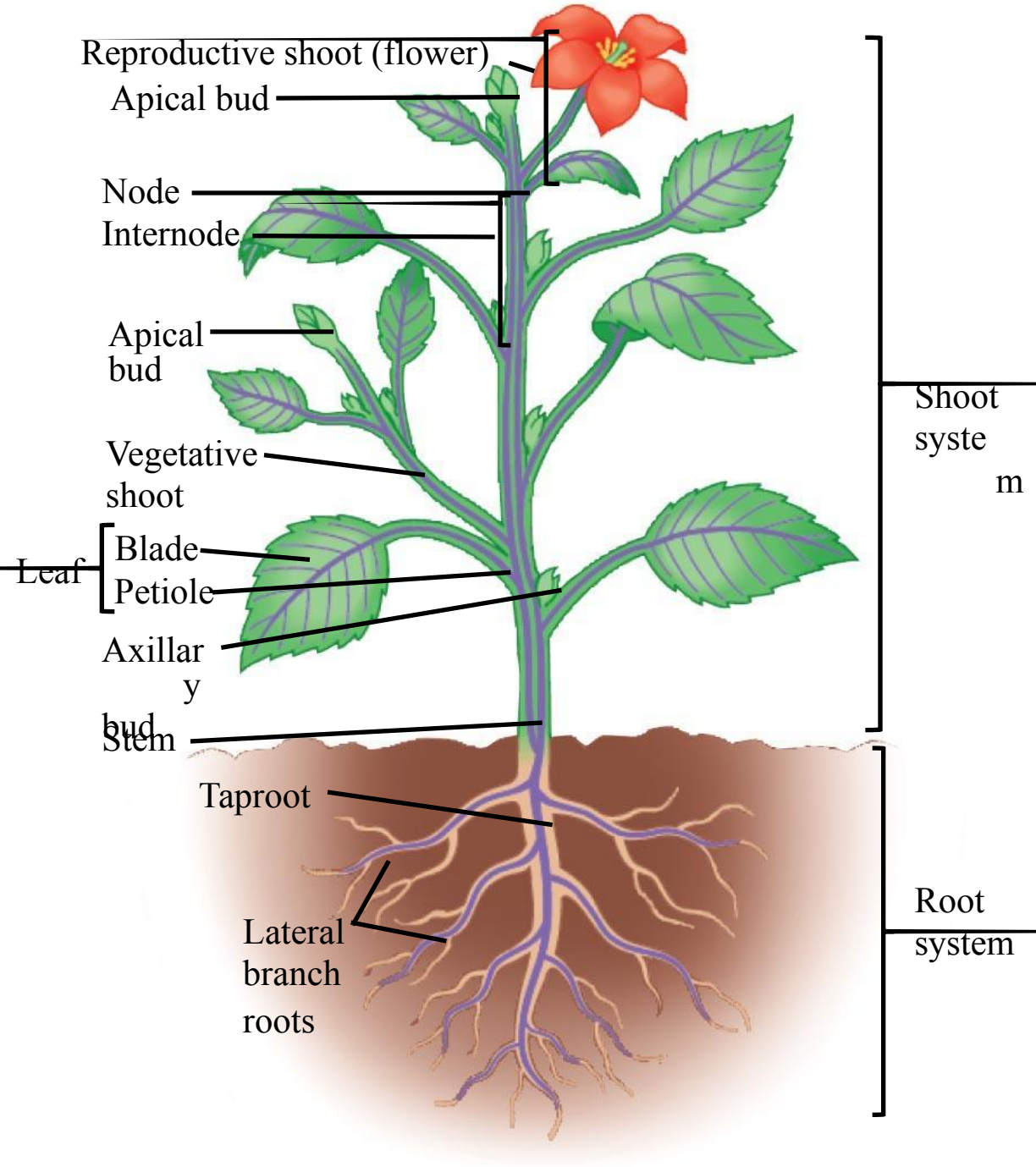


Phloem: transports sugars

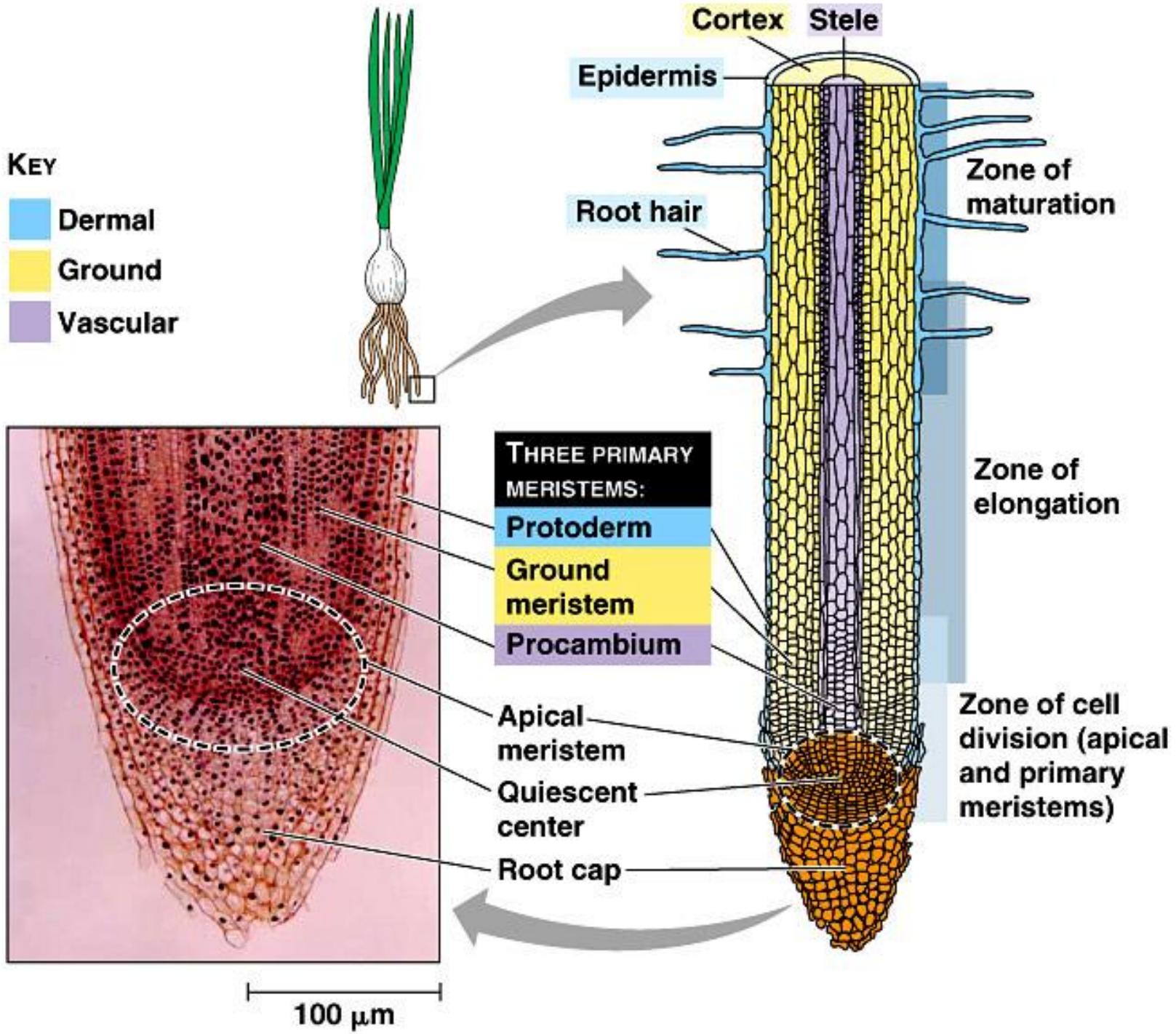
- Phloem composed of cells called **sieve tube members (STM)**
- **Companion cells** join sieve tube members, are related, and help to load materials into STM
- End walls of STM have large pores called **sieve plates**



Plant organs and their structure and functions



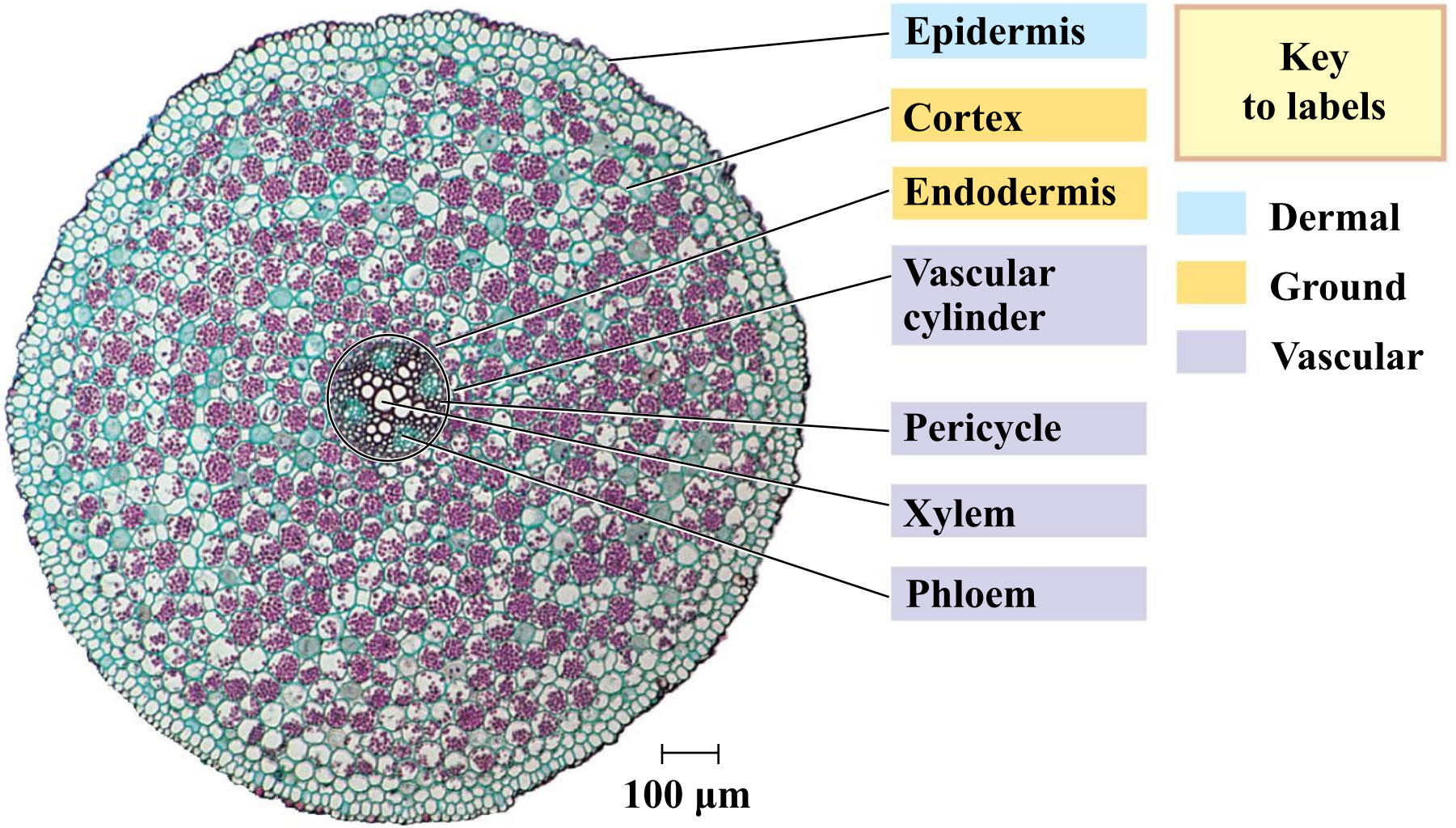
Root


Cortex
Stele
Epidermis
Zone of maturation
Root hair
KEY
Dermal
Ground
Vascular
THREE PRIMARY MERISTEMS:
Protoderm
Ground meristem
Procambium
Zone of elongation
Apical meristem
Quiescent center
Root cap
Zone of cell division (apical and primary meristems)
100 µm

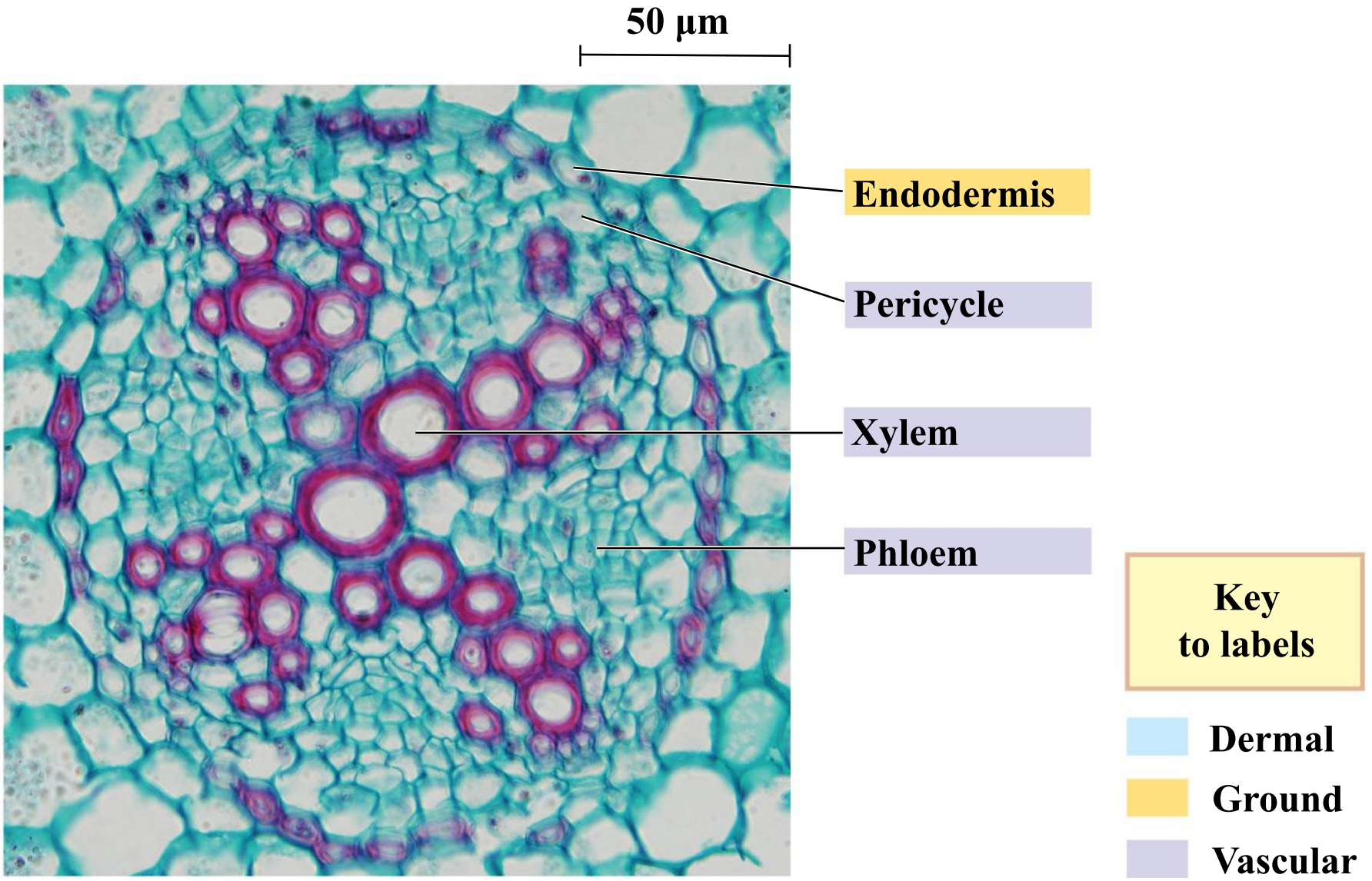
Plant Root

- The primary growth of roots produces the epidermis, ground tissue, and vascular tissue
- In angiosperm roots, the stele is a vascular cylinder
- In most eudicots, the xylem is starlike in appearance with phloem between the “arms”
- In many monocots, a core of parenchyma cells is surrounded by rings of xylem then phloem

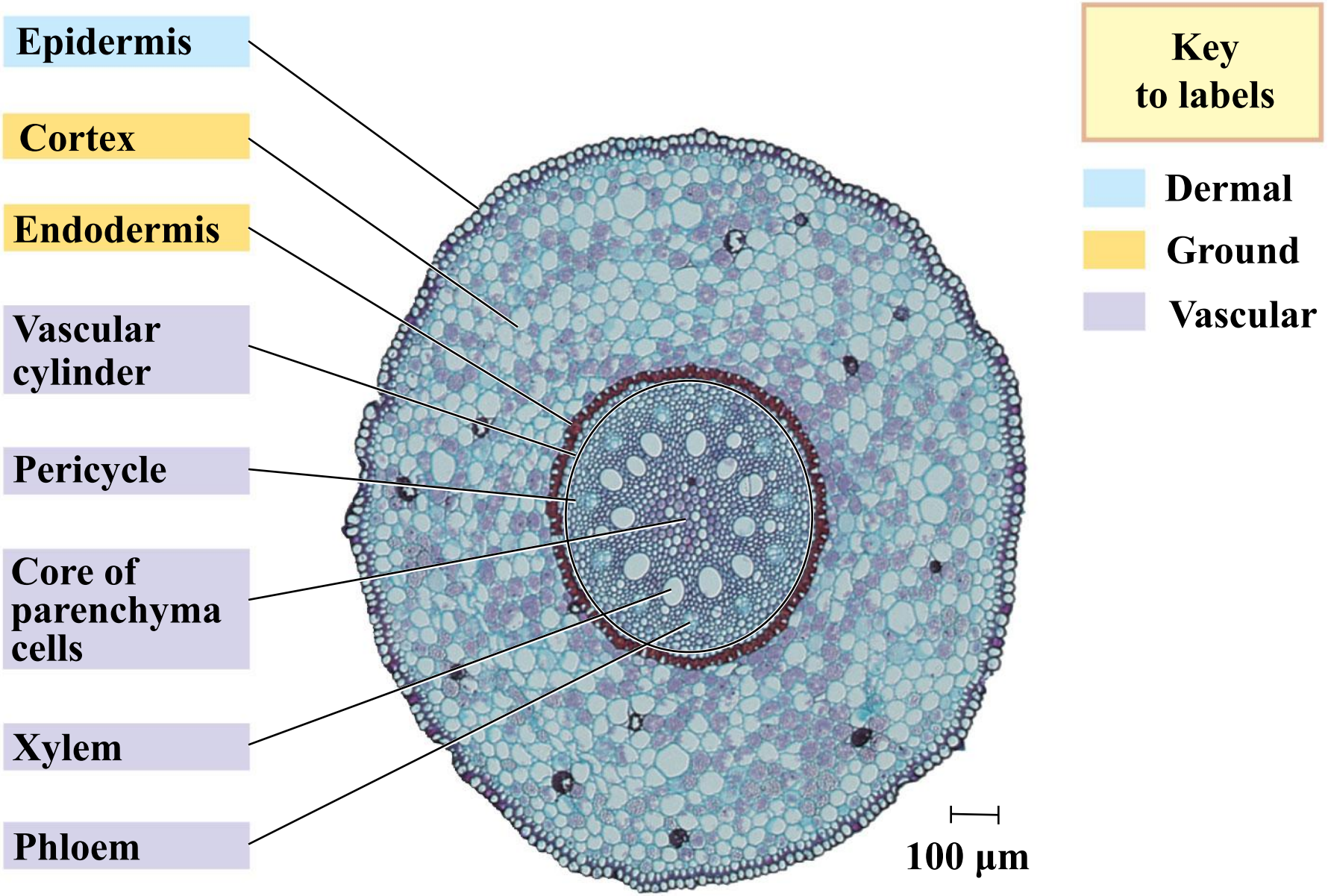
Root with xylem and phloem in the center (typical of eudicots)



Central part of eudicot plant root with xylem and phloem



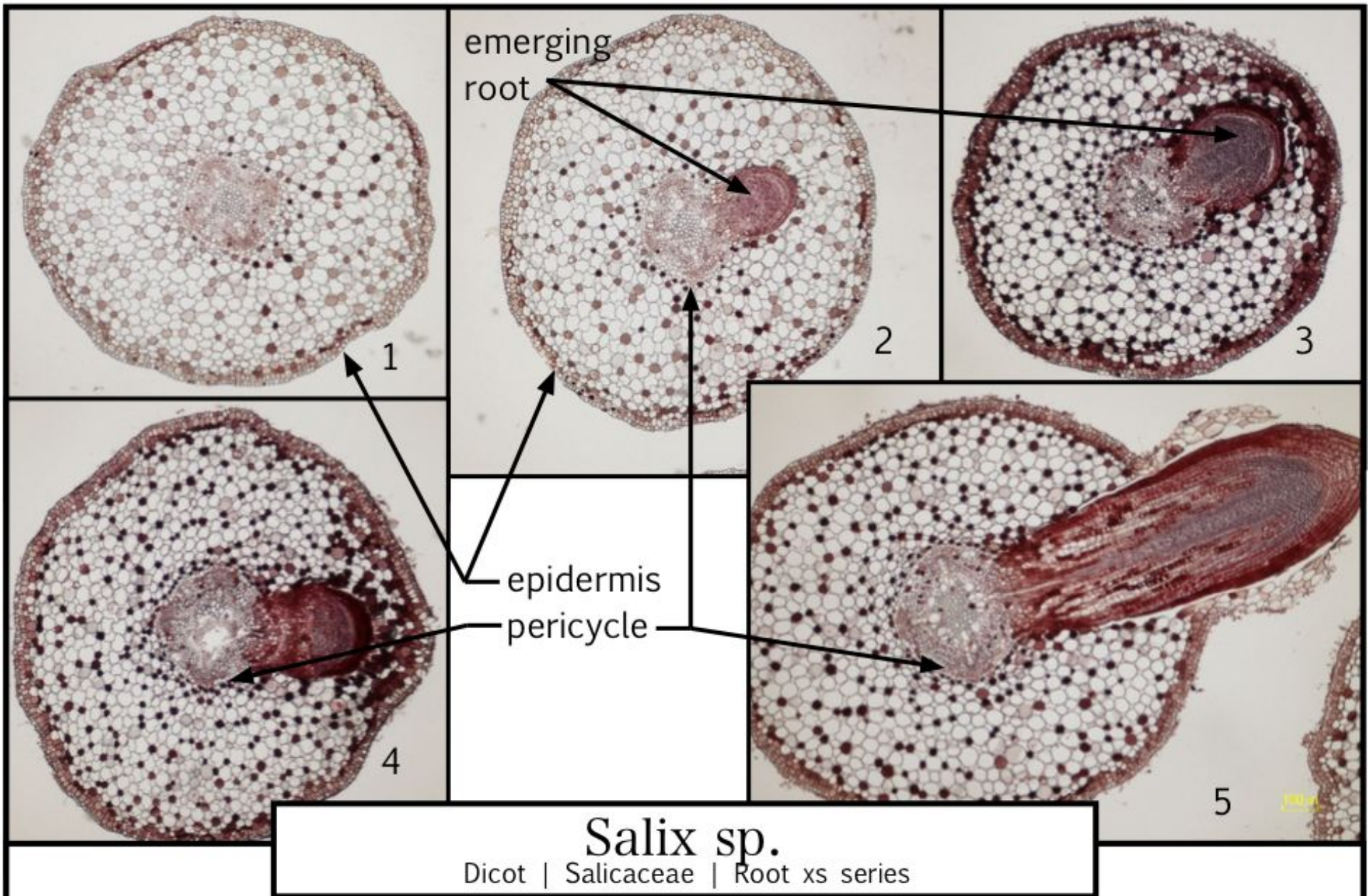
Root with parenchyma in the center (typical of monocots)



Anatomy of a Root

- The ground tissue, mostly parenchyma cells, fills the cortex – the area between the vascular cylinder and epidermis
- The innermost layer of the cortex is called the **endodermis**
- The endodermis regulates passage of substances from the soil into the vascular cylinder
- Lateral roots arise from within the **pericycle**, the outermost cell layer in the vascular cylinder

The emergence of a root from the pericycle



Root modifications

Prop roots

Storage roots

"Strangling" aerial roots

Pneumatophores

Buttress roots

Types of vascular bundles in plants

1. Simple Bundles: Xylem and phloem strands are located on alternate radii in radial vascular bundles. These are mainly found in roots.

2. Conjoint bundles: Xylem and phloem combine together into one bundles, Xylem lies towards the centre and phloem towards the periphery. There are two types of conjoint bundles.

2.1. Collateral: Xylem and phloem lie on the same radius, xylem towards the centre and phloem towards the periphery. When cambium is present in collateral bundles, such bundle is called open, e.g. in dicot stems and collateral bundle without cambium is called closed, e.g. in monocot stems.

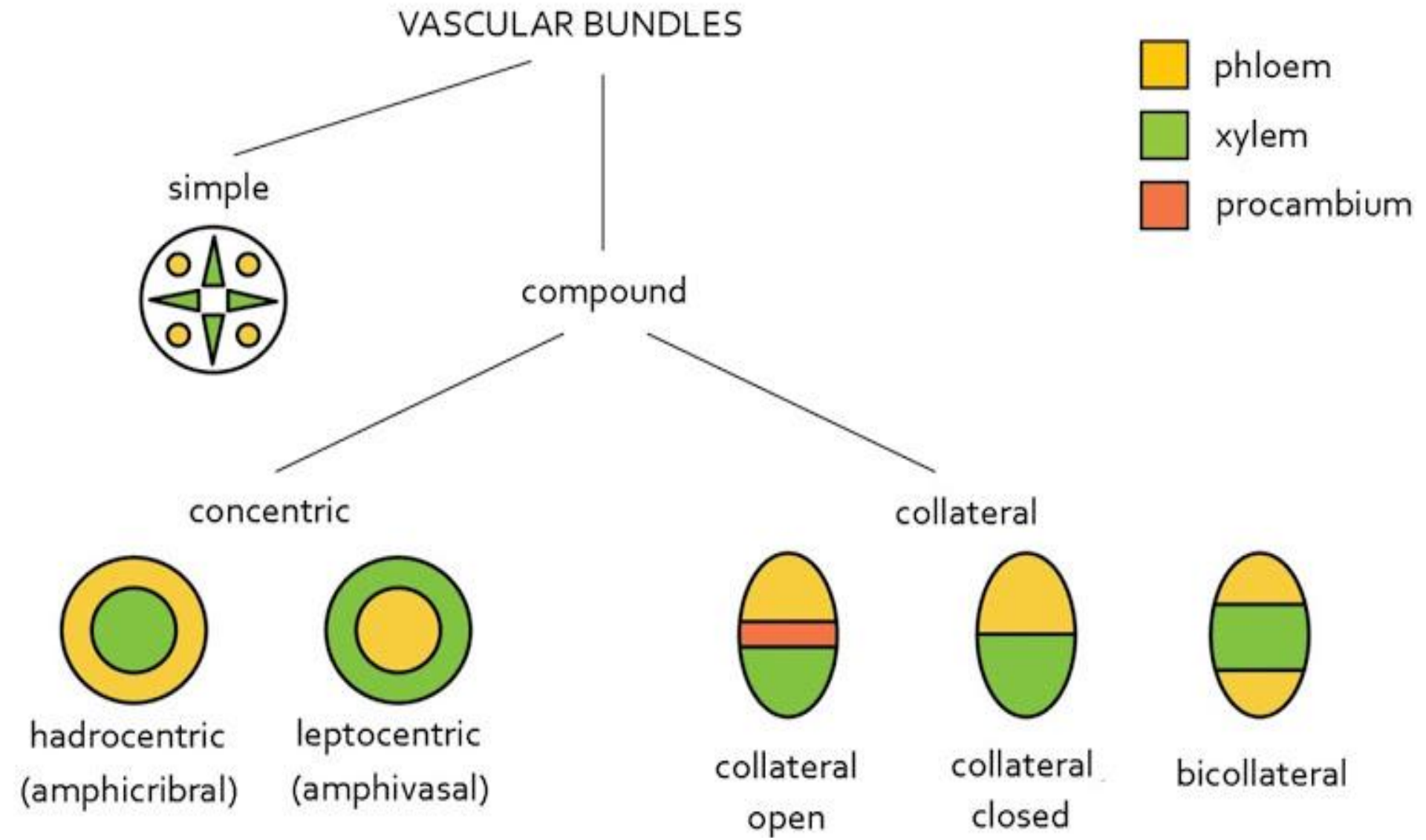
2.2. Bicollateral: The phloem strands are present on both outer and inner side of xylem.

3. Concentric Bundles: In this type of vascular bundle, one tissue is completely surrounded by the other. These are of two types Amphivasal and Amphicribral.

3.1. Amphivasal: Xylem surrounds the phloem, e.g. Dracaena.

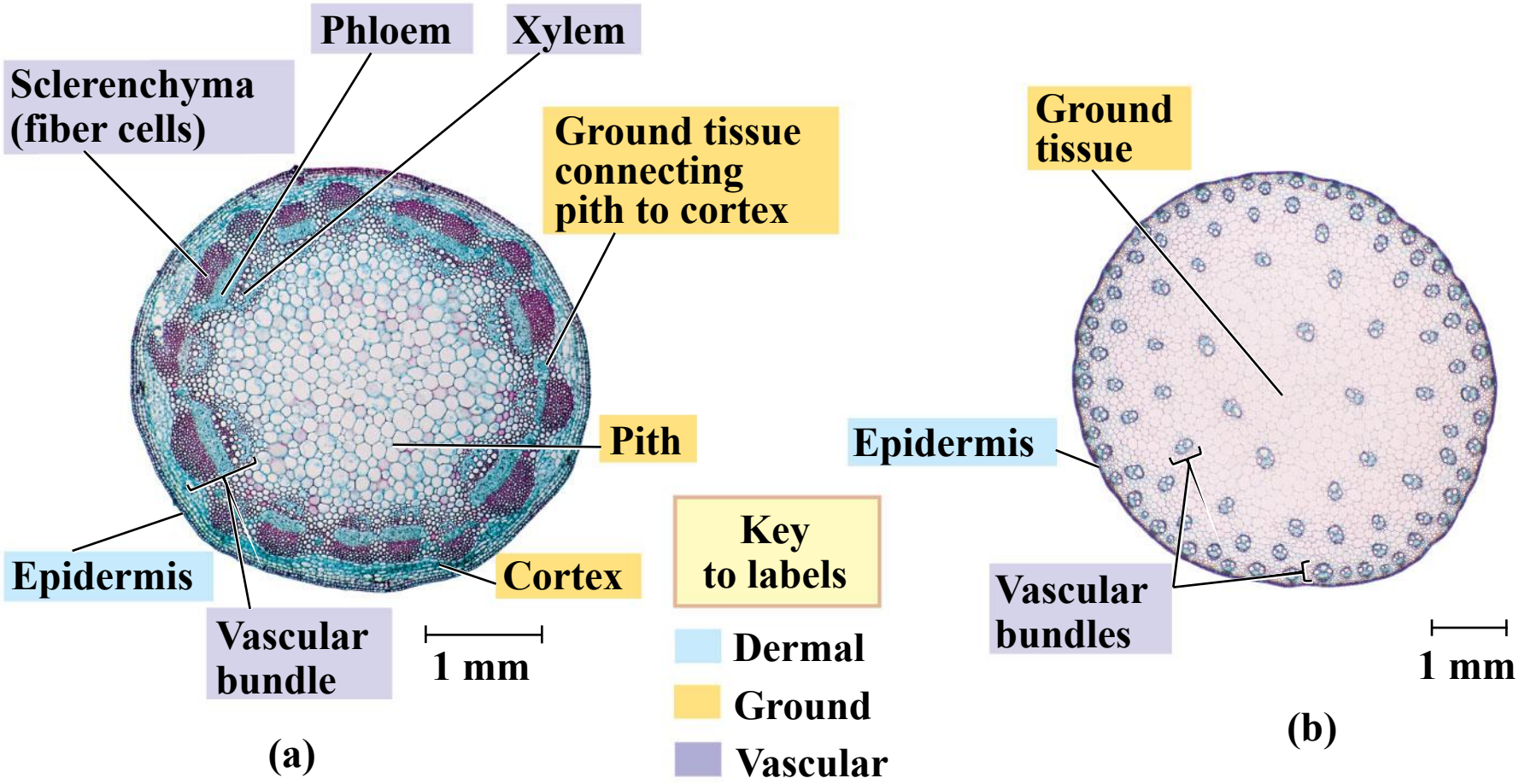
3.2. Amphicribral: Phloem surrounds the xylem, e.g. in Ferns.

Types of vascular bundles in plants



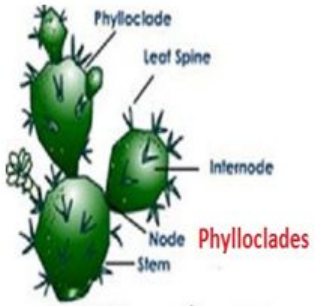
Differences between stem anatomy of monocots and dicots

- **In gymnosperms and most eudicots (a)** The vascular tissue consists of vascular bundles arranged in a ring
- **In most monocot stems (b)** The vascular bundles are scattered throughout the ground tissue, rather than forming a ring

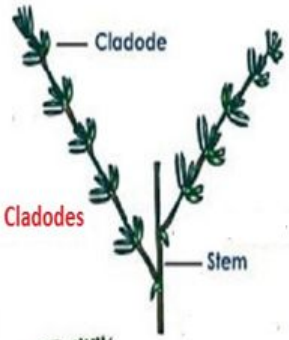


Stem modifications

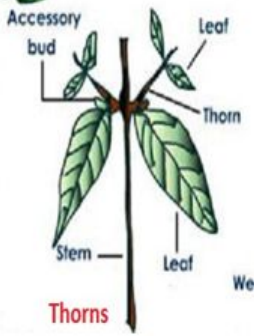
Aerial modification of stem



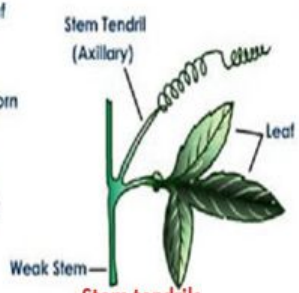
Phylloclades



Cladodes

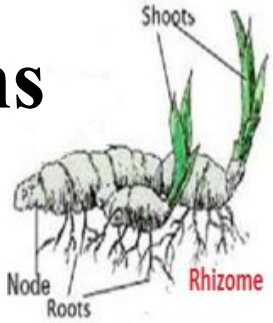


Thorns



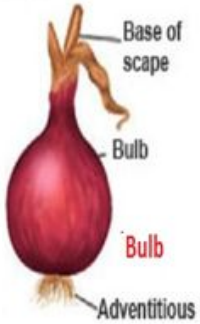
Stem tendrils

Underground modification of stem

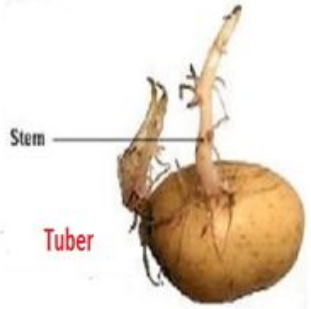


Rhizome

Corm



Bulb



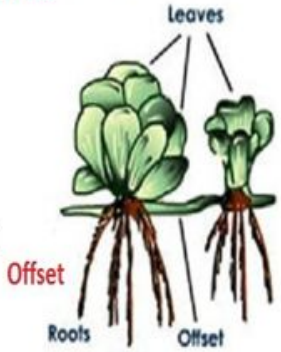
Tuber

Sub-aerial modification of stem


Runner

Stolon

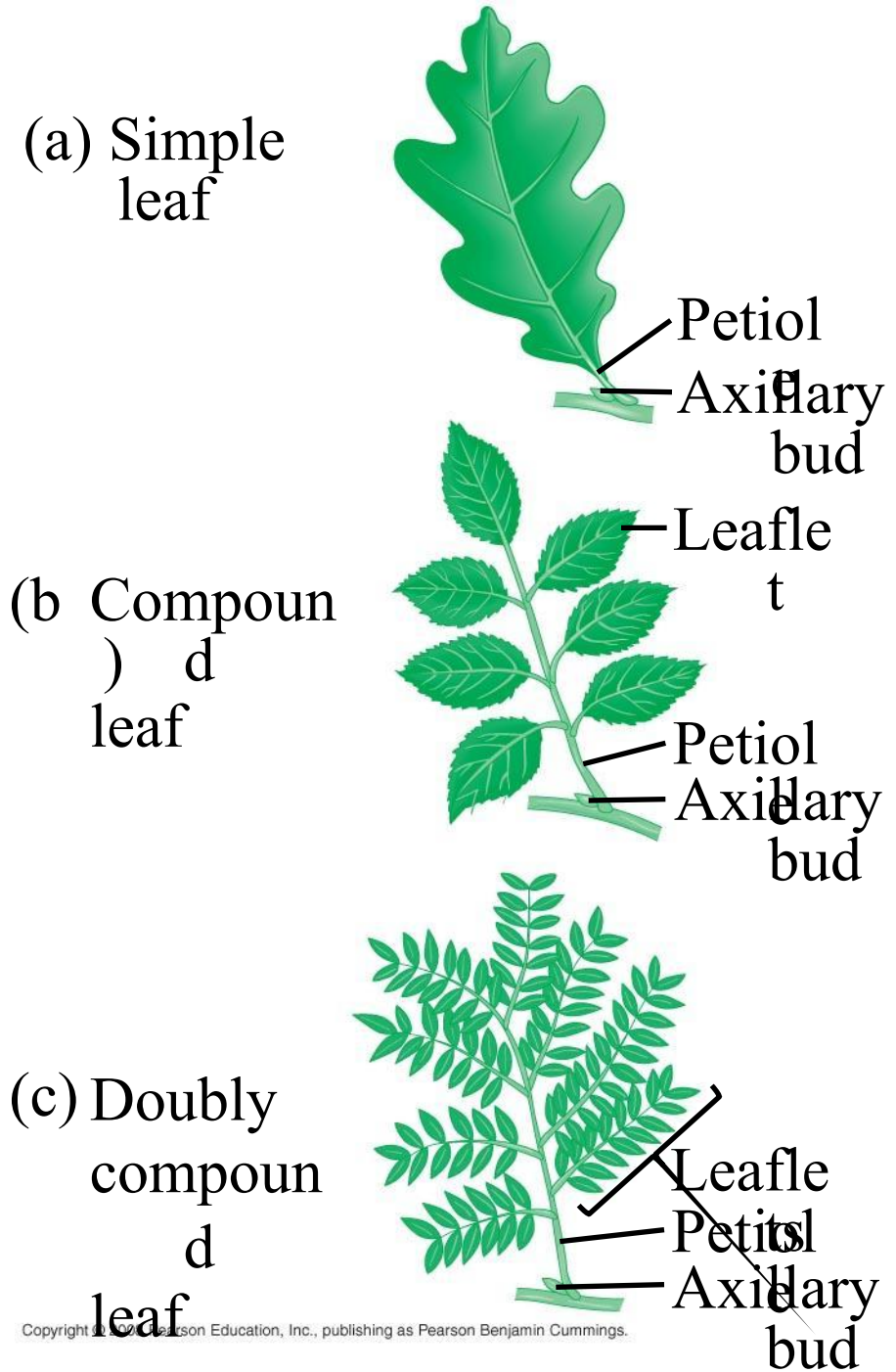
Sucker



Leaves – the main photosynthetic organs

- Leaves generally consist of a flattened **blade** and a stalk called the **petiole**, which joins the leaf to a node of the stem.
- Monocots and eudicots differ in the arrangement of **veins**, the vascular tissue of leaves:
  - Most monocots have parallel veins.
  - Most eudicots have branching veins.

Simple vs. Compound Leaves



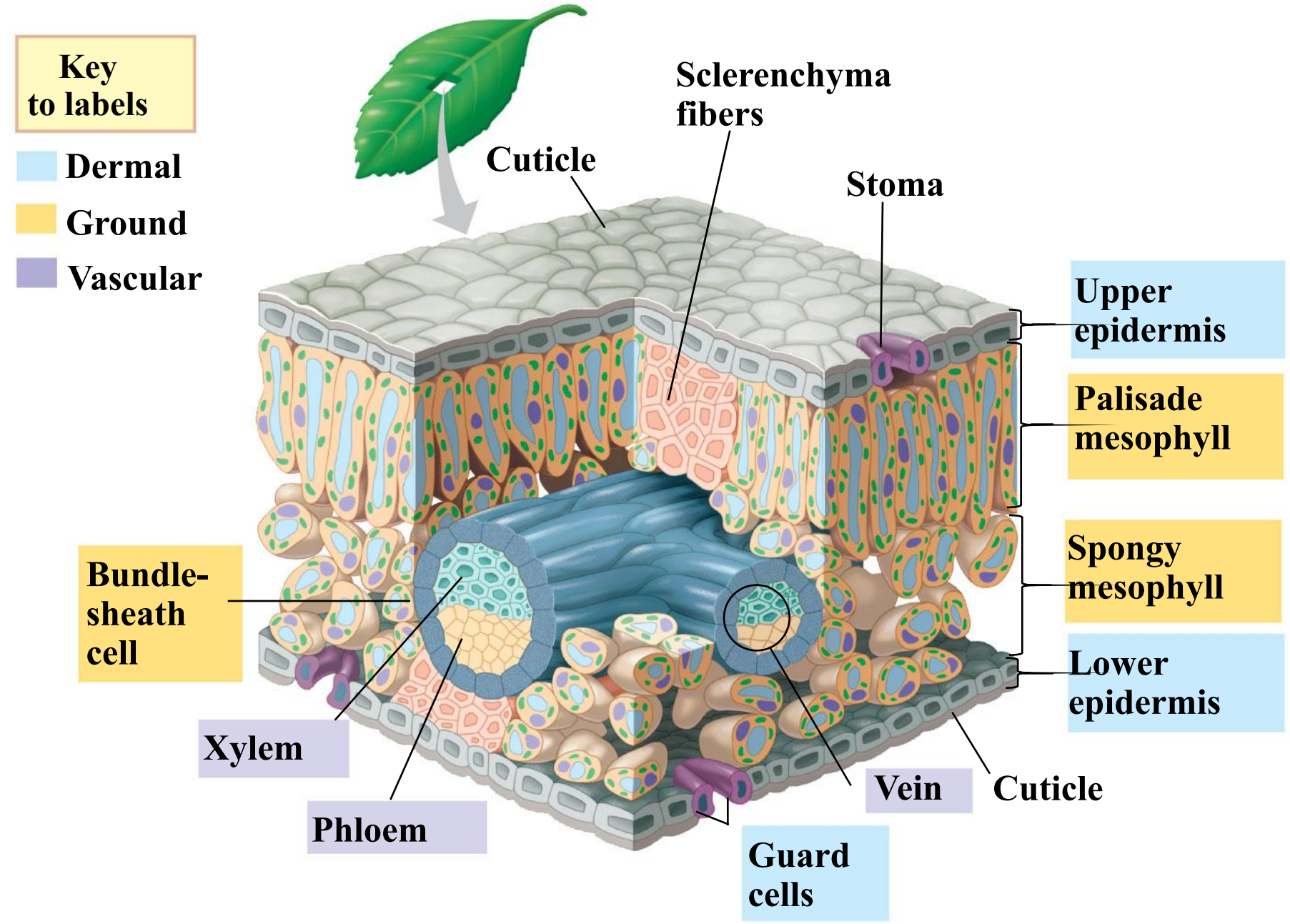
Tissue Organization of Leaves

- The epidermis in leaves is interrupted by **stomata**, which allow CO_2 exchange between the air and the photosynthetic cells in a leaf.
- Each stomatal pore is flanked by two **guard cells**, which regulate its opening and closing.
- The ground tissue in a leaf, called **mesophyll**, is sandwiched between the upper and lower epidermis.

Tissue Organization of Leaves

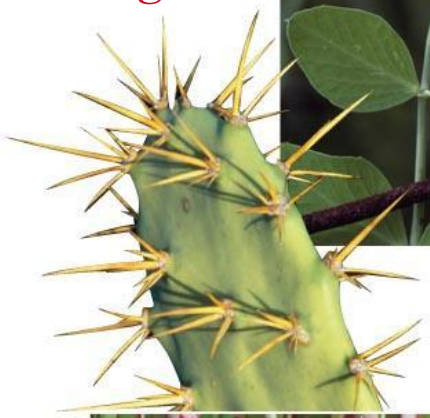
- Below the *palisade mesophyll* in the upper part of the leaf is loosely arranged *spongy mesophyll*, where gas exchange occurs.
- The vascular tissue of each leaf is continuous with the vascular tissue of the stem.
- Veins are the leaf's vascular bundles and function as the leaf's skeleton.
- Each vein in a leaf is enclosed by a protective bundle sheath.

Leaf Structure



Leaf modifications

- Tendrils
  cling



- Spines
  "prickly"
  Photosynthesis is carried out mainly by the flesh/stems

- Storage Leaves
  succulent plant leaves store water

- Reproductive leaves
  Little plantlets fall off and take root in the soil

- Bracts
  Look like petals
  Attract pollinators

Flowers

What is a flower?

= **<u>Shoot system</u>** bearing **modified leaves**:

Perianth

Calyx (sepals) - green, protective

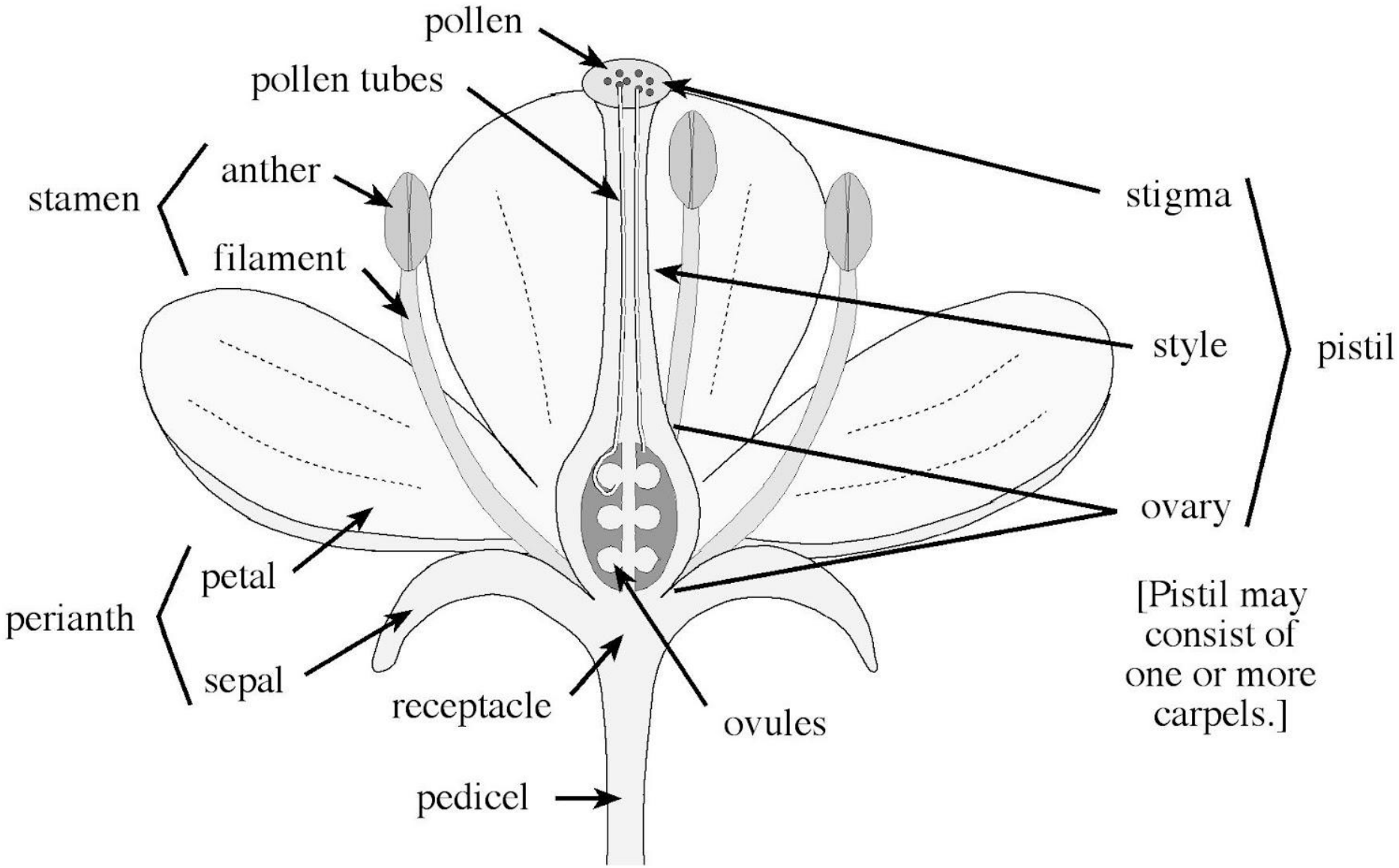
Corolla (petals) - colored, attractant

Stamens - male

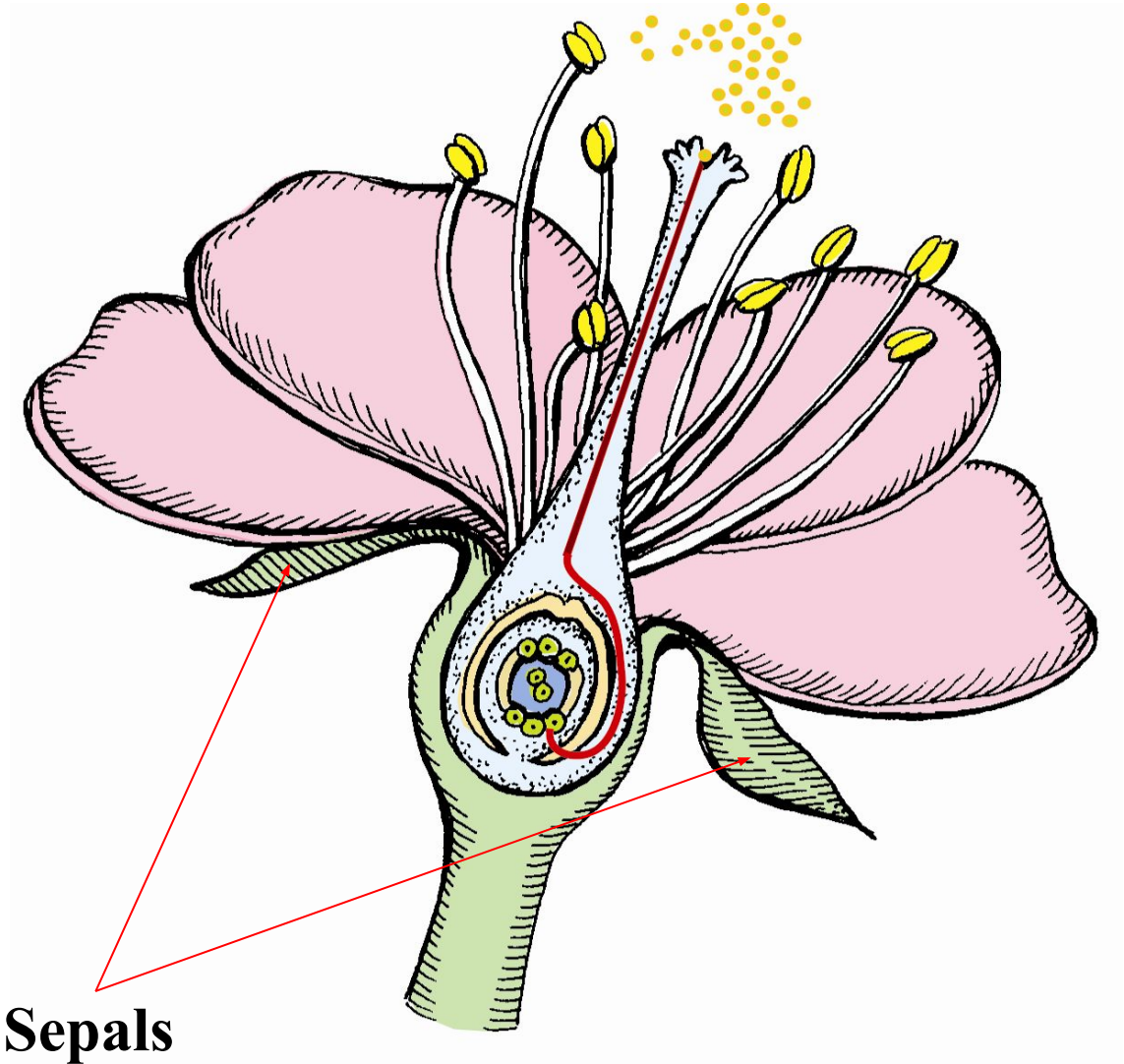
Carpels - female

} modified leaves

Flower parts:



Sepals

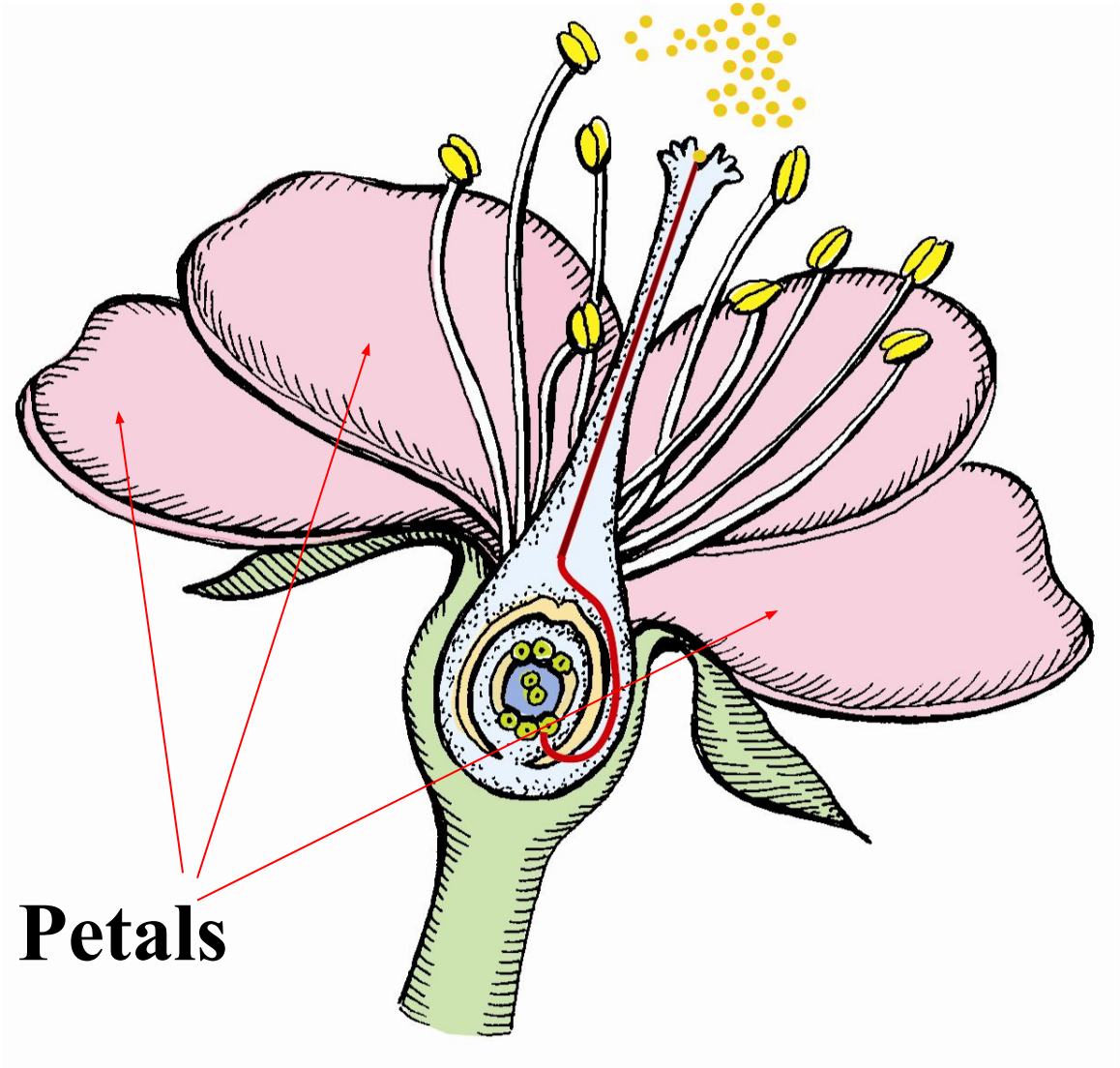


Sepals are leaf-like structures that form an outer ring around the base of a flower.

Sepals enclose and protect a flower bud before it opens.

The complete ring of sepals is called the calyx.

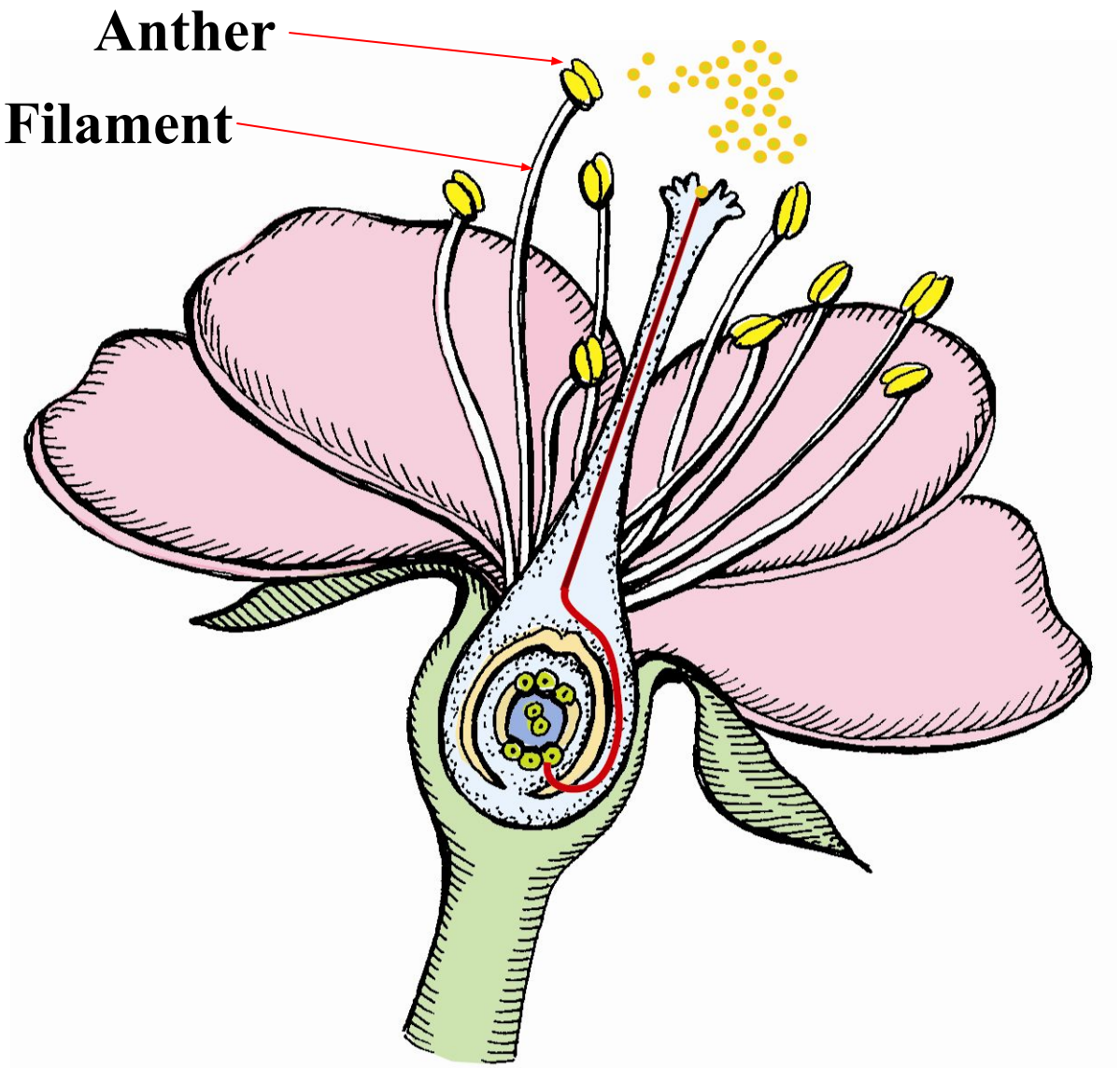
Petals



Petals are often the bright and colored part of a flower.

Petal colors and scents attract specific pollinators.

Stamens

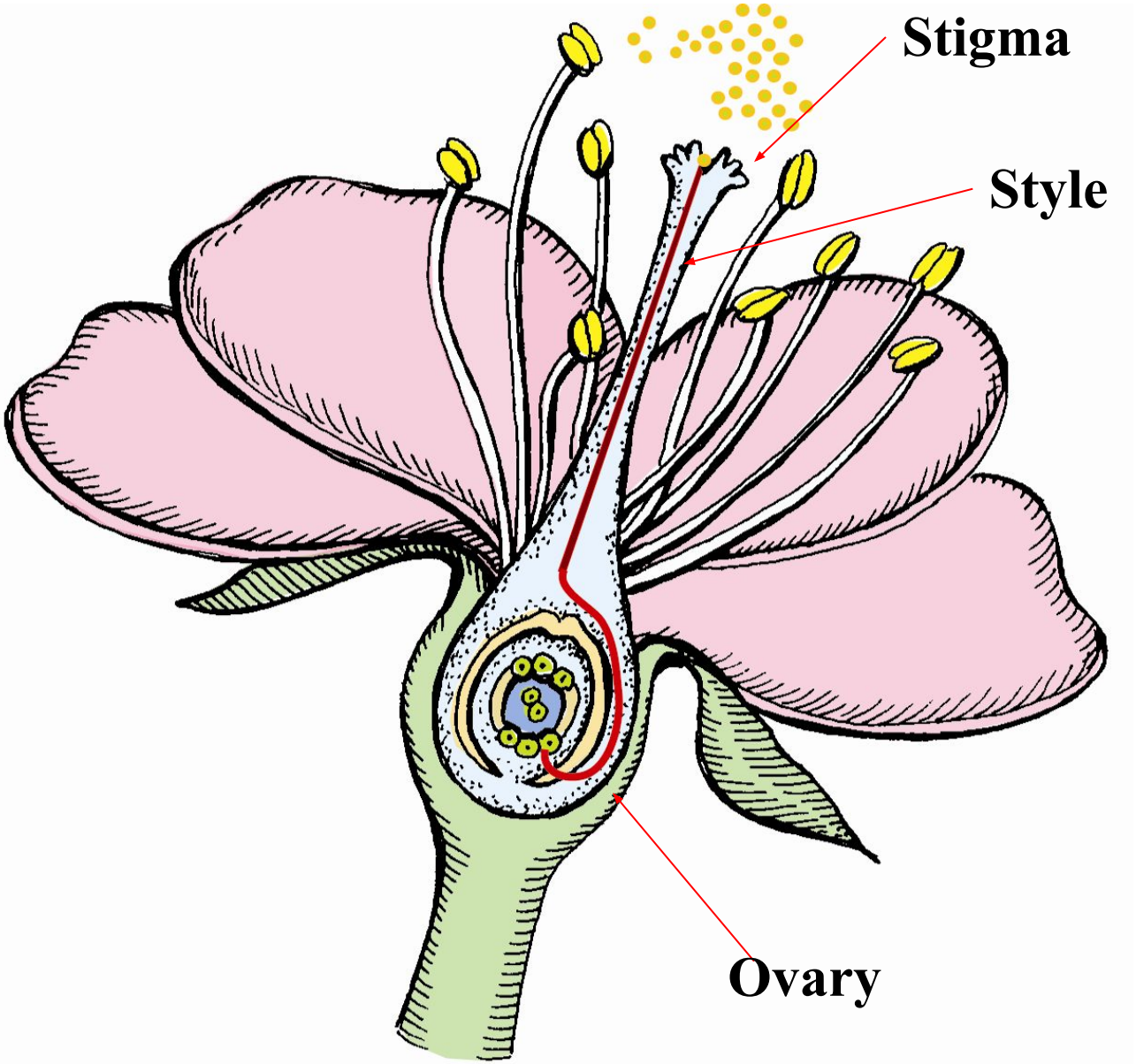


The **stamen** contains both the filament and the anther.

The filament is a stalk-like structure that holds the anther.

Stamens are the male reproductive parts of a flower.

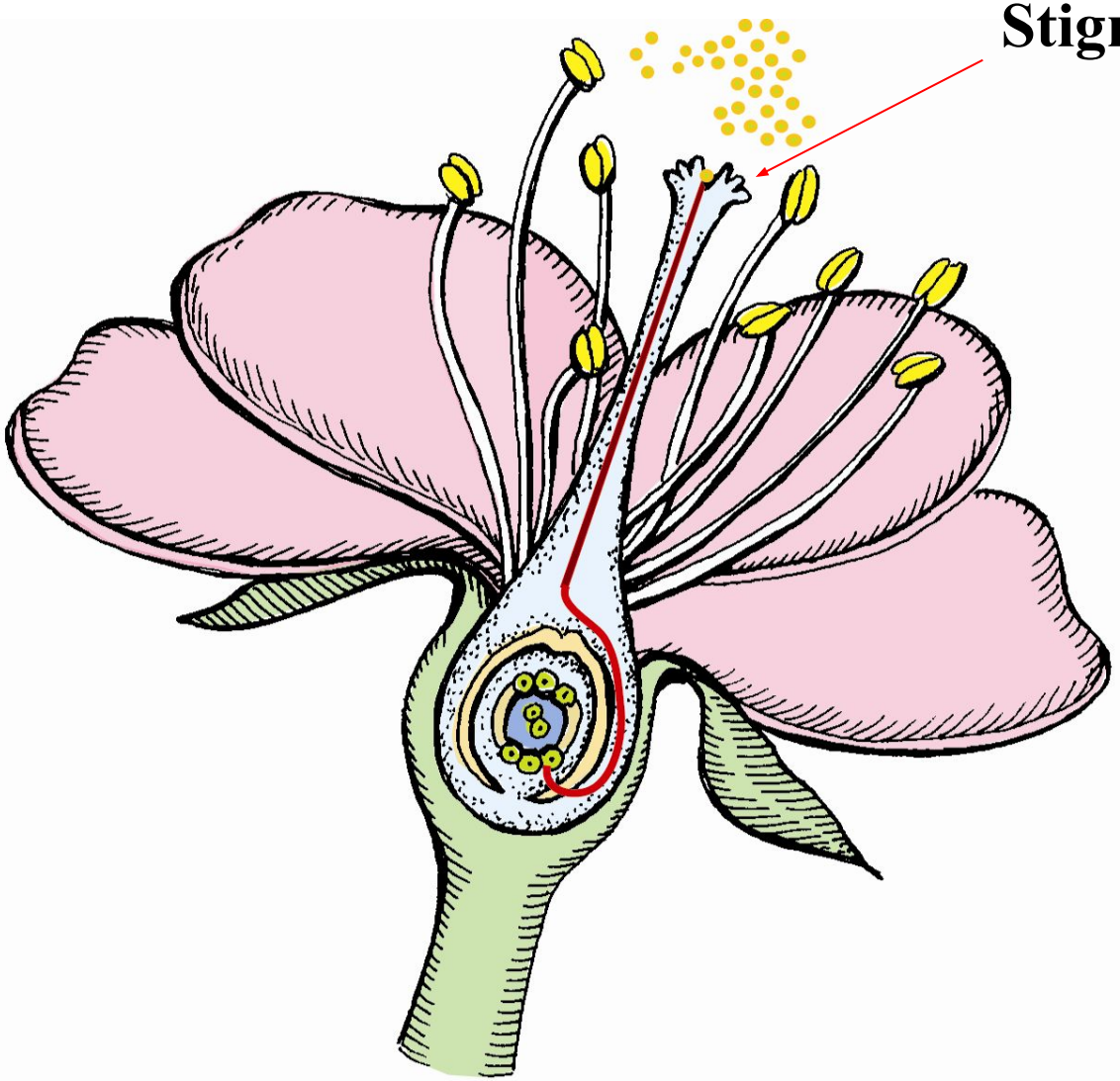
Pistil



The **pistil** includes three parts:

1. **Stigma**
2. **Style**
3. **Ovary**

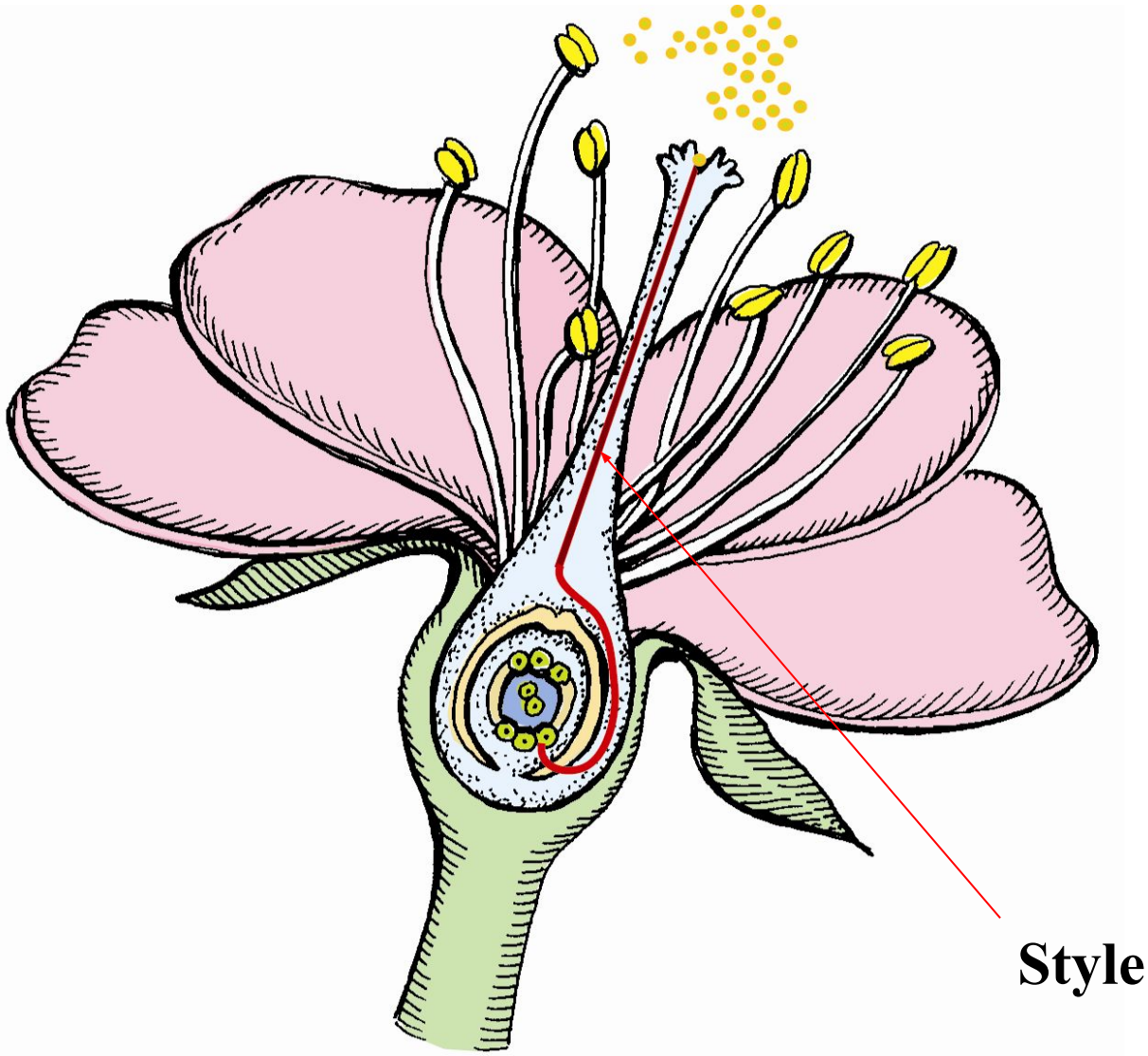
Pistil 1. Stigma



The **stigma** is a sticky, flattened surface that projects upwards towards the pollinator.

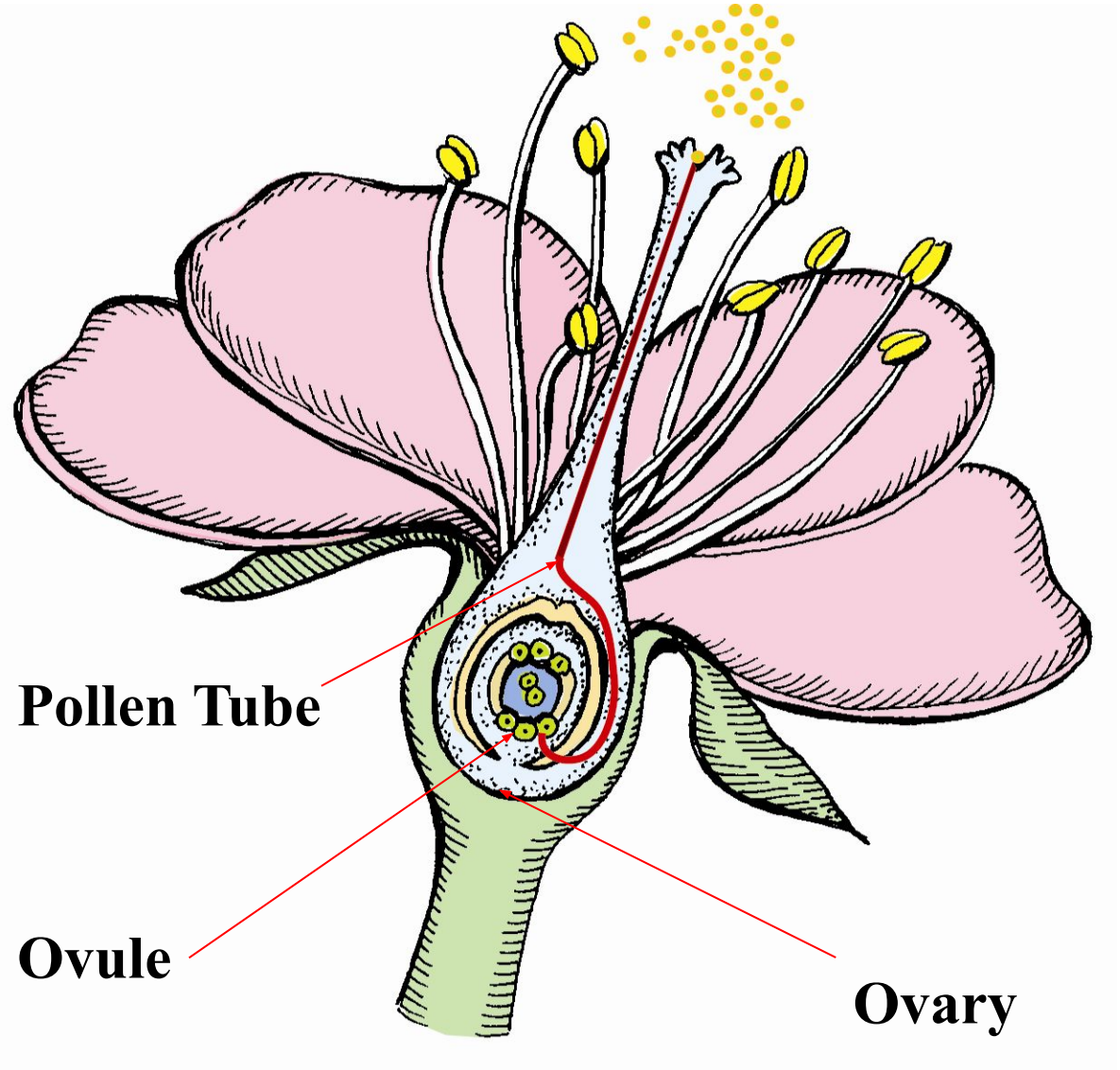
Birds and insects collect nectar from previously visited plants and brush against the sticky surface of the stigma.

Pistil 2. Style



The **style** is a supportive structure that holds the stigma in a position to maximize the chances of pollination.

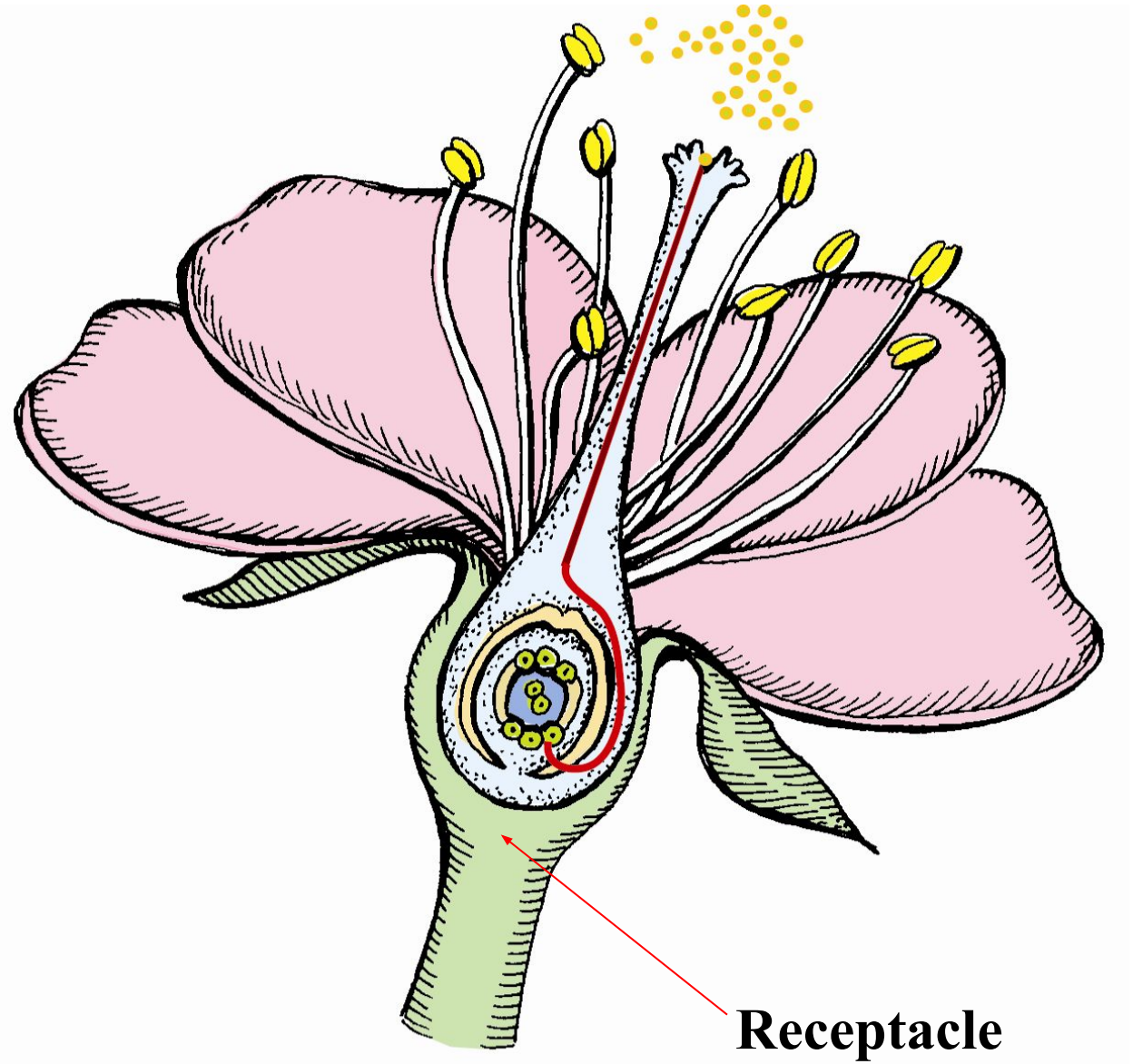
Pistil 3. Ovary



The **ovary** is an enlarged structure that contains the female sex cells, or ovules.

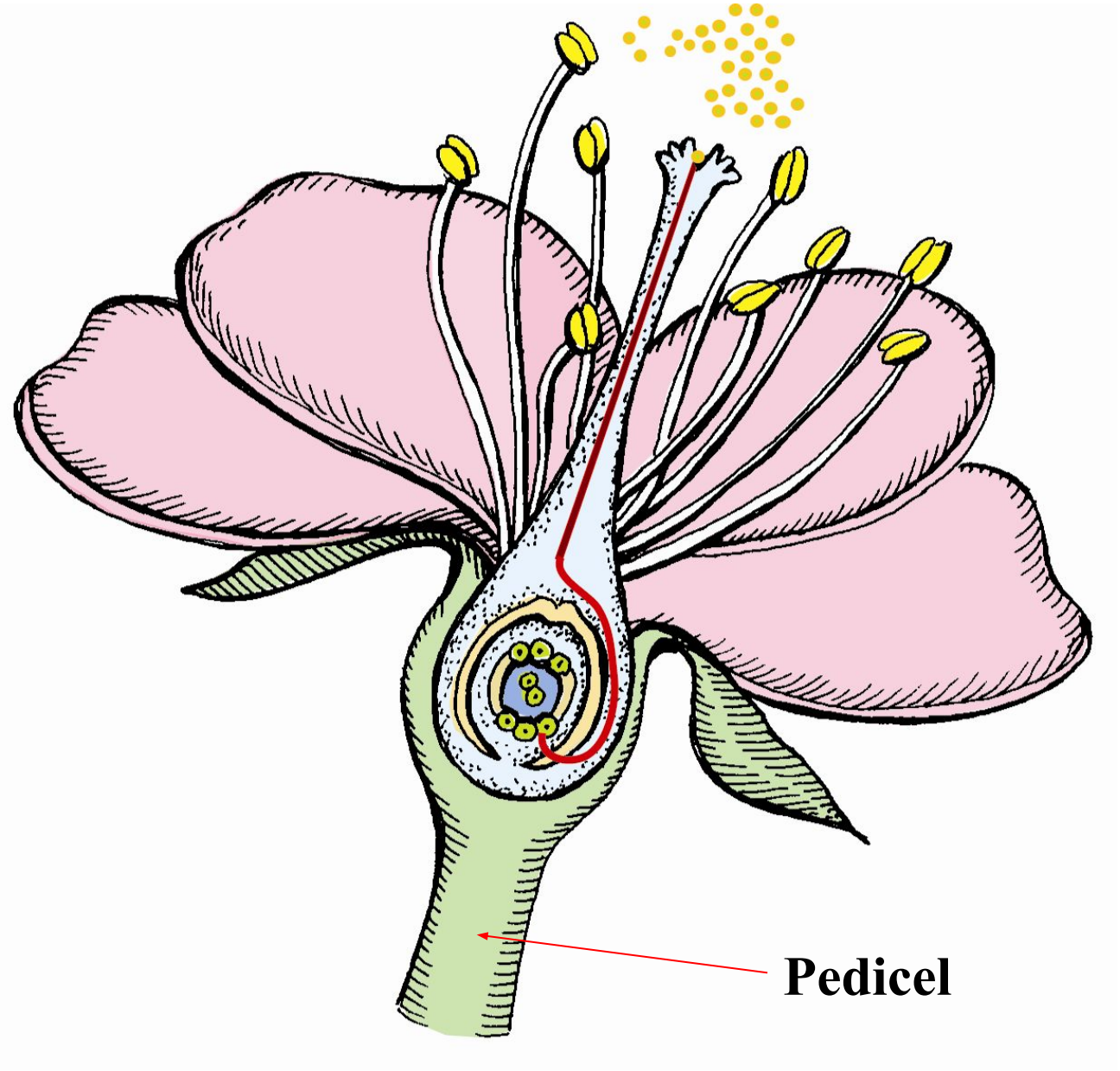
The pollen tube grows through the ovary and into an ovule.

Receptacle



The enlarged part of the pedicel where it joins the flower is the **receptacle**.

Pedicel



The **pedicel** (flower stalk) supports the flower.

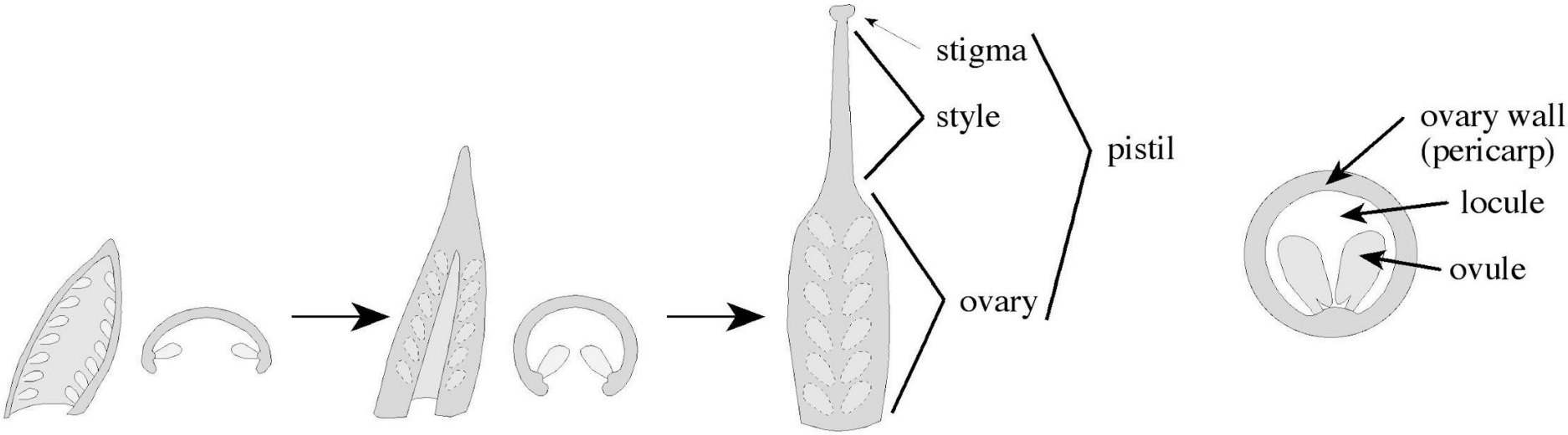
Carpels

Carpel = conduplicate megasporophyll

Conduplicate = folded

Megasporophyll = “female leaf, bearing seeds”

Carpel totally encloses ovules/seeds

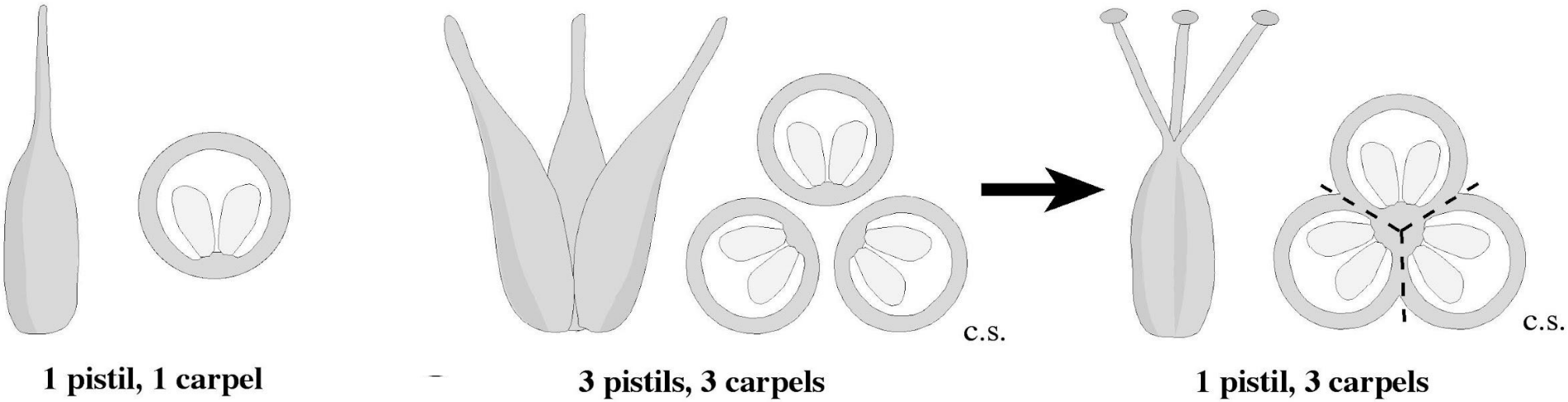


Carpels can fuse together

Gynoecium = all female parts

Pistil = ovary + style + stigma

Pistil can be one carpel or many



1 pistil, 1 carpel

3 pistils, 3 carpels

1 pistil, 3 carpels

Monocarpous

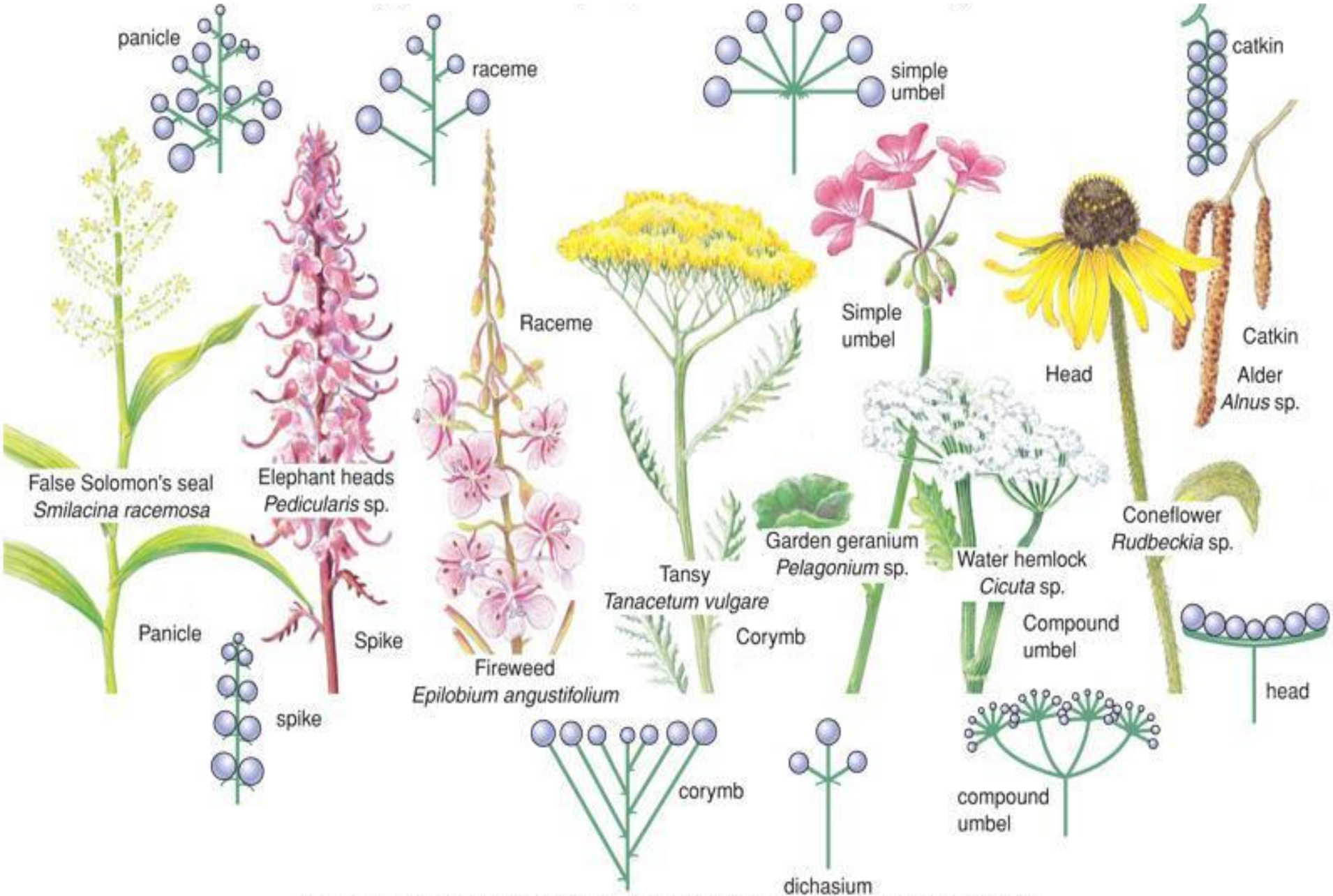
Apocarpous

Syncarpous

Functions of Carpel

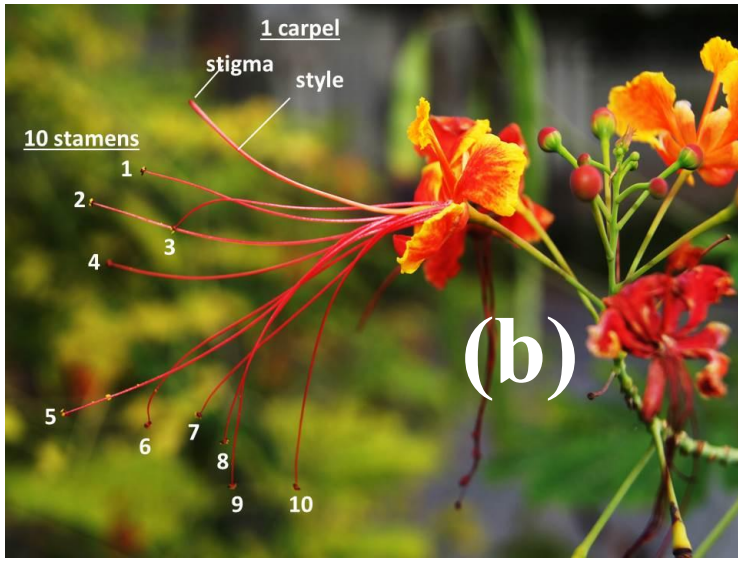
1. Protects young seeds
2. Site of pollen germination
   - Can induce **self-incompatibility reactions**
3. Fruits forming

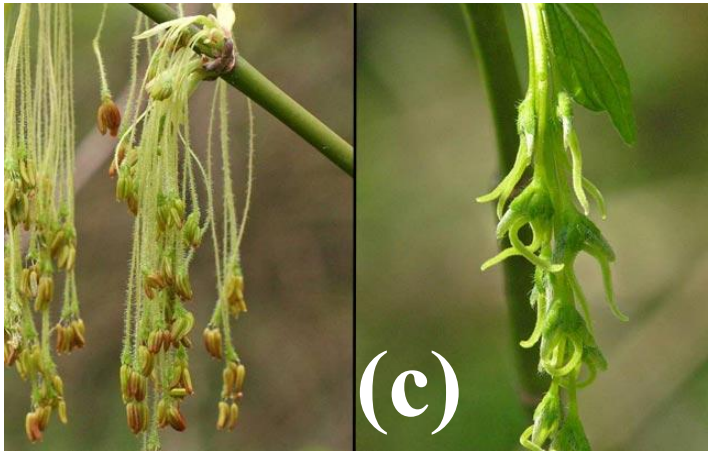
Flowers can be produced singly or in inflorescences

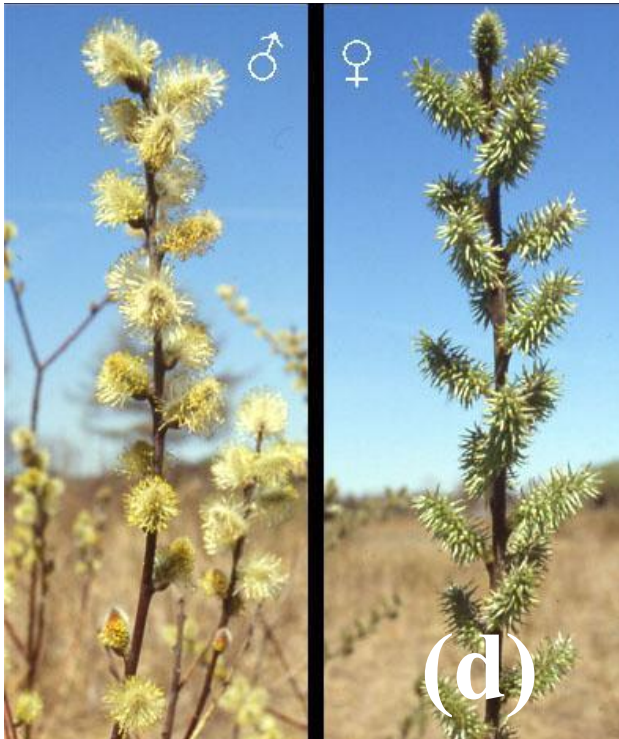


Flower types

- **unisexual flowers:** they have inside either pistil or stamens **(a)**
- **bisexual flowers:** they have inside both pistil and stamens **(b)**
- **monoecious plant:** flowers are of both sexes are in all plants **(c)**
- **dioecious plant:** in one plant there are male flowers and in the other female **(d)**







Flower Symmetry

- Flower Symmetry is the divisibility of the flower vertically in two halves.
  - **Actinomorphic:** If a flower can be divided into two equal longitudinal halves from more than one vertical planes passing through the center then it is known as an actinomorphic flower.
  - **Zygomorphic:** If a flower can be divided into two equal longitudinal halves from only one vertical plane passing through the center then it is known as a zygomorphic flower.
  - **Asymmetrical:** If a flower cannot be divided into two equal longitudinal halves from any vertical plane then it is known as an asymmetrical flower.

Fruits

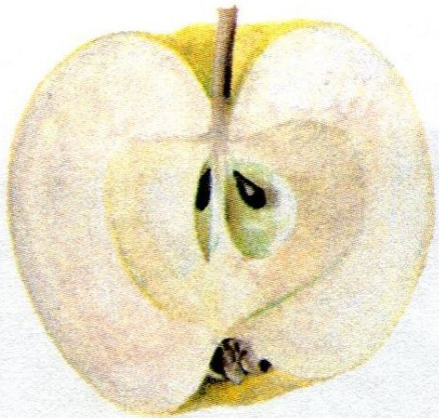
Fruit = mature ovary (plus accessory parts)

Function: seed dispersal

- composed of seed and pericarp
- pericarp arises by the growth of cells of the ovary
- kinds of fruits
  - Fleshy
  - Dry

Fleshy Fruits

- fleshy fruits are dispersed by animals:
  - soft pericarp
  - pome (apple)
  - drupe (plum)
  - berry (tomato)



Dry Fruits

- dry fruits are dispersed mechanically, by wind, water, etc.:
- dehiscent
  - follicle
  - seedpod
  - capsule
  - silicule, silicula
- non-dehiscent
  - caryopsis
  - achaene
  - nut