General Botany (Bot 102)

علم النبات العام

(102 نبت)

Part (1)

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Course specification- an overview
عرض توصيف المقرر

A. Basic information:
-Lecture: 2hour
-Labs: 2 (1x2) hours
Total credit hours: 3

B. Professional information:

(1) Goals & Objectives

- The course provides background material for students who have not previously been exposed thoroughly to basic Botany at university level.
- Knowledge of the fundamental and applied aspects of different botany fields of study, considering the levels of organization, plant structure and function, classification of the plant kingdom and interactions between plants and their environment.

(2) Intended Learning Outcomes (ILO'o)

المخرجات التعليمية المستهدفة

a. Knowledge and understanding:

- Knowledge of fundamental and concepts of Botany.
- Demonstrate the ability of how to utilize the theoretical concepts in applicable form.
- Knowledge of the major fields of Botany.
- What characters link plants to each other and to their environment? How flexible are these links? And how intricate or intermeshed? How do plants evolve and function in their environment? ….their reproduction? …acquisition of energy and nutrients? ……?

b. Intellectual skills:

- Knowledge integration and evaluation of Botanical processes at different levels of organization and classification from molecules to biomes (zonobiomes).
- Testing hypothesis and solve problems with self-direction and originality.
- What can organisms tell us about the past, present and future course of their existence?

c. Professional and practical skills:

- Ability to work in laboratory and field either independently or as a member of a team.
- Ability to do research and report on many areas of Botanical and biological sciences

d. General and transferable skills:

- Problem analysis and solving at theoretical and practical levels.
- Learn in familiar and unfamiliar situation with open mentality and in the spirit of critical enquiry
- Know how to cope with situations (bad or good) and accept to live with others.

(3) Course content

Course content covers the basic principles of Botany that deal with:

- levels of organization from molecules to biomes
- Plant cell structure and division
- Basics of Mendel's Genetics
- Plant structure (Morphological & Anatomical perspectives) and function (basics of plant physiology)
- Classification of plant kingdom
- Plant environment and interactions among plants.

(4) Teaching and Learning Methods

- Lectures
- Laboratory studies
- Student group assignment
- Class discussion and reading materials
- Term papers (internet search)

(5) Student Assessment Methods

- **Written exams and quizzes:** to assess the ability to manage and present the understanding in appropriate manner.
- **Practical exams and assignments:** to assess the skills and abilities and evaluate the outreach of used methodology.
- **Feedback questionnaires:** to assess the student satisfaction, efficiency of instructors and suitability of course contents.
- **Oral exam or group discussion (optional):** to assess the ability to present knowledge and understanding.

❖Assessment schedule:

-Monthly exams and assignments+ class attendance	30
-Laboratory exam and assignment	30
-Final written exam	40
Total Marks	**100**

List of references

(A) Course notes:

Lecture and laboratory hand outs and assigned reading materials

(2) Text books

1-Plant Biology in brief. Mohammed H. Al-whaibi (2011). King Saud University, Academic publishing & Press.

2- Biology of plants 5th Ed. by Raven, P.H., Evert, R.F. and Eichhorn, S.E.(1992) W.H. Freeman and company, Worth Publishers. New York

Supporting books:

3-Biology of Plants 5th ed. by Raven et al. 1992 Worth Publishers. (Translation into Arabic by Al-Whaibi, M. H. and A. S. Al-Khalil, 2002., (2005 second Ed.) Scientific Publications, King Saud University Press, Riyadh, Saudi Arabia. (In Arabic).

4-Manual of Biology of Plants.2002. (2005 second Ed.) Arif, I. A., A. S. Al-Khalil, Al-Whaibi, M. H., R. M. Al-Summ and K. M. Zayed. Scientific Publications, King Saud University Press, Riyadh, Saudi Arabia. (In Arabic).

5- Study Guide to Plant Biology (In Brief). 2008. Al-Whaibi, M. H. and A. S. Al-Khalil) Scientific Publications, King Saud University Press, Riyadh, Saudi Arabia. (In Arabic).

6- Raven, P.H., Evert, R.F. and Eichhorn, S.E.(1999). Biology of plants 6th. E. W.H. Freeman and company, Worth Publishers. New York.

7. Raven, P.H., Evert, R.F. and Eichhorn, S.E.(2005). Biology of plants 7th. E. W.H. Freeman and company, Worth Publishers. New York

(C) Periodicals & Websites: To be listed and handed out during lecture time.

Why study plants?

We could not live without plants

- Plants produce most of the oxygen we breathe.

- Plants produce most of the chemically stored energy we consume as food and burn for fuel.

- Plants produce an assortment of useful chemicals.

Plants are diverse









Ferns

Grasses

Flowering Plants

Broad-leafed plants

Club mosses

Seed Plants

Cone-bearing plants

Vascular Plants

Mosses

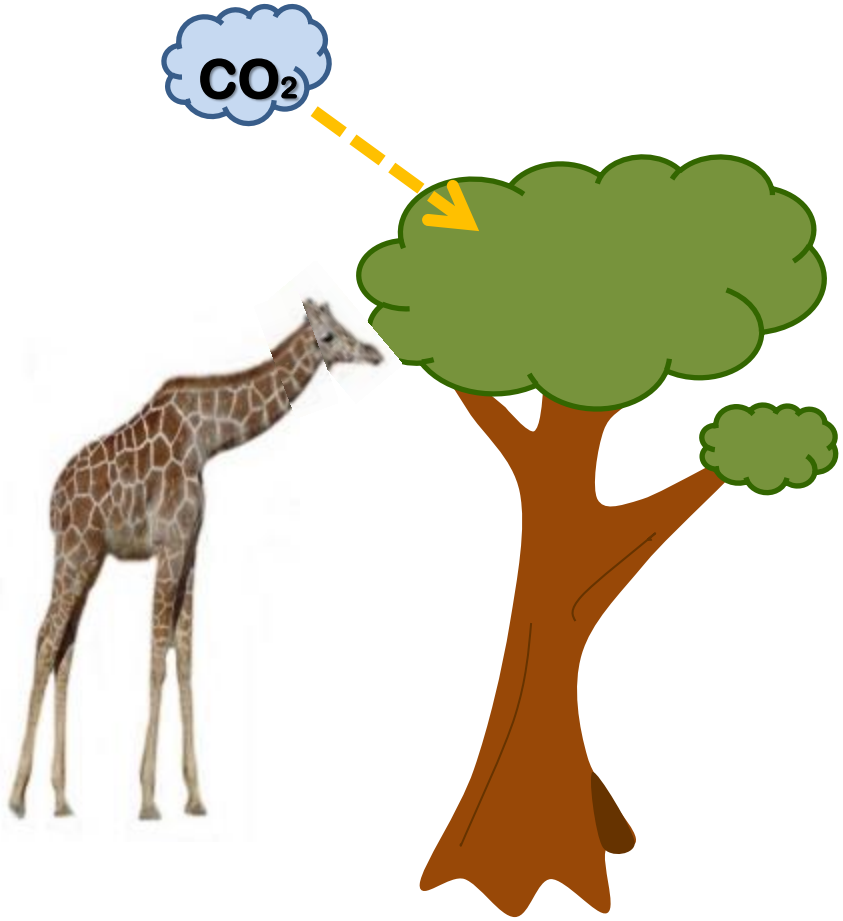
Liverworts

Land Plants

Green algae

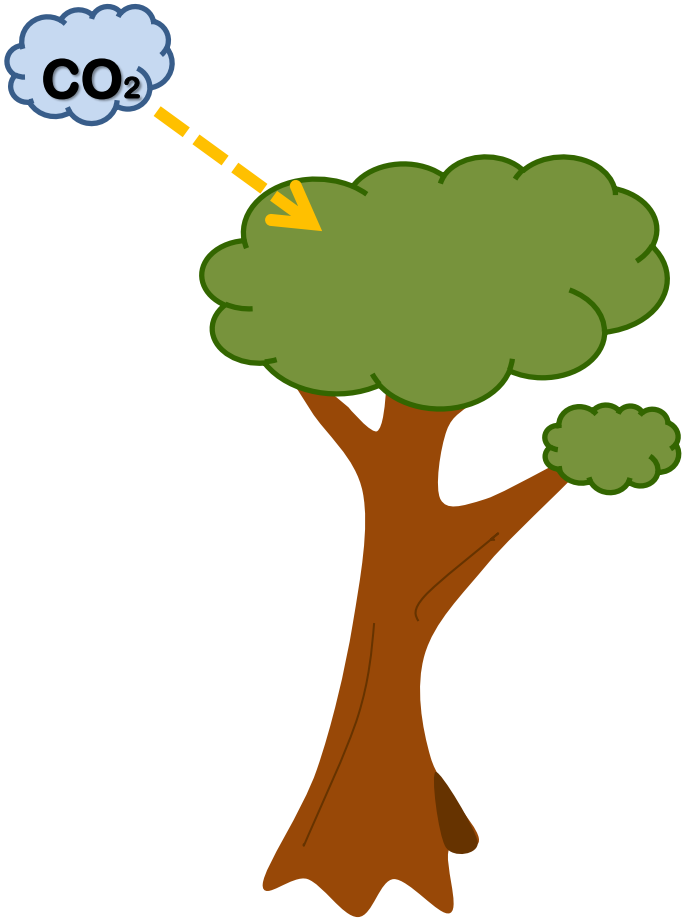
Plants have evolved the ability to thrive in diverse land habitats.

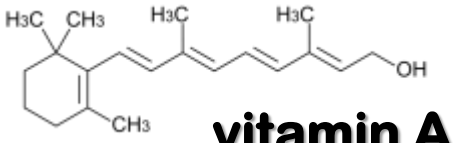
Plants fix carbon dioxide into energy- rich molecules where human & animals can use as food



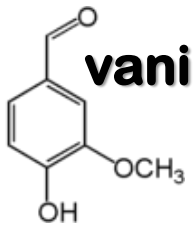
Plants convert CO_2 gas into sugars through the process of photosynthesis.

Plants can produce an amazing assortment of chemicals

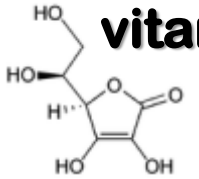




vitamin A

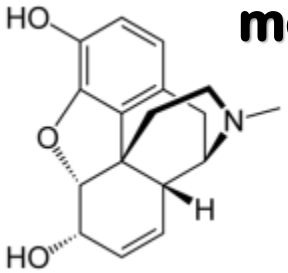


vanillin



vitamin C

caffeine



morphine

More reasons ……..?

- To help conserve endangered plants and threatened environments
- To learn more about the natural world
- To enhance the abilities of plants to provide us with food, medicines, and energy

Mendel's studies of peas revealed the laws of inheritance

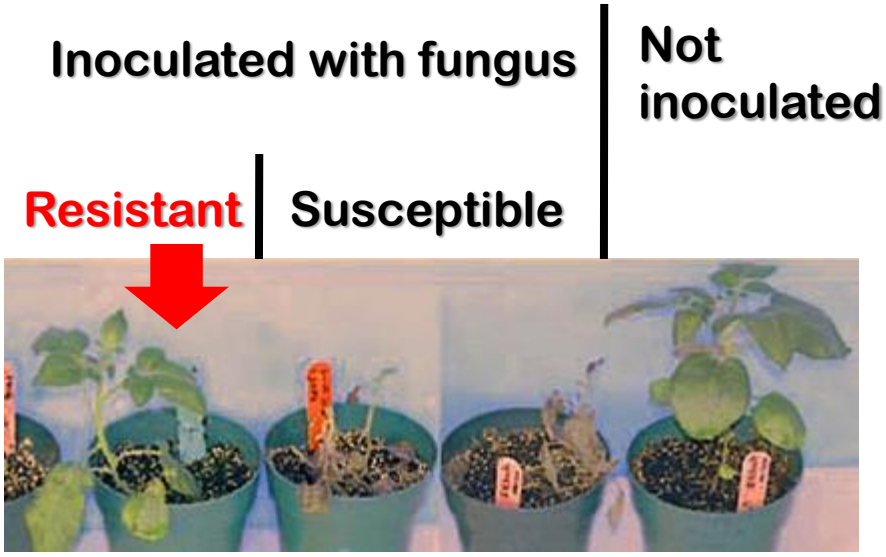
Plant scientists can contribute to the alleviation of hunger

By developing plants that

- **are drought or stress tolerant**
- **require less fertilizer or water**
- **are resistant to pathogens**
- **are more nutritious**

Identification of resistance genes

Geneticists have identified the gene conferring resistance and are introducing it into edible varieties.



The plant on the left carries the resistance gene and is free from disease symptoms.

Plant biologists study ways to keep plants fresh after harvesting

After harvesting, fruits soften, ripen, and eventually rot.

These processes make the fruit less appealing and affect the nutritional qualities.

Genetically biofortified foods

Iron-enriched rice

Vitamin A–enriched rice

Wild-type (top) and antioxidant-enriched tomatoes

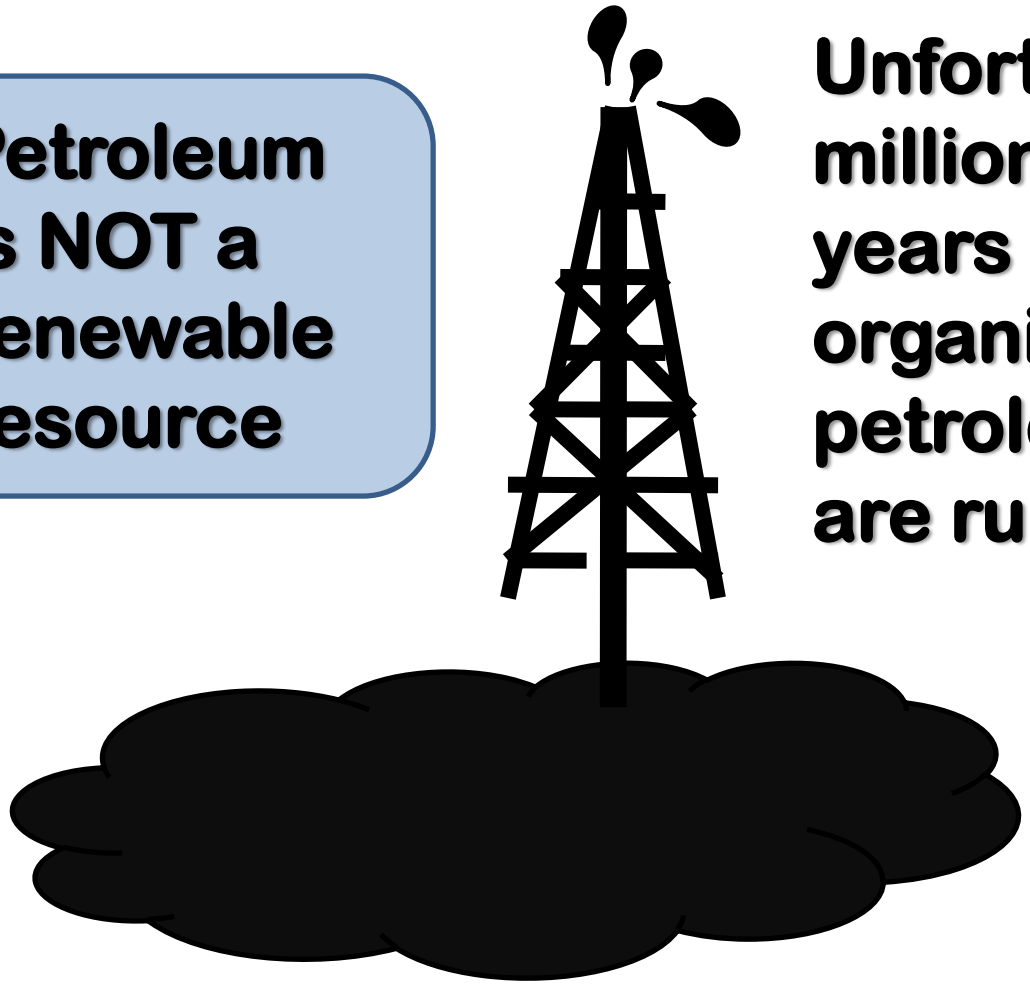
Plants provide us with more than food

Plants:

- are sources of novel therapeutic drugs
- provide better fibers for paper or fabric
- are sources of biorenewable products
- provide renewable energy sources

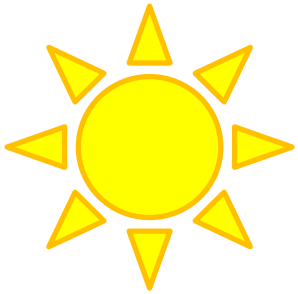
Plants can replace petroleum for many products and purposes

Petroleum is NOT a renewable resource

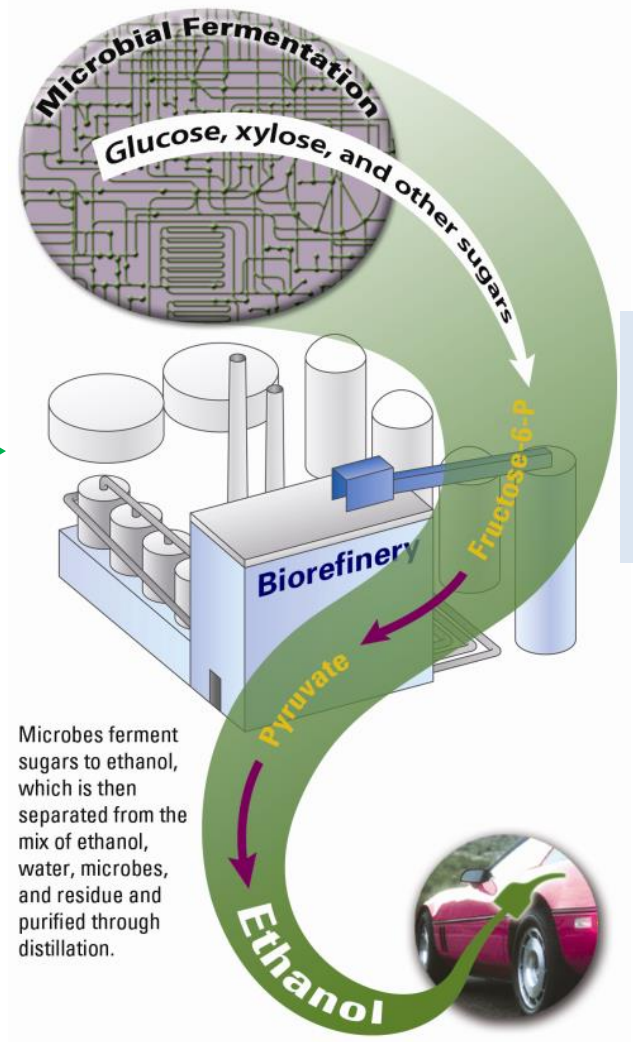


Unfortunately, it takes millions and millions of years to convert dead organic material into petroleum…and we are running out of it.

Plants can be a source of biofuels



Energy from sunlight



Sugars, starches and cellulose can be fermented into ethanol

What is Life?

Life is a characteristic that distinguishes objects that have self-sustaining biological processes, other things are classified as inanimate.

Properties of life …..

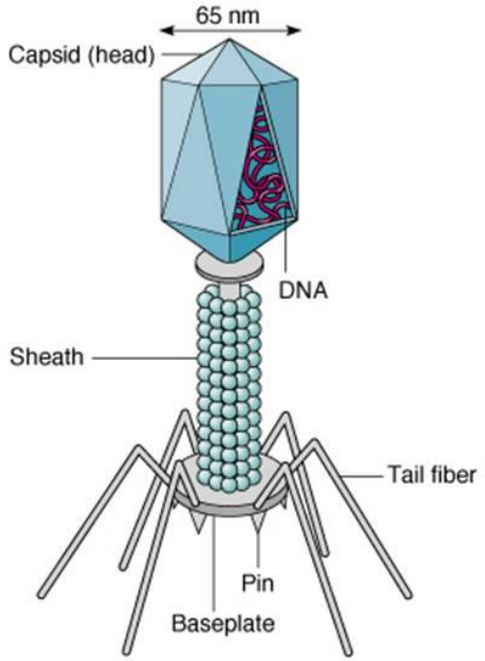
- Cellular structure (unit of life)
- Metabolism (perform function)
- Movement (intracellular)
- Homeostasis
- Organization
- Growth
- Adaptation
- Behavior (response to stimuli)
- Reproduction (avoid extinction)
- Pass on their traits to offspring (heredity)

PLANT CELL

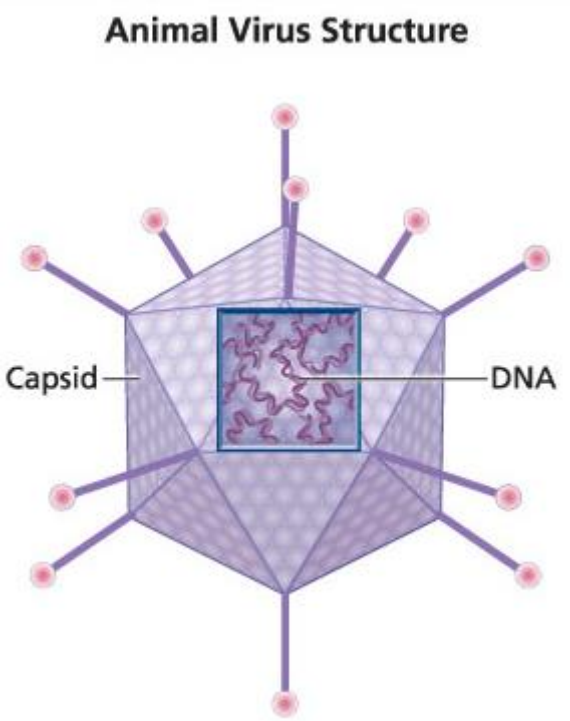
CELLULAR COMPONENTS & PROCESES

The cell theory states:

1. The cell is the basic unit of structure and function of all living things.
2. All living things are composed of one or more cells.
3. All cells come from pre-existing cells.
4. The cells of all living things carry on similar chemical activities.
5. All cells carry on their metabolic activities in organelles.

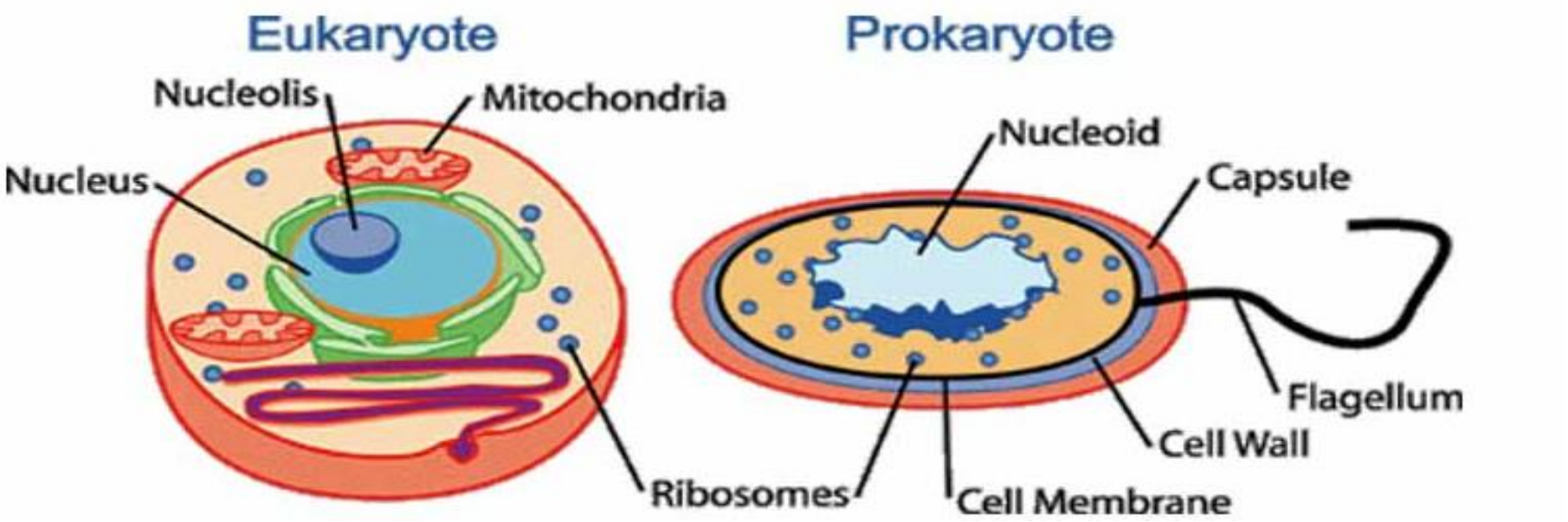


(a) A T-even bacteriophage



A virus and a prion are not considered cellular nor living organisms because of their simplicity (only Nucleic acid surrounded by a protein coat in the case of a virus or only a single strand of protein in the case of a prion). Neither exhibit characteristics of life unless they are in a host cell and cannot replicate outside the host cell.

types of cells:



- **Which ONE is more complicated?**

There are two types of cells:

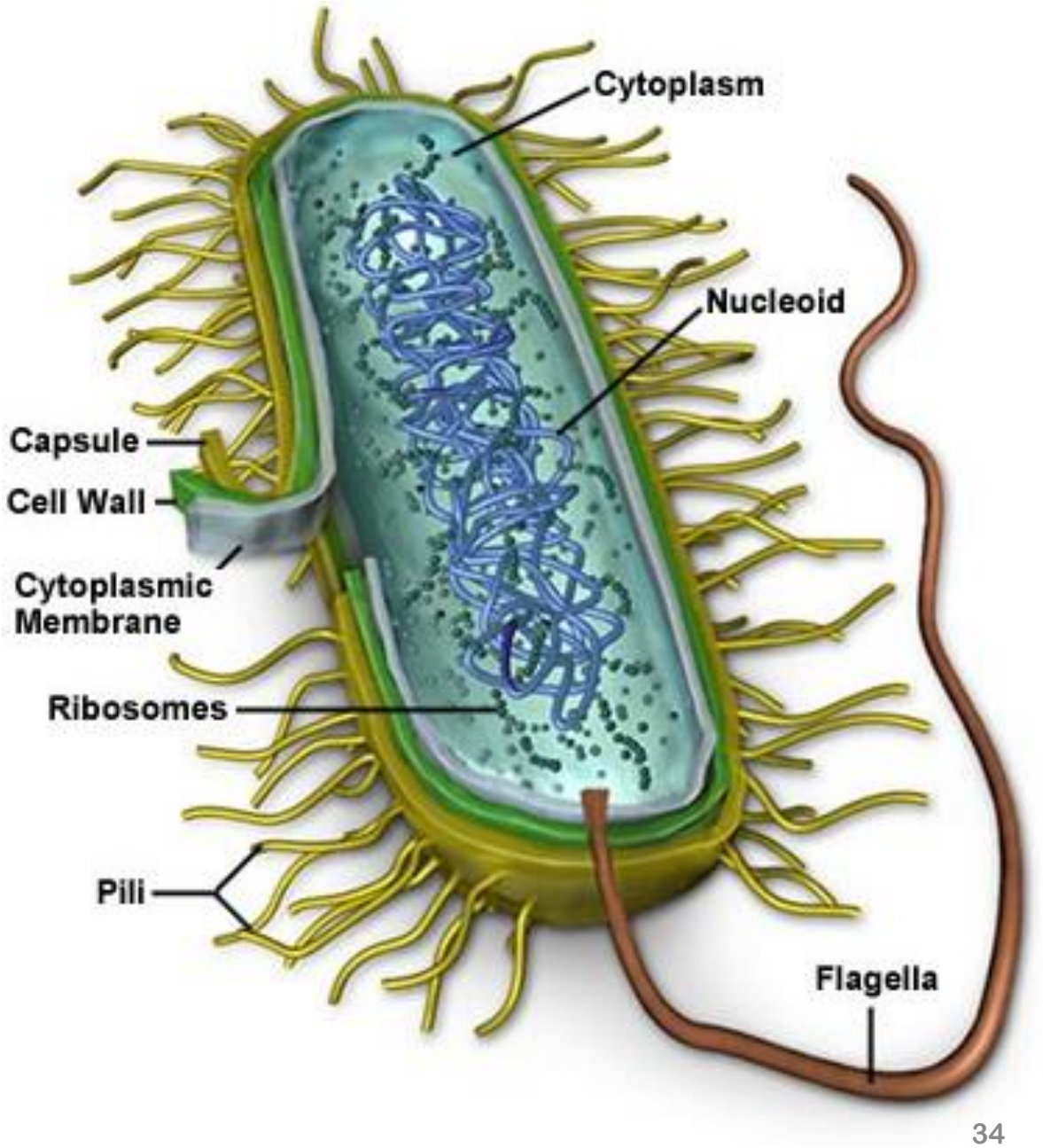
1. **Prokaryotic-cells** that DO NOT have a well-defined NUCLEUS or other cell ORGANELLES
2. **Eukaryotic-cells** have a NUCLEUS with nuclear membrane & cell ORGANELLES

- Which is more complicated?

Prokaryote cells

1. Oldest of cell types, first appeared 3.5 billion years ago.
2. Cells that do not contain a nucleus.
3. DNA is not contained in an internal structure.
4. Have a cell membrane.
5. Do not have membrane-bound organelles.
6. Generally smaller and simpler than eukaryotic cells.
7. Can live in hostile environments. Halophiles and thermophiles that are archeabacteria.
8. Very diverse in their metabolic process: obligate aerobes (require O_2), obligate anaerobes (killed by O_2), and facultative anaerobes (can survive with or without O_2).
9. Example: Bacteria

Prokaryotic Cell Structure

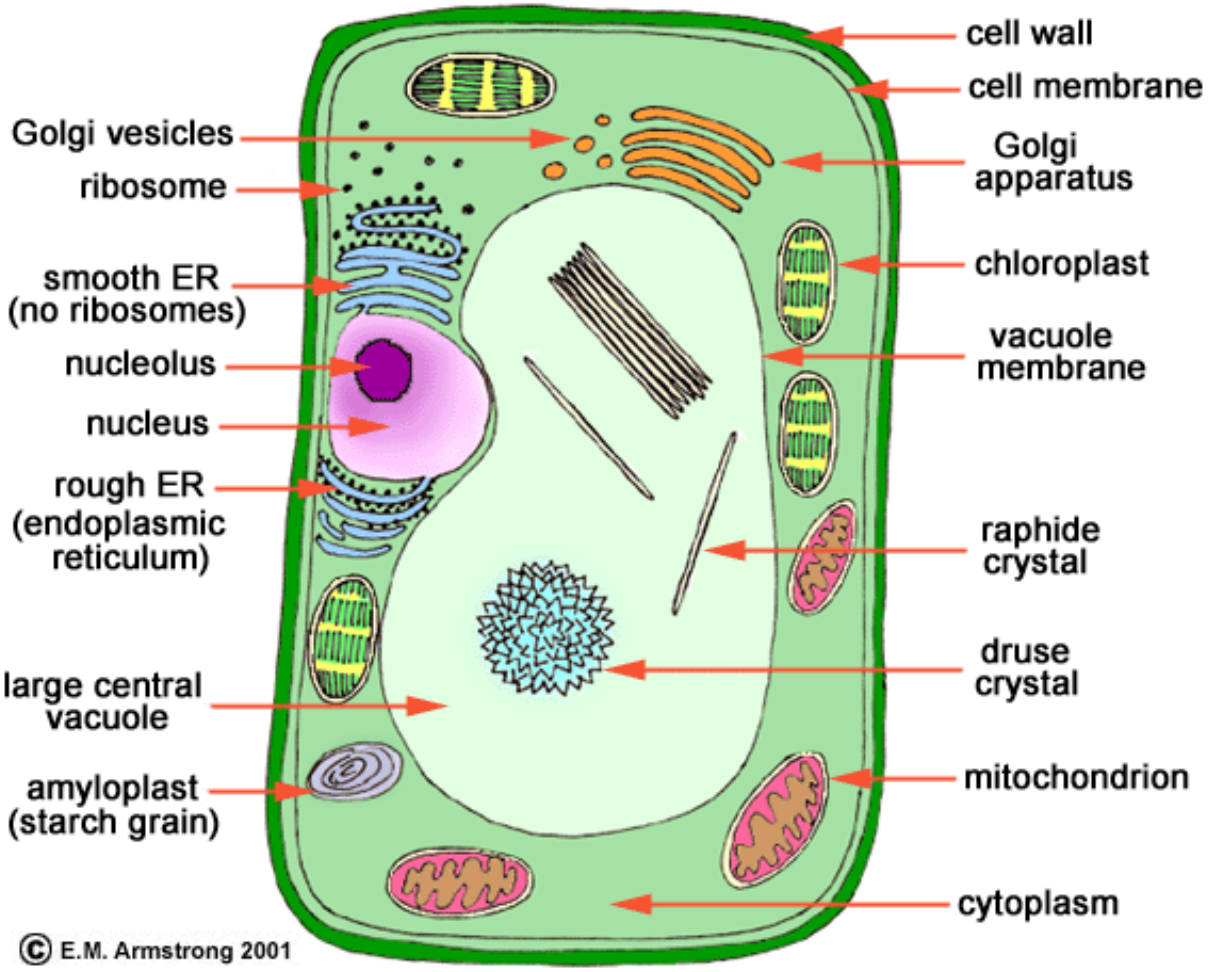


Eukaryote cells

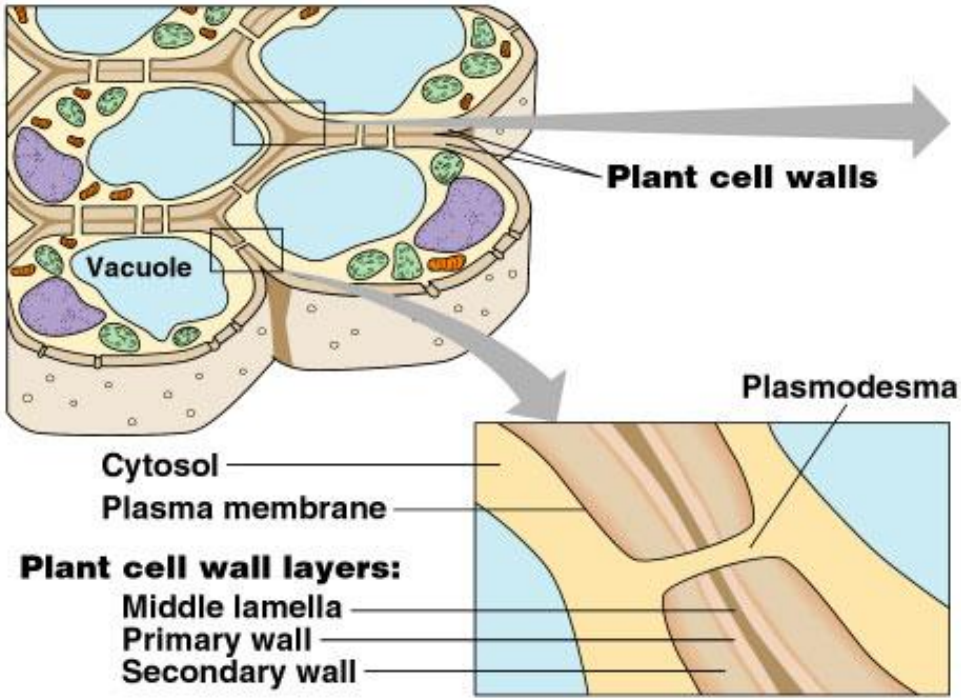
1. First appeared in the fossil record 1.5 billion years ago.
2. Eukaryotes are organisms that have a nucleus in each cell.
3. The nucleus contains that cell's DNA.
4. Have a cell membrane.
5. Generally larger and more complex than prokaryotic cells.
6. Have complex membrane bound organelles (mitochondrion, chloroplast, Golgi apparatus, etc.)
7. Many eukaryotic cells are highly specialized.
8. Examples: Plants, animals, fungi, and protists.

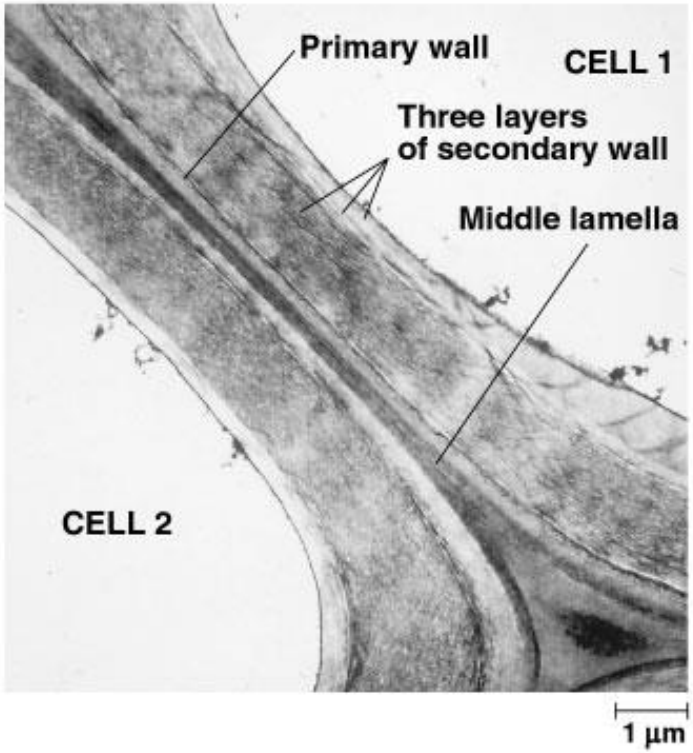
Eukaryotic Cell Structure and Function

- Plasma Membrane
- Nucleus
- Ribosomes
- Nucleolus
- Endoplasmic Reticulum
- Golgi Bodies
- Plastids
- Chloroplasts
- Mitochondria
- Vacuoles
- Microtubules
- Cytoplasm



Cell Wall





Cell wall consists of:

(1) Middle lamella – mostly pectin, cements adjacent cells together

(2) Primary cell wall

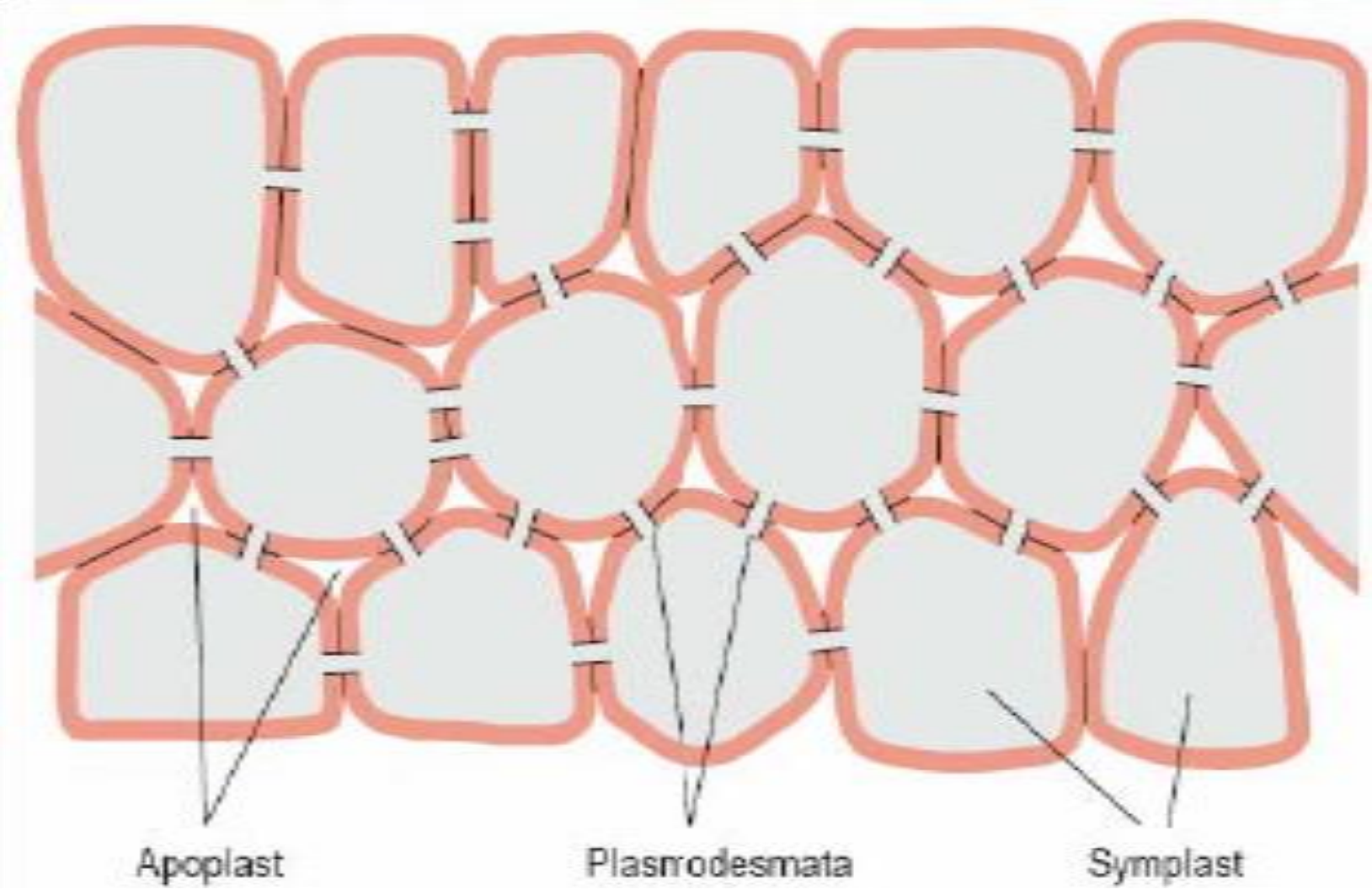
- Found in all plant cells
- Cellulose matrix with hemicellulose, proteins, pectin, lignin, cutin, and wax
- Characteristic of undifferentiated cells or ones that still are growing

(3) Secondary cell wall

- Just inside primary cell wall
- Characteristic of mature cells
- Comprised of hemicellulose and lignin

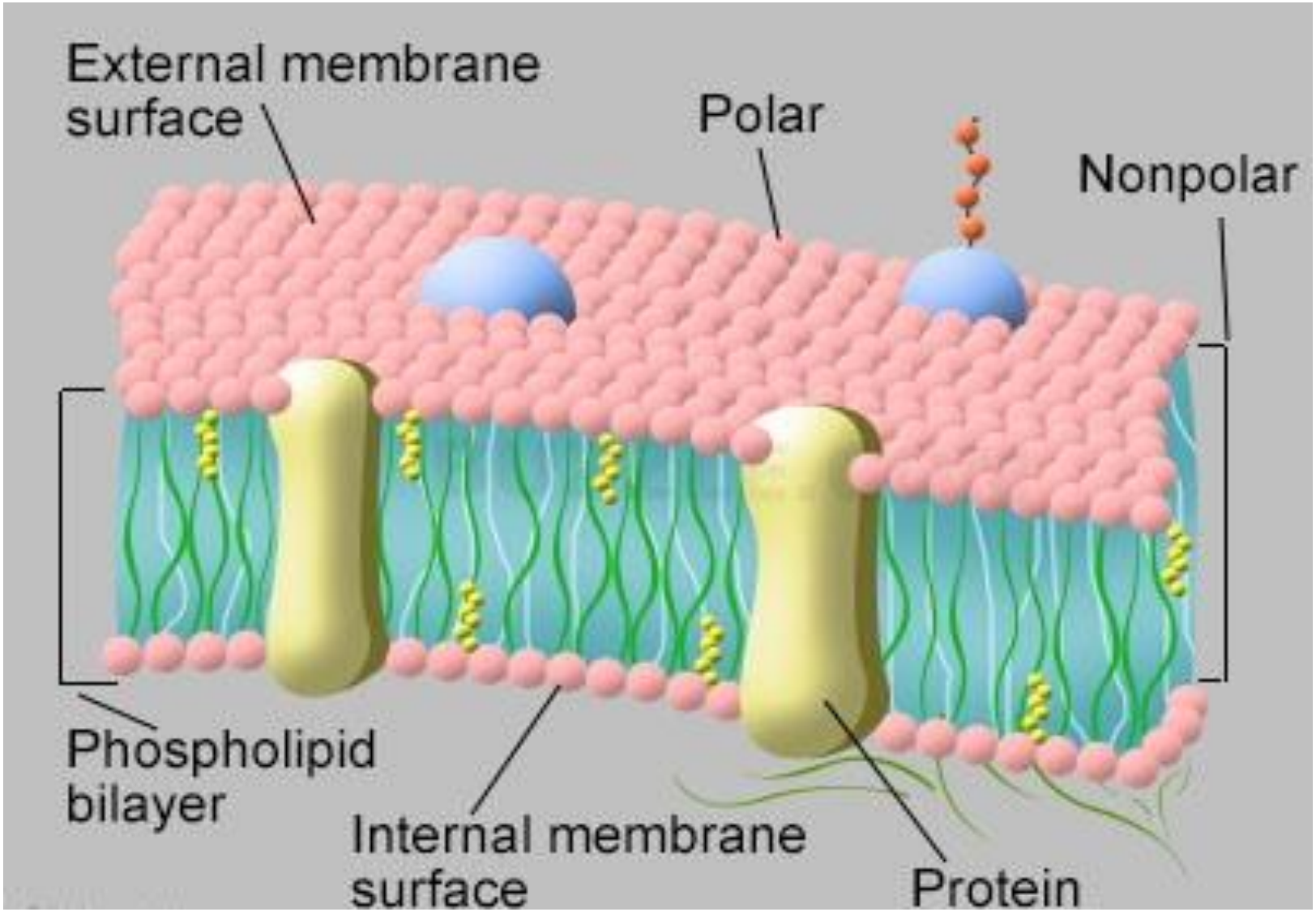
Connections between Cells:

Plasmodesmata



pits

Cell or Plasma Membrane Structure



Cell or Plasma Membrane

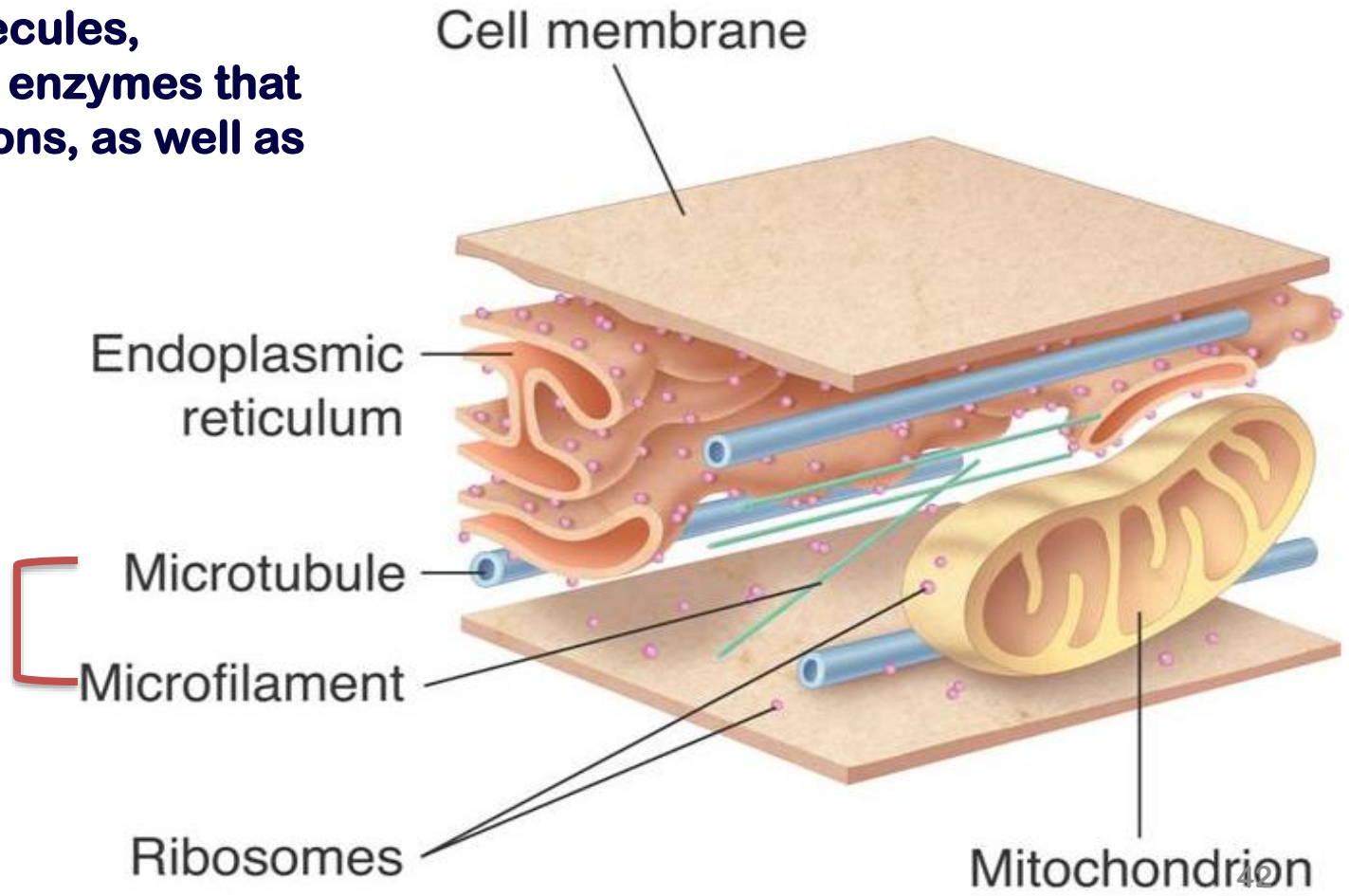
- The cell membrane's function is to form a barrier between the cell's inner and outer environment. It is selectively permeable meaning that it allows certain materials to pass through and prevents the movement of other through it.

- It is composed of a phospholipid bilayer with protein molecules (integral proteins) embedded within in the bilayer. Some of these proteins pass completely through both layers of phospholipids. There are also other types of molecules such as cholesterol and carbohydrates that are associated with the cell membrane's outer surface.

- The phospholipids and proteins are not in a static state, but have the ability to move from one location to another or change positions within the bilayer. Therefore the molecules which make up the membrane are described as being in a fluid state. The structure of the membrane is called the "fluid-mosaic model." The membrane is literally a mosaic of molecules that have the ability to move from area to area on the surface of the membrane.

Cytoplasm

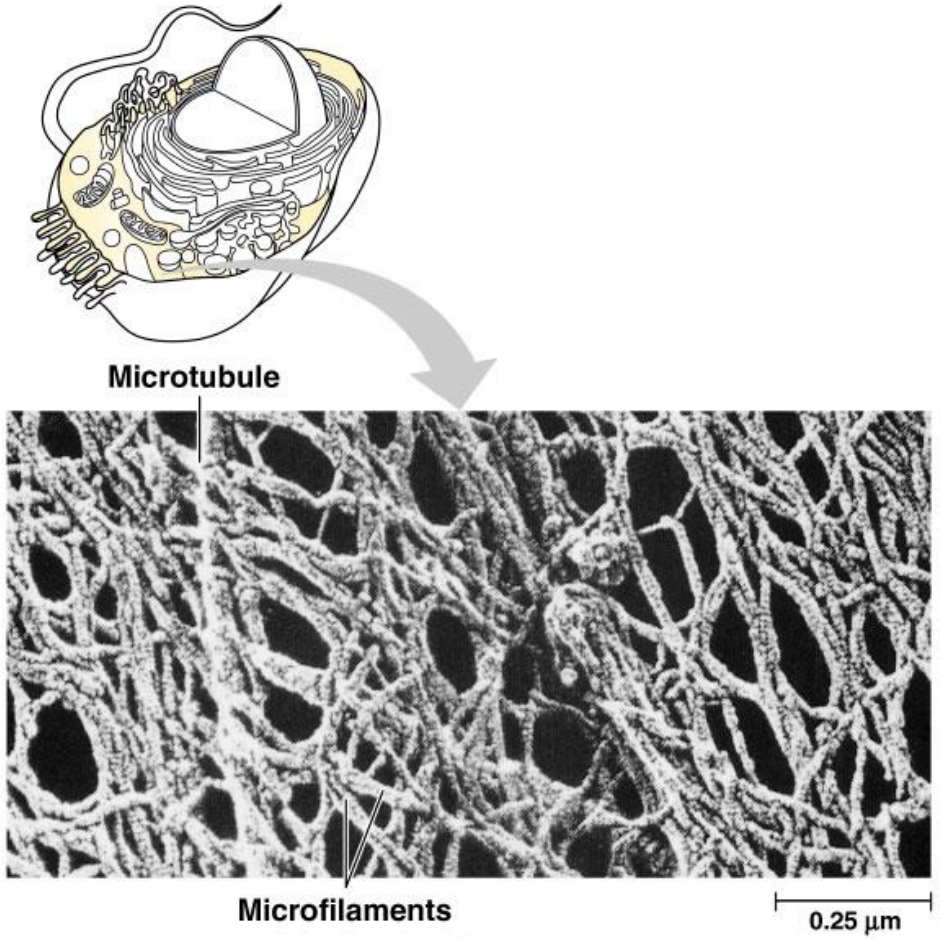
A watery solution made of cytosol that contains the cell organelles. Cytoplasm includes salts, an assortment of organic molecules, including many enzymes that catalyze reactions, as well as water



Cytoskeleton

Cytoskeleton:

The cytoskeleton is a "framework" that supports the cell membrane and other cell structures within the cytoplasm.



Cytoskeleton

- Eukaryotic cells are given their shape and internal organization by the cytoskeleton.
- The cytoskeleton is made up of:
- Microfilaments and microtubules

Microfilaments

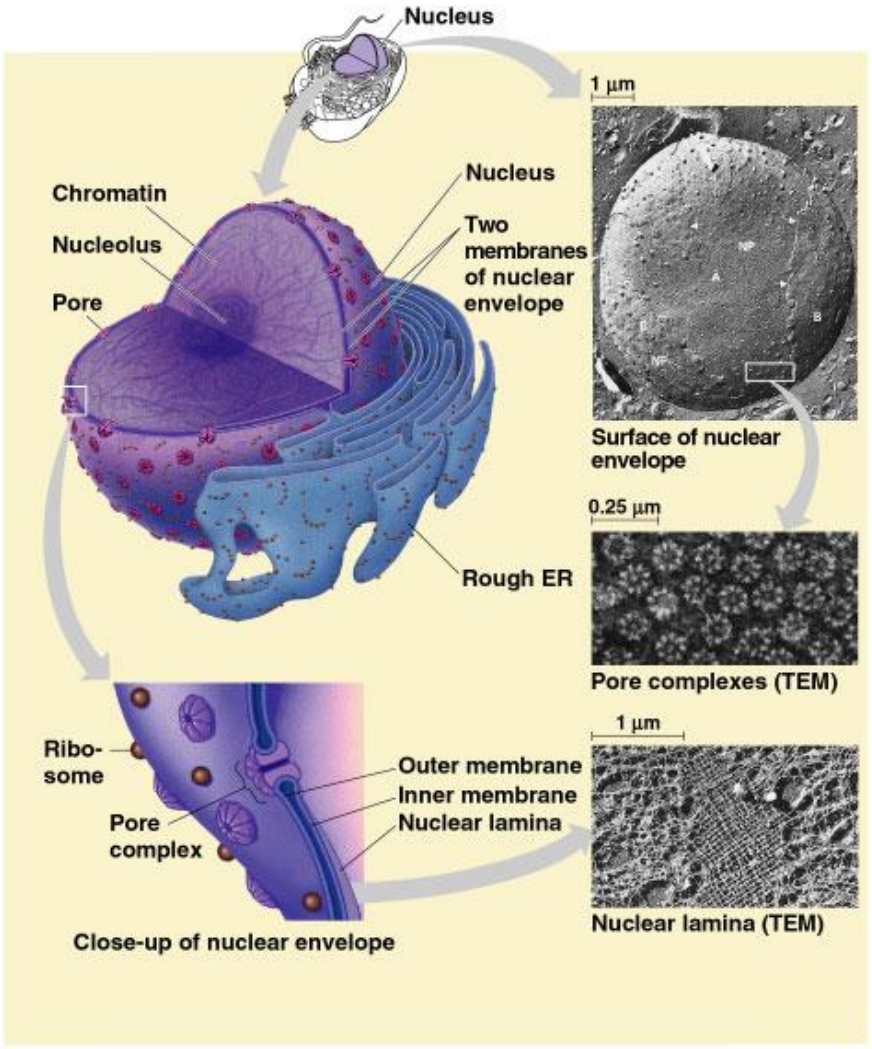
- are threadlike structures made up of the protein actin.
- form extensive networks in some cells.
- produce a tough, flexible framework that supports the cell.
- help some cells move.

Microtubules

- are hollow structures made up of proteins known as tubulins. maintain cell shape.
- are important in cell division.
- build projections from the cell surface—cilia and flagella—that enable some cells to swim rapidly through liquids.

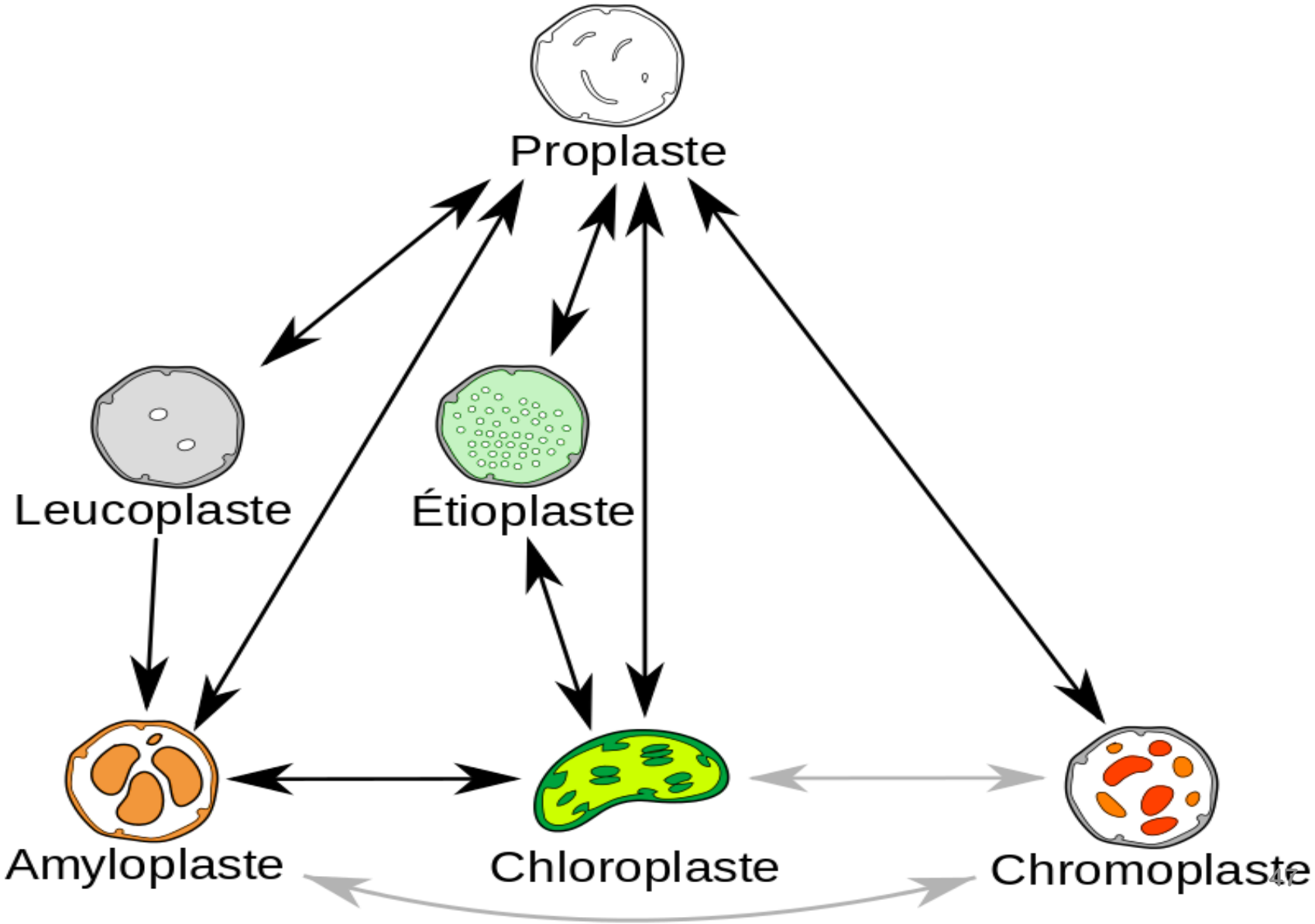
Nucleus

The Nucleus is enclosed in an envelope which is a double membrane structure. It has pore complexes in the membranes which allow the movement of materials in and out of the structure. It contains DNA and proteins in the form of loose threads called chromatin. During mitosis or meiosis the chromatin super coils to form chromosomes. Self duplicating structure divides when the cell divides. The nucleolus is a structure composed of RNA located in the nucleoplasm. There maybe be more than one present and it functions in the production of ribosomes. The overall function of the nucleus is the regulation of cellular activities.



Cell Organelles

Plastids


Proplaste
Leucoplaste
Étioplaste
Amyloplaste
Chloroplaste
Chromoplaste

Plastids

Plastids are structures that function in storage and photosynthesis according to their type.

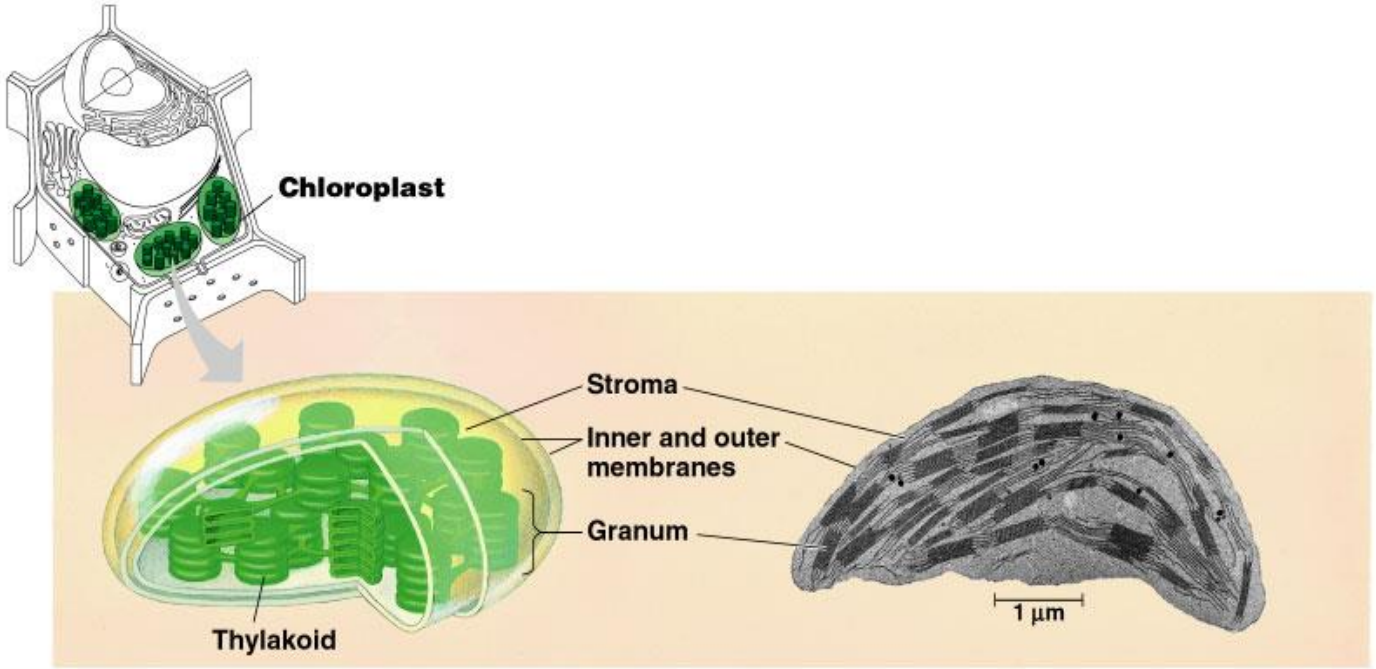
Amyloplasts (Leucoplastides) are large white structure where starch is stored. They are responsible for the color of an Irish potato.

Chromoplasts contain pigments and are responsible for the orange and yellow colors of fruits and flowers.

Chloroplasts are double membrane structures where the process of photosynthesis occurs.

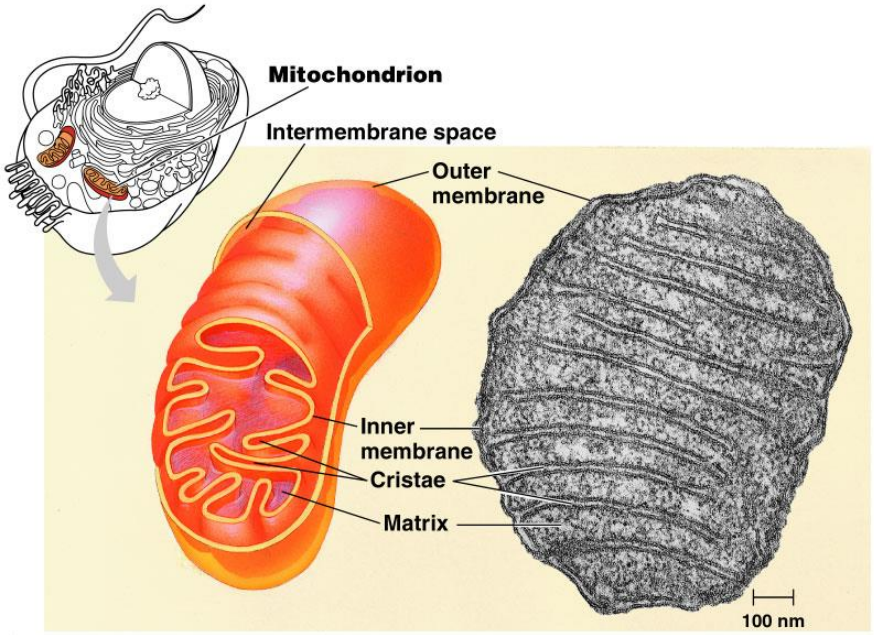
Plastids

The inner membrane is arranged in flattened sacs called **thylakoids**. The thylakoids are stacked one on top of another. A stack of thylakoids is called a **granum** or **grana** (pl). The space in between the grana is called the **stroma**.



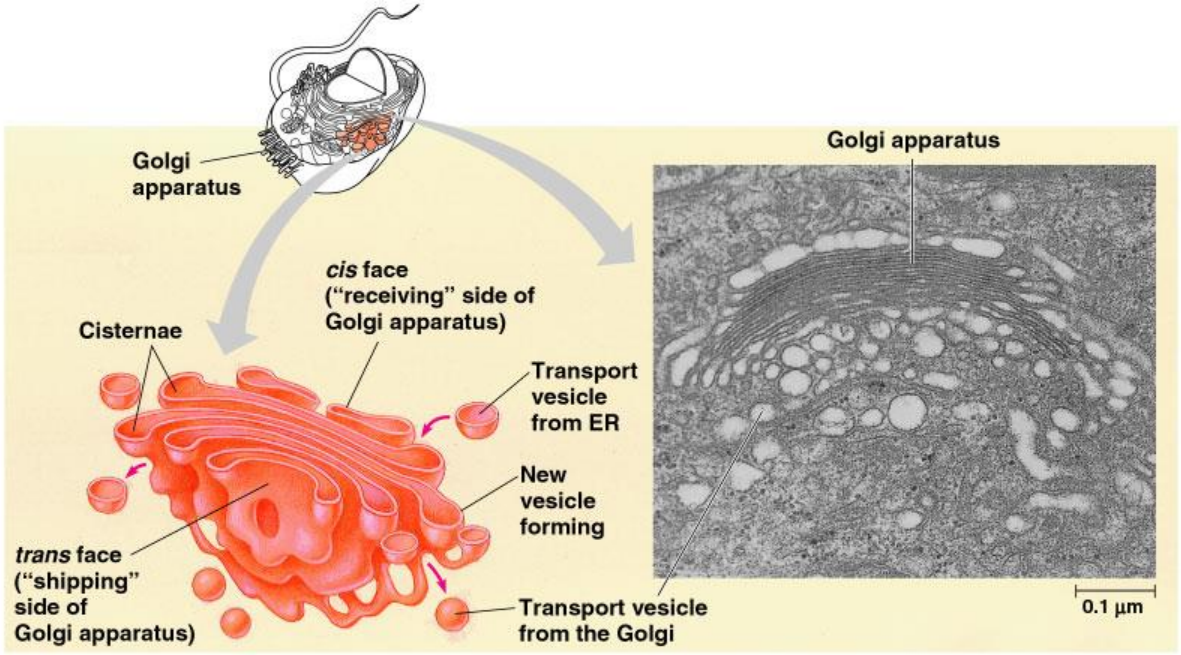
Mitochondria

The mitochondria is a **double membrane** structure with an outer membrane which surrounds a highly folded inner membrane. It is the site of aerobic cellular respiration in which **ATP is produced**. The inner membrane has finger like projection called **cristae** which increase the surface area. The inner space within the mitochondrion is called the **matrix** and contains cytoplasm, ribosomes, and DNA. Mitochondrion are self replicating. They are found in both plant and animal cells and are sometimes called "**the powerhouse of the cell**".



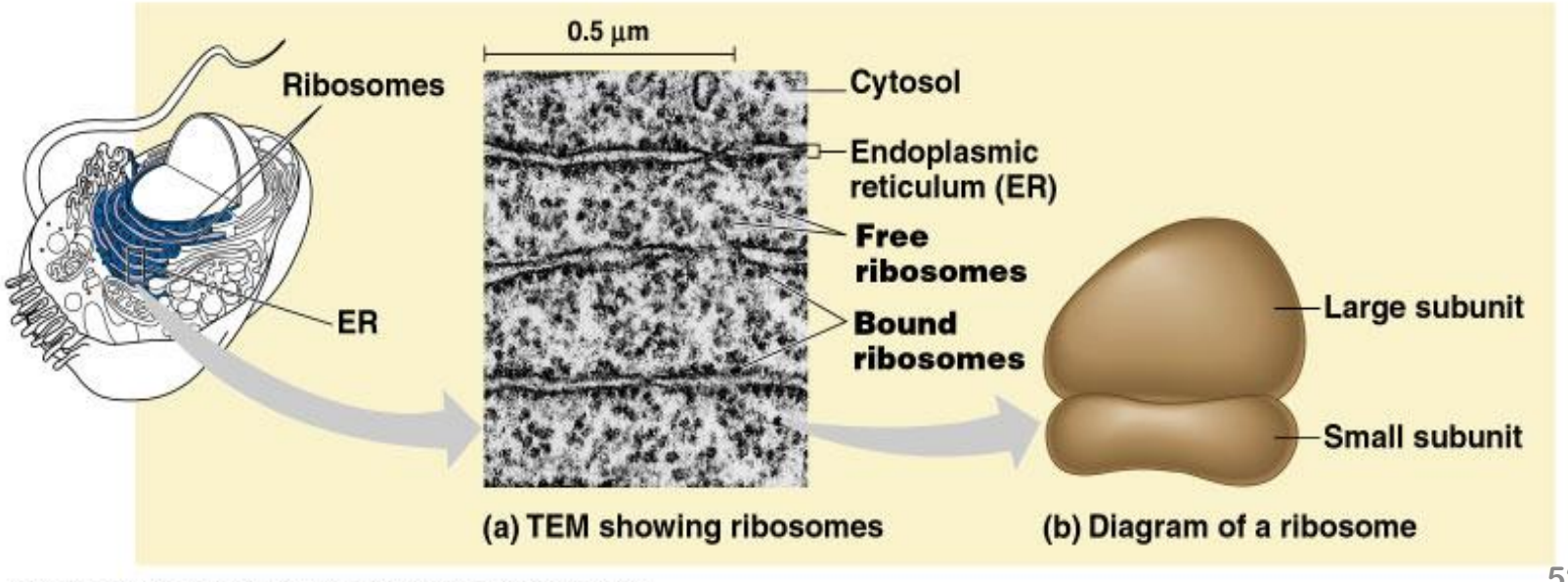
Golgi Apparatus (Dictyosome)

The Golgi apparatus appears as a series of flattened, stacked, membrane sacs. The Golgi apparatus is the center for manufacturing, modifying, and packaging of materials for transport. It receives secretory proteins from the RER and modifies and packages the materials in small secretory vesicles. It is found in both animal and plant cells. In plant cells it maybe referred to as Dictyosome.



Ribosomes

Ribosomes are the structures within the cell which read m-RNA and assembles amino acids into polypeptide chains. They are found free floating in the cytoplasm or attached to the nuclear envelope or the rough endoplasmic reticulum. They are found in all prokaryotic and eukaryotic cell types. They are composed of two subunits. Prokaryotic cells have smaller ribosomes (70s) and eukaryotic cells have the larger (80s) form.

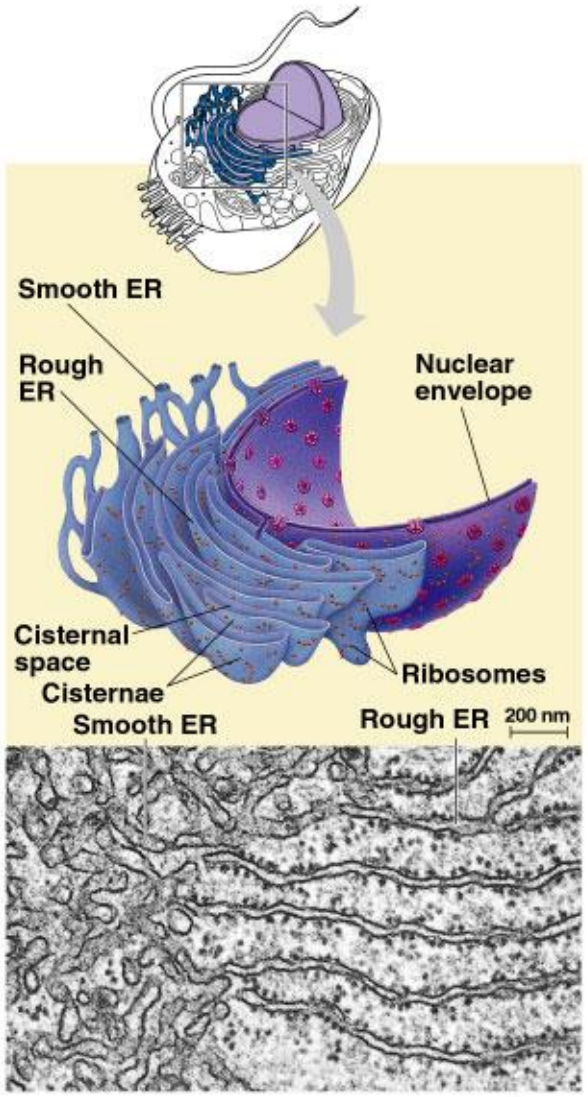


Endoplasmic Reticulum

The endoplasmic reticulum (ER) is a series of single membrane channels which run throughout the cytoplasm of the cell.

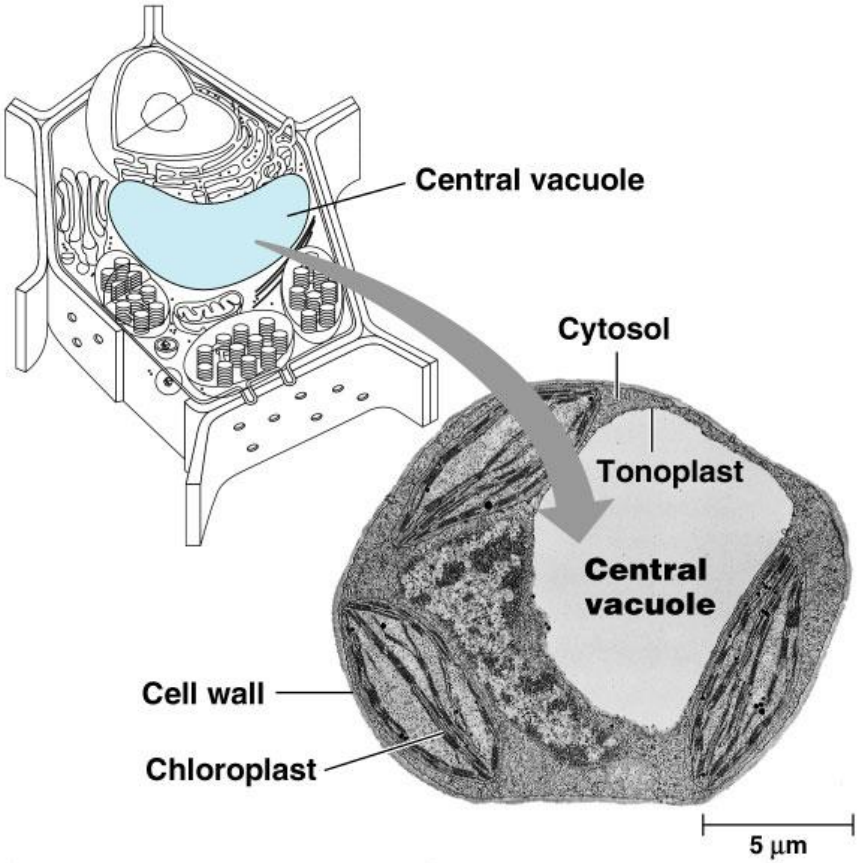
The smooth endoplasmic reticulum (SER) is free of ribosomes and functions in lipid synthesis, metabolism of carbohydrates, and as a detoxification center of the cell.

The rough endoplasmic reticulum (RER) has ribosomes bound to its outer membrane layer and is the active site of protein synthesis. These are secretory proteins which will be released by the cell. Both forms of endoplasmic reticulum are found in plant and animal cells.



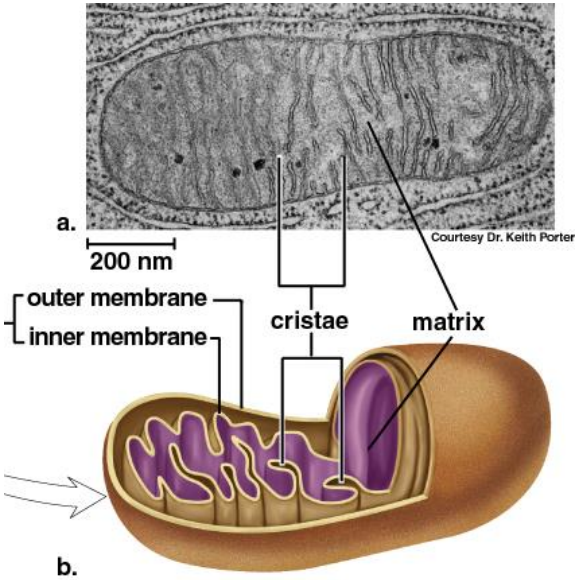
Vacuoles

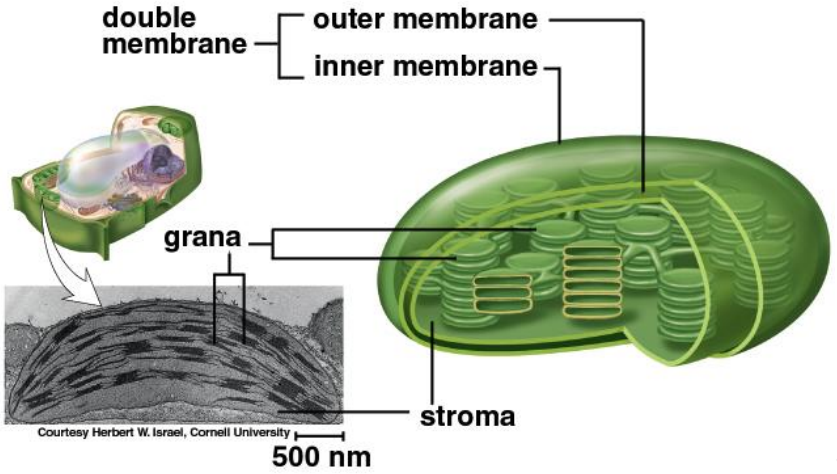
Vacuoles are **storage areas** and can also serve as the **site of chemical digestion** within the cell itself. Vacuoles in animal cells are often small. However, plant cells often have a large centrally located vacuole which contains **water and dissolved solutes**, surrounded by a membrane called the **tonoplast**. Freshwater **Protists** contain specialized vacuoles which act as "**water pumps**" to remove excess water that enters their cytoplasm. These specialized vacuoles are called **contractile vacuoles**.



Self-Replicating Organelles

- **Mitochondria**
  - Involved in energy release
- **Plastids**
  - Involved in energy capture and storage.
    - Chloroplasts
    - Amyloplasts
    - Chromoplasts





The Cellular Basis of Reproduction and Inheritance

Cell Reproduction

The Cell Cycle

A. Growth

- Increase in cell size.

B. Division

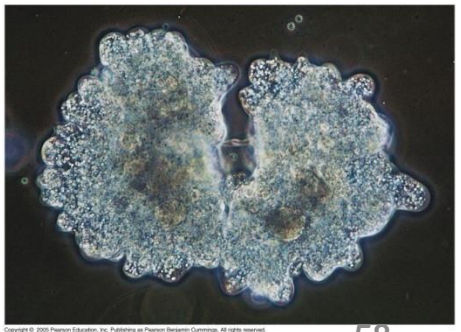
- Production of new cells
- Two overlapping processes
  - Karyokinesis – nuclear division
  - Cytokinesis – cytoplasm division

Methods of Reproduction

Asexual reproduction

- Chromosomes are duplicated and cell divides
- One copy of each chromosome is placed in each cell
- Each "daughter" cell is genetically identical to the parent and the other daughter
  - Type of Cellular Division required: mitosis

Advantage = fast and convenient
Disadvantage = very little genetic variation

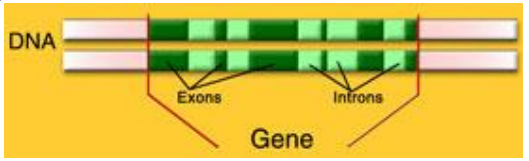


Sexual reproduction

- Offspring inherit DNA from both of their parents
  - Type of Cellular Division required: meiosis
- Offspring can show great variation
  - Advantage = lots of genetic variation
  - Disadvantage = metabolically expensive

Related Terms

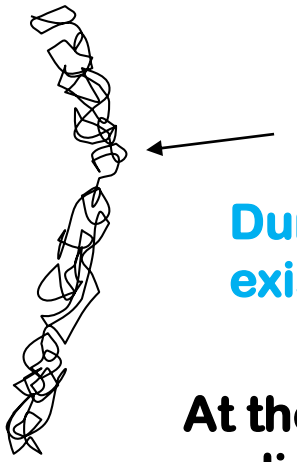
- **Chromatin**
  - Material in an active nucleus.
    - Submicroscopic "threads" consisting of 50% DNA and 50% supporting proteins.
    - Abundant water and dissolved chemicals.
- **Gene**
  - a unit of heredity information determining the nature of a specific trait and have specific places on chromosomes.
  - a section of DNA that codes for a protein, tRNA or rRNA molecule
- **DNA Replication**
  - Conversion of one strand/piece of DNA into two identical strands/pieces.



- **Chromosome Set**
  - One copy of each of the different chromosomes in the nucleus containing one copy of each different gene.
- **Haploid Number** (n)
  - The number of chromosomes comprising one set.
    - For humans, n=23
    - For some ferns, n=250
  - A haploid individual has one set of chromosomes per cell.
- **Diploid Number** (2n)
  - The number of chromosomes in a cell containing two sets.
  - A diploid individual has 2 sets per cell.
  - (Triploid is 3 sets, Tetraploid is 4 sets, etc.)

Structure of the Chromosome

Chromosome – a package of hereditary material with supporting proteins visible in condensed form during cell division.

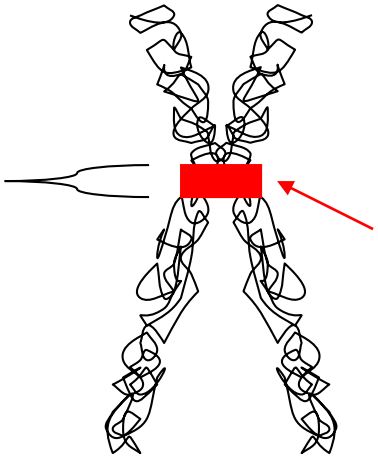


Chromatid – a single strand of DNA

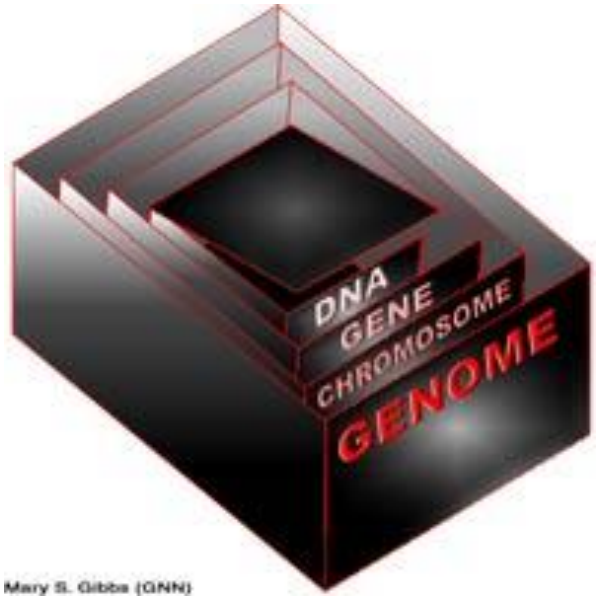
During most of the life of a cell the chromosomes exist as a single strand called a "monad".

At the beginning of karyokinesis the single strand is replicated forming two identical chromatids attached to one another, a "dyad".

Sister chromatids have identical DNA
Centromere
Kinetechore on centromere provides binding site for microtubules

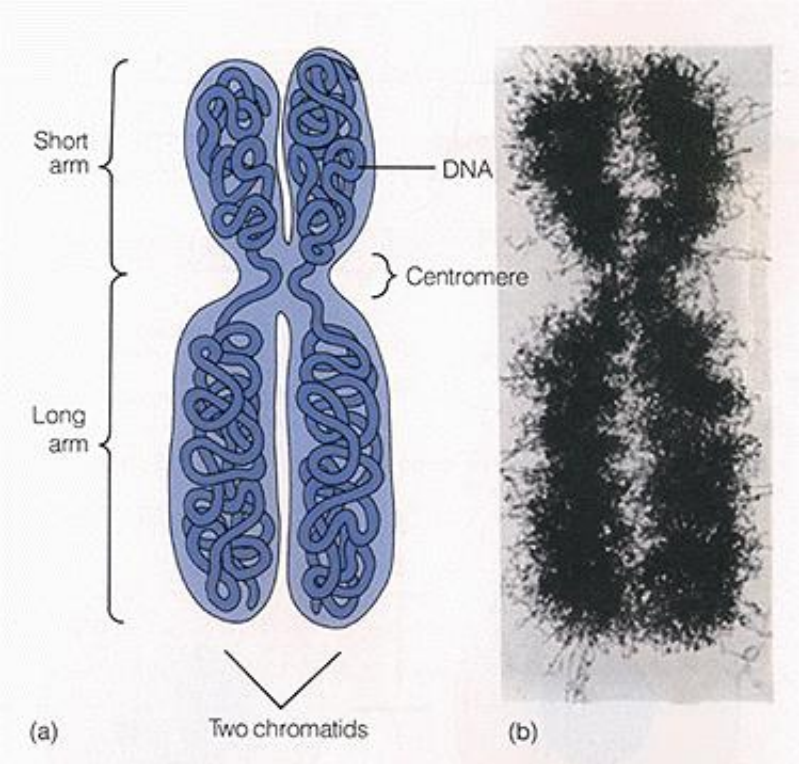


- **Genome:** Complete complement of an organism's DNA.
  - Includes **genes** (control traits) and non-coding DNA organized in **chromosomes**.



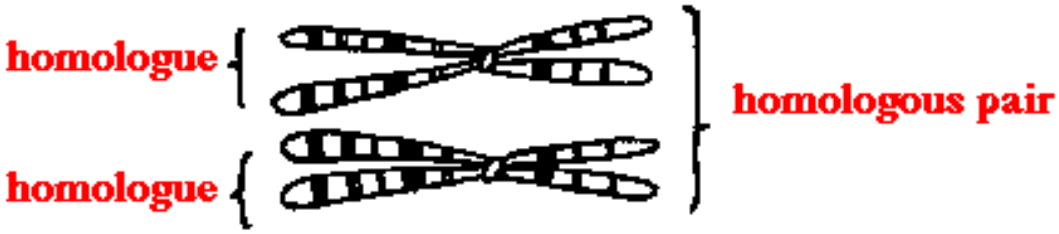
- **Eukaryotes & DNA:**

- Many eukaryotes have 1000 times as much DNA as prokaryotes.
- DNA is located in the nucleus in the form of chromosomes.
- Chromosomes are DNA wound tightly around proteins called histones.



•Homologues

- **Chromosomes exist in homologous pairs in diploid cells.**



Exception: Sex chromosomes in human (X, Y).

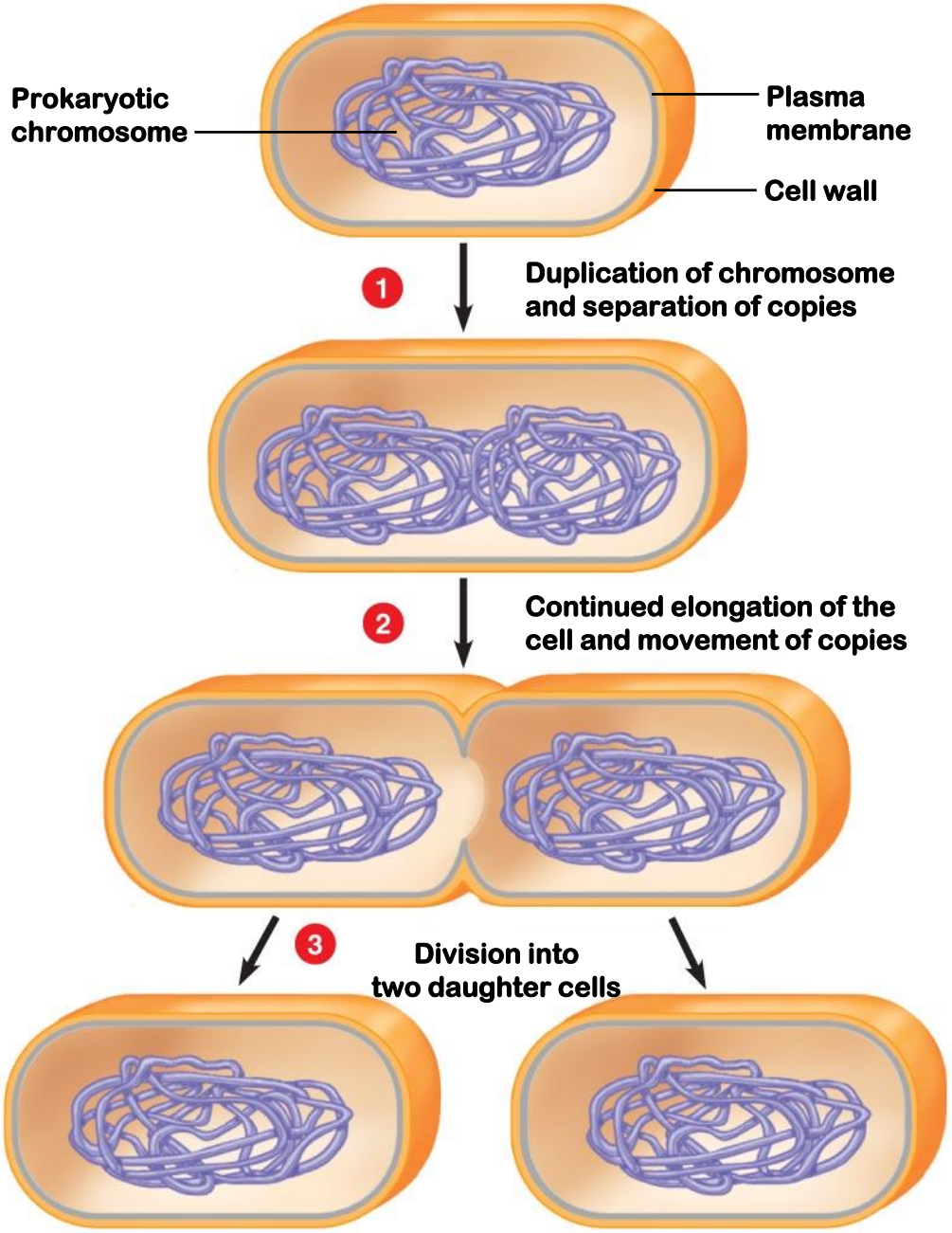
Other chromosomes are known as autosomes, they have homologues.

Cell Division

Binary Fission, Mitosis & Meiosis

Prokaryotic cells reproduce asexually by a type of cell division called binary fission

binary fission



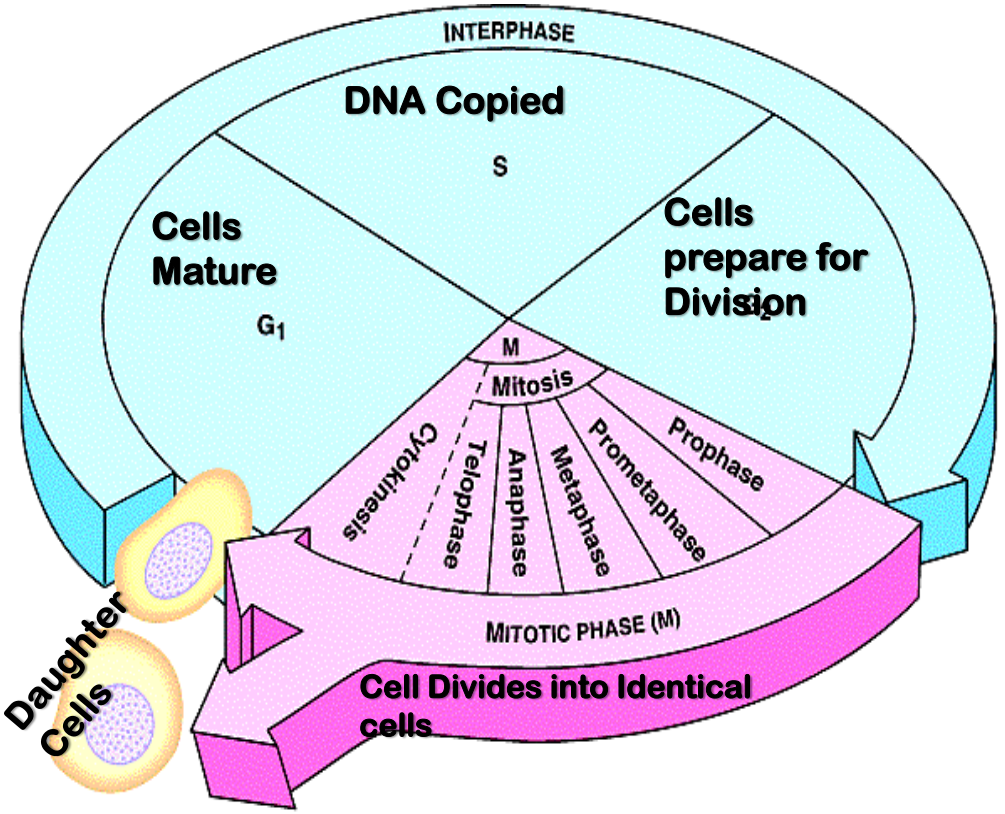
- The circular DNA molecule replicates to form 2 chromosomes
- The chromosome copies move apart
- The cell elongates
- The plasma membrane grows inward, dividing the parent into two daughter cells

Mitosis

- Eukaryotes divide by a more complicated system called Mitosis
- This is because:
  1. They have a nucleus which must be broken up and then reformed
  2. They have their DNA "packaged" in the form of Chromosomes
  3. Chromosomes are composed of Chromatin
  4. Also contain Nucleosomes containing Histones - Proteins the DNA is wrapped around Name for the DNA/Protein complex is Chromatin
  5. They usually have more than 1 chromosome (Humans have 23 pairs)
  6. They have numerous organelles to equally share

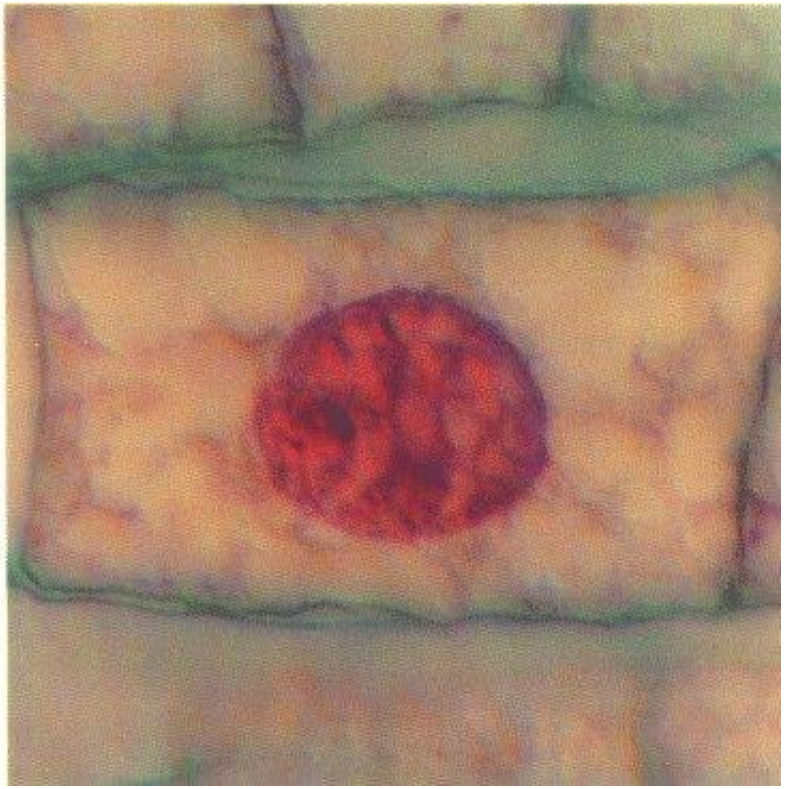
The Cell Cycle

- Most of the cell's life is spent doing its regular function.
- Cells divide along a rough time frame called its Cell Cycle.
- The Cell cycle consists of the following steps:
- **G1 (Gap 1) Phase** - Cell performs its **normal function** (cells which do not divide stay in this stage for their entire life span)
- **S (Synthesis) Phase** - Here the cell actively **duplicates its DNA** in preparation for division
- **G2 (Gap 2) Phase** - Amount of cytoplasm (including organelles) increases in **preparation for division**.
- **Mitosis** - Actual division occurs



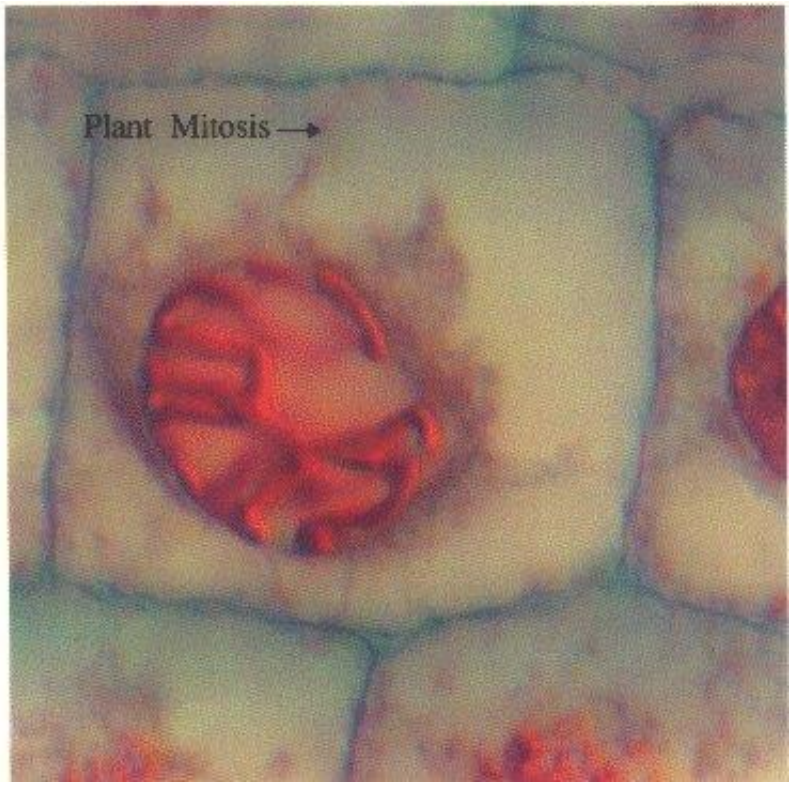
Interphase

- **Cell Replicates its DNA/Chromosomes in preparation of upcoming division**



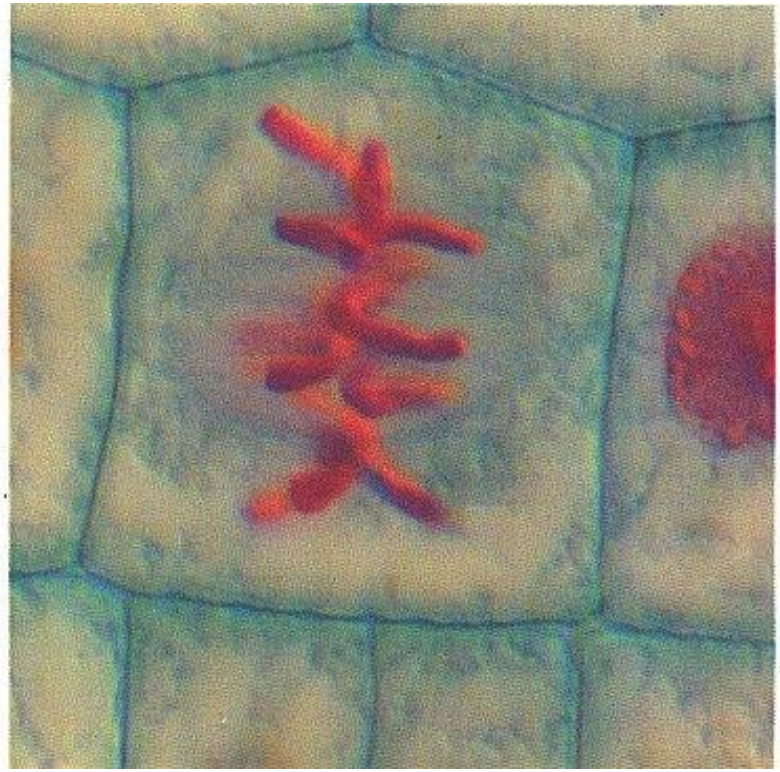
Prophase

1. Chromosomes Shorten and become visible.
2. Centrosome move to opposite sides of the cell
3. Nuclear envelope disappears
4. Spindle Fibers & Astral Fibers both together are known as the Spindle Apparatus begin to form



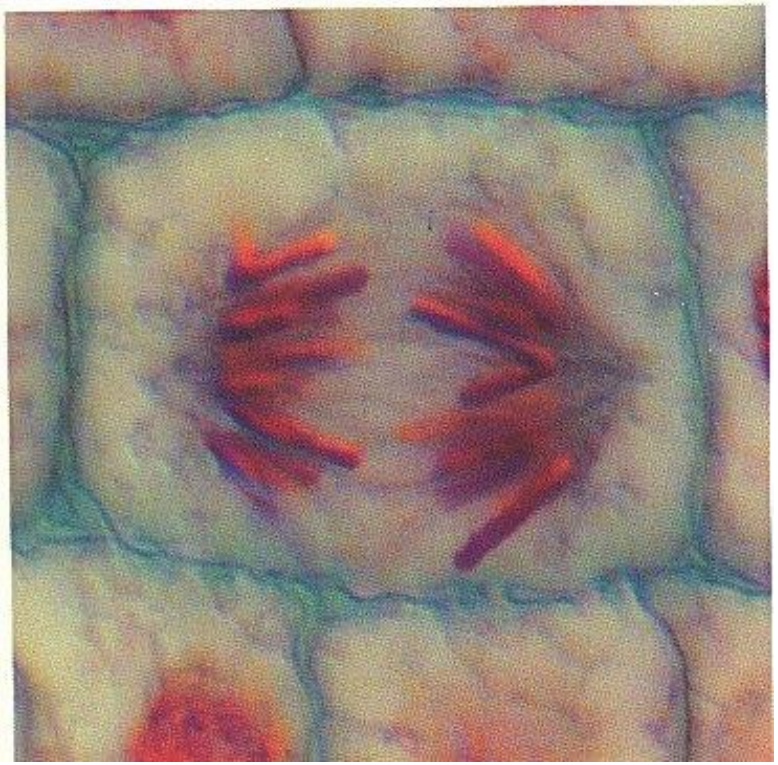
Metaphase

- Chromosomes line up along center of cell called the Metaphase Plate
- Chromosomes attach to spindle fibers
- Spindle & Astral fibers are now clearly visible



Anaphase

- Centromeres break up separating chromosome copies
- Chromosomes are pulled apart to opposite sides of cell
- Spindle & Astral fibers begin to break down



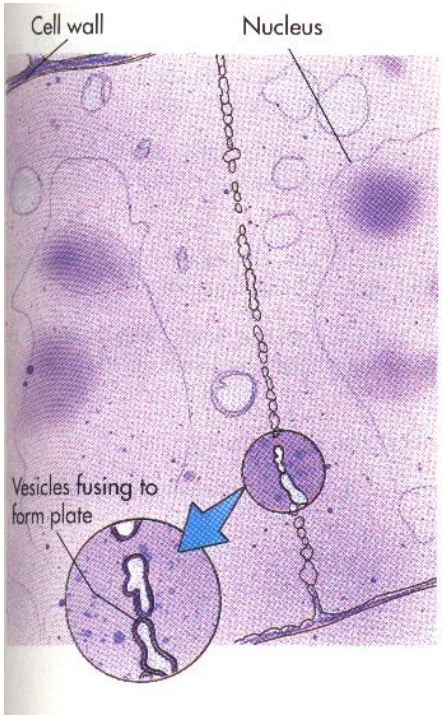
Telophase (cytokinesis)

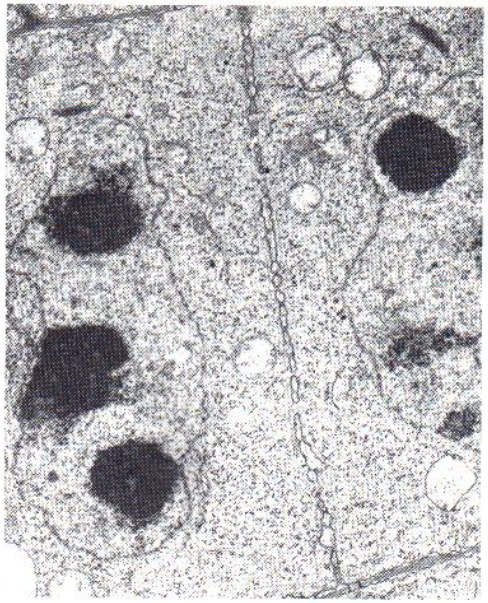
- Nuclear envelope forms around both sets of chromosomes
- DNA uncoils
- Spindle & Astral fibers completely disappear
  - Cytokenesis happens with most (but not all) cells
  - Cytoplasm & organelles move (mostly equally) to either side of the cell. Cell Membrane "pinches" to form 2 separate cells

Plant Cytokinesis- division of the cytoplasm

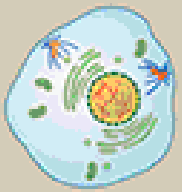
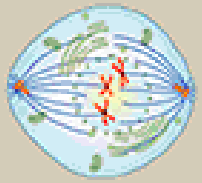
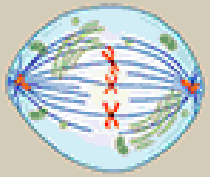
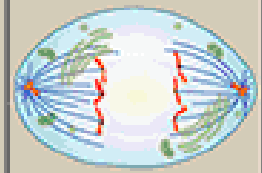
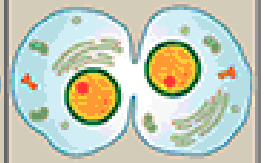
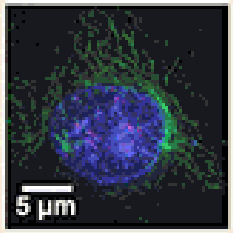
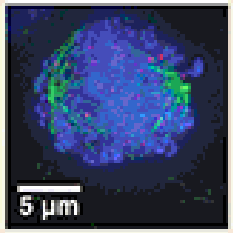
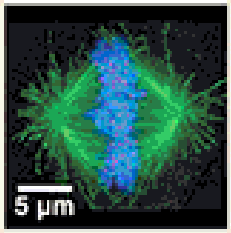
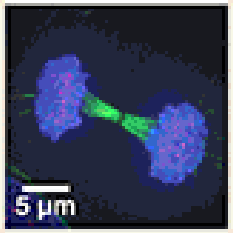
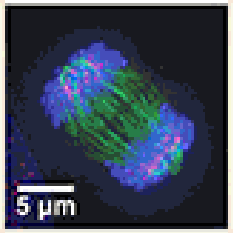
- With Plants, a cell wall must be formed between the 2 daughter cells.
- Vessicles containing Cellulose form and fuse between the tow daughter cells, eventually forming a complete cell wall.

❑Vesicles containing cell wall material line up across middle of cell
❑Vesicles merge and form cell plate
❑Cell plate grows until it divides the cell in 2





Overview of Mitosis

Prophase	Prometaphase	Metaphase	Anaphase	Telophase	Cytokinesis
					
• Chromosomes condense and become visible • Spindle fibers emerge from the centrosomes • Nuclear envelope breaks down • Centrosomes move toward opposite poles	• Chromosomes continue to condense • Kinetochores appear at the centromeres • Mitotic spindle microtubules attach to kinetochores	• Chromosomes are lined up at the metaphase plate • Each sister chromatid is attached to a spindle fiber originating from opposite poles	• Centromeres split in two • Sister chromatids (now called chromosomes) are pulled toward opposite poles • Certain spindle fibers begin to elongate the cell	• Chromosomes arrive at opposite poles and begin to decondense • Nuclear envelope material surrounds each set of chromosomes • The mitotic spindle breaks down • Spindle fibers continue to push poles apart	• Animal cells: a cleavage furrow separates the daughter cells • Plant cells: a cell plate, the precursor to a new cell wall, separates the daughter cells
					

MITOSIS

Overview of Mitosis

- Occurs in somatic cells
- Longitudinal division of replicated chromosomes in one nucleus to form two genetically identical daughter nuclei.

- Each "daughter" nucleus has the same number of chromosomes (and sets) that the "parent" nucleus had.

- Mitosis requires One division.
  - 1 cell → 2 cells *(called daughter cells)*
  - Daughter cells are genetically identical

Chromosome number does not change.

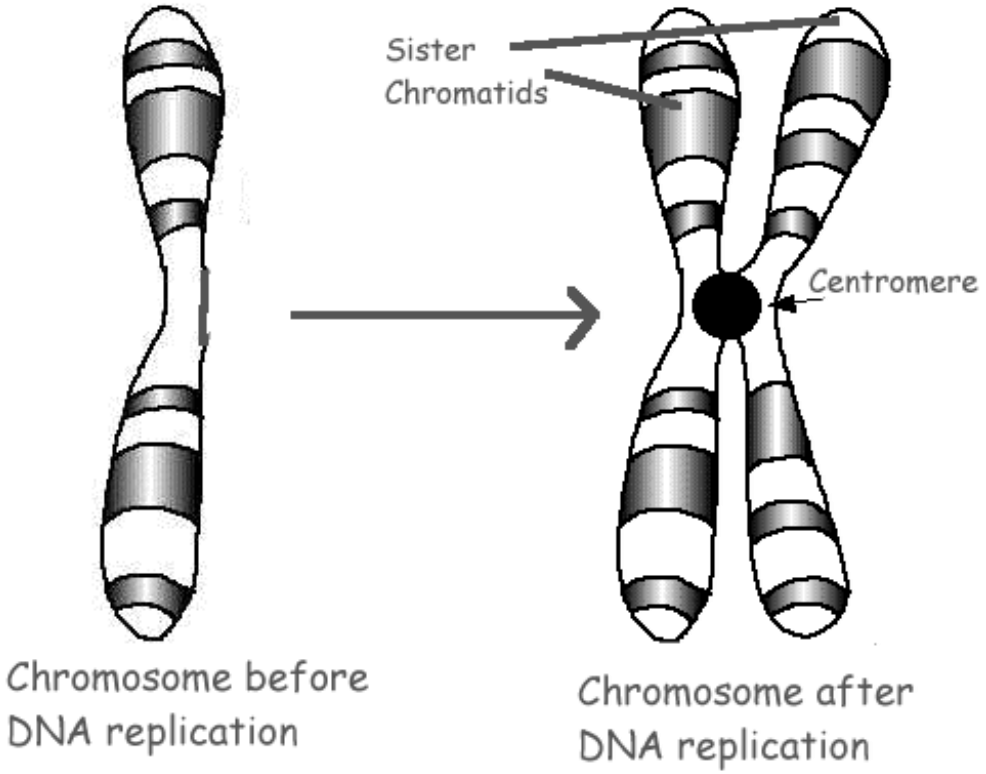
Meiosis

- Similar in many ways to mitosis
- Several differences
- Involves 2 cell divisions
- Results in 4 cells with ½ the normal genetic information

Meiosis Phases

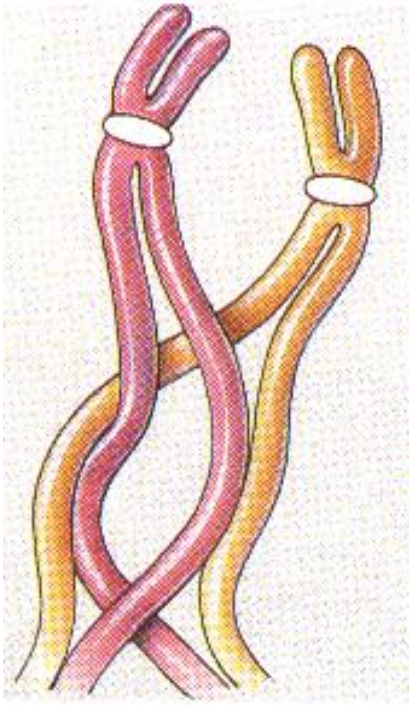
- **Meiosis occurs in 2 phases; Meiosis I, & Meiosis II.**

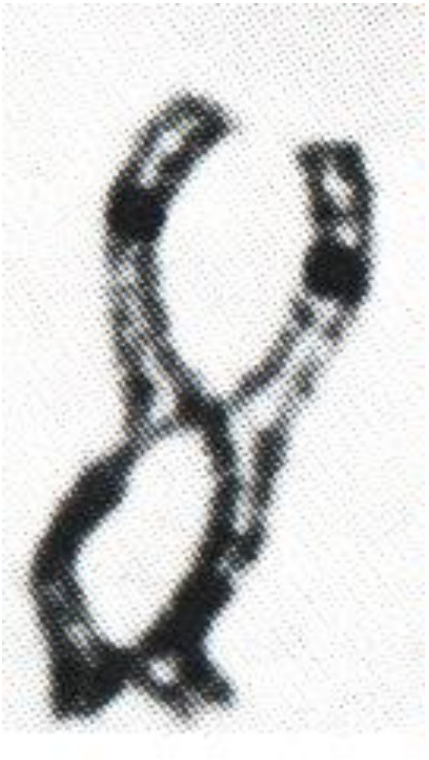
- **Meiosis I.**
  - **Prior to division, amount of DNA doubles**



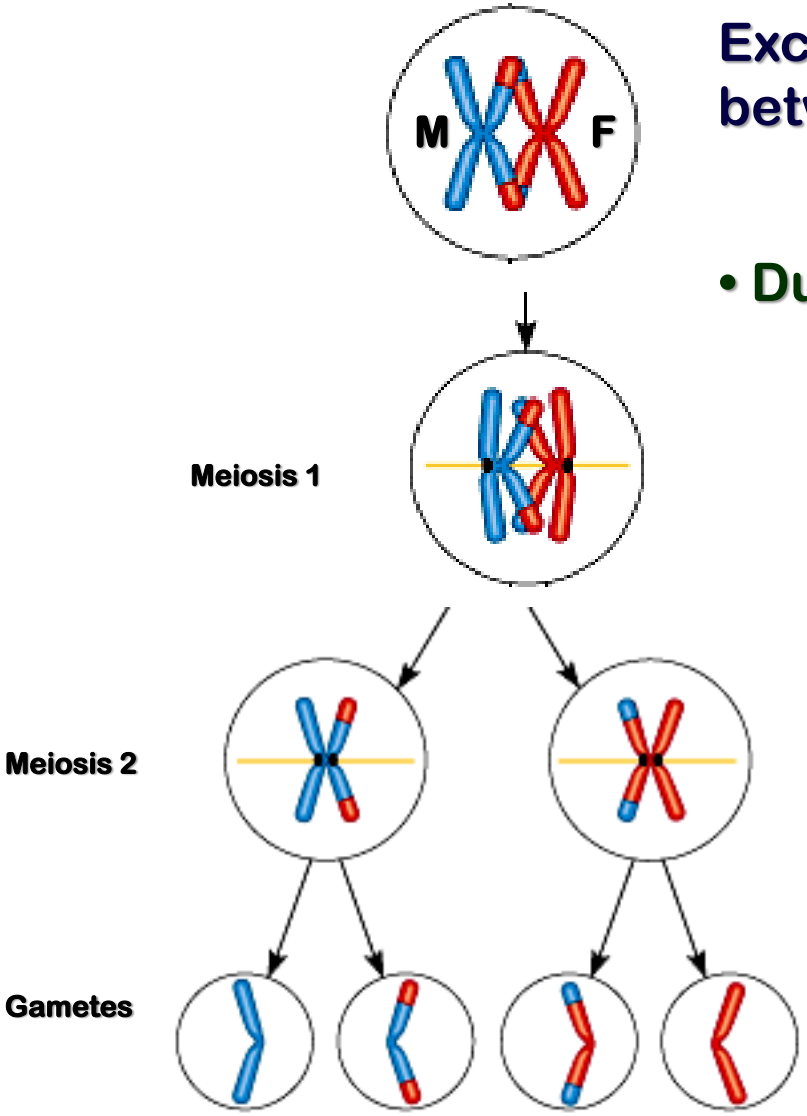
Crossing Over

- During metaphase 1 homologous chromosomes line-up along the metaphase plate
- Areas of homologous chromosomes connect at areas called Chiasmata





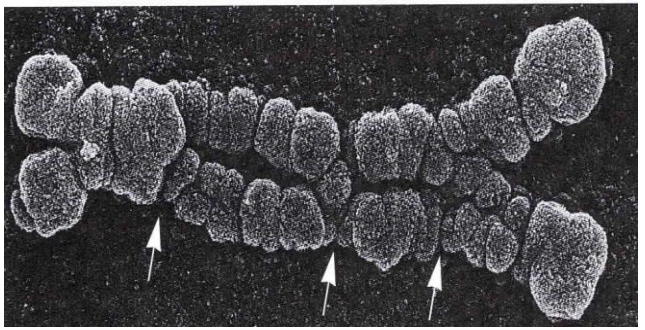
Crossing over (contd.)



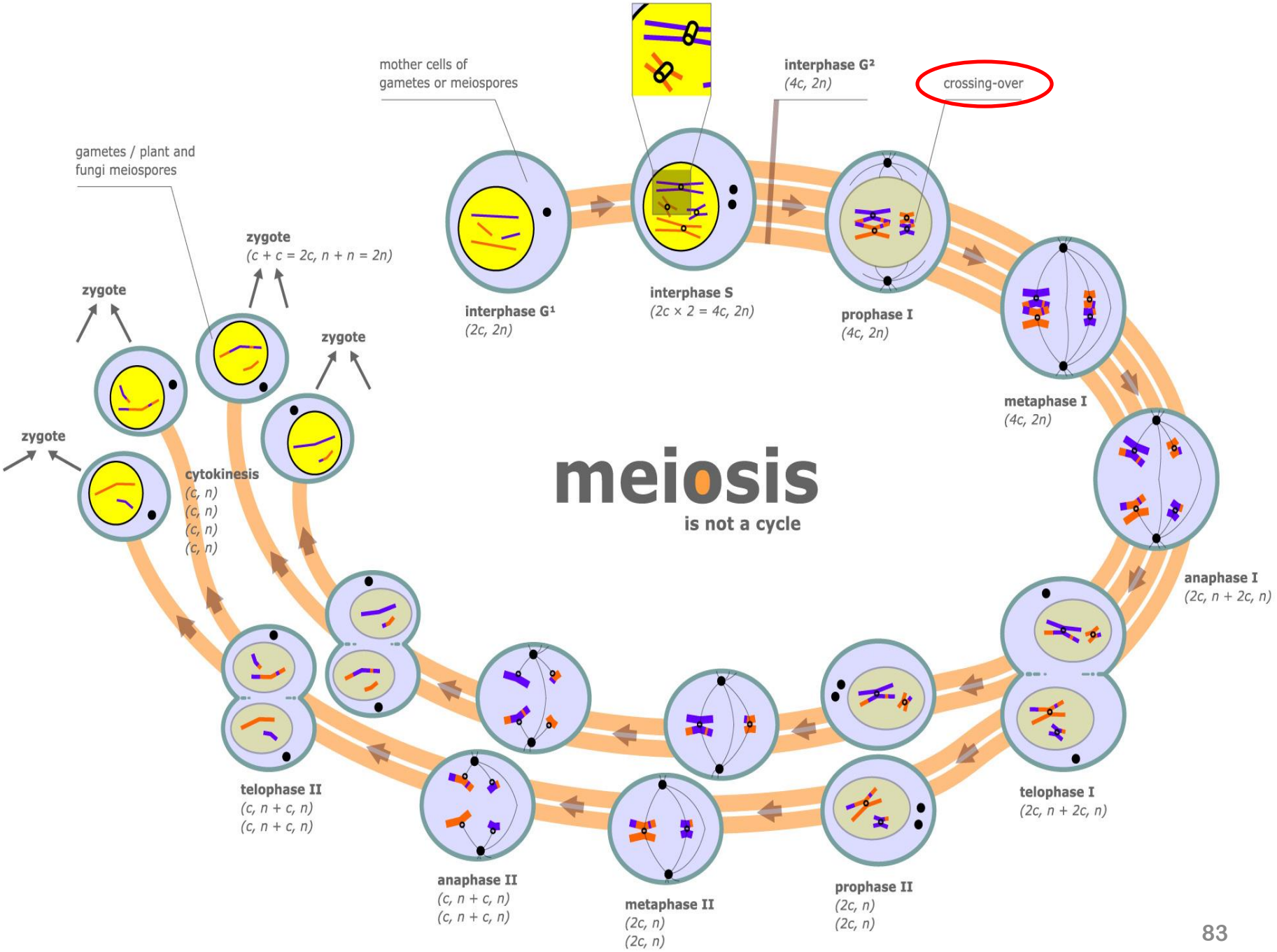
Exchange of genetic material between Homologous Chromosomes

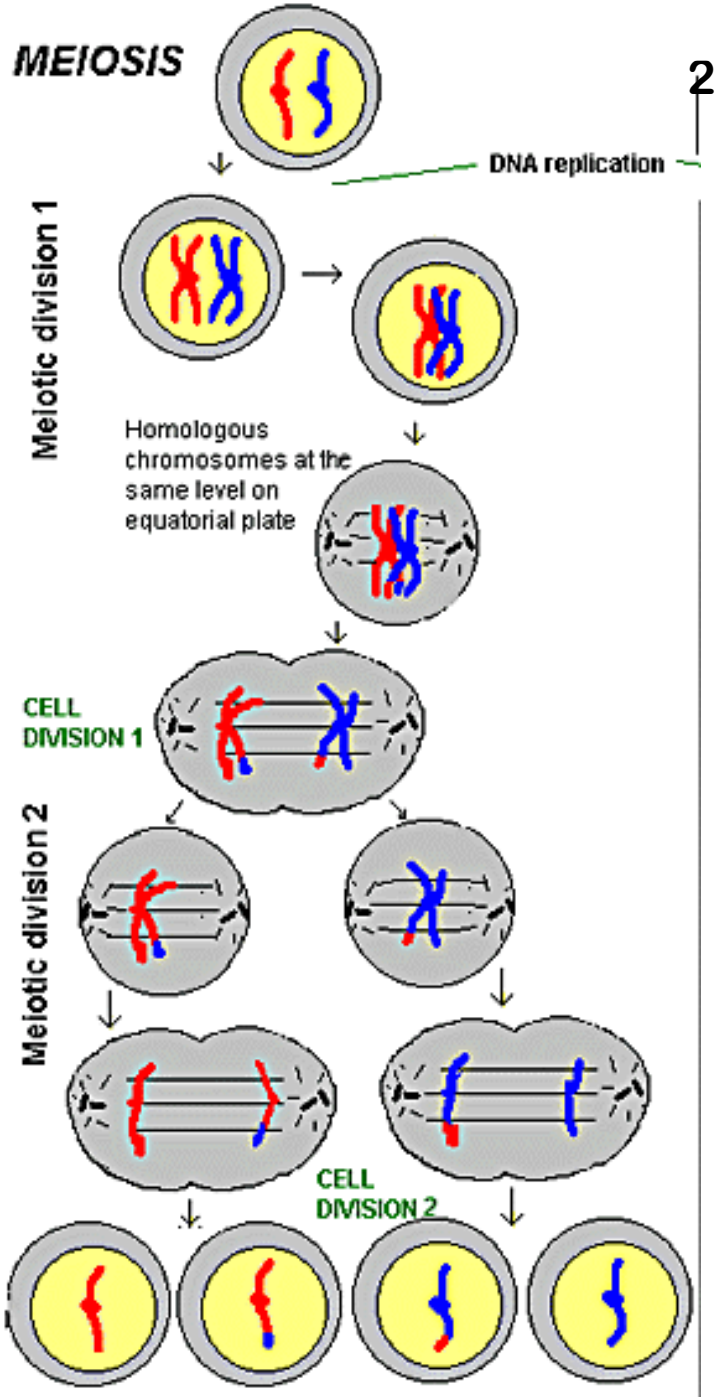
- **During Prophase I**

occurs at CHIASMA



Produces <u>new genetic combinations</u> --Chromosomes with both <u>Maternal</u> & <u>Paternal</u> components


mother cells of
gametes or meiospores
interphase G²
(4c, 2n)
crossing-over
gametes / plant and
fungi meiospores
zygote
(c + c = 2c, n + n = 2n)
zygote
zygote
zygote
interphase G¹
(2c, 2n)
interphase S
(2c × 2 = 4c, 2n)
prophase I
(4c, 2n)
metaphase I
(4c, 2n)
anaphase I
(2c, n + 2c, n)
telophase I
(2c, n + 2c, n)
prophase II
(2c, n)
(2c, n)
metaphase II
(2c, n)
(2c, n)
anaphase II
(c, n + c, n)
(c, n + c, n)
telophase II
(c, n + c, n)
(c, n + c, n)
cytokinesis
(c, n)
(c, n)
(c, n)
(c, n)
meiosis
is not a cycle



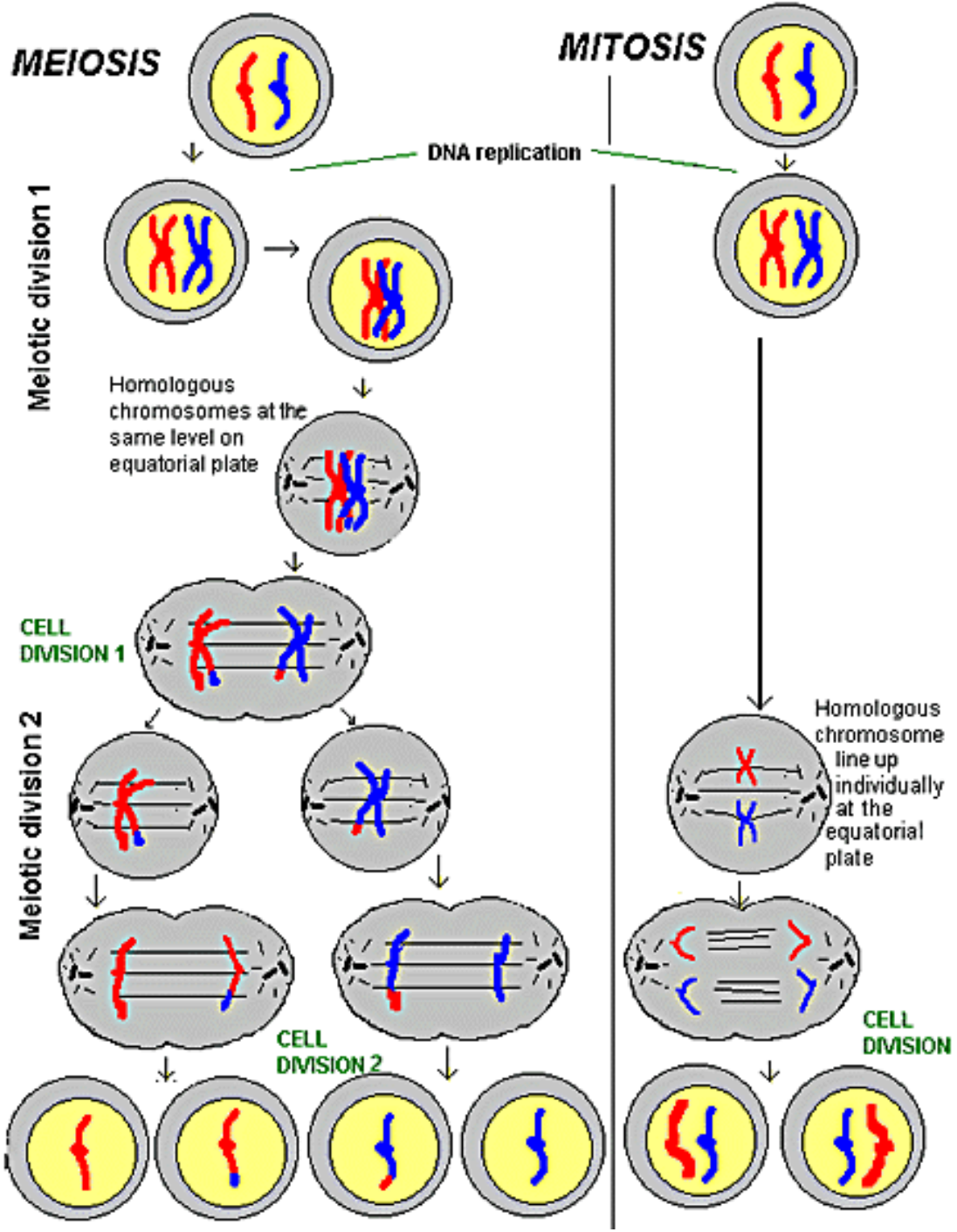
Crossing over occurs in meiosis I

Homologous chromosomes separate in meiosis I

2 cells, N = 1 for each

Sister chromatids separate in meiosis II

4 cells, N = 1 for each. Chromosomes are different due to crossing over


MEIOSIS
MITOSIS
DNA replication
Meiotic division 1
Homologous chromosomes at the same level on equatorial plate
CELL DIVISION 1
Meiotic division 2
Homologous chromosome line up individually at the equatorial plate
CELL DIVISION 2
CELL DIVISION

Classic (Mendel) Genetics

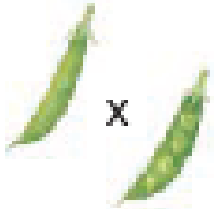
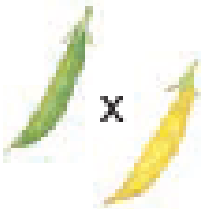
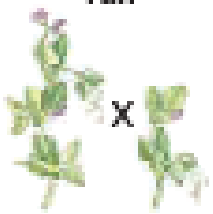
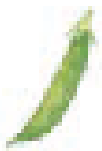
Gregor Mendel: Father of Genetics

- Genetics is the scientific study of **heredity**.
- Gregor Mendel (1860's) an Austrian Monk, was interested in figuring out how heredity was determined in plants and animals.
  - used pea plants
  - **quantitative** approach to collect data.
- Mendel studied seven different pea plant traits.
  - Seed shape & color, pod shape & color, plant height, flower color and seed coat color
- A **trait** is a specific characteristic, such as seed color or plant height, that varies from one individual to another.

Gregor Mendel's Experiment

- He called the offspring of the P-generation, the F1, or "first filial," generation. *Filius* is the Latin word for "son."
  - These pea plants were cross pollinated.
  - In cross-pollination, male sex cells in pollen from the flower on one plant fertilize the egg cells of a flower on another plant.
- The offspring of crosses between parents with different traits are called hybrids.
- The F2 generation was allowed to self-pollinate (on the same plant).
- Out of 929 F2 Generation plants, 705 were purple and 224 were white.
  - Ratio of 3 purple to 1 white flowers

Mendel's Seven F_1 Crosses on Pea Plants

	Seed Shape	Seed Color	Seed Coat Color	Pod Shape	Pod Color	Flower Position	Plant Height
P	Round  Wrinkled	Yellow  Green	Gray  White	Smooth  Constricted	Green  Yellow	Axial  Terminal	Tall  Short
F_1	 Round	 Yellow	 Gray	 Smooth	 Green	 Axial	 Tall

Mendel's F_1 Crosses When Mendel crossed plants with contrasting characters for the same trait, the resulting offspring had only one of the characters. From these experiments, Mendel concluded that some alleles are dominant and others are recessive.

Mendel's conclusions: Rules

1. Rule of Unit Factors

Each organism has 2 factors for each of its traits (alleles: gene alternatives)

2. Rule of Dominance

For each trait there exists 2 possible factors that are expressed in physical characters, one that may be dominant, and the other recessive.

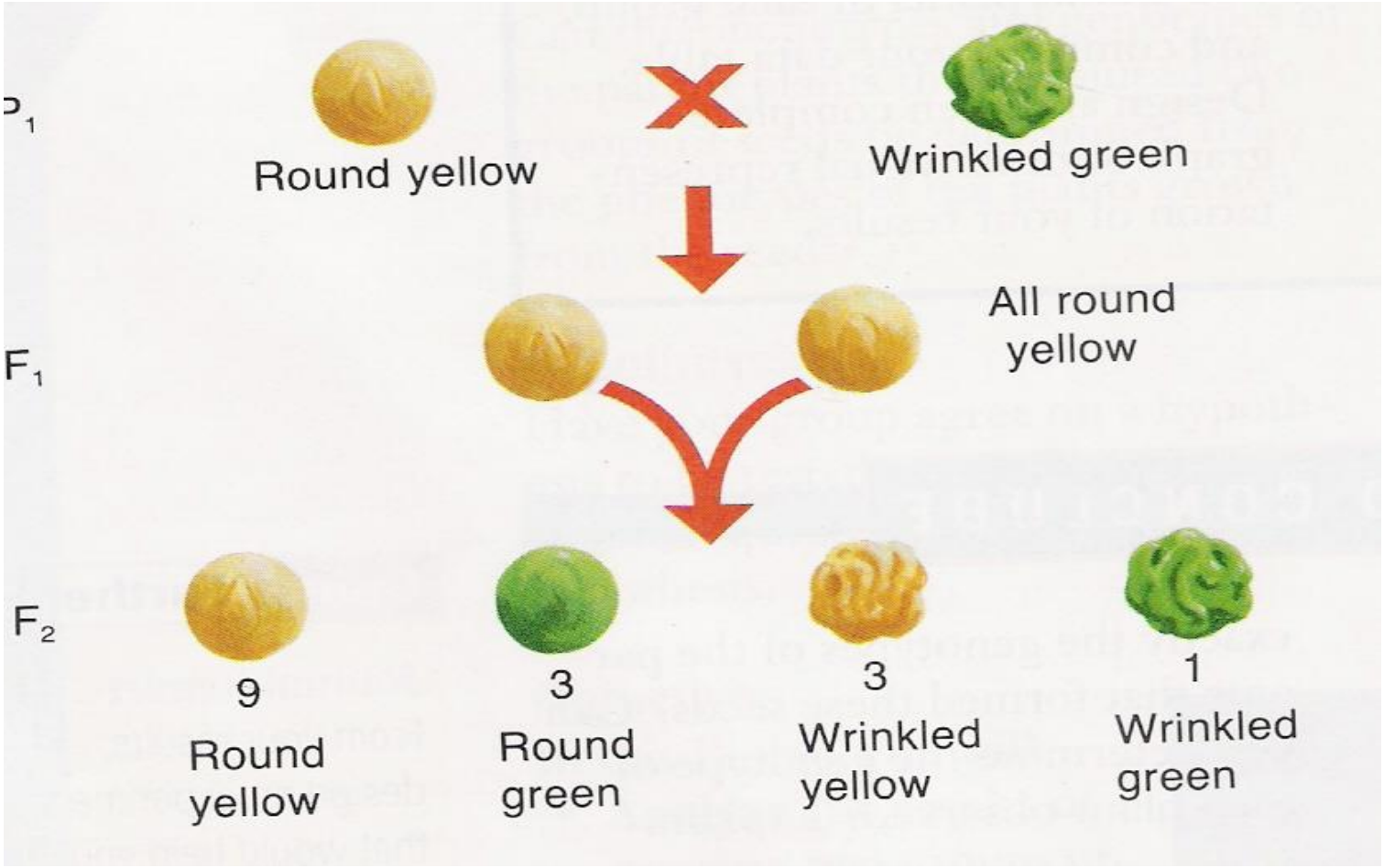
3. Law of Segregation

The two alleles for each trait must separate when gametes form.

Expression of Traits

1. **Phenotype**: physical expression of a gene
2. **Genotype**: a make of genes on a chromosome
3. **Homozygous**: alleles for a trait are the same
4. **Heterozygous**: alleles for a trait are opposite

Dihybrid cross



Punnett Square for Dihybrid Cross

(Cross between 2 parents that are Heterozygous for two traits)

Law of Independent assortment – different traits are passed independently of each other. All possible combinations of gametes with the two traits must be considered possible.

Round Yellow Seeds X Round Yellow Seeds

RrYy X RrYy

Did this mean that the two dominant alleles would always stay together?

When Mendel let the F_1 self pollinate, he got a definite ratio of visible phenotypes:

9 with both dominant

(RY)-Round Yellow

3 one dominant and one recessive

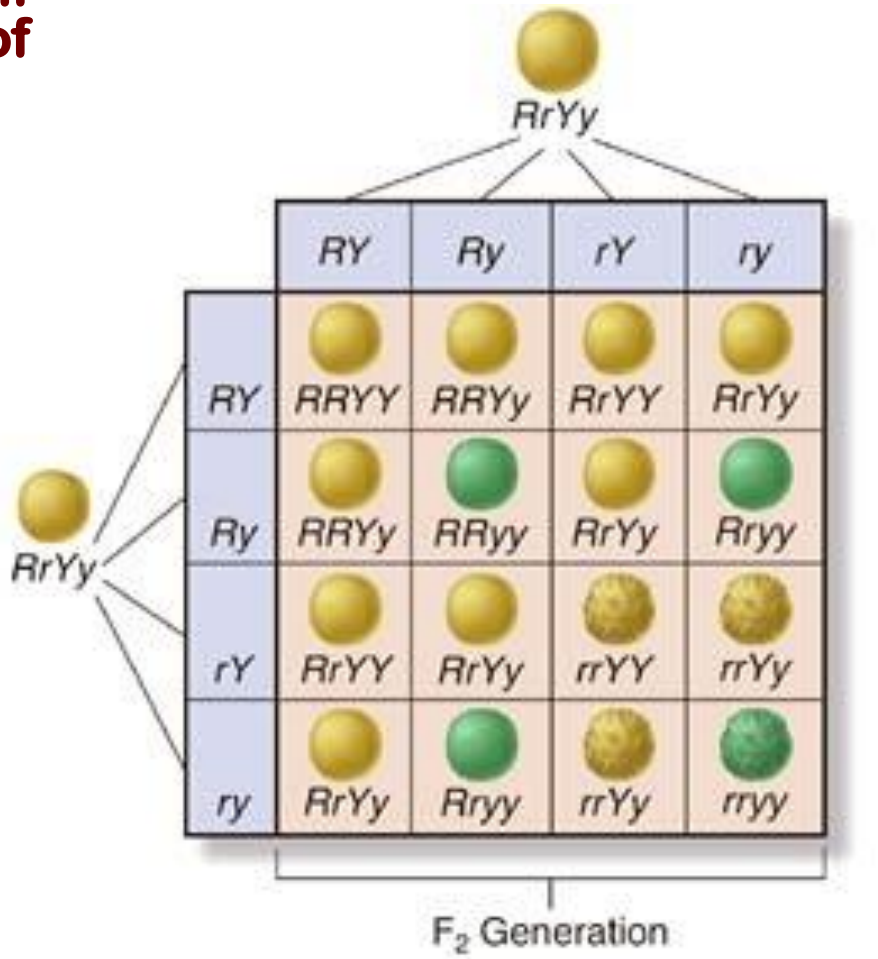
(Ry)-round green

3 one recessive and one dominant

(rY)–wrinkled yellow

1 both recessive

(rryy)-wrinkled green



Mendel's Dihybrid Crosses
(cross involving two different traits)

A. experimenting with plants that had two different traits that differed from each other

1. used true-breeding pea plants that had round yellow seeds (RRYY)

2. crossed with true-breeding pea plants that had wrinkled green seeds (rryy)

3. already knew that round was dominant and wrinkled was recessive and yellow was dominant and green was recessive

B. F_1 generation produced all round yellow seeds

C. F_2 generation produced

9 round yellow
3 round green
3 wrinkled yellow
1 wrinkled green

D. **The Law of Independent Assortment**

Genes for different traits are inherited independently of each other.

Plant Structure (Morphology & Anatomy)

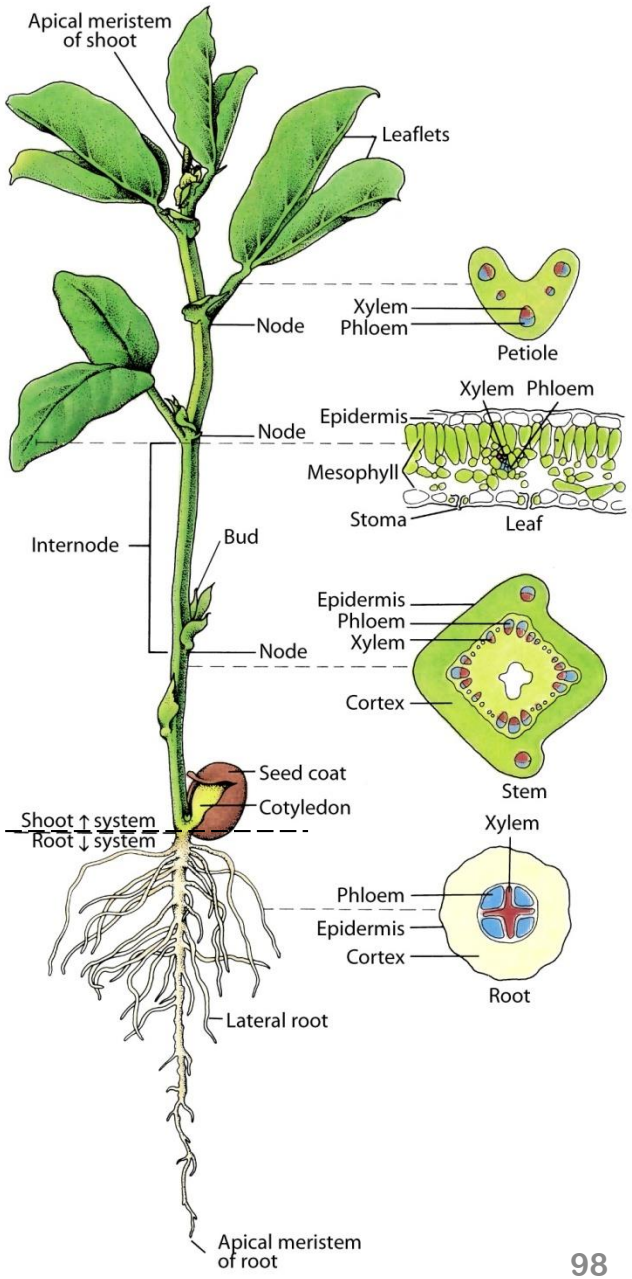
Plant Morphology

Shoot system

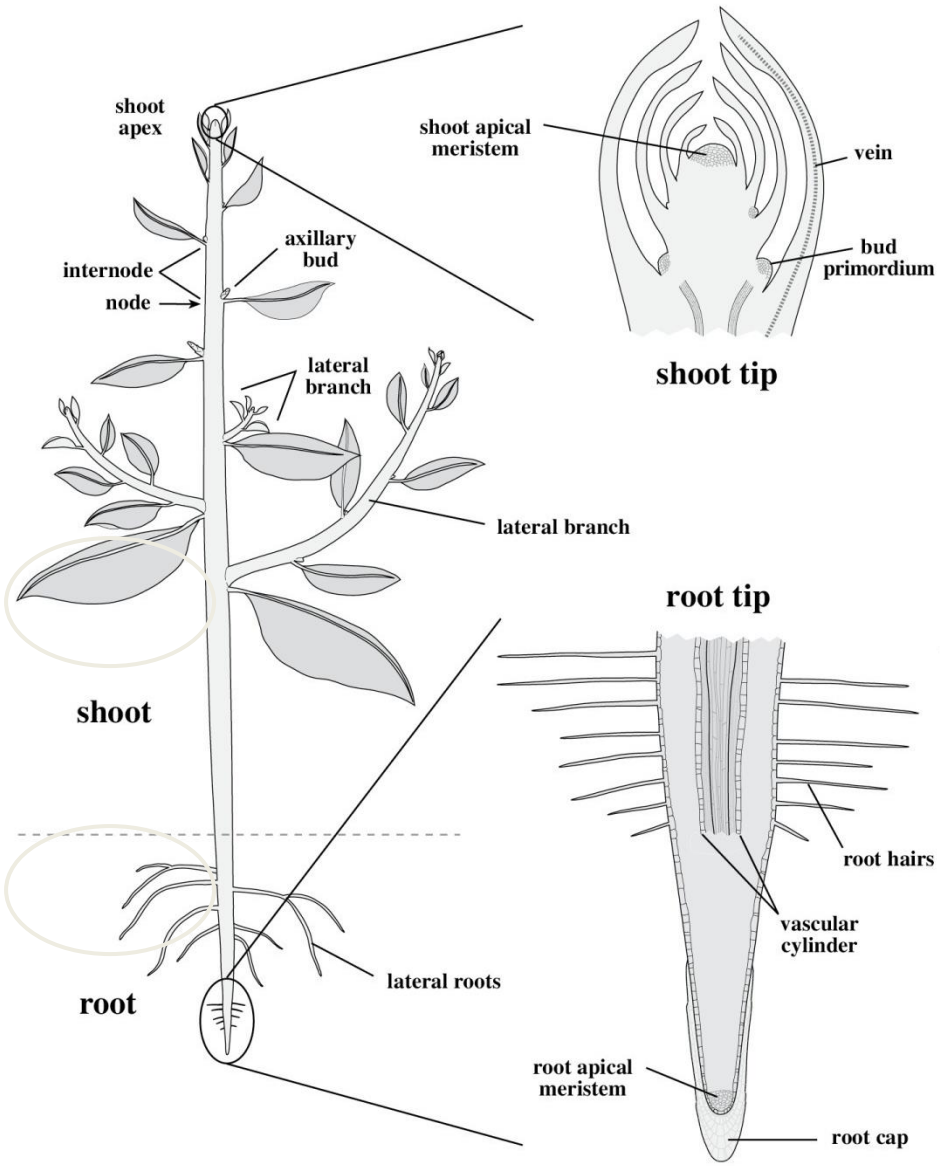
- Stem
  - Supports and places leaves
  - Transports H_2O and nutrients
- Leaves
  - Photosynthesis
- Reproductive structures - Flowers

Root system

- Anchors the plant
- Absorbs water and minerals
- Storage (CHO) & synthesis of some hormones
- Propagation



Root & Shoot Tips



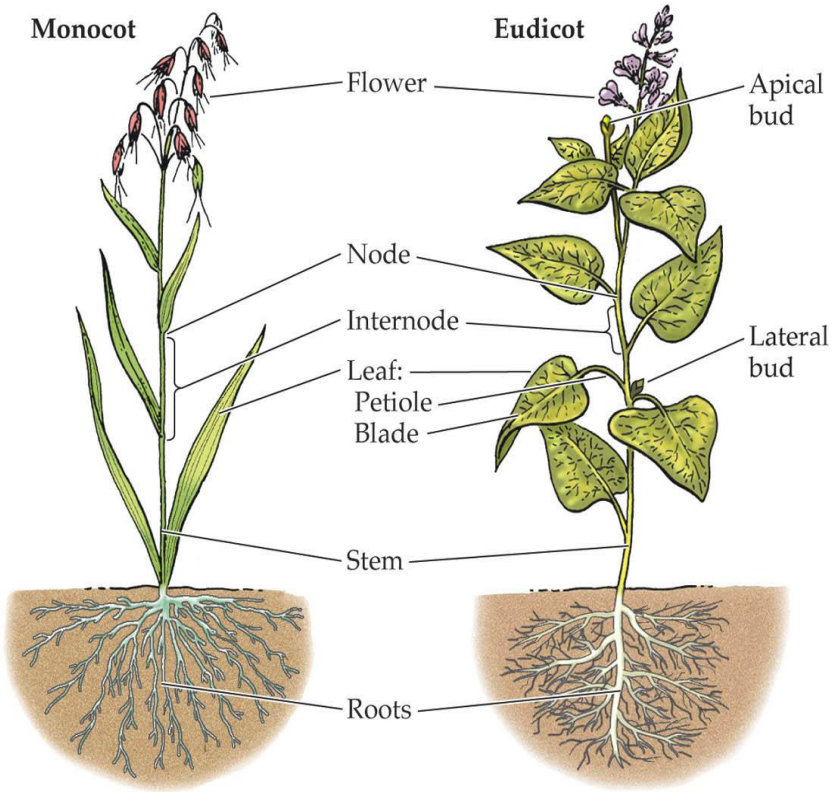
Dicots & Monocots

Flowering plants possess three kinds of vegetative (non-reproductive) organs: roots, stems, and leaves.

The flower is the reproductive organ of the Angiosperms.

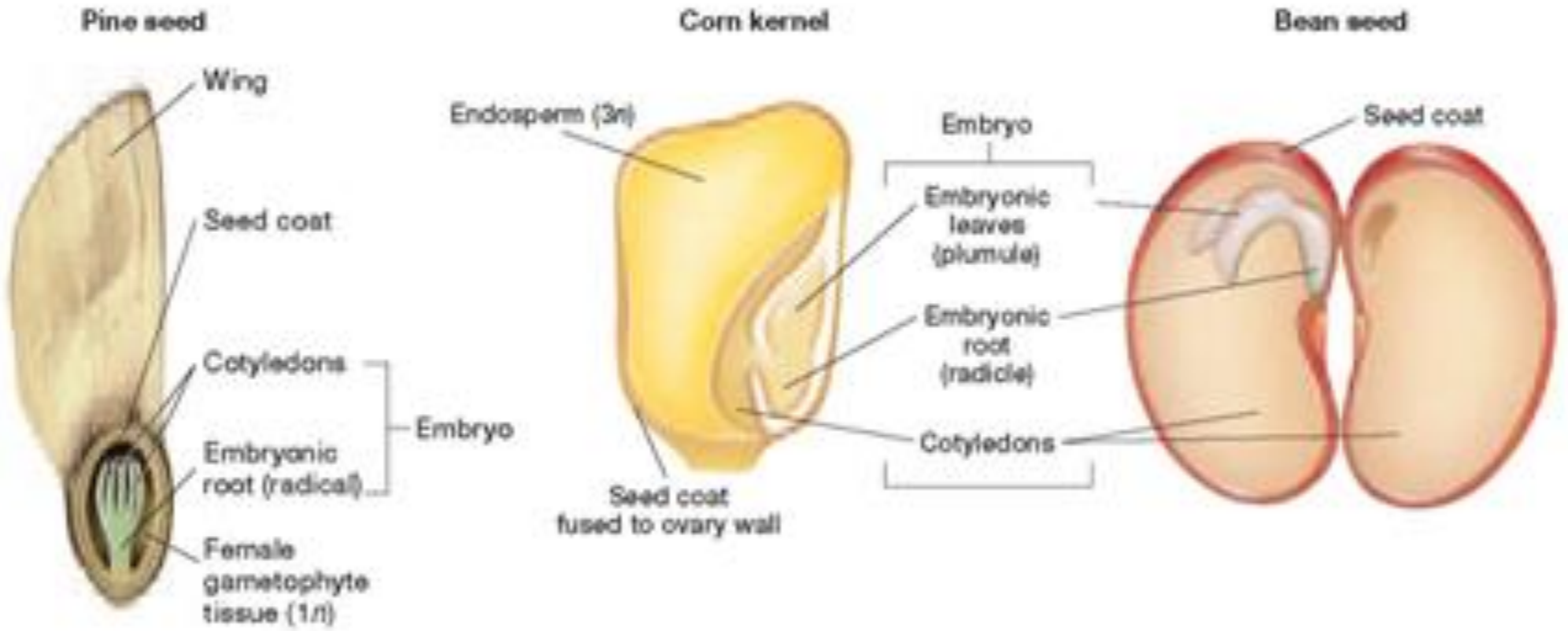
Shoots consist of:
<u>Stems</u> and <u>leaves</u>;
Functions are photosynthesis, support, reproduction, storage and transport

<u>Roots</u> Functions are anchorage, and absorption of water and Minerals, provides nutrients for the shoot and can be an area of storage



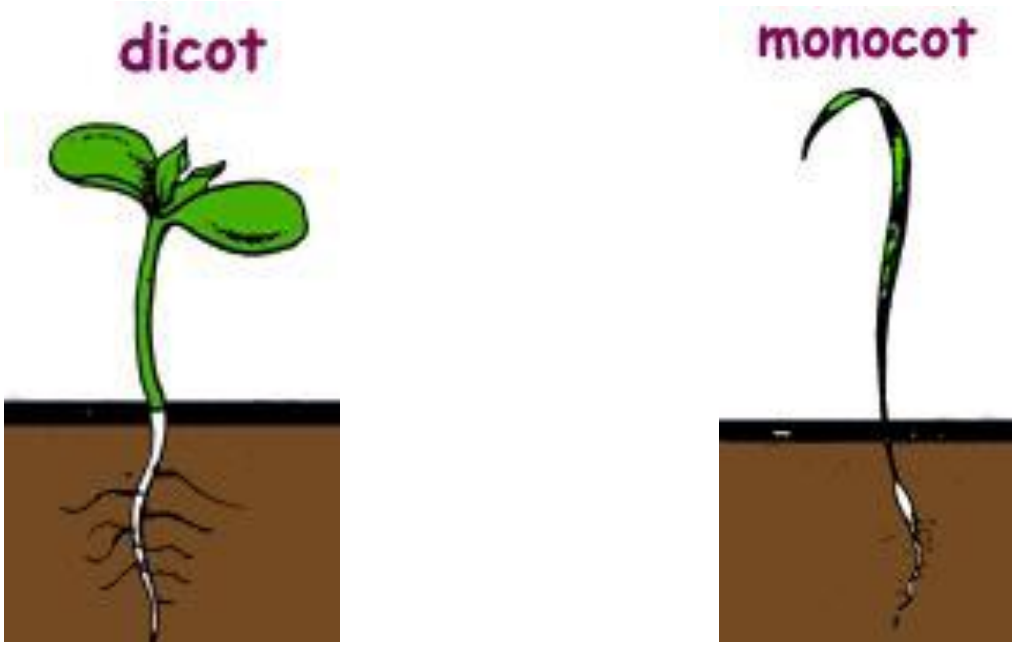
LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 35.2 Vegetative Organs and Systems

Seed Structure



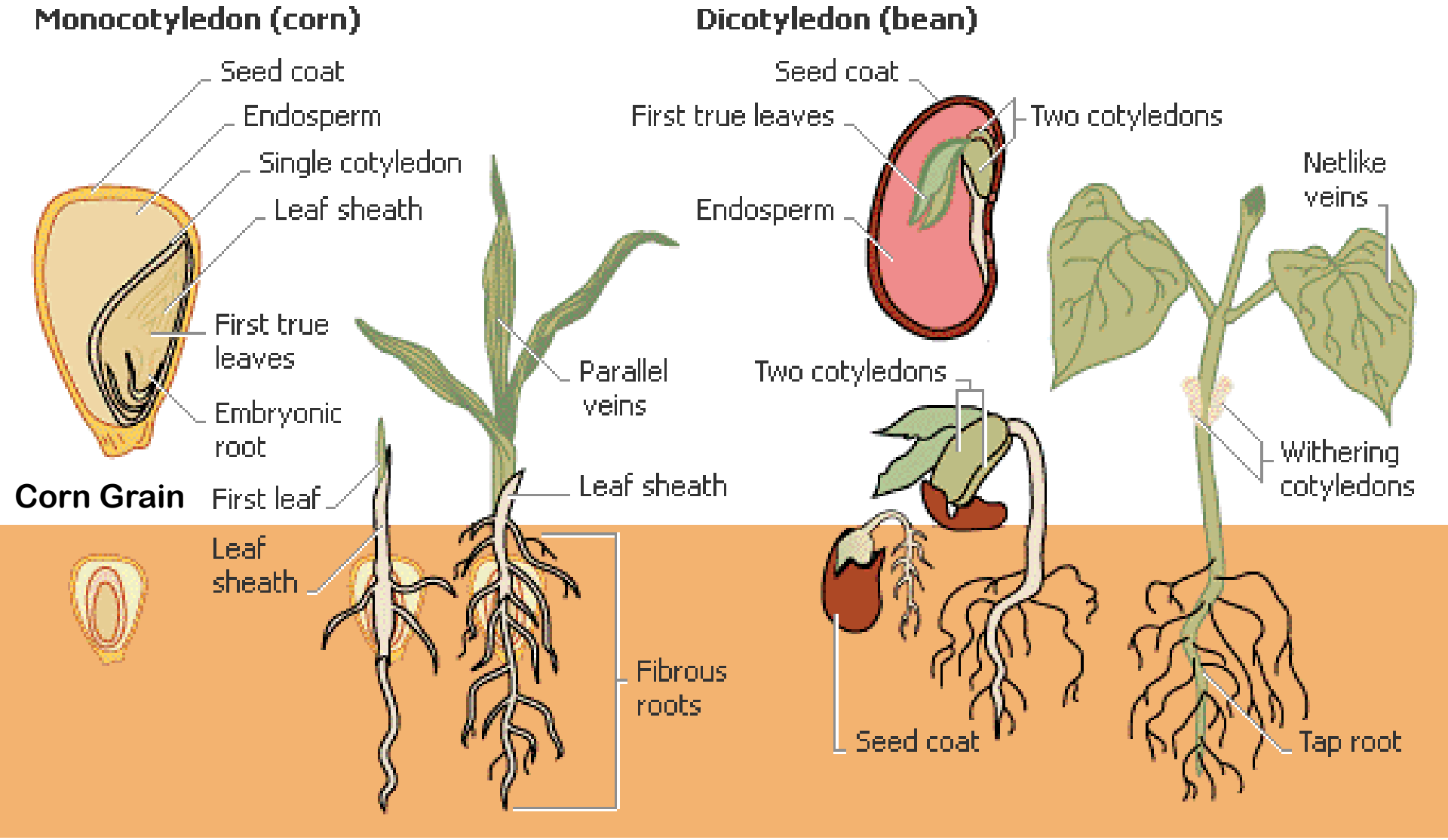
- A seed is a sporophyte embryo with its own food supply in a protective coat
- Seed plants (gymnosperms and angiosperms) retain their spores

Plant Seedling



- **Monocotyledons (Monocots)- have a single seed leaf**
- **Dicotyledons (Dicots)- have double seed leaves**

Seed Germination



Roots

Function - absorption, anchorage

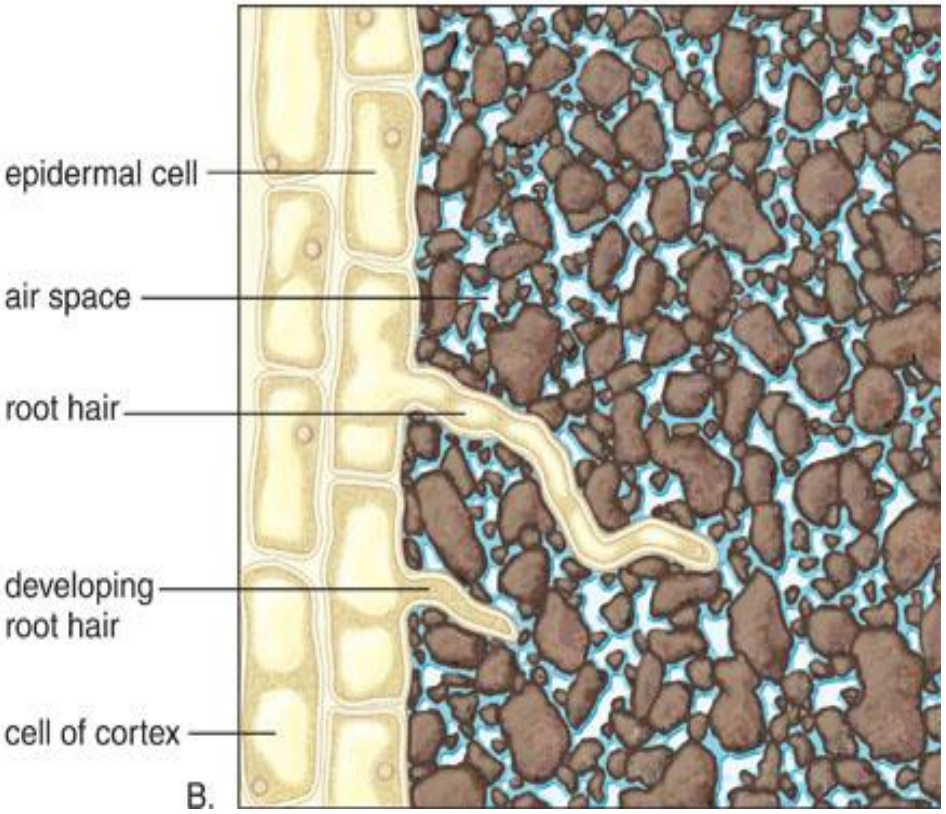
Structure – root cap, root hairs, endodermis

Adventitious roots - arise from non-root organ to perform specific function

Lateral roots - arise from another root (1˚, 2˚, etc.)

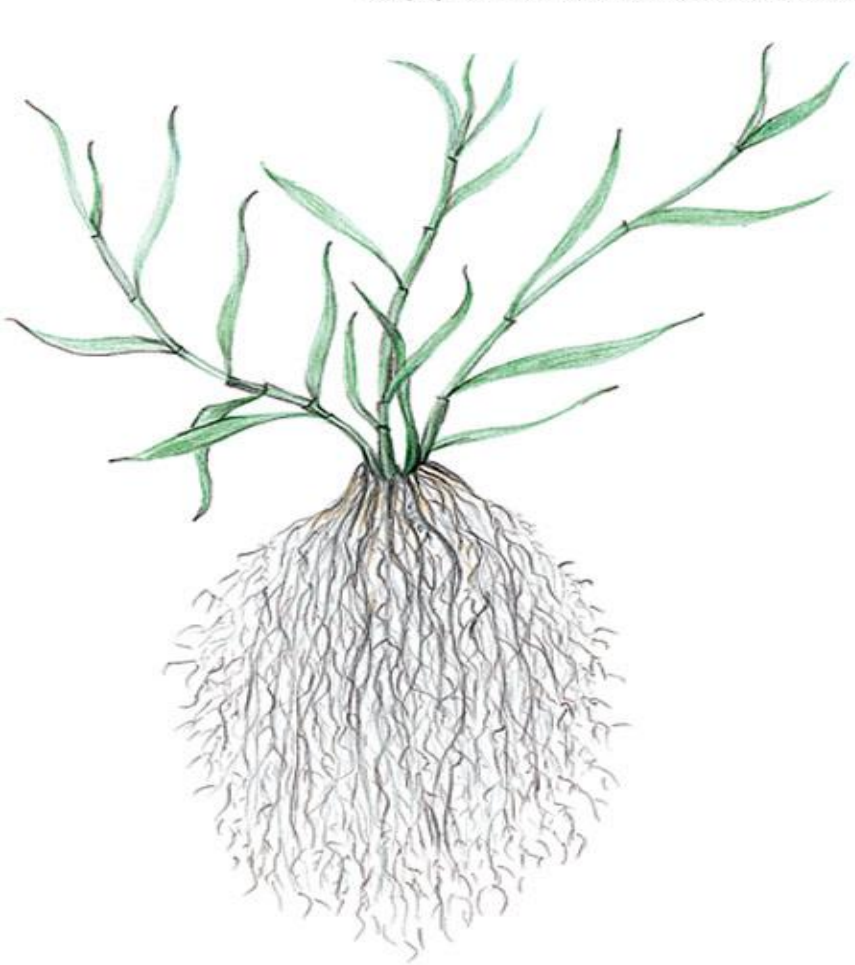
Roots: Specialized for H_2O & Nutrient Absorption

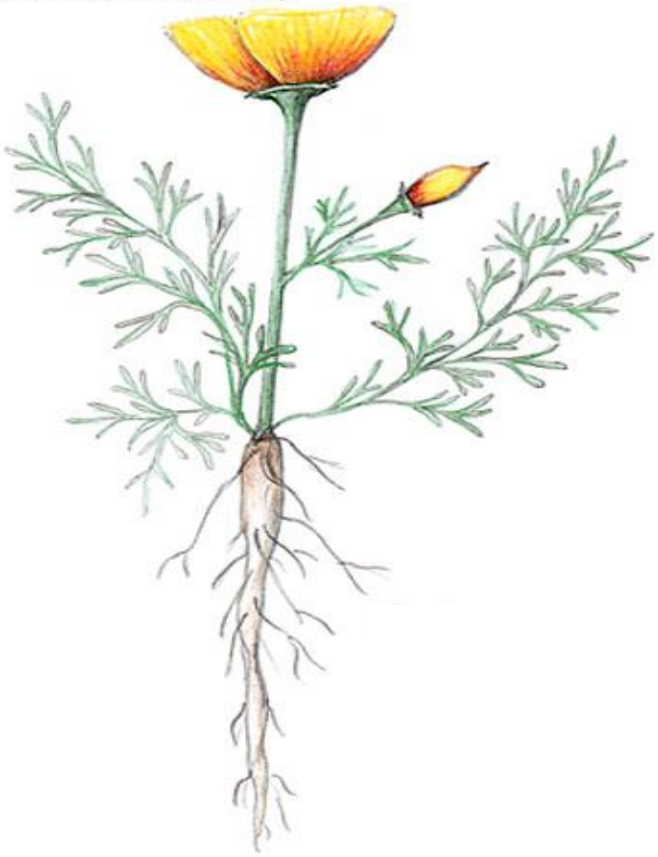
A.



B.

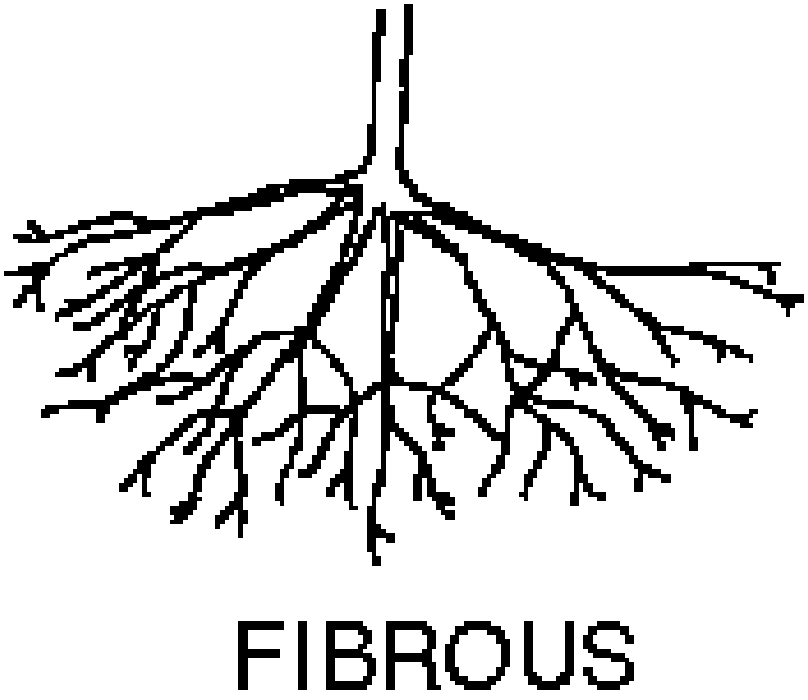
Root Types: Adventitious & Tap Root System





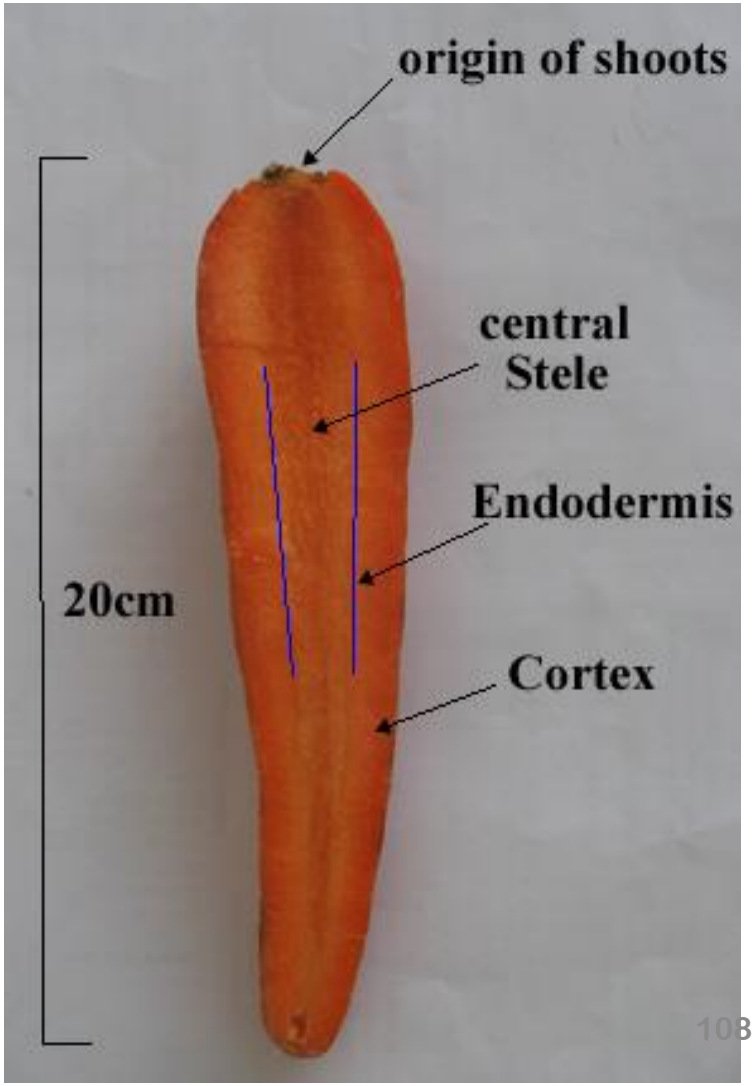
Fibrous Root System

- Develops when the secondary roots become the main roots.
- Shallow roots but spread over a broad area.
- Helps prevent erosion.



Tap Root System

- Develops from the primary root.
- Reaches deep into the ground
- Helps the plant during periods of drought.

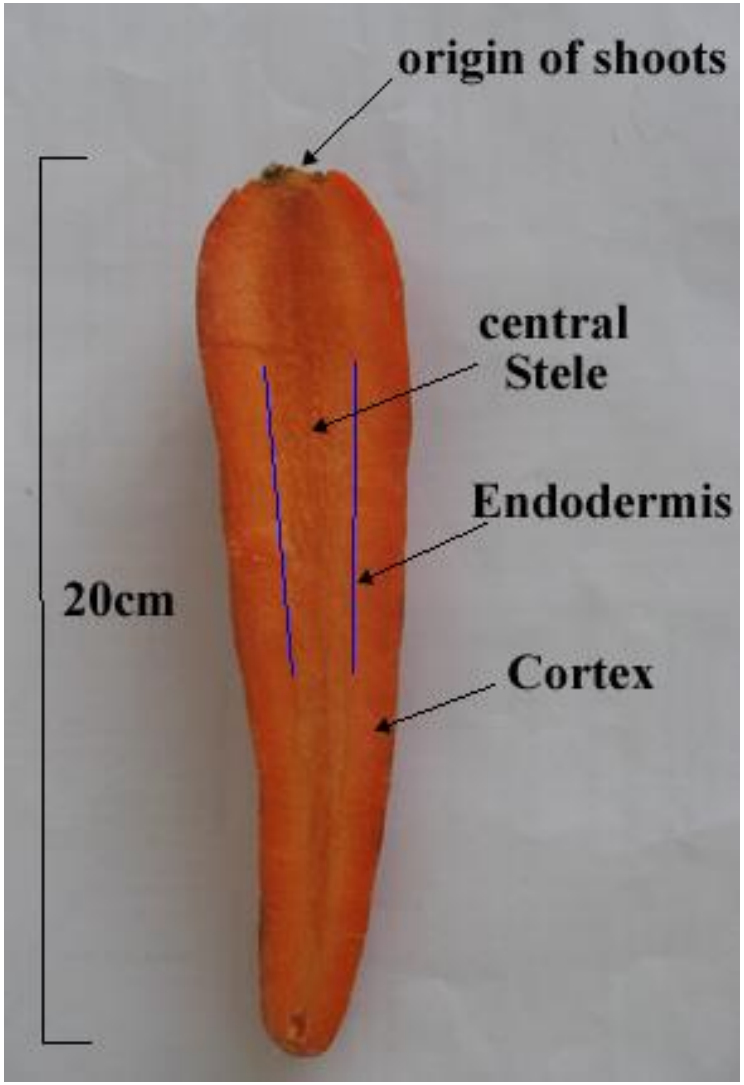


Root Modifications:
Storage Roots

Storage roots *Raphanus sativus*, radish

Storage roots, Sweet potato

Carrot: Tap Root modification



Function: Storage of water.

Carrot plants are often associated with very sandy soils.

The enlarged root is familiar to those who have eaten the vegetable.

The root modification allows the storage of water in the cortex and central stele.

The mass of the root stabilizes the plant in the loose sandy soils.

buttress roots

buttress roots, rusty-leaved fig

Respiratory roots

Pneumatophores (respiratory roots)
***Avicennia marina*, black mangrove**

Prop roots

Prop roots (also adventitious)

Haustoria – parasitic roots

Root Adaptations .....??

(a)

(b)

(c)

(d)

(e)

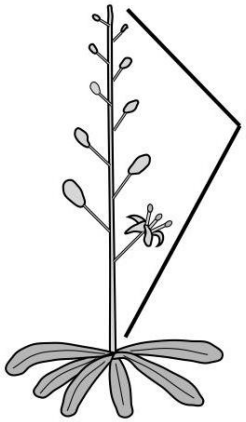
Shoot
(Stem + Associated Leaves)

Stems

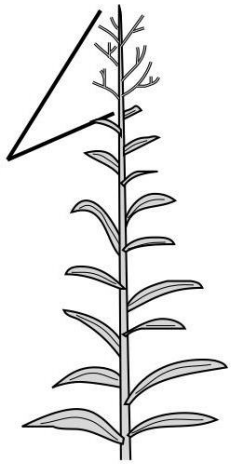
The two main functions of the stems are conduction and support

- **Conduction** involves moving substances manufactured in the leaves through the phloem to other parts of the plant including developing leaves, stems, roots, developing flowers, seeds and fruits and the xylem carries water from the roots to the leaves, where water is transpired
- **Support** involves holding the plant off the ground - supporting the principal photosynthetic organs of the plant (the leaves) as well as flowers, seeds and fruits

Stem Habit
=relative position of stem (+ growth, structure)

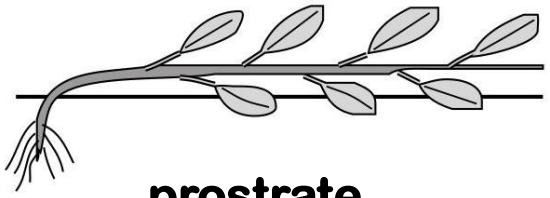


acaulescent

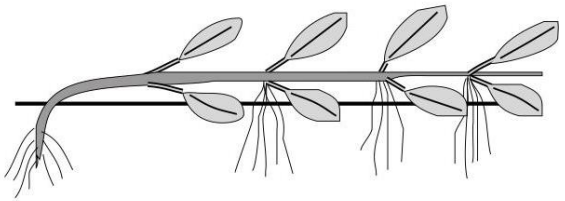


caulescent

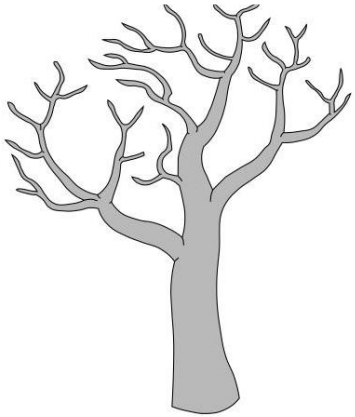
cespitose



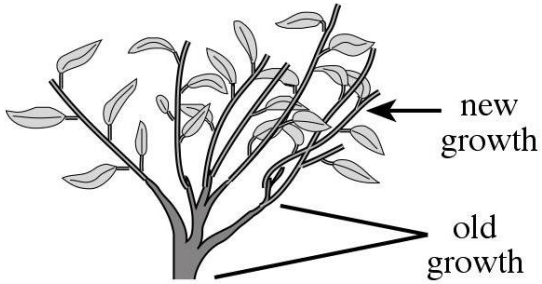
prostrate



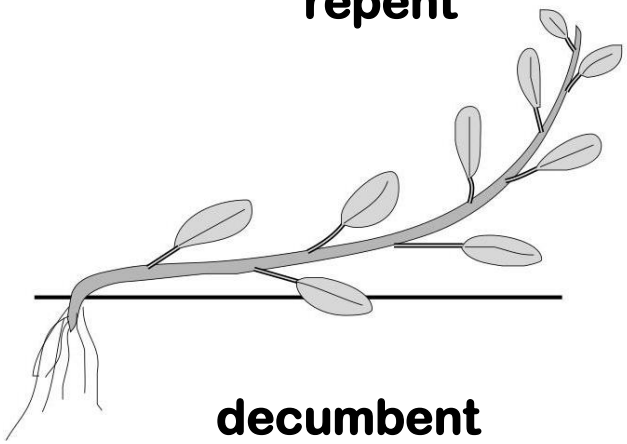
repent



arborescent

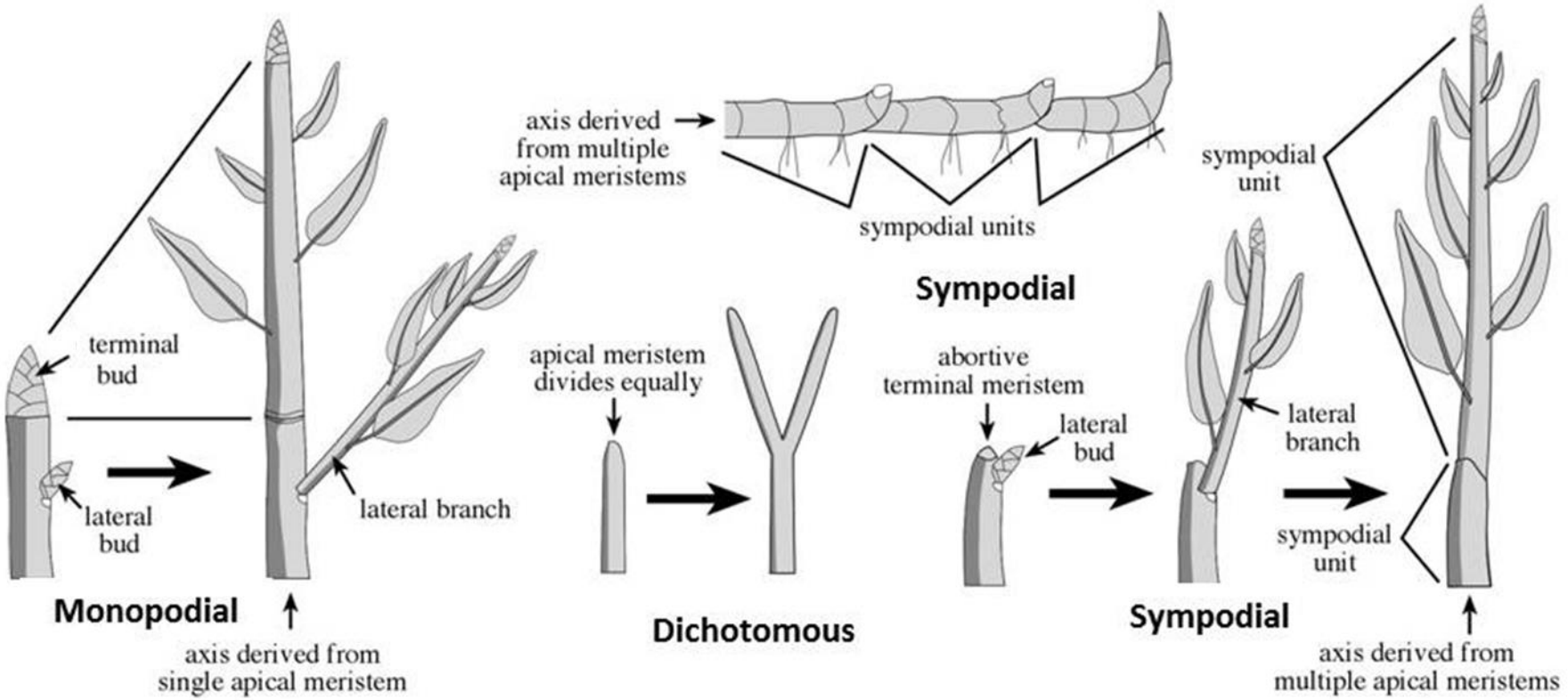


suffrutescent



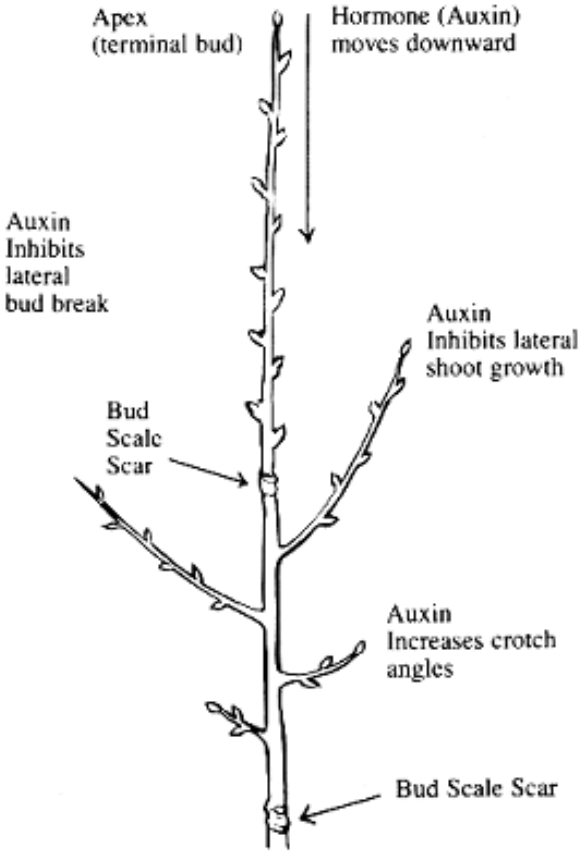
decumbent

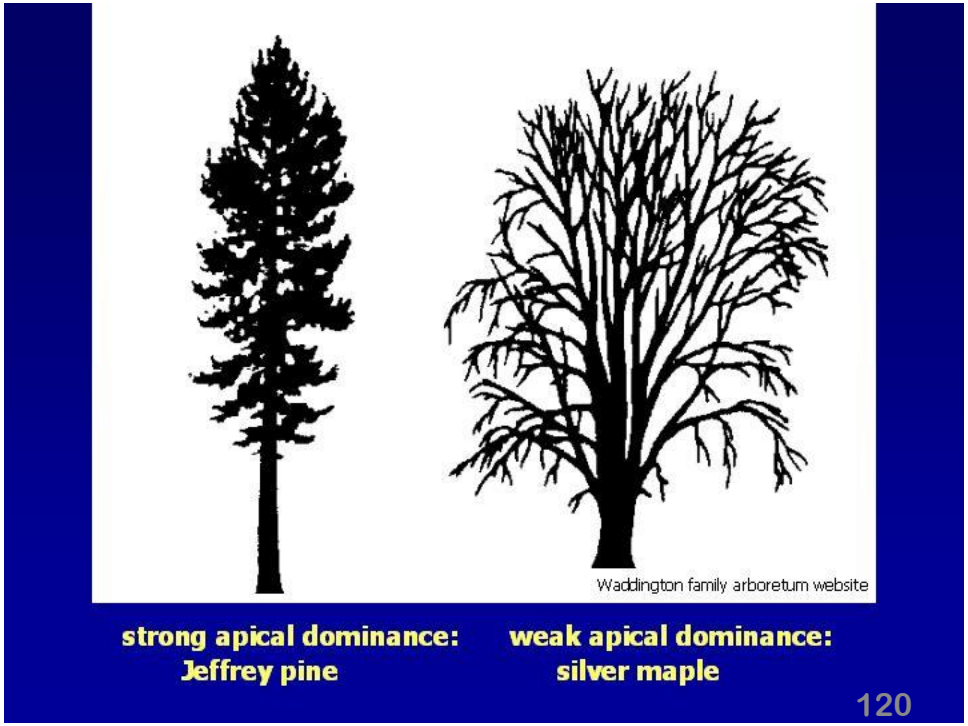
Stem Branching



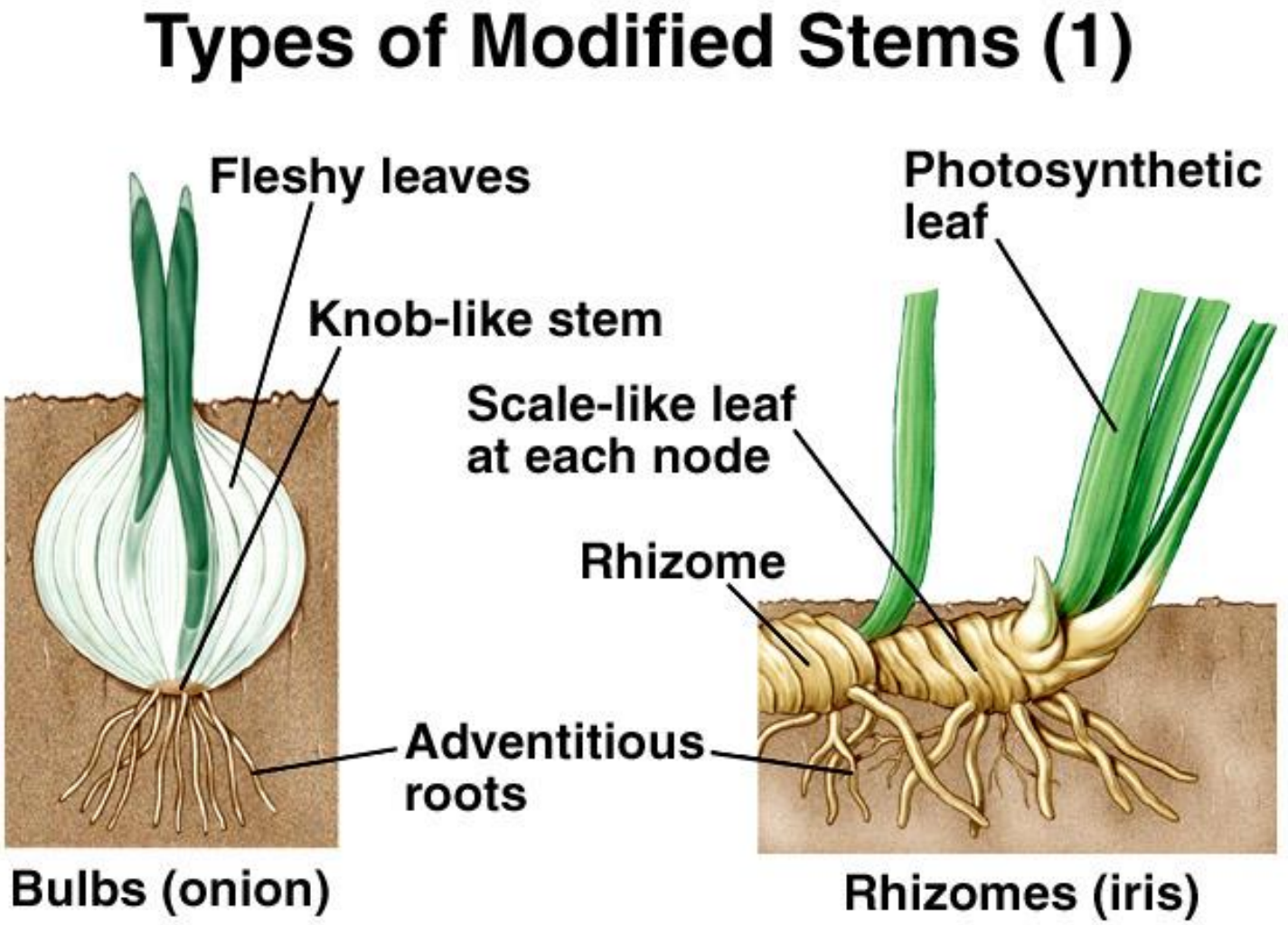
Apical Dominance

Usually the growing terminal bud inhibits the development of the lateral buds, a phenomenon known as apical dominance – as the influence of the apical meristem lessens the growth of the lateral buds which proceed with their development.

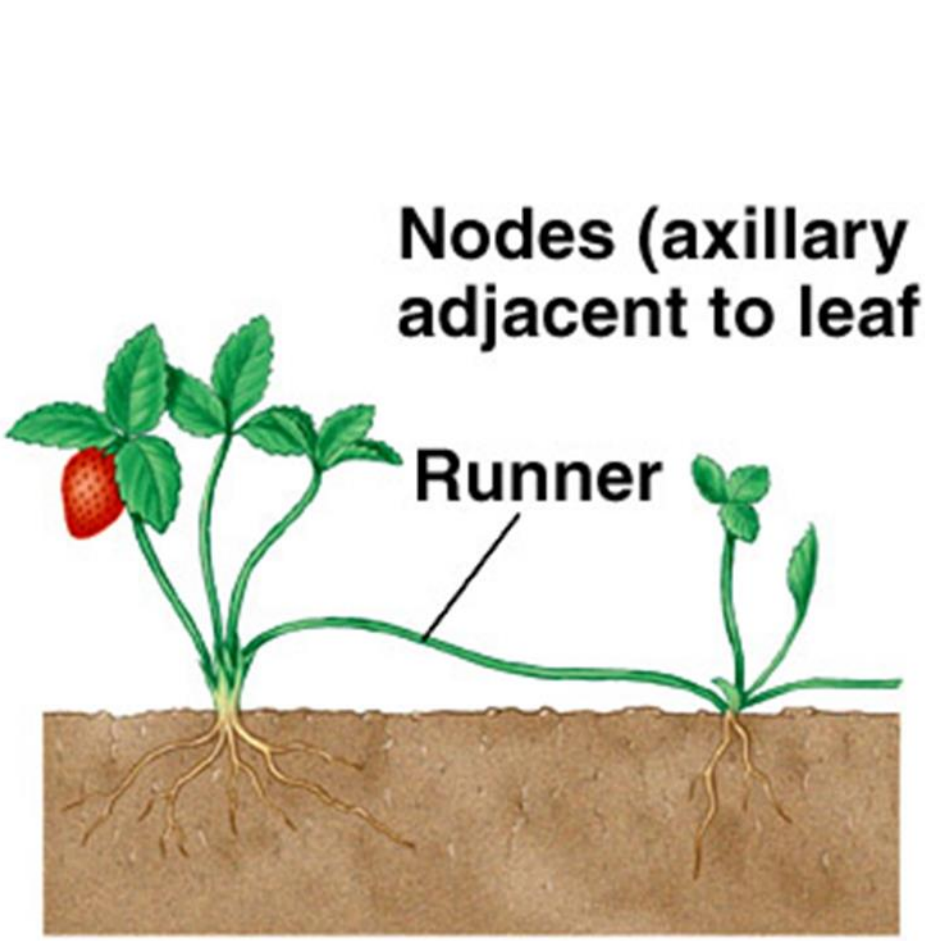




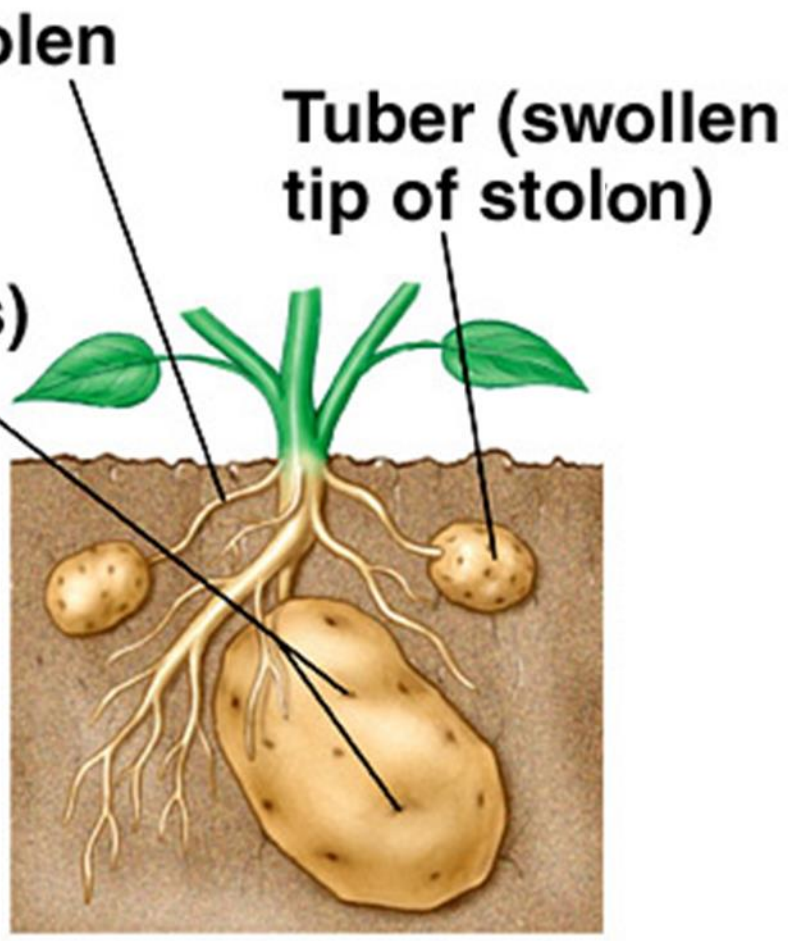
Stem (Shoot) Types & Modifications



Types of Modified Stems (2)

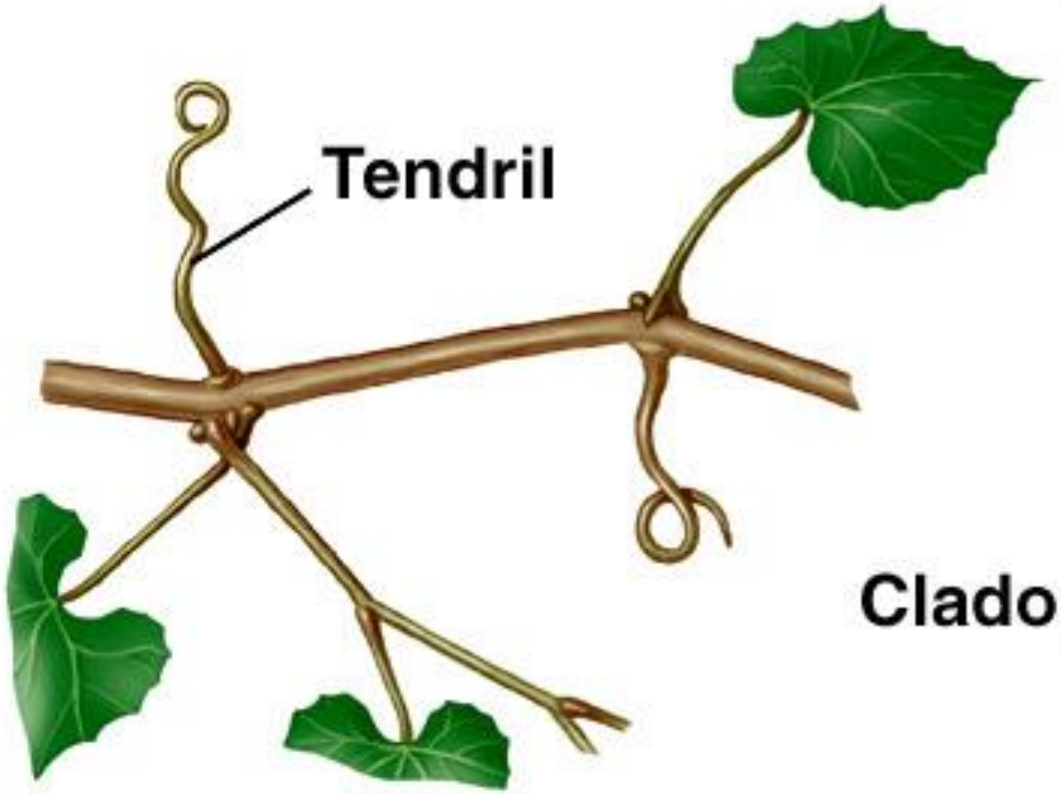


Runners (strawberry)

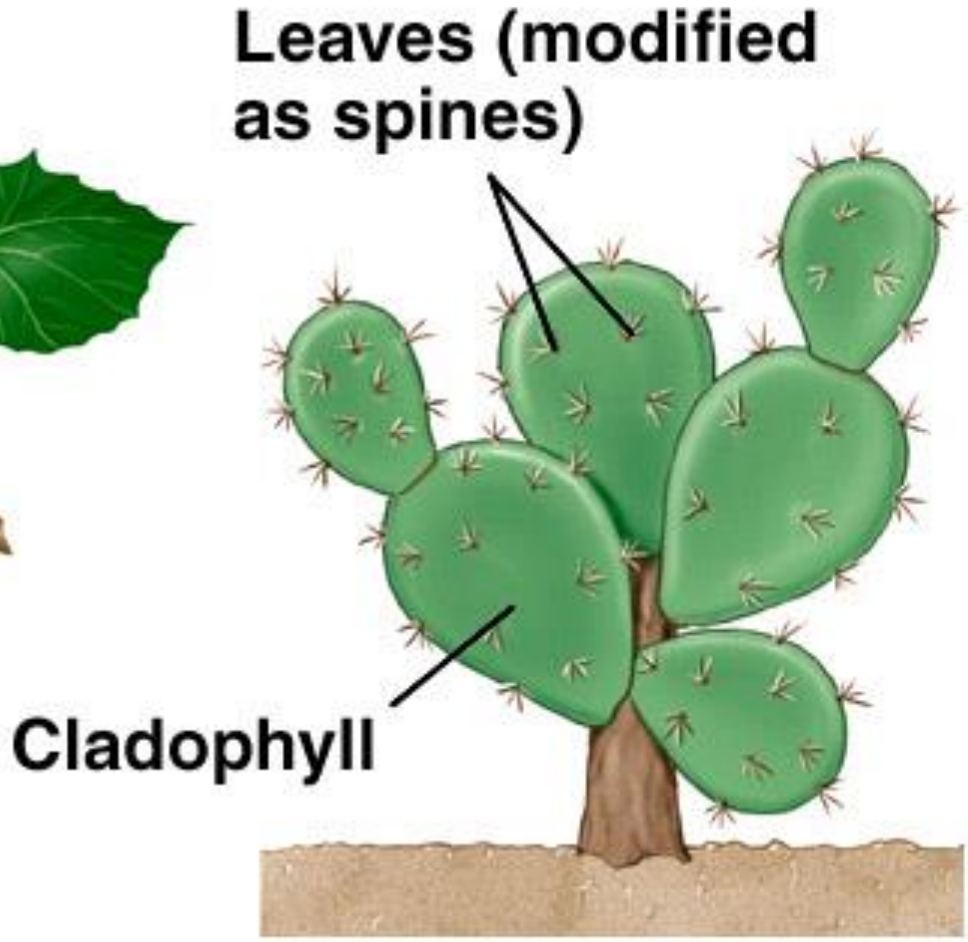


Tubers (potato)

Types of Modified Stems (3)

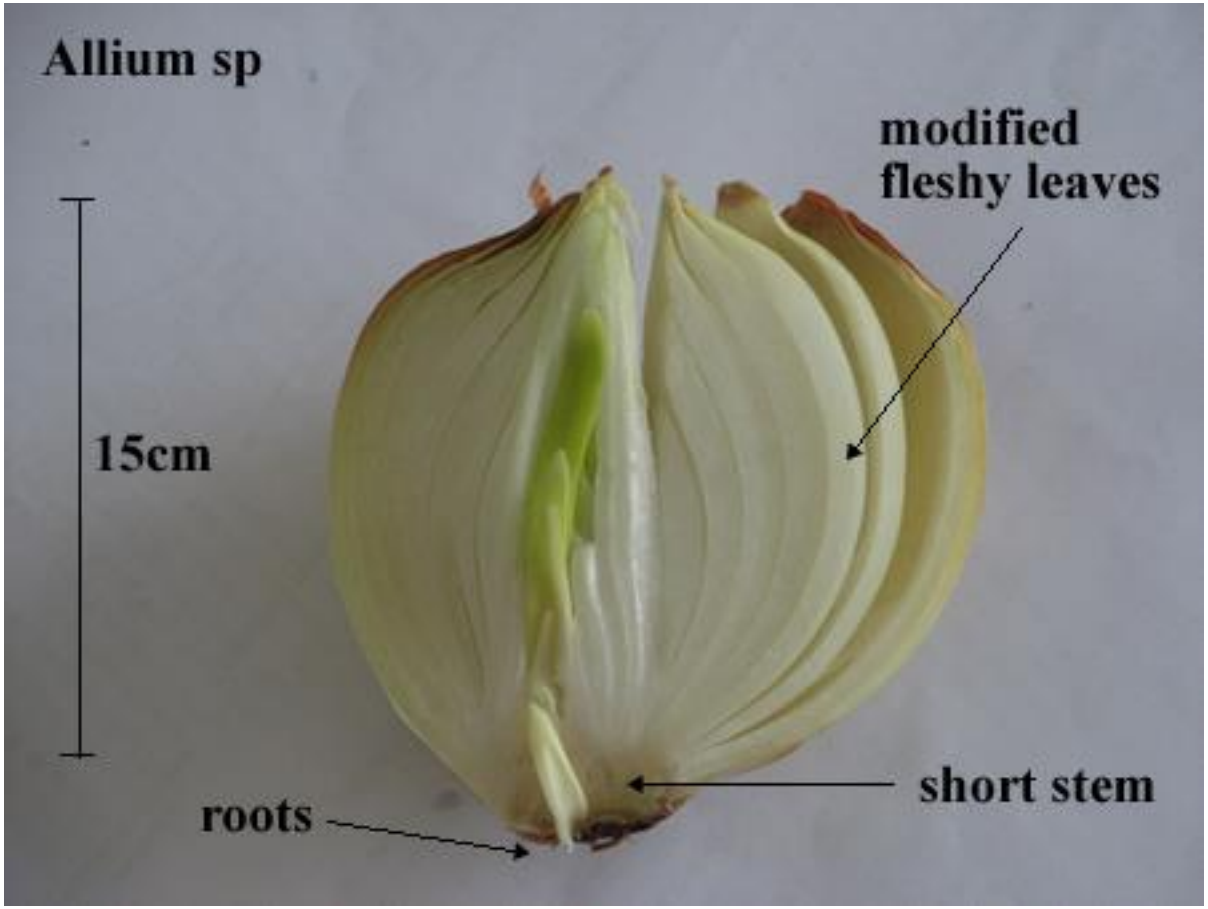


Tendrils (grape)

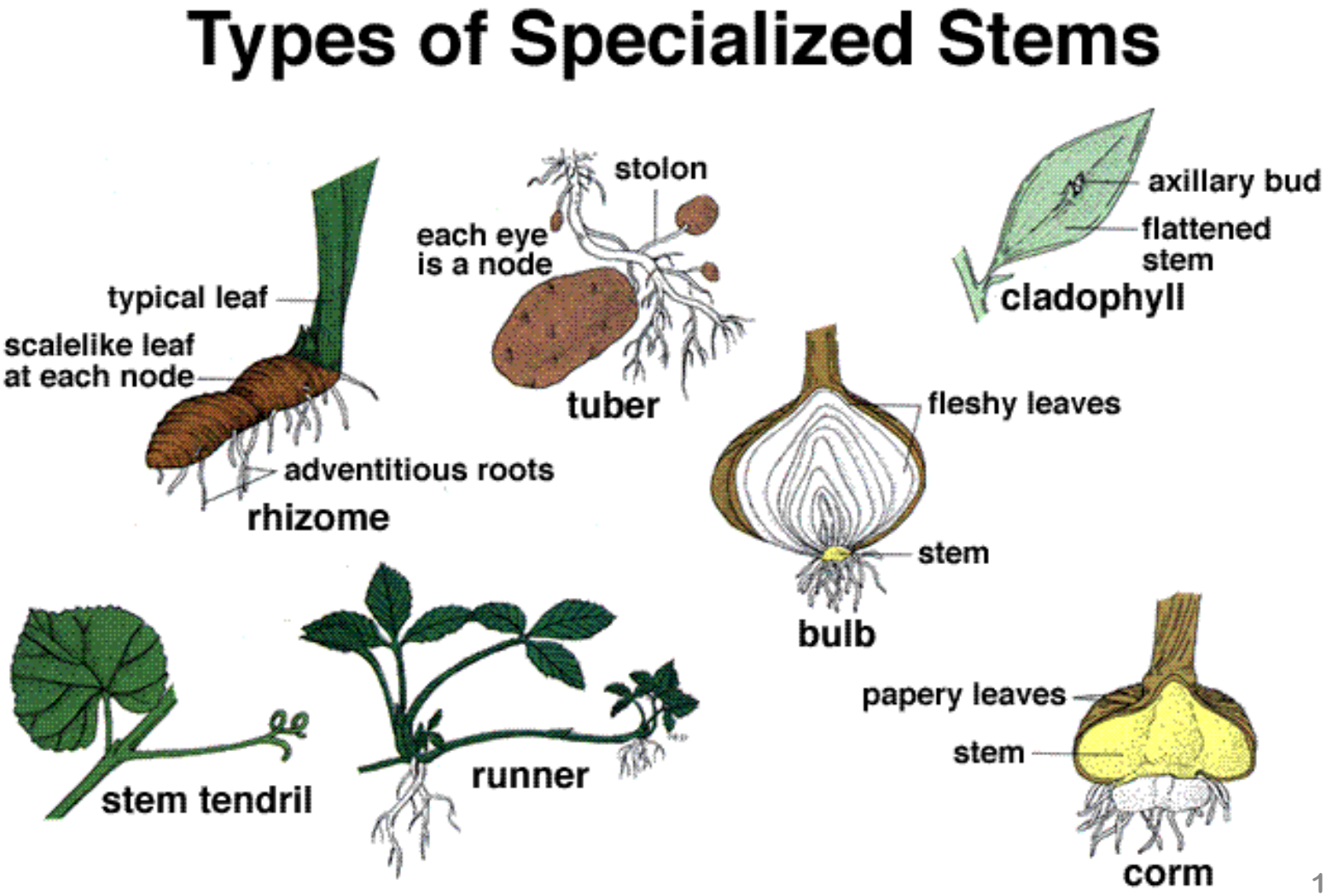


Cladophylls (prickly pear)

Onion Bulb



Compare ……???



Leaves

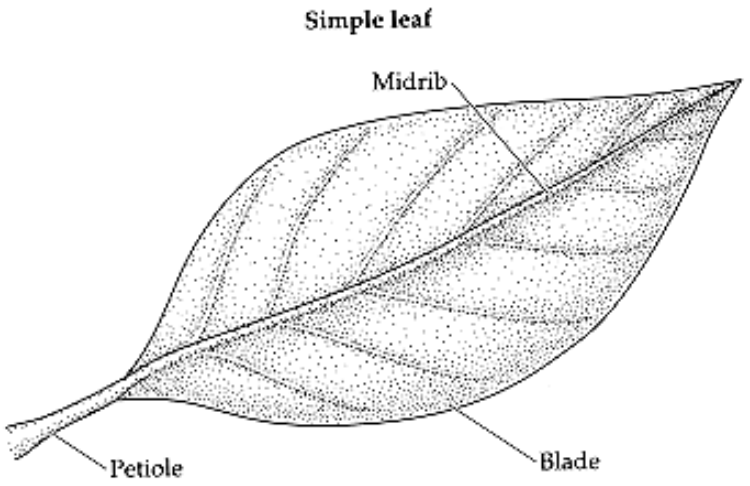
Leaves

- **The leaf- Is the main photosynthetic organ of most vascular plants**
- **Leaves generally consist of a flattened blade and a petiole, which joins the leaf to a node of the stem**
- **Leaves may appear different based on whether they grow in shade or full sun**
- **Some plant species have evolved modified leaves that serve various functions**
  - **Climbing, pollinator attraction, storage, digestion, prevention of water loss, etc.**

Leaves

External Parts of the Leaf:

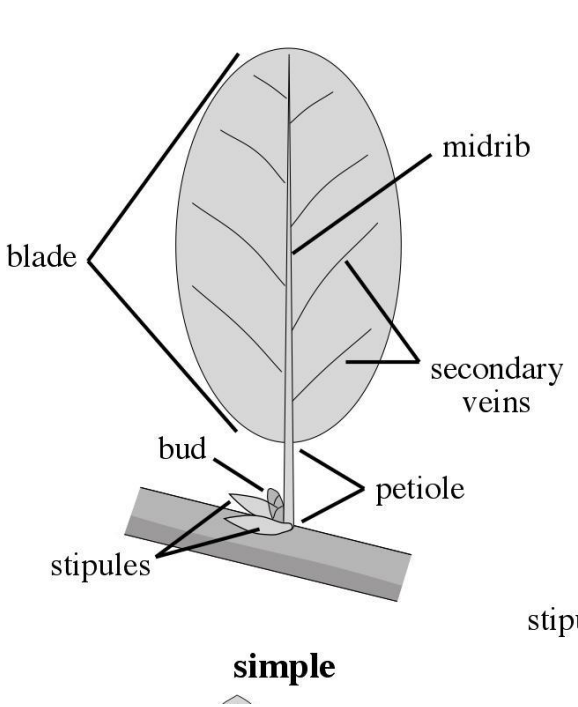
- **Petiole** عنق
  - Leaf stalk or part that connects the leaf to the stem.



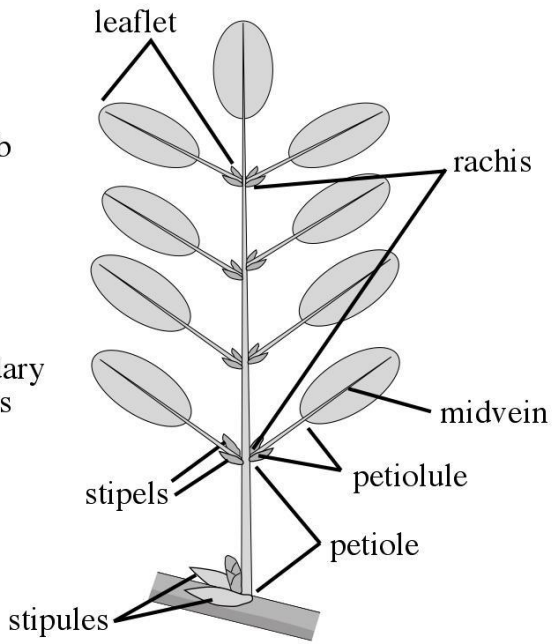
- **Blade** نصل
  - The large, flat part of a leaf.

- **Midrib** عرق وسطي
  - The large center vein.

Leaf Types



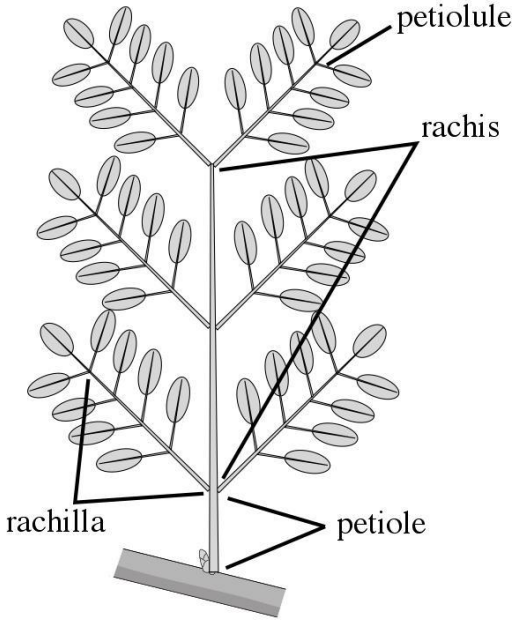
simple



pinnately compound

imparipinnate

paripinnate



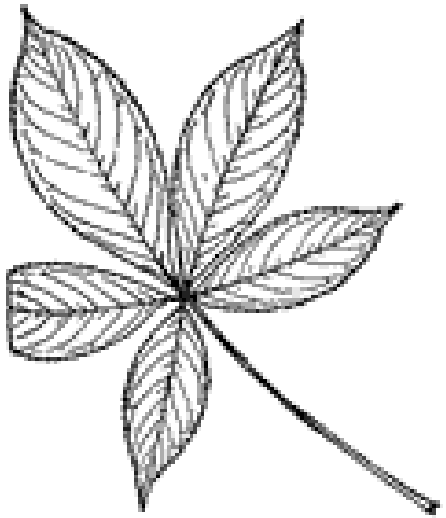
bipinnately compound

(a) Simple leaf. ورقة بسيطة **A simple leaf is a single, undivided blade. Some simple leaves are deeply lobed.**

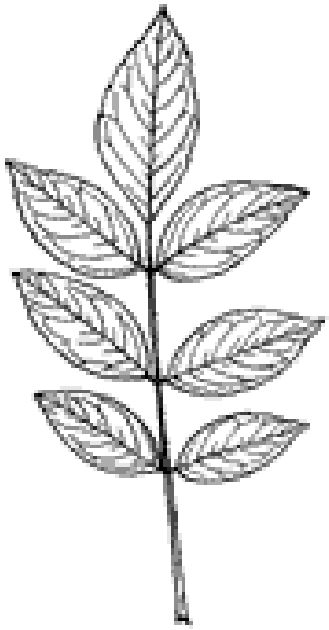
(b) Compound leaf (Pinnate). مركبة ريشية **In a compound leaf, the blade consists of multiple leaflets. Note that a leaflet has no axillary bud at its base.**

(c) Doubly compound leaf (Bipinnate). مركبة ريشية مزدوجة **In a doubly compound leaf, each leaflet is divided into smaller leaflets.**

Compound Leaves



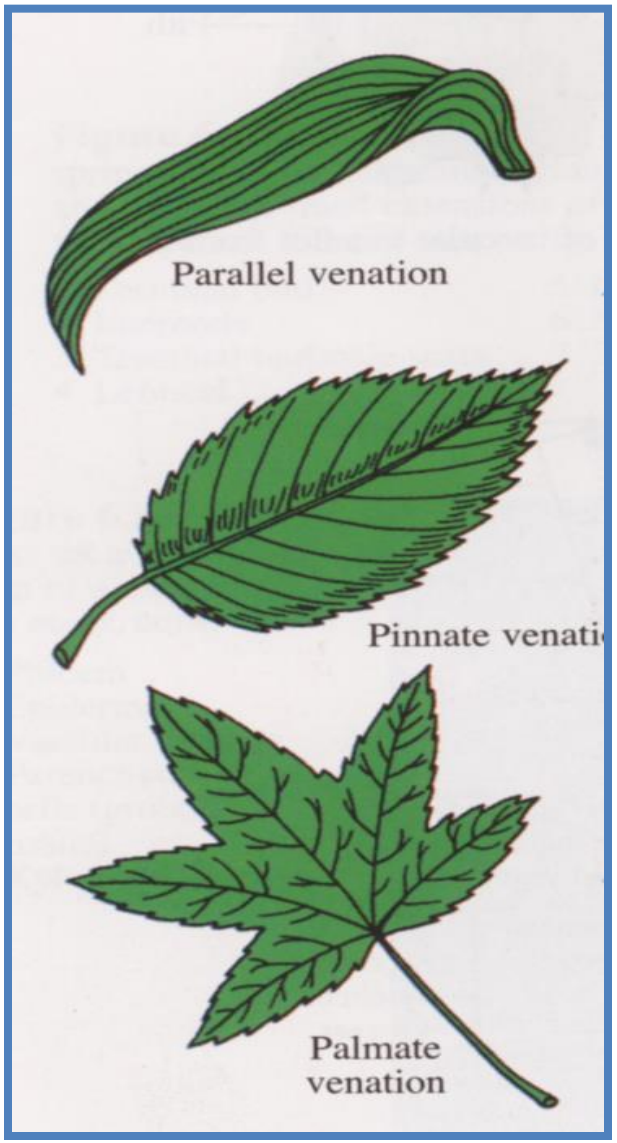
palmately compound



pinnately compound

Bi-Pinnately Compound Leaf

Leaf Venation



- **Parallel-** متوازي **veins extend the entire length of the leaf with little or no cross-linking**
- **Pinnate-** ريشي **leaves have one major vein from which others branch**
- **Palmate-** راحي **leaves have several veins which branch**

Dicot and Monocot Leaves

Reticulate
شبكي

Parallel
متوازي

Leaf Adaptations/ Modifications

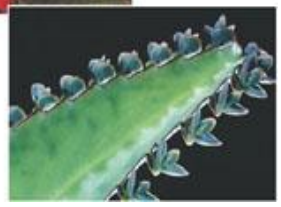
Some plant species have evolved modified leaves to serve various functions.

(a) **Tendrils.** The tendrils by which this pea plant clings to a support are modified leaves. After it has "lassoed" a support, a tendril forms a coil that brings the plant closer to the support. Tendrils are typically modified leaves, but some tendrils are modified stems, as in grapevines.

(b) **Spines.** The spines of cacti, such as this prickly pear, are actually leaves, and photosynthesis is carried out mainly by the fleshy green stems.

(c) **Storage leaves.** Most succulents, such as this ice plant, have leaves modified for storing water.

(d) **Bracts.** Red parts of the poinsettia are often mistaken for petals but are actually modified leaves called bracts that surround a group of flowers. Such brightly colored leaves attract pollinators.



(e) **Reproductive leaves.** The leaves of some succulents, such as *Kalanchoe daigremontiana,* produce adventitious plantlets, which fall off the leaf and take root in the soil.

Tendril

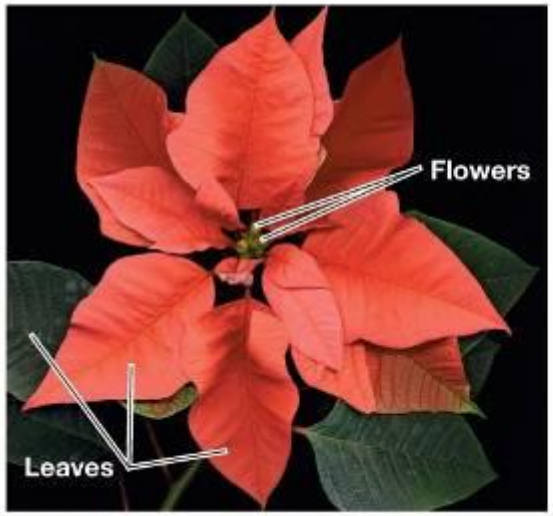
Spiny leaf- Cacti spines

Succulent leaves

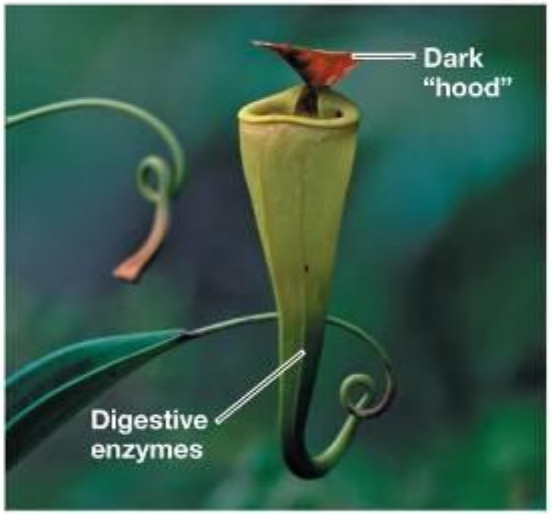
Brightly-colored leaves-
to attract pollinators

Leaf Modifications

(d) Poinsettia leaves attract pollinators.



(e) Pitcher plant leaves trap insects.

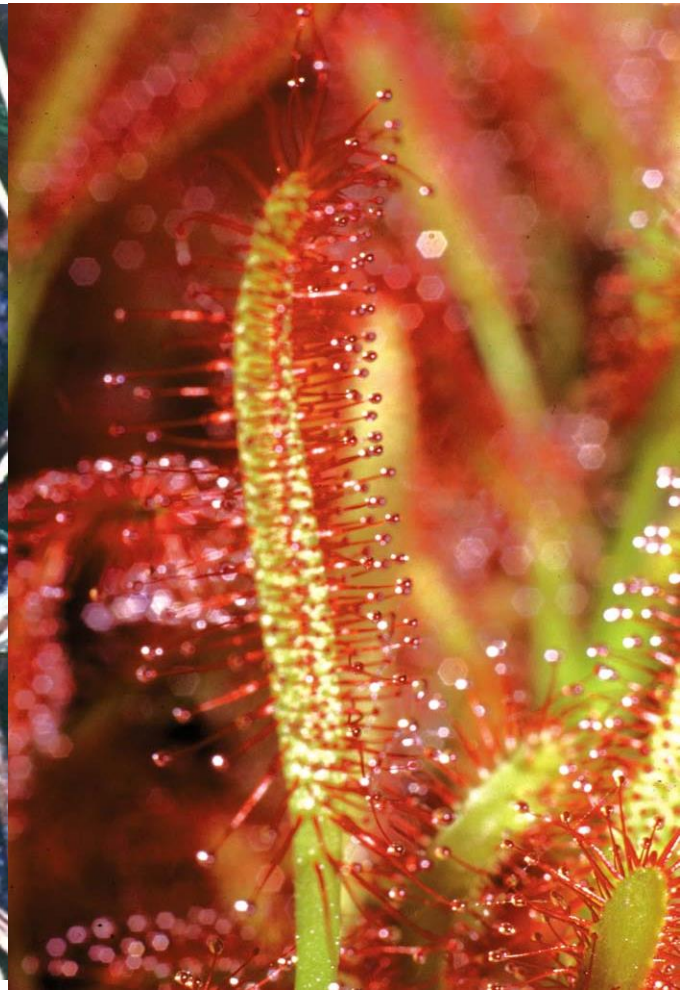


(f) Flowerpot plant leaves collect soil.

Sharp things

- **Thorn** - sharp-pointed stem/shoot (fr. axillary bud)
- **Spine** - sharp-pointed leaf or leaf part
  - **leaf spine** (also leaflet spine)
  - **stipular spine**
  - **petiolar spine**
- **Prickle** - sharp pointed epidermal appendage

Leaf Structural/ Functional Types



Tentacular Leaf - *Drosera* spp Sundew (Droseraceae)

Carnivorus plants

- Insect-Trapping Leaves in areas with low soil N
- Insect digested by enzymes to release N from proteins

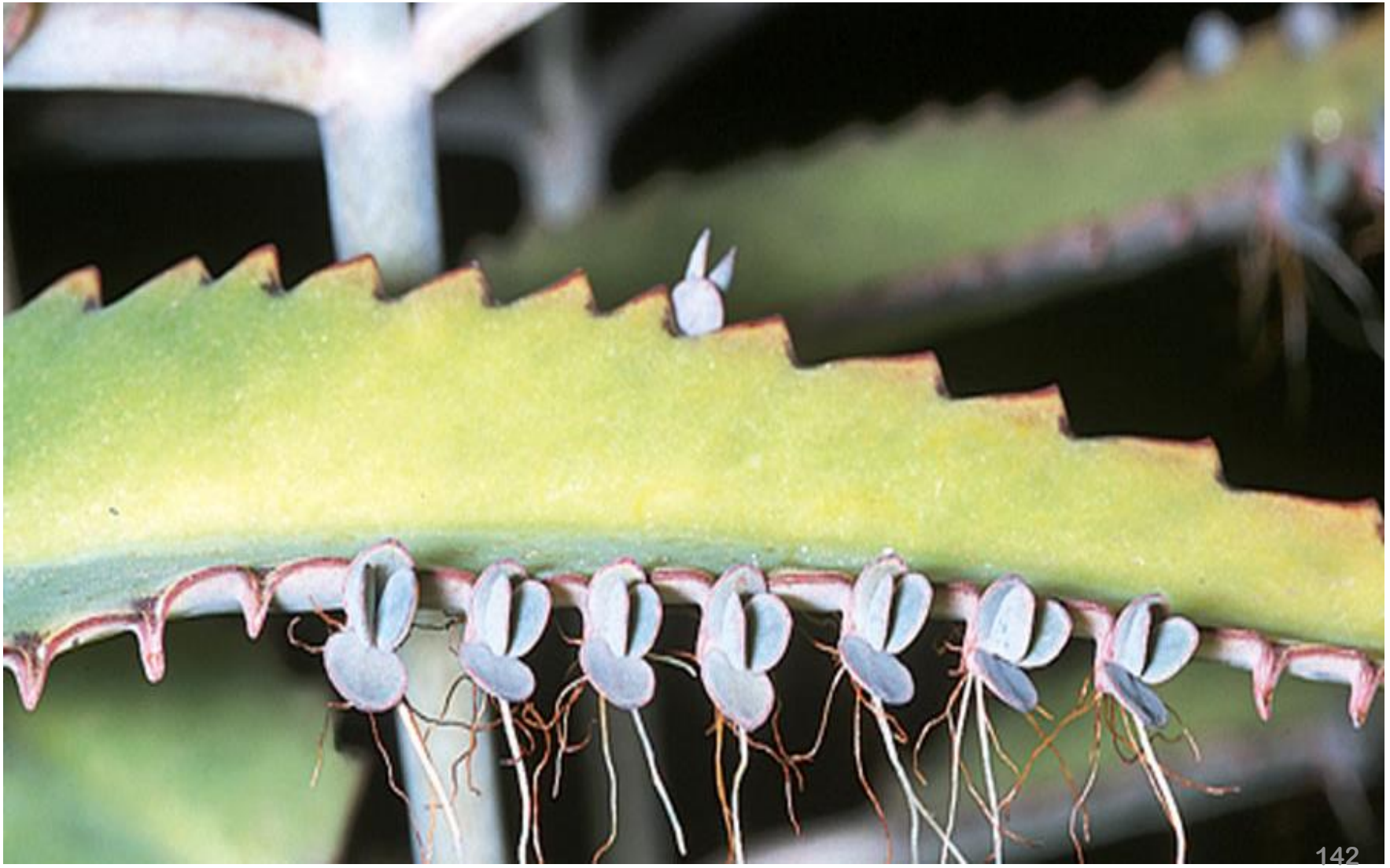
Trap Leaf - *Dionaea muscipula* Venus Fly Trap

Fig. 39.5

A Carnivorous Plant

Pitcher plant leaf

Reproductive Leaves - New plants at tips.



Sun & Shade Leaves

Sun and Shade Leaves

Shade Leaves

Sun Leaves

Grown in shade Grown in sun

Plant Tissues & organs

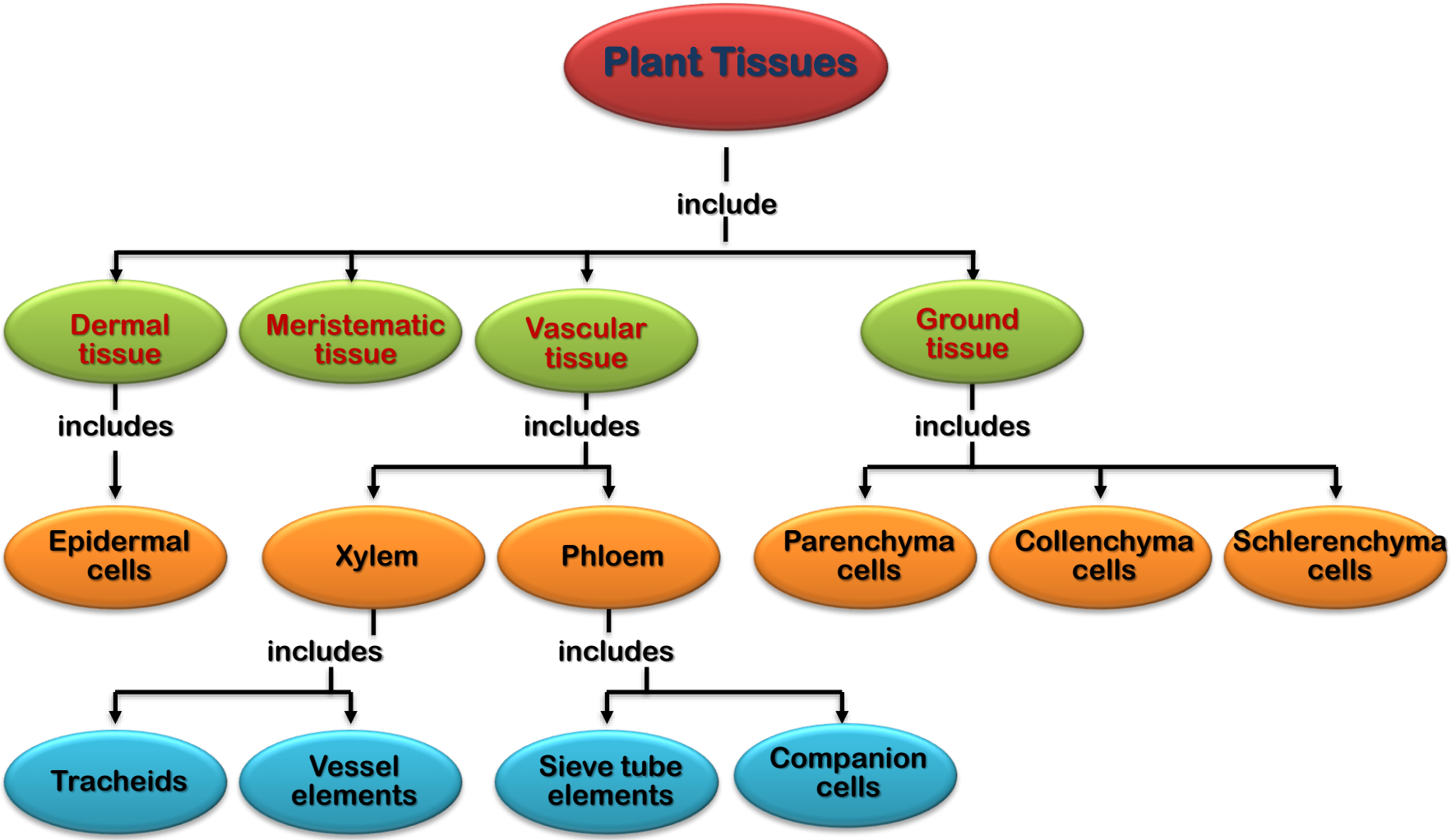
Plant Tissues

- A **tissue** is an organization of cells that work together as a functional unit.
- **Parenchyma** cells make up parenchyma tissue, which is a simple tissue.
- **Xylem** and **phloem** are complex tissues; they are composed of a number of different cell types **(Vascular tissue)**.
- Tissues are grouped into **tissue systems** that extend throughout the body of the plant from to form the various **organs** of the plant.
- There are four plant tissue systems: ***vascular, dermal, ground and meristematic tissue.***

Tissue Systems

Tissue Systems:

1. Ground tissue includes:
    - Parenchyma tissue
    - Collenchyma tissue
    - Sclerenchyma tissue
2. Vascular tissue includes:
    - Xylem tissue
    - Phloem tissue
3. Dermal tissue:
    - Epidermis
4. Meristematic tissue


Plant Tissues
include
Dermal tissue
Meristematic tissue
Vascular tissue
Ground tissue
includes
includes
includes
Epidermal cells
Xylem
Phloem
Parenchyma cells
Collenchyma cells
Schlerenchyma cells
includes
includes
Tracheids
Vessel elements
Sieve tube elements
Companion cells

Dermal Tissue:

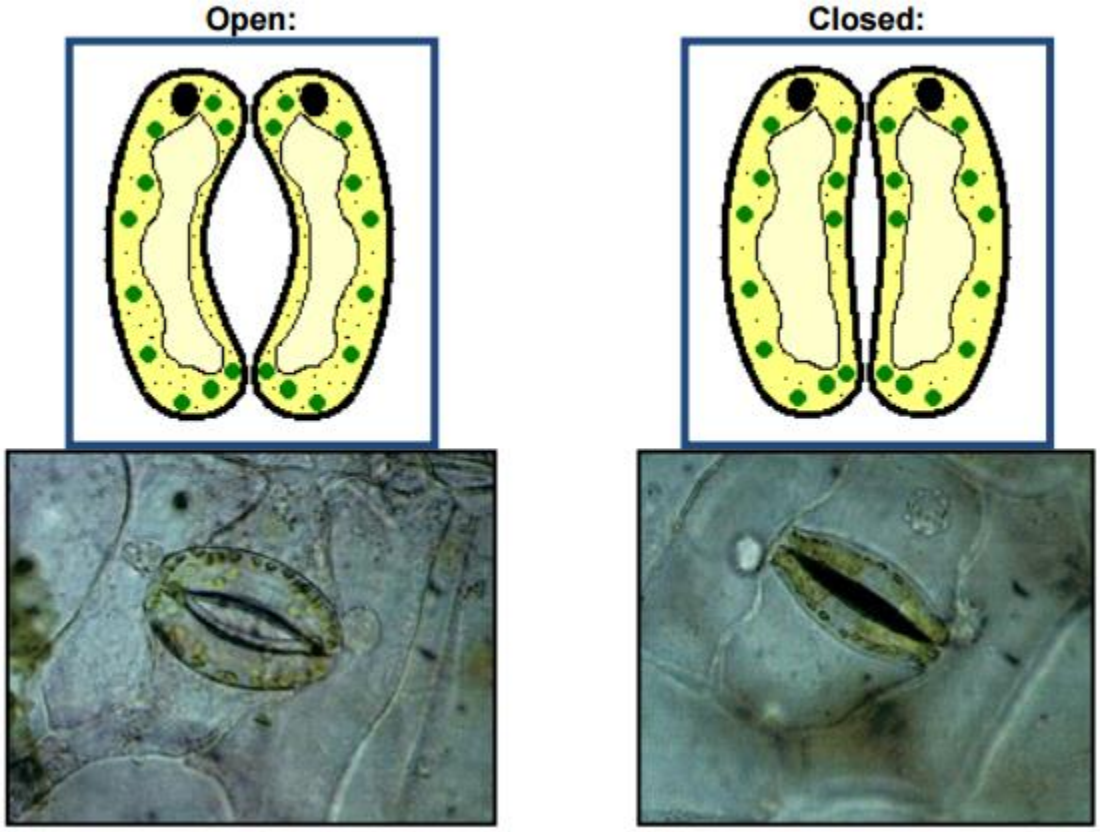
- Covers the plant body and consists of epidermis in young plants & non-woody plants that is replaced later by periderm in woody plant
- Epidermis is made of parenchyma cells in a single layer
- Epidermis on stem and leaves prevents water loss by transpiration & produces a waxy material called cuticle

Dermal Tissue:

Guard Cells surrounding stoma

- Openings in the epidermis on the underside of a leaf where gases are exchanged are called **stomata** (stoma, singular)
- **Sausage-shaped guard** cells are found on each side of the stoma to help open and close the pore to prevent water loss
- **Dead cork** cells replace epidermis in woody stems & roots

Dermal Tissue:



Ground Tissue

- The ground tissue system makes up the rest of a plant and consists primarily of parenchyma tissue.
- Ground tissue functions primarily in storage, support, photosynthesis, and the production of defensive and attractant substances (oils and toxins).

Vascular Tissue

- The vascular tissue system includes the xylem and phloem; it is the conductive or "plumbing" system of the plant.
- The phloem transports carbohydrates from sites of production (sources such as leaves) to sites of utilization for energy or where it is being stored (sinks) elsewhere in the plant.
- The xylem distributes water and mineral ions taken up by the roots to the stem and leaves.

Meristems (Plant Stem Cells)

- **There are 3 main types of meristematic tissue in vascular seed plants ---- apical, intercalary, & lateral meristems**

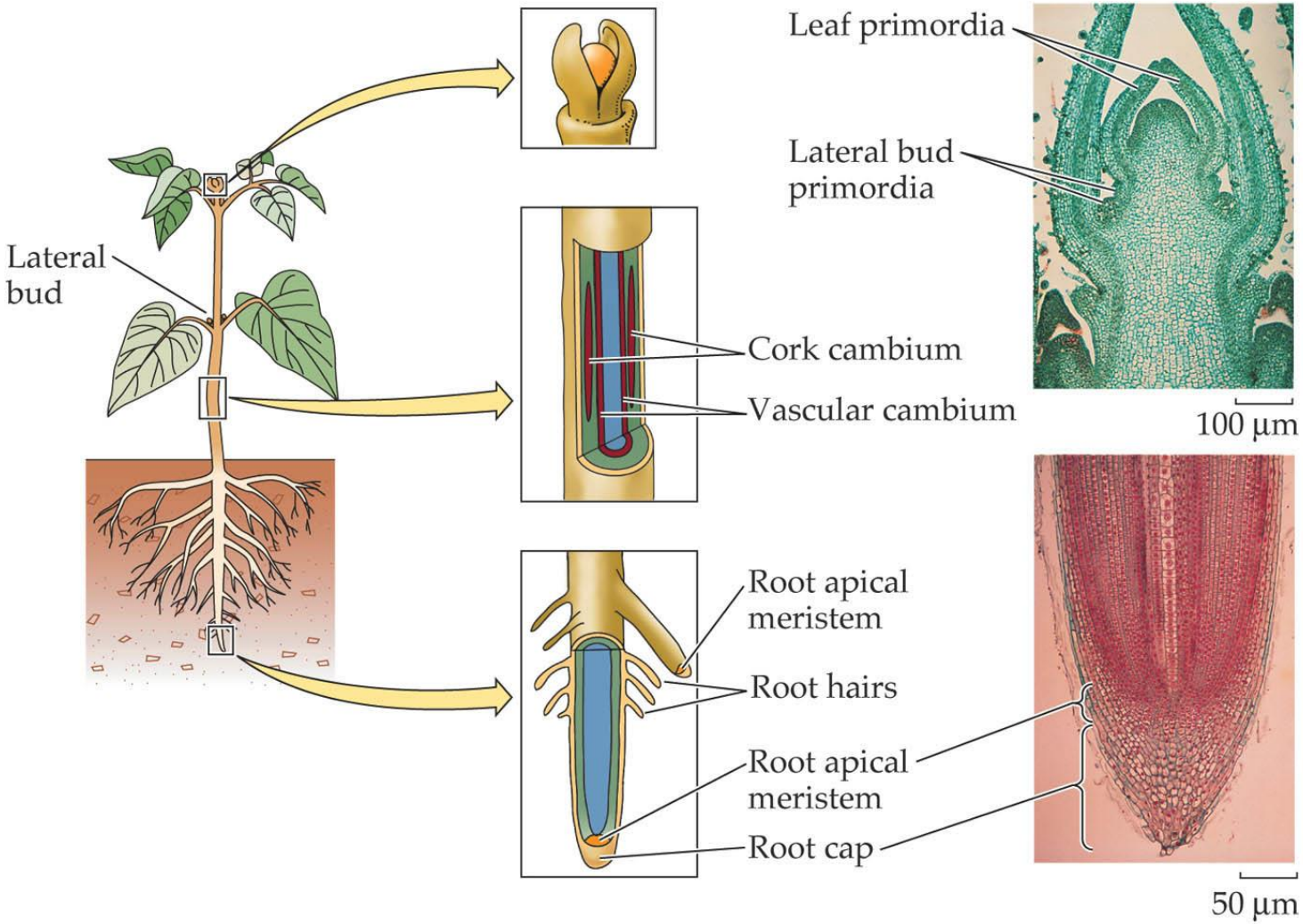
Meristems (Plant Stem Cells)

- **There are 3 main types of meristematic tissue in vascular seed plants ---- apical, intercalary, & lateral meristems**

TABLE 31-2 *Types of Meristems*

Type	Location	Function
Apical meristem	tips of stems and roots	growth; increase length at tips
Intercalary meristem	between the tip and base of stems and leaves	growth; increase length between nodes
Lateral meristem	sides of stems and roots	growth; increase diameter

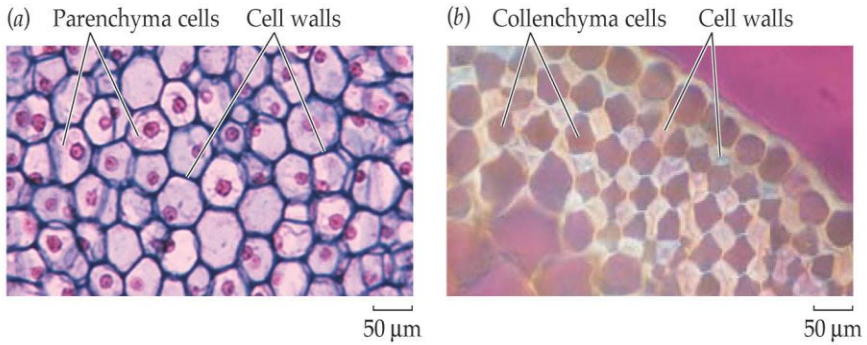
Location of Meristematic Tissues

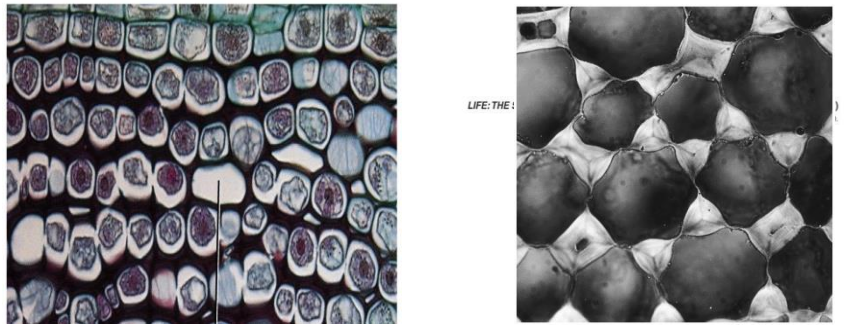


LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 35.13 Apical and Lateral Meristems

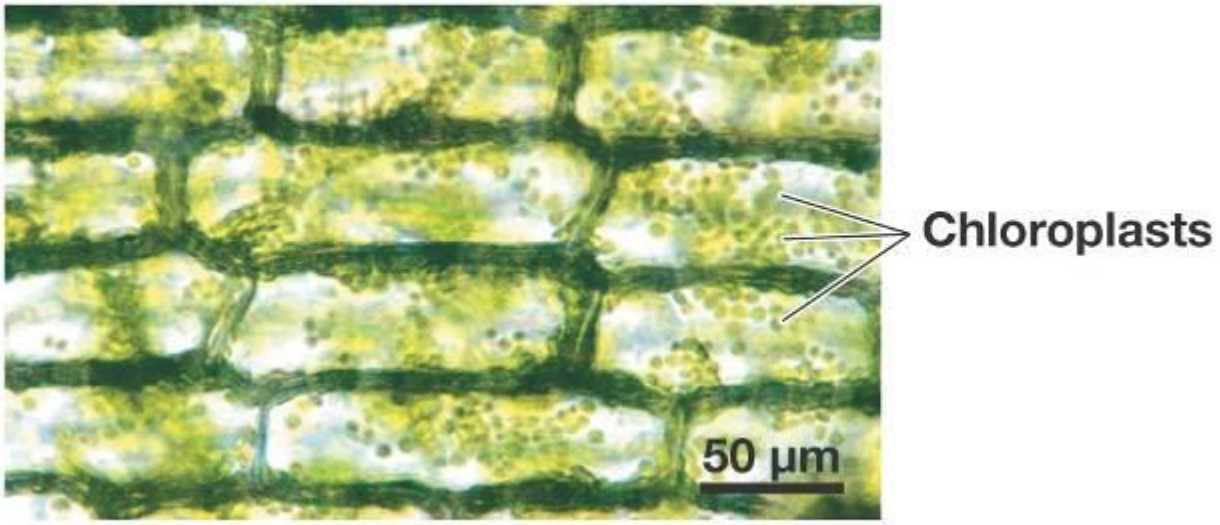
Plant Cell Types (Support and Storage)

- ***Parenchyma cells*** are the most numerous type of cell in young plants.
- Parenchyma cells usually have thin walls and large central vacuoles.
- The photosynthetic cells in leaves or stems are parenchyma cells filled with chloroplasts. These cells are called ***chlorenchyma*** cells.
- Some parenchyma cells store lipids or starch (potatoes).
- Other parenchyma cells serve as "packing material" and play a vital role in supporting the stem especially in nonwoody stems.
- ***Collenchyma cells*** are supporting cells that lay down primary cell walls that are thick in the corners.
- Collenchyma cells provide support to leaf petioles, nonwoody stems, and growing organs.
- These cell types compose the cortex and pith tissues of the root and stems.

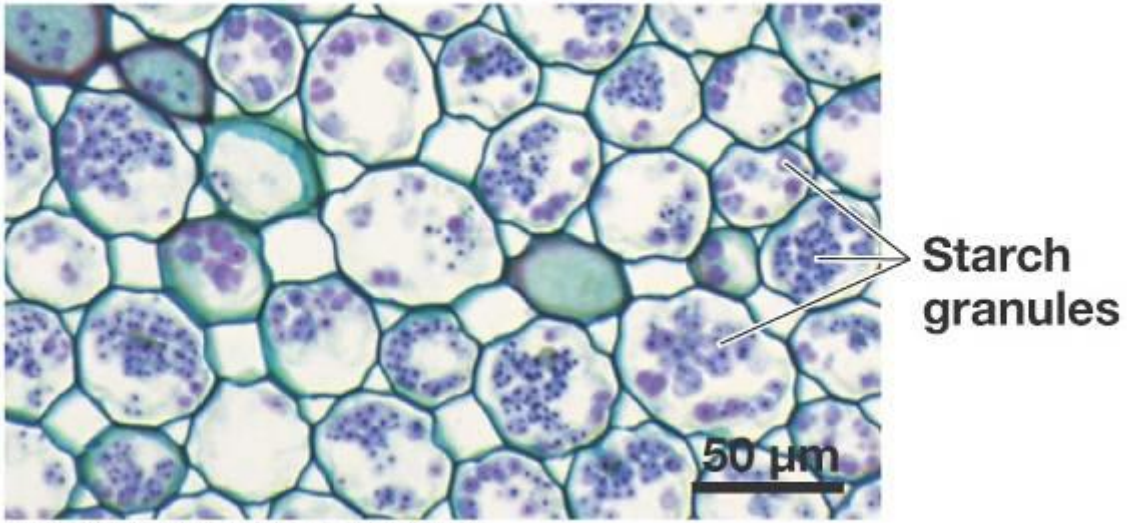


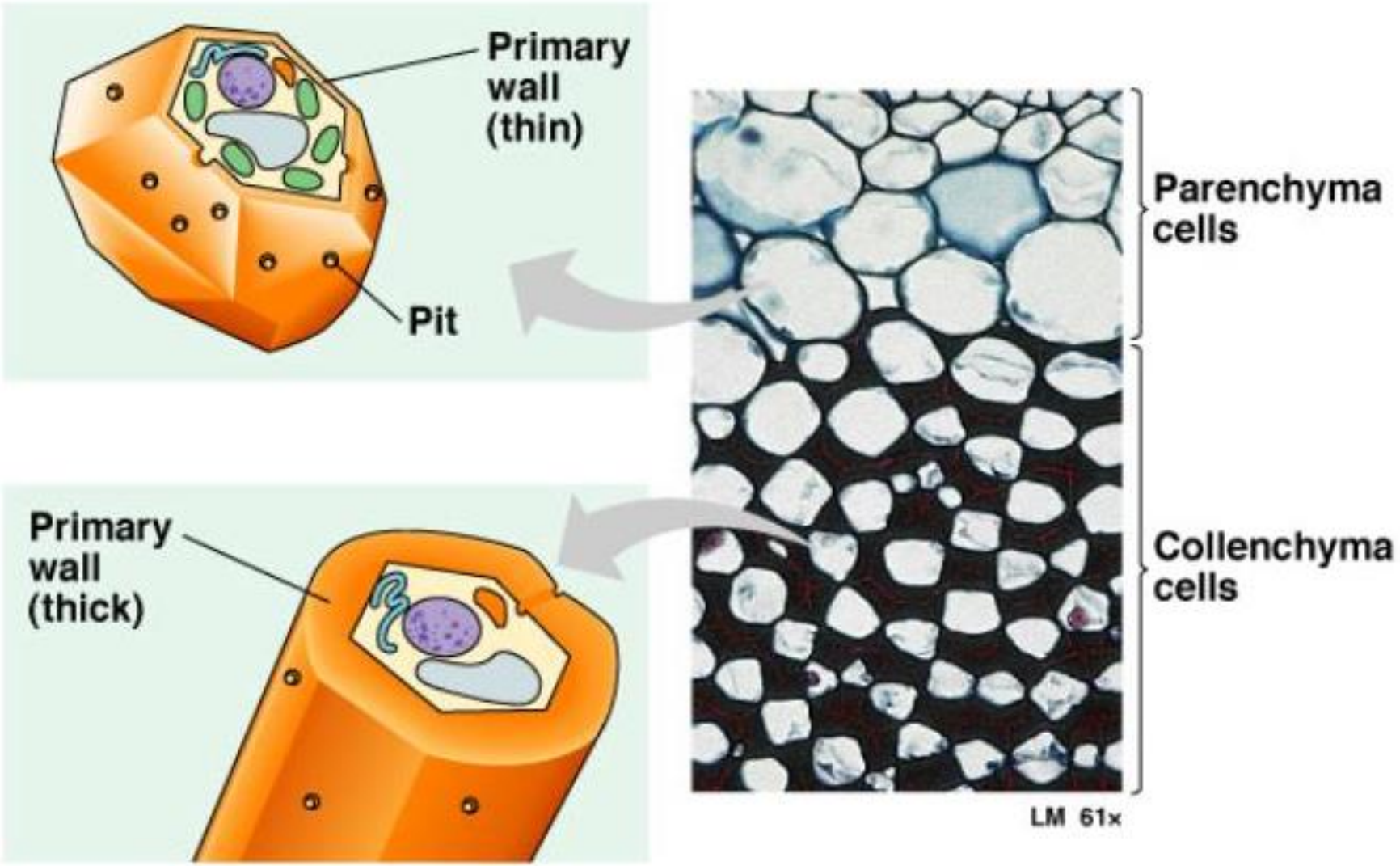


(a) In leaves, parenchyma cells function in photosynthesis and gas exchange.



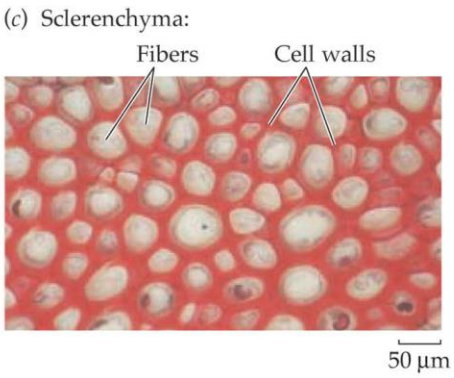
(b) In roots, parenchyma cells function in carbohydrate storage.

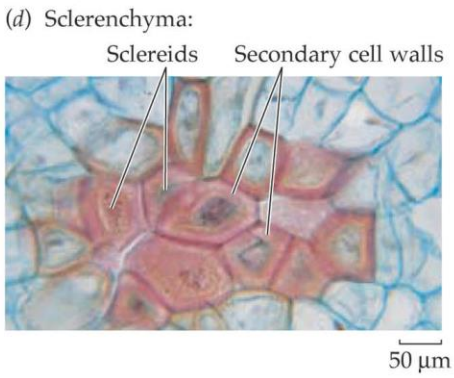


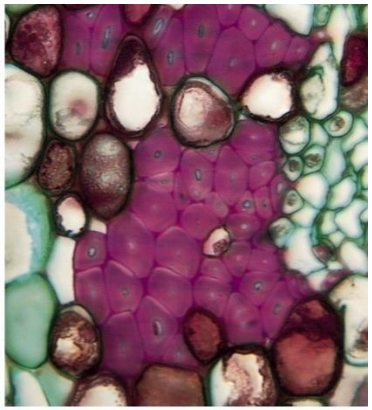

Primary wall (thin)
Pit
Primary wall (thick)
Parenchyma cells
Collenchyma cells
LM 61×

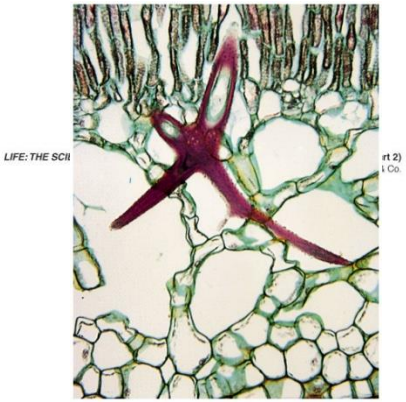
Plant Cell Types (Support)

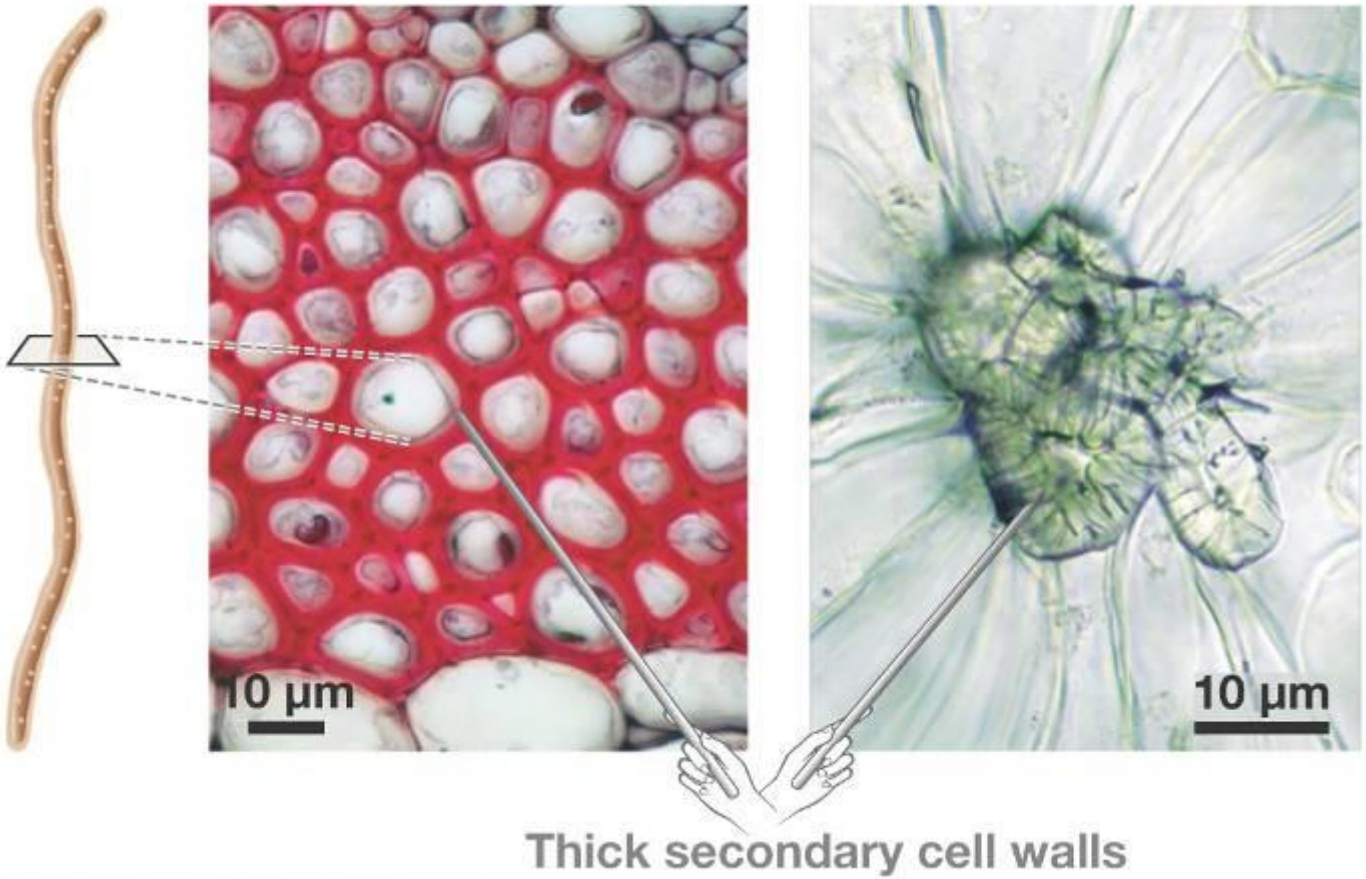
- ***Sclerenchyma cells*** are the main supporting cells of a plant. They have a thick secondary cell wall that contains a substance called lignin, a component of wood. Therefore they are found in woody plants.
- There are two types of sclerenchyma cells: elongated fibers and variously shaped sclereids.
- Fibers often organize into bundles. (They are common components of xylem.)
- Sclereids may pack together very densely. (Sclereids are found in fruits such as pears and are what given them their gritty texture.) They are often referred to as "stone cells".



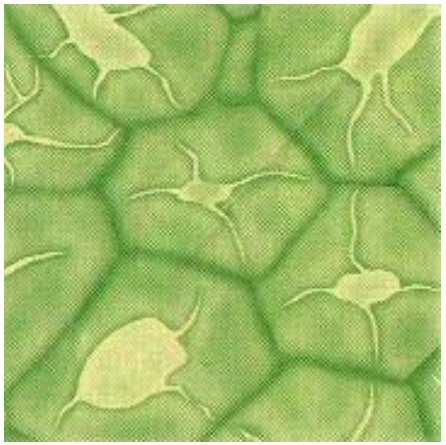






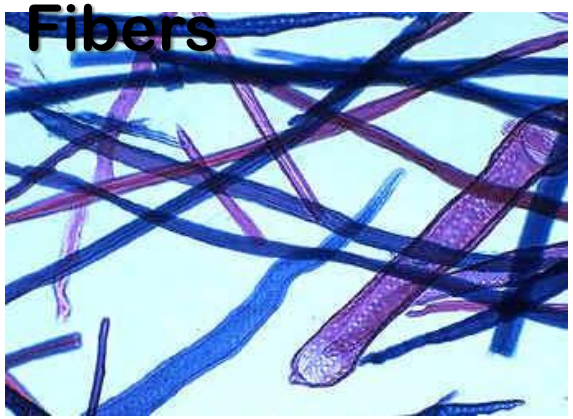


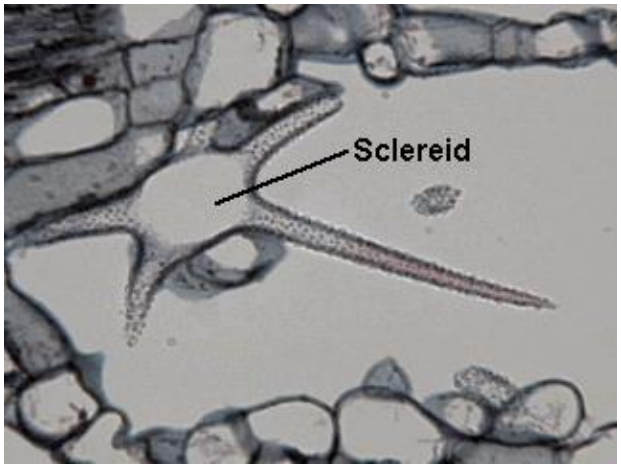
Sclerenchyma & Sclereids



Sclerynchyma

Sclerynchyma Fibers





Sclereid Fibers

Plant Cell Types: Vascular Tissue (Transport)

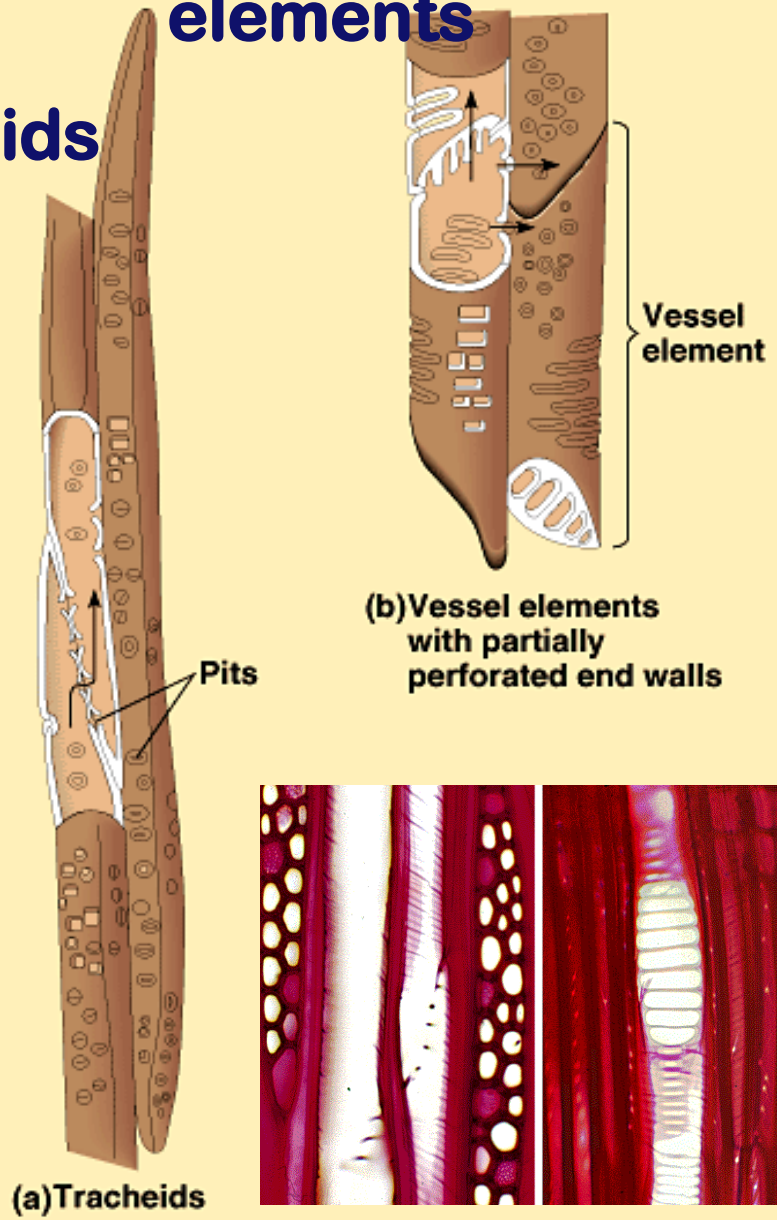
Xylem

- The xylem conducts water from roots to above ground plant parts. It contains conducting cells called *tracheary elements*.
- Tracheids are evolutionarily more ancient tracheary elements found in gymnosperms.
- Both tracheary elements: *Vessel elements* and *tracheids* undergo apoptosis (die) and do their jobs as empty cells (only the cell walls remain).
- *Vessel elements* are the water "pipeline" system in flowering plants, also formed from dead cells. Flowering plants have both tracheids and vessel elements.
- Vessel elements are generally larger in diameter than tracheids and are laid down end-to-end to form hollow tubes.

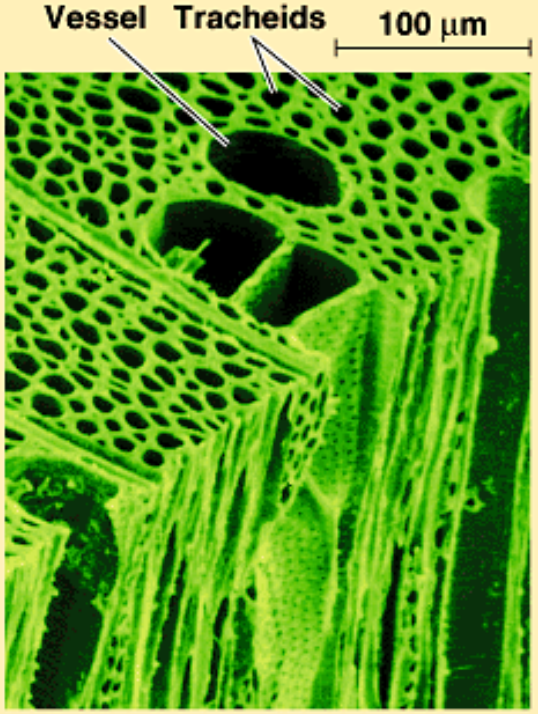
Xylem

vessel elements

tracheids



dead cells → water-conducting cells of xylem



(c)Tracheids and vessels (colorized SEM)

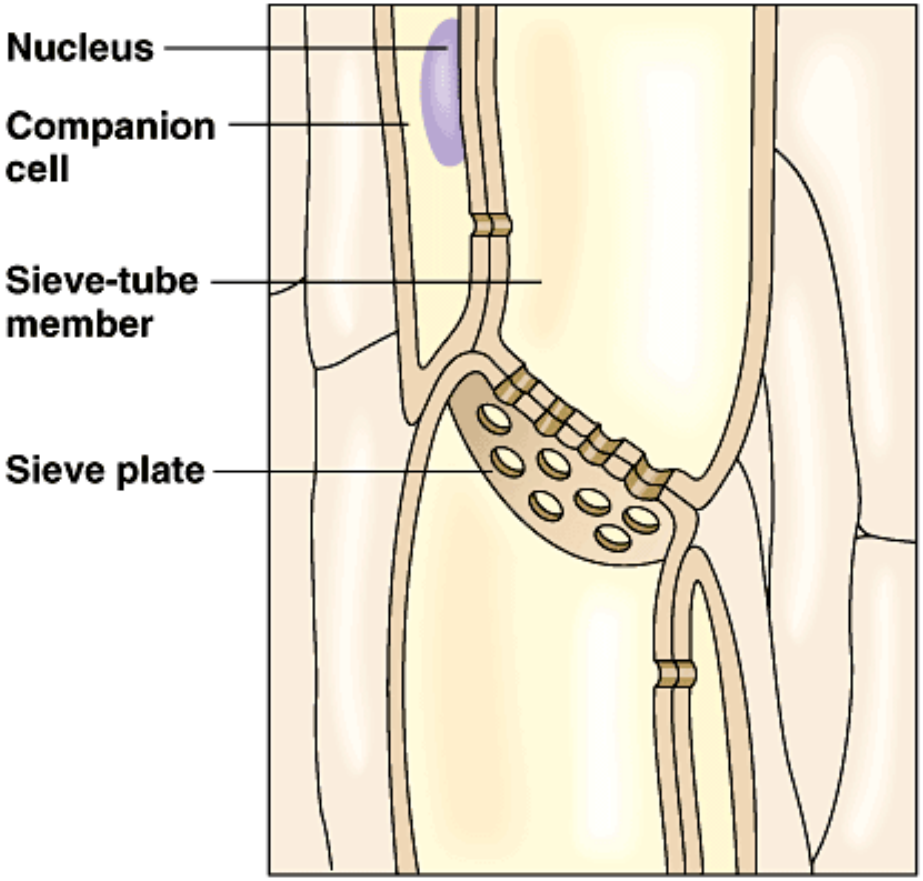
Plant Cell Types: Vascular Tissue (Transport)

Phloem

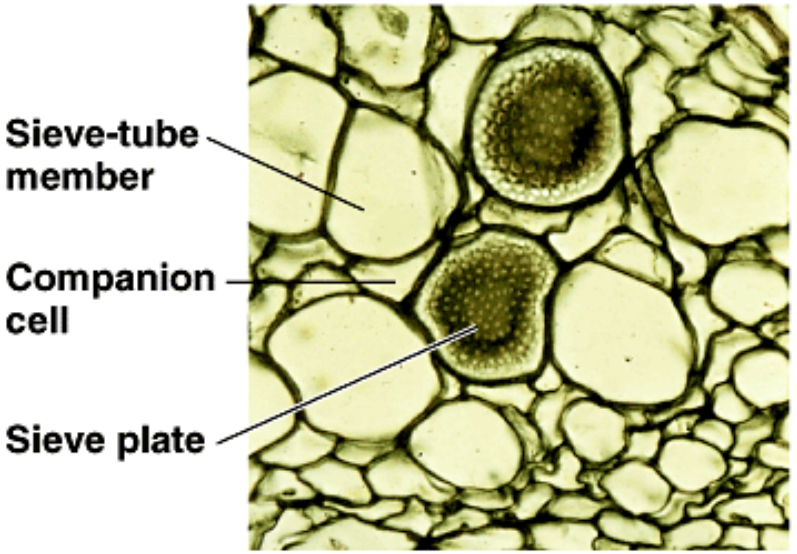
- Cells of the phloem are alive when they do their job, unlike those of the xylem.
- The characteristic cell of the phloem is the *sieve tube member* in flowering plants.
- Cells of the phloem are arranged end-to-end and form long sieve tubes, which transport carbohydrates and other materials.
- The plasmodesmata in sieve tube members enlarge as they mature, resulting in end walls that look like sieves. called sieve plate
- At functional maturity, a sieve tube is filled with sieve tube sap (water, sugars, and other solutes).
- The sieve tube members have adjacent companion cells.
- *Companion cells* retain all their organelles and may regulate the performance of and support the sieve tube members.

Phloem

- sieve tube elements & companion cells

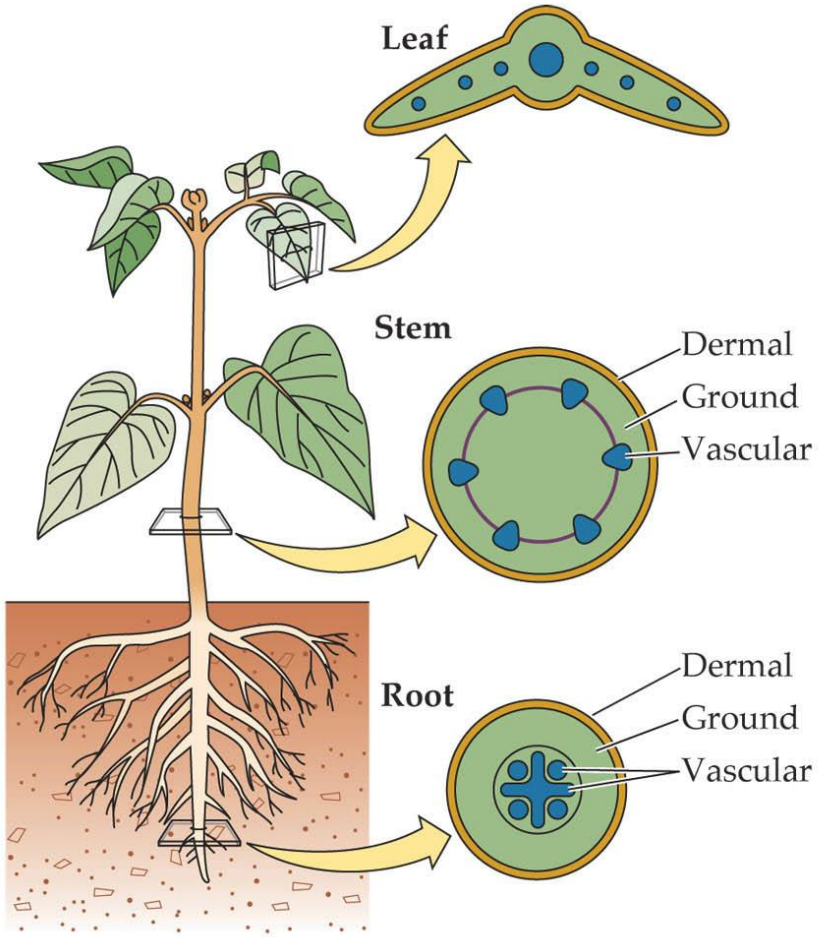


(a) Longitudinal view



(b) Transverse section (LM)

Plant Organs

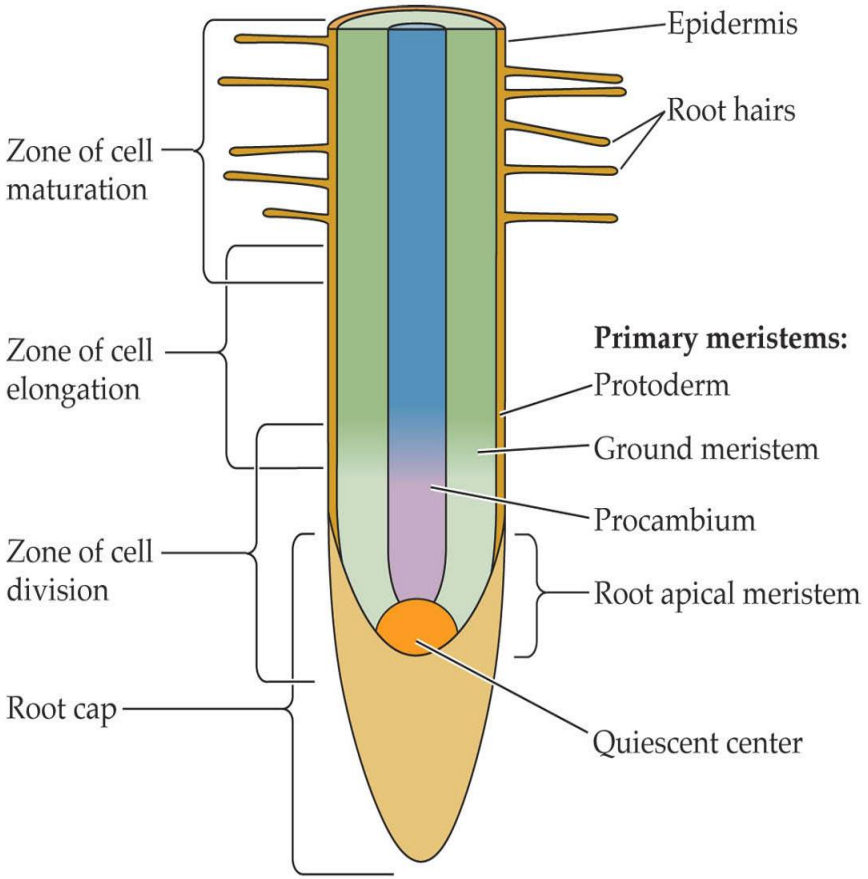


LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 35.12 Three Tissue Systems Extend throughout the Plant Body

Structure of Primary Plant Organs

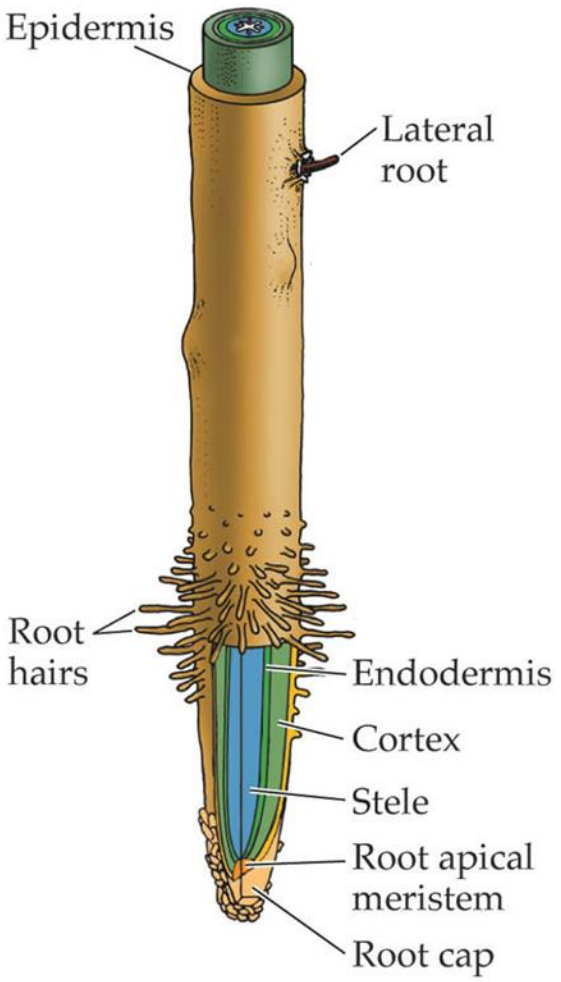
Root Tip Zones

- ***The root tip***
  - covered by a root cap, which protects the delicate apical meristem as the root pushes through soil during primary growth
- ***Zone of cell division***
  - Actively dividing, including root apical meristem, produces root cap cells
- ***Zone of elongation***
  - Root cells elongate, pushes root tip further into soil
- ***Zone of maturation***
  - Cells complete maturation, become fully functional

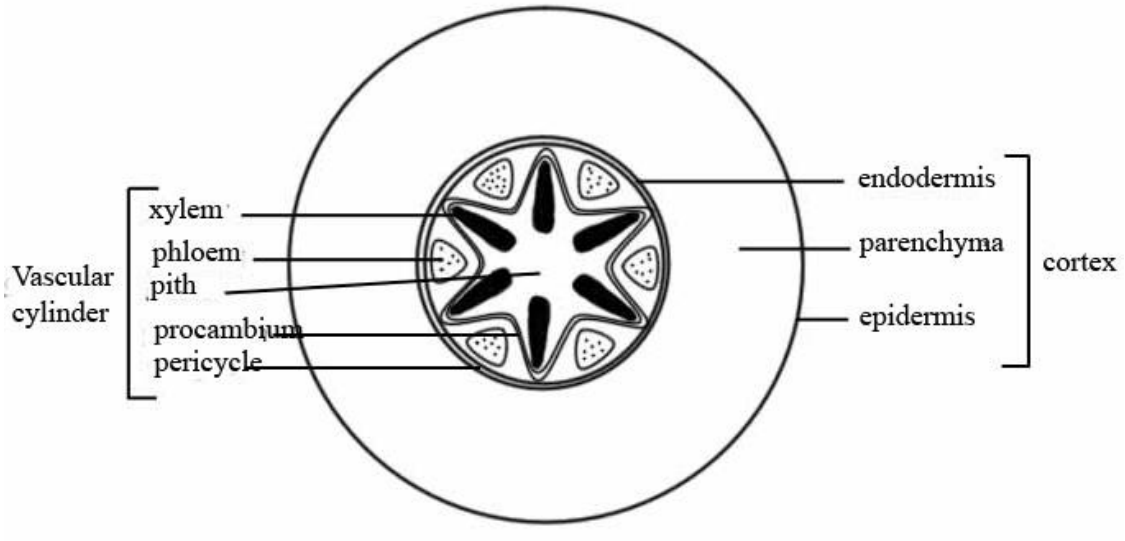


Structure of the Root:

- Root cap
- Apical meristem
- Epidermis



Structure of the Root:



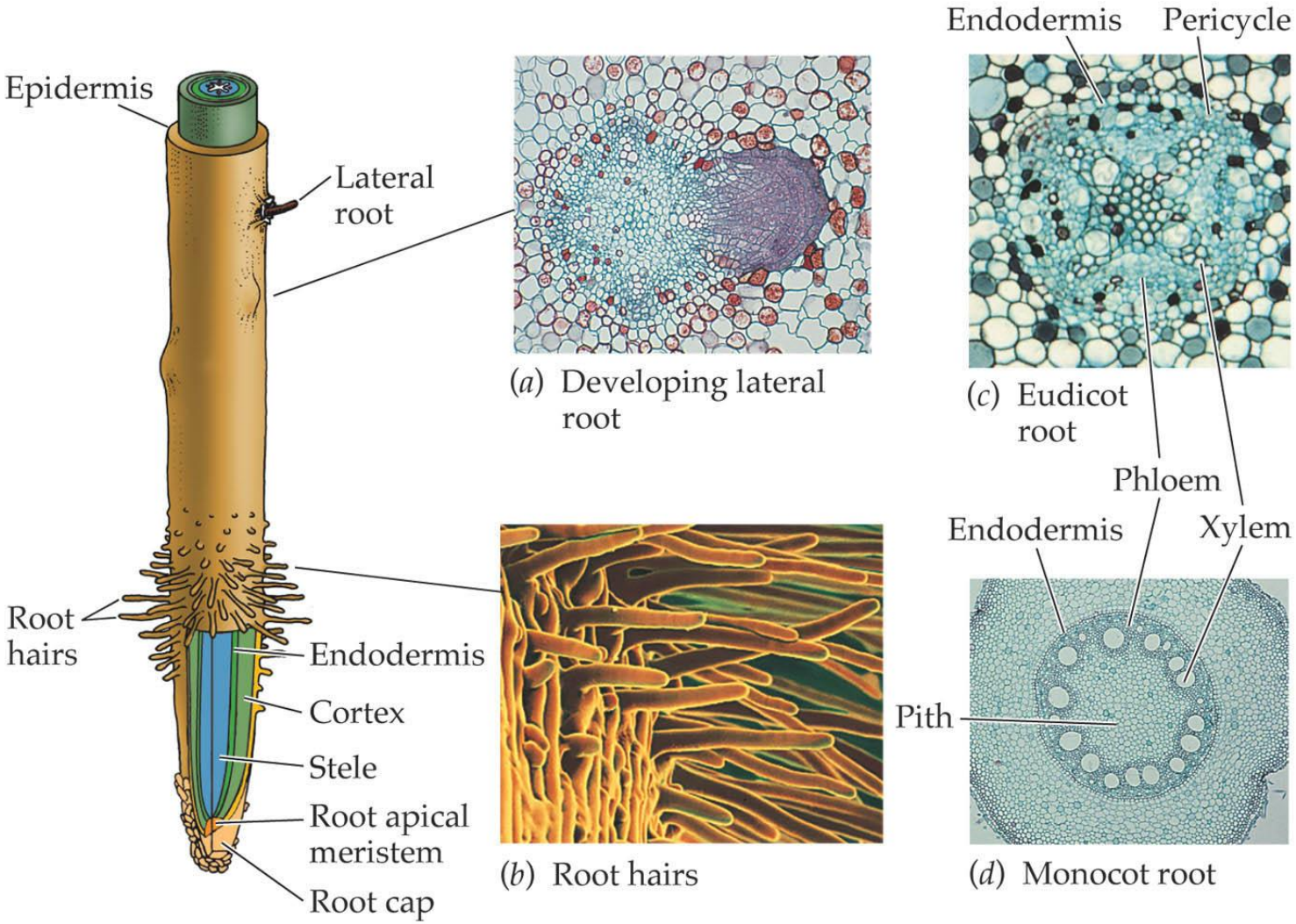
Structure of the Root:

- **Root cap** covers the apical meristem (growth tissue) at the tip of the root & produces a slimy substance so roots can more easily grow through the ground
- **Apical meristem** replaces cells of the root cap as they are damaged
- **Epidermis** covers the outside of the root & has extensions called root hairs that absorb water & minerals and increase the surface area of the root

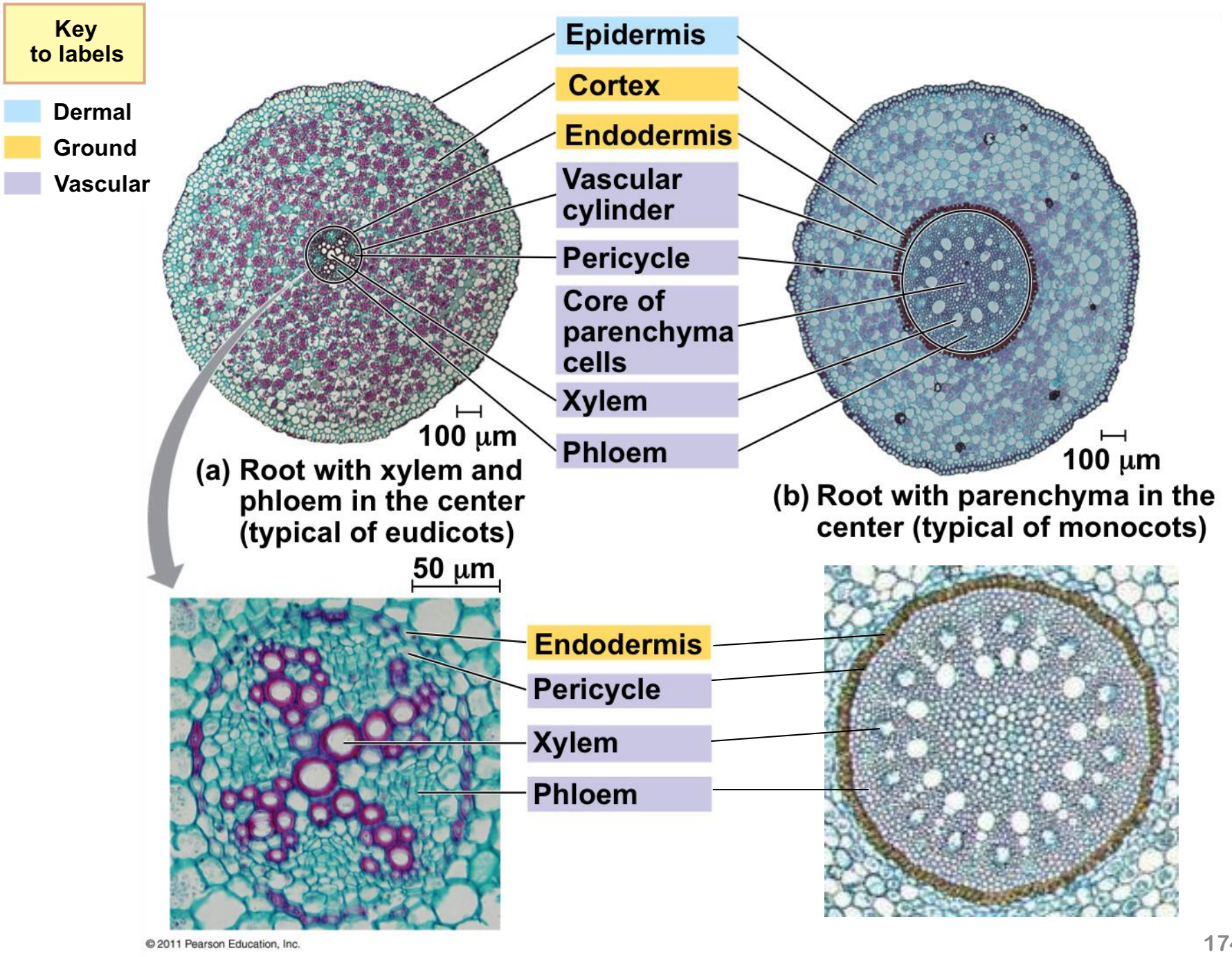
Structure of the Root:

- The core of the root is called the vascular cylinder, contains xylem & phloem
- A band of ground tissue called cortex surrounds the vascular cylinder
- A single cell layer called endodermis separates the cortex & vascular tissue
- Endodermal cells are coated with a waxy layer called the Casparian strip so water is channeled into the vascular tissue
- The Pericycle is the outermost layer of central vascular tissue & forms lateral roots

Root Structure (Monocot vs Eudicot)



LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 35.16 Root Anatomy



Stem Structure & Function:

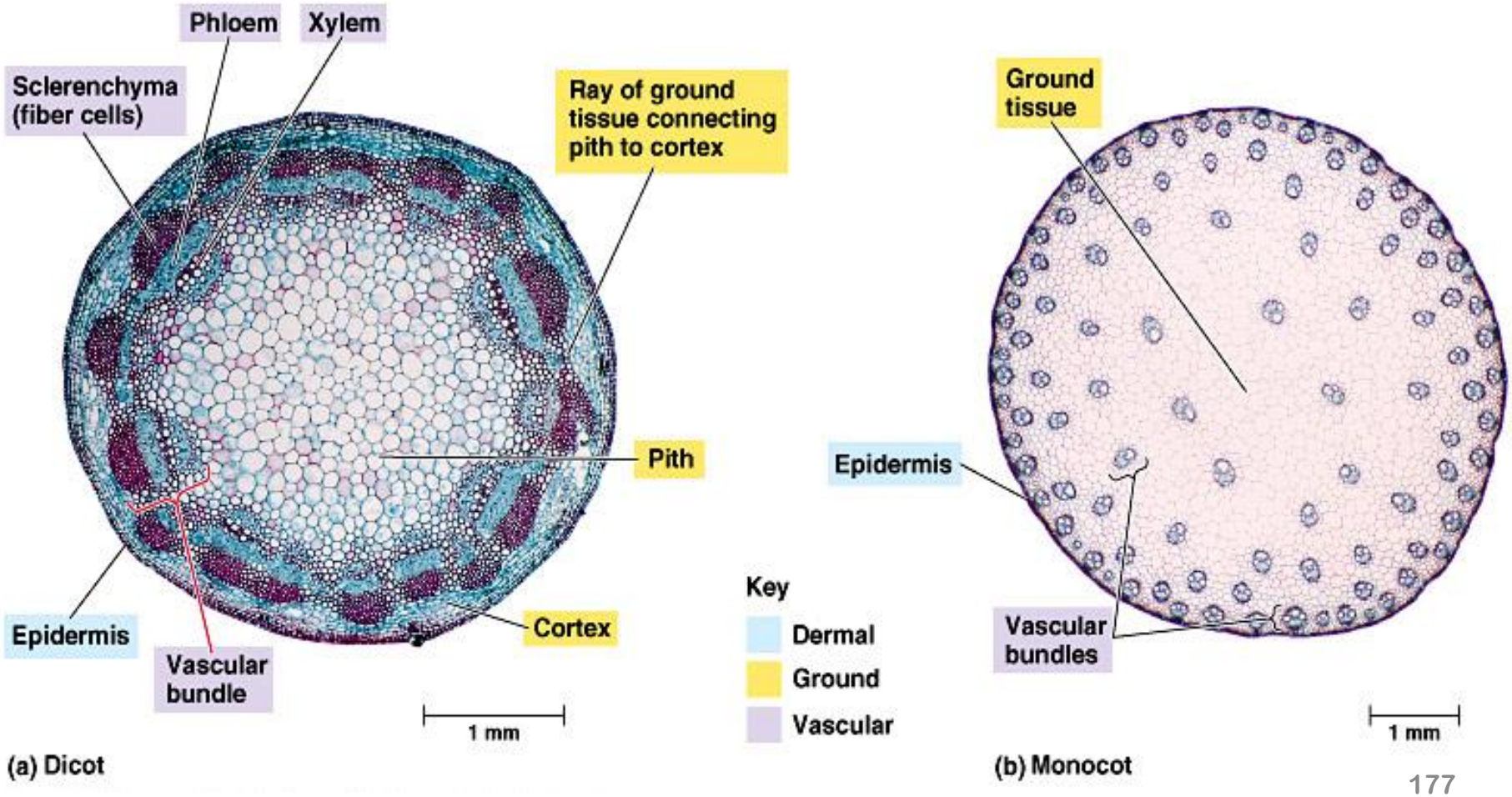
- Adapted to support leaves
- Transport water & minerals
- Transport sugars (usually sucrose) from Source (where they're made) to Sink (where they're stored)
- Movement of sugars is called translocation
- Store food and/or water
- Tubers (potatoes) underground food storage stems
- Stems grow from the tip or apical meristem
- Stems increase in circumference by lateral meristems
- Leaves are attached to stems at nodes & have lateral buds that can develop into new stems or branches
- Internode is space between nodes on a stem

- The tip of each stem usually has a Terminal Bud enclosed by specialized leaves called Bud Scales
- Vascular Tissue is arranged in bundles with xylem toward the inside & phloem toward the outside
- Vascular bundles are scattered throughout monocot stems
- Vascular bundles are arranged in rings in dicot stems

Stem Structure

Dicot (woody plants)

Monocot (grasses)

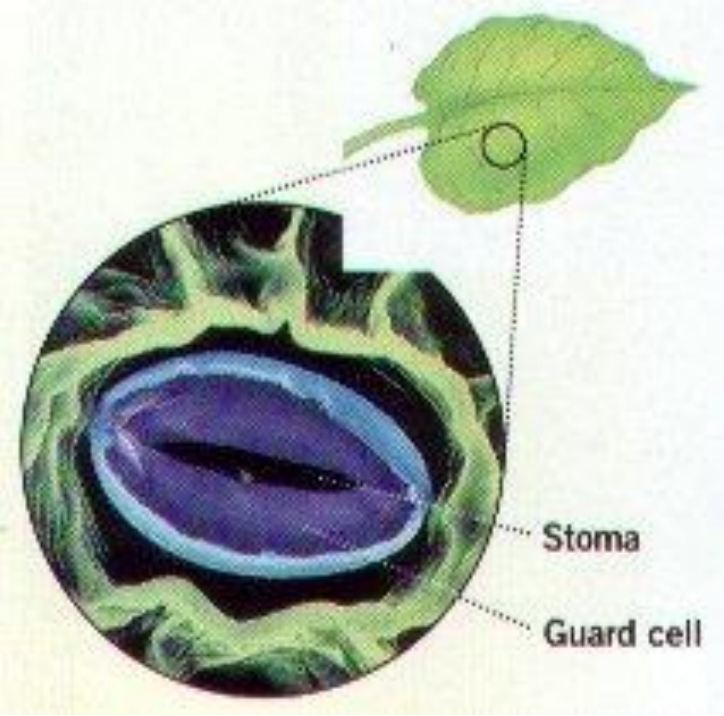


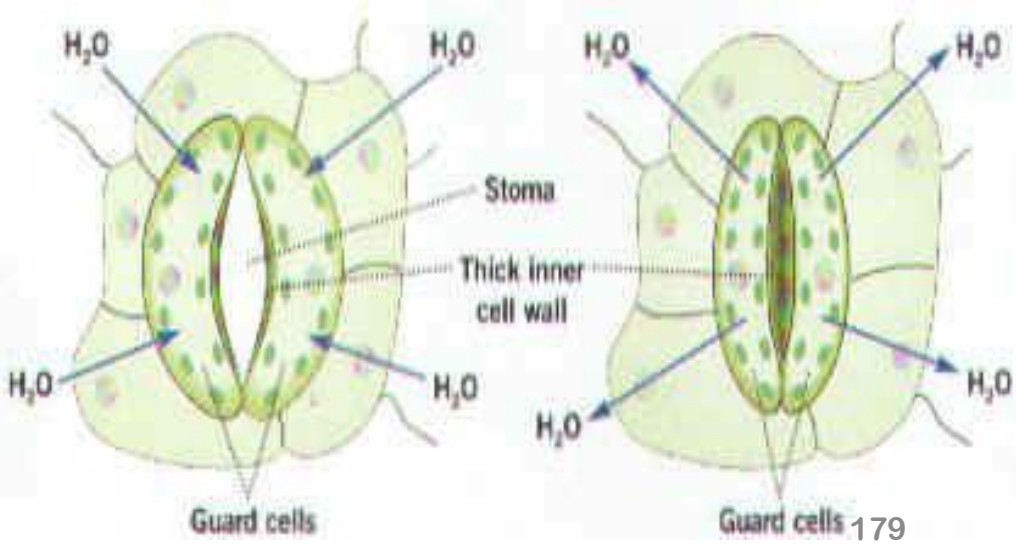
Leaf Structure

- Leaf anatomy is adapted to carry out photosynthesis, limit evaporative water loss, and transport the products of photosynthesis to the rest of the plant.
- The two zones in leaf parenchyma that photosynthesize are the palisade mesophyll and the spongy mesophyll.
- Within the mesophyll is air space through which CO_2 can diffuse to the photosynthesizing cells.
- Veins (vascular bundles) supply mesophyll cells with water and minerals, and they transport the products of photosynthesis to the rest of the plant.
- The epidermis of the leaf is the outermost cell layer, which is covered by a waxy cuticle. The epidermis functions to keep water and photosynthetic products in the leaf.
- Guard cells allow controlled gas exchange through pores in the leaf (the stomata).

Stomata:

- Openings called stomata on the underside of leaves for gas exchange (CO_2 & O_2)
- Two guard cells on either side of the stomata open & close the openings
- When guard cells LOSE water, the stoma CLOSE, while the stoma OPEN when guard cells GAIN water & swell





Leaf Structure

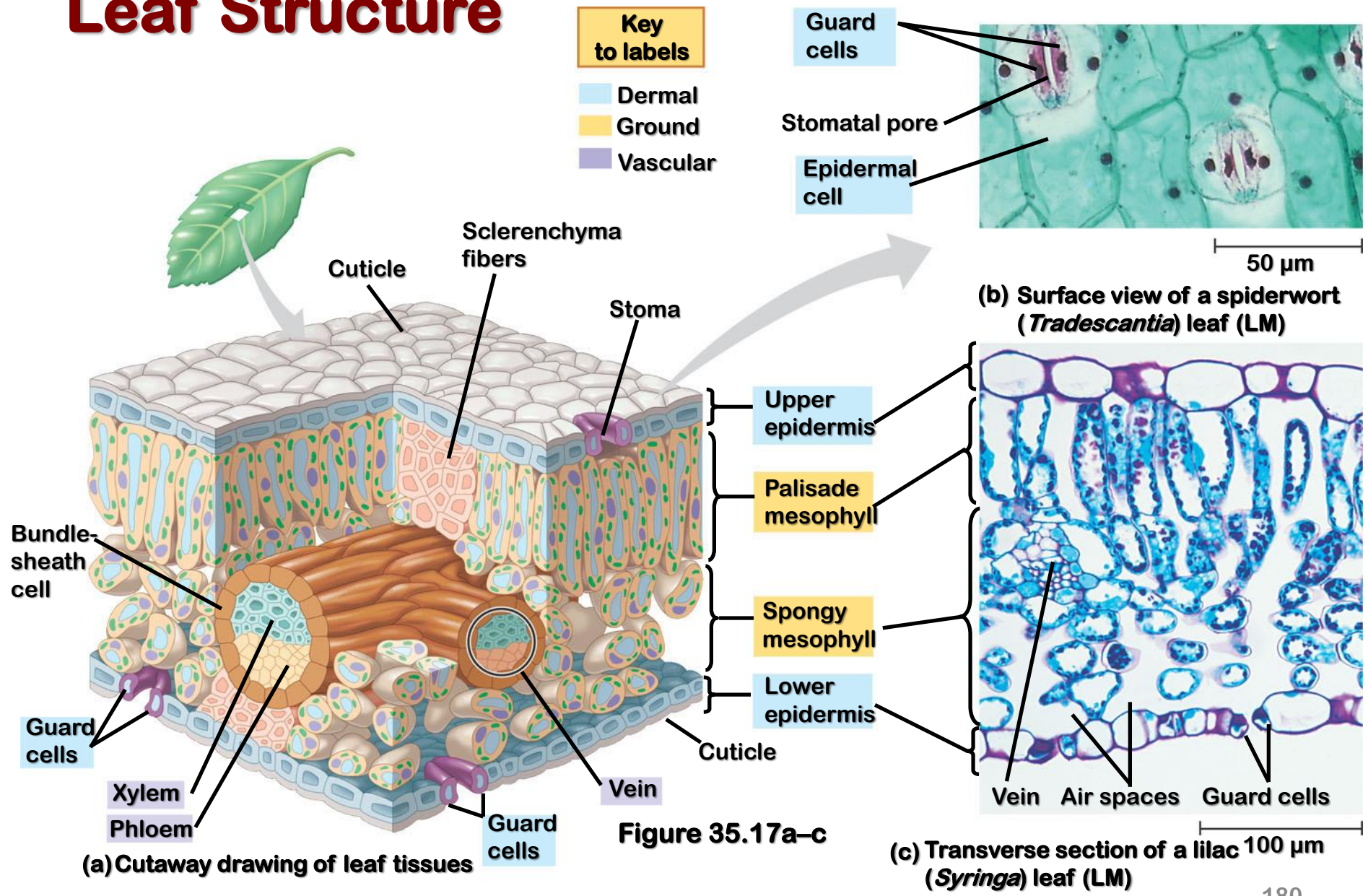
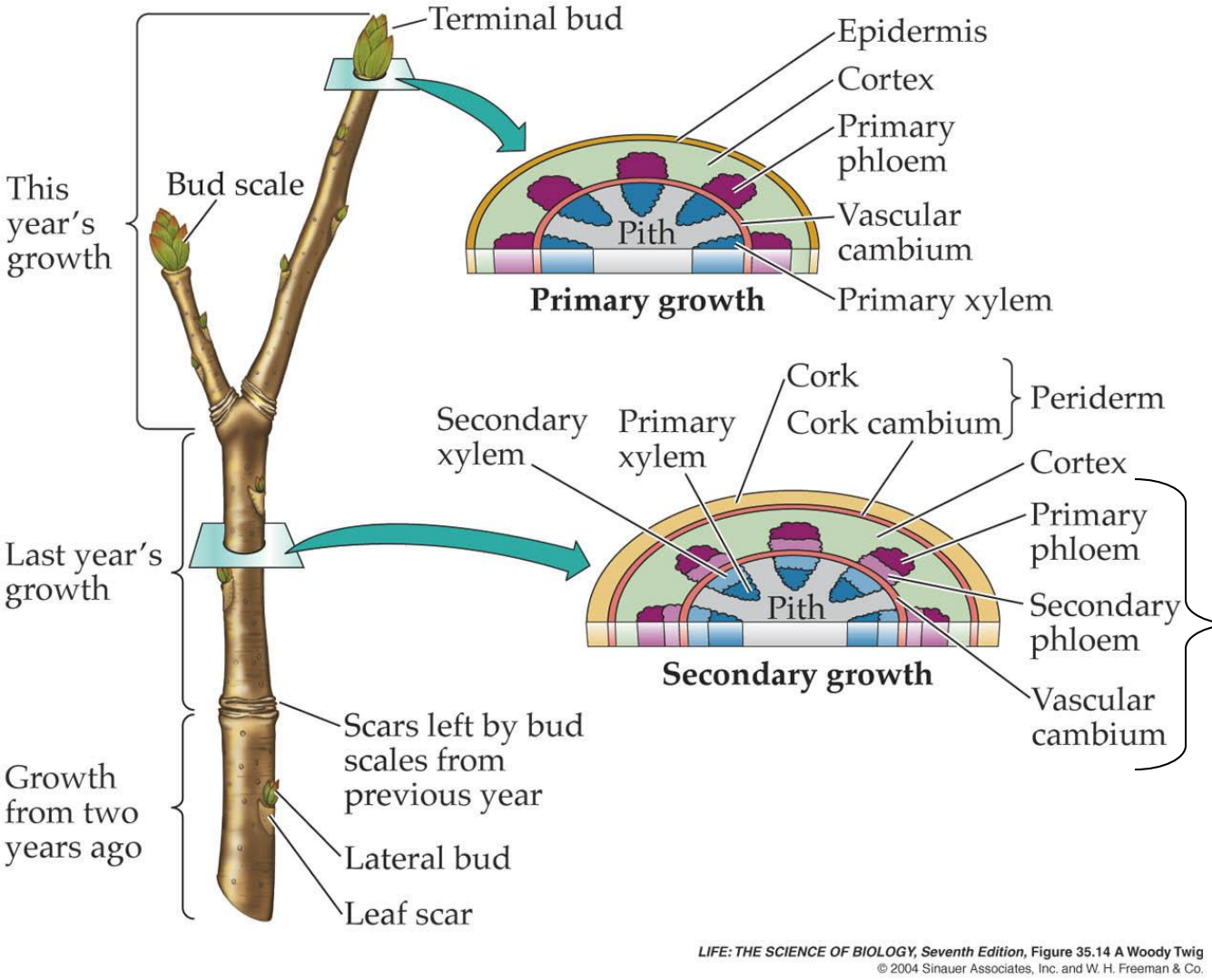


Figure 35.17a–c

Plant Secondary Growth

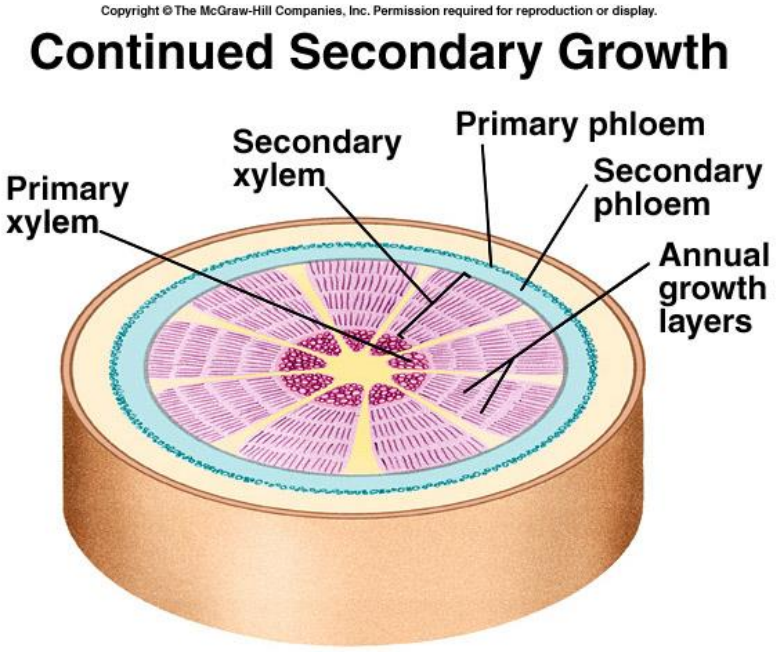


LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 35.14 A Woody Twig

These tissues form a vascular bundle. In woody plants they grow together and fuse to form a continuous ring creating annual growth rings.

Mature Dicot Stem

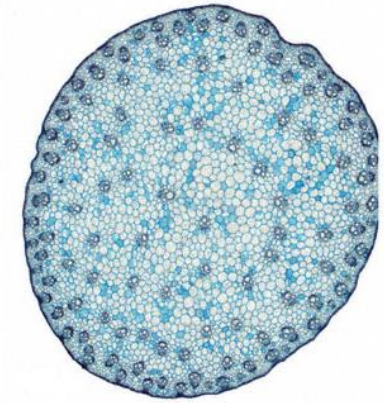
- Secondary growth increases the diameter of stems and roots.
- Secondary growth results from the activity of vascular and cork cambium.
- Vascular rays connect storage parenchyma to the sieve tubes of the phloem.
- Only eudicots have a vascular cambium and a cork cambium and thus undergo secondary growth.
- Cross sections of most tree trunks in temperate zone forests have annual rings.
- Annual rings form due to differential rates of growth in spring (when water is plentiful) and in summer.
- Wood that is no longer conducting water is known as heartwood.
- Sapwood is wood that is actively conducting water and minerals in the tree.

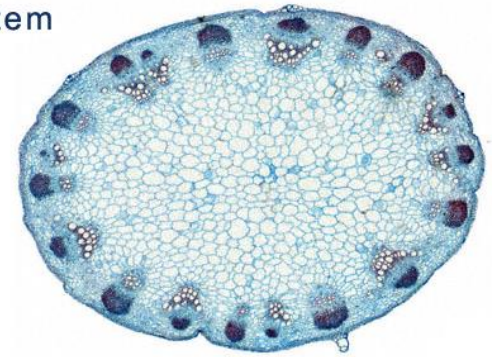


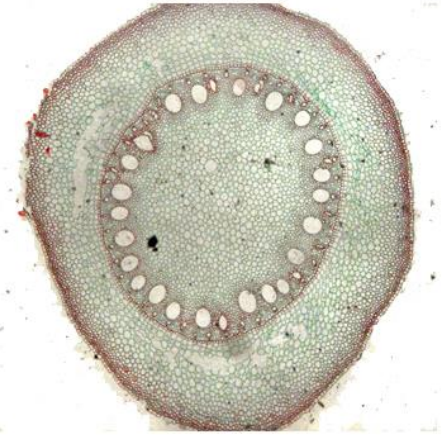
Monocot

Dicot

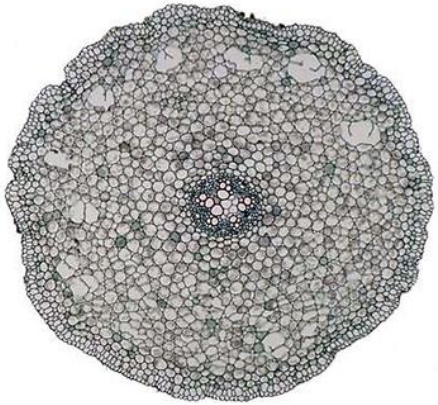
Stem



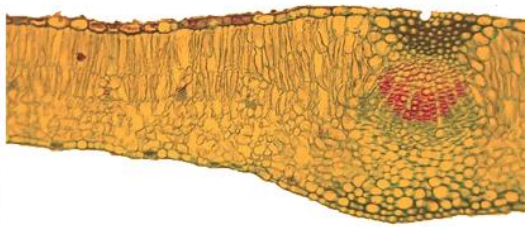




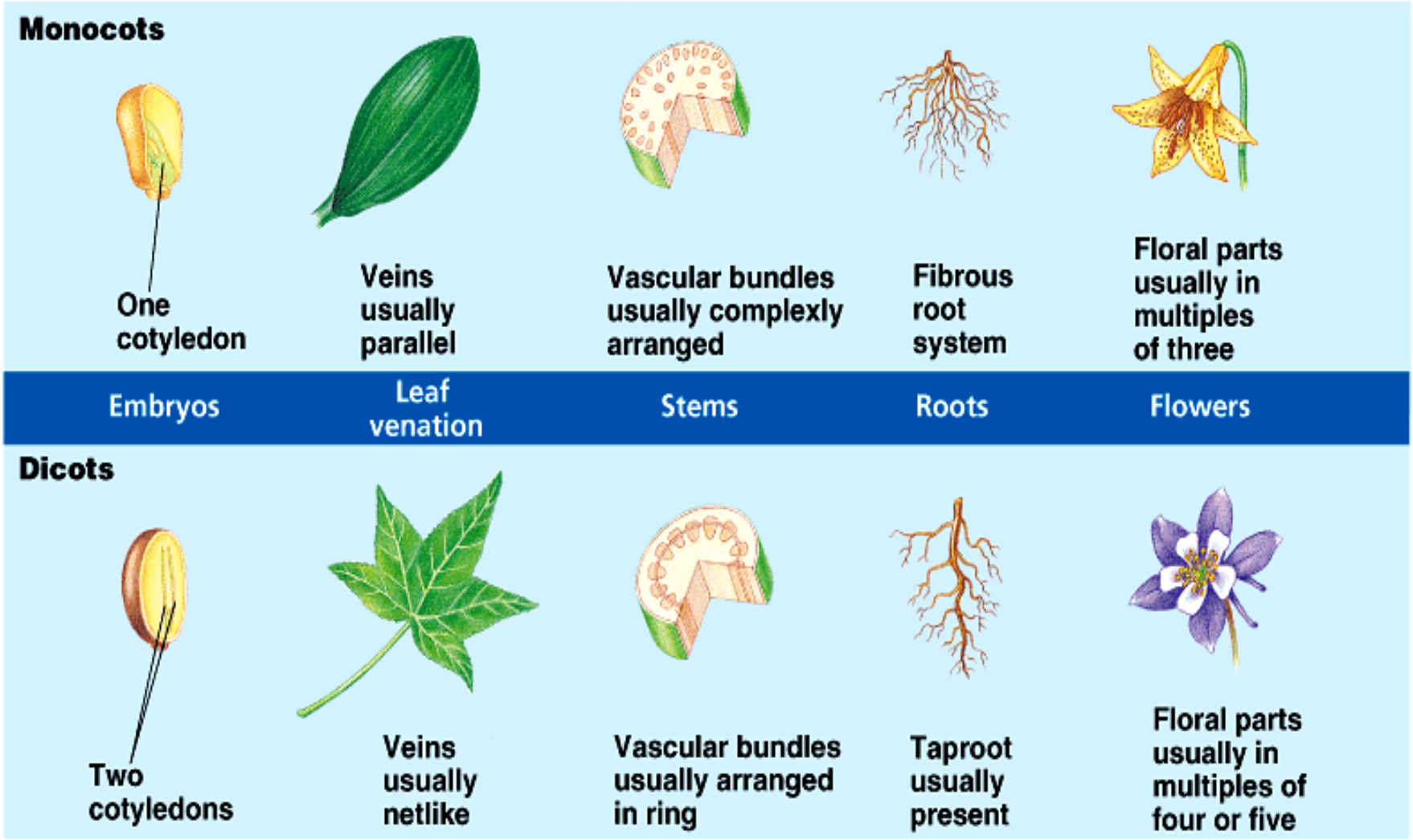
Root



Leaf



Monocots vs. Dicots



Plant tissue	Cell type	Site
Epidermis	Ground cells; guard cells; cells forming trichomes; Sclerenchyma cells	Outer layer of plant body
Periderm	Cork cells; cork cambium cells; parenchyma cells of phelloderm; Sclerenchyma cells	Outer layer; mainly stems
Xylem	Tracheids; vessel members; Sclerenchyma cells; Parenchyma cells	All organs
Phloem	Sieve cells or sieve-tube members; albuminous cells or companion cells; other parenchyma cells; Sclerenchyma cells	All organs
Parenchyma	Parenchyma cells	Cortex, pith
Collenchyma	Collenchyma cells	Mainly stems
Sclerenchyma	Sclerenchyma cells	All organs