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General Biology

Lectures (1 & 2): The Cell

College of Applied Sciences
Biology Department

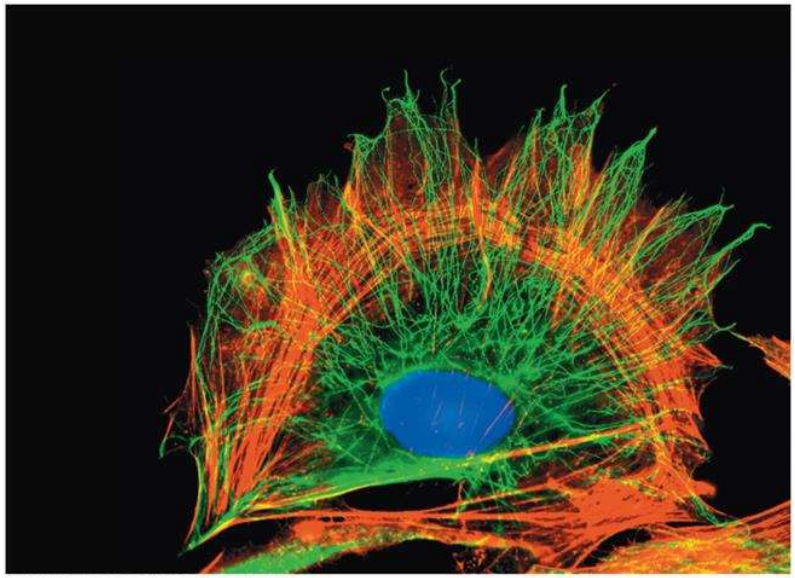
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1. A Tour of the cell

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Biology Department

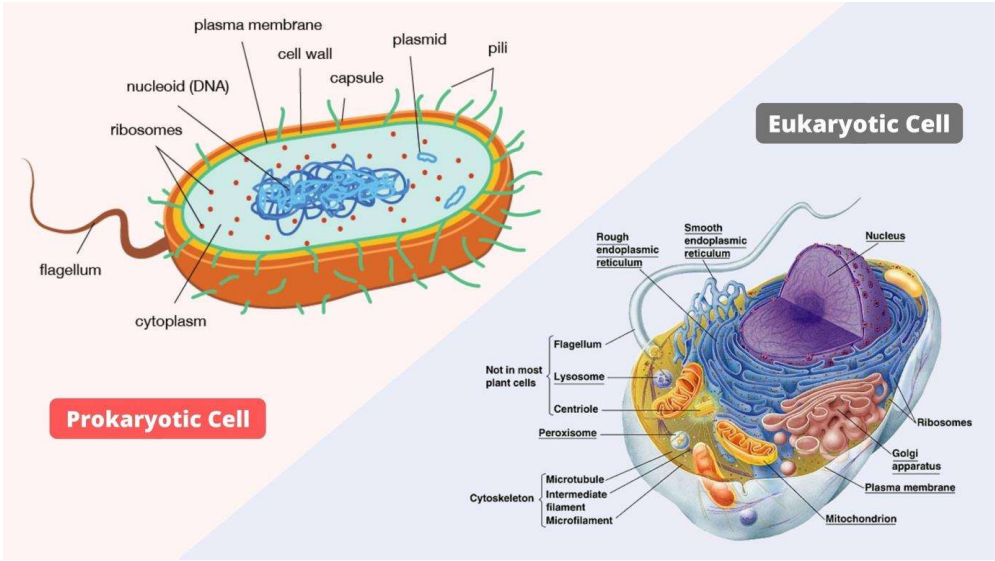
Overview: The Fundamental Units of Life

- All organisms are made of cells.
- The cell is the simplest collection of matter that can live.
- All cells are related by their descent from earlier cells.

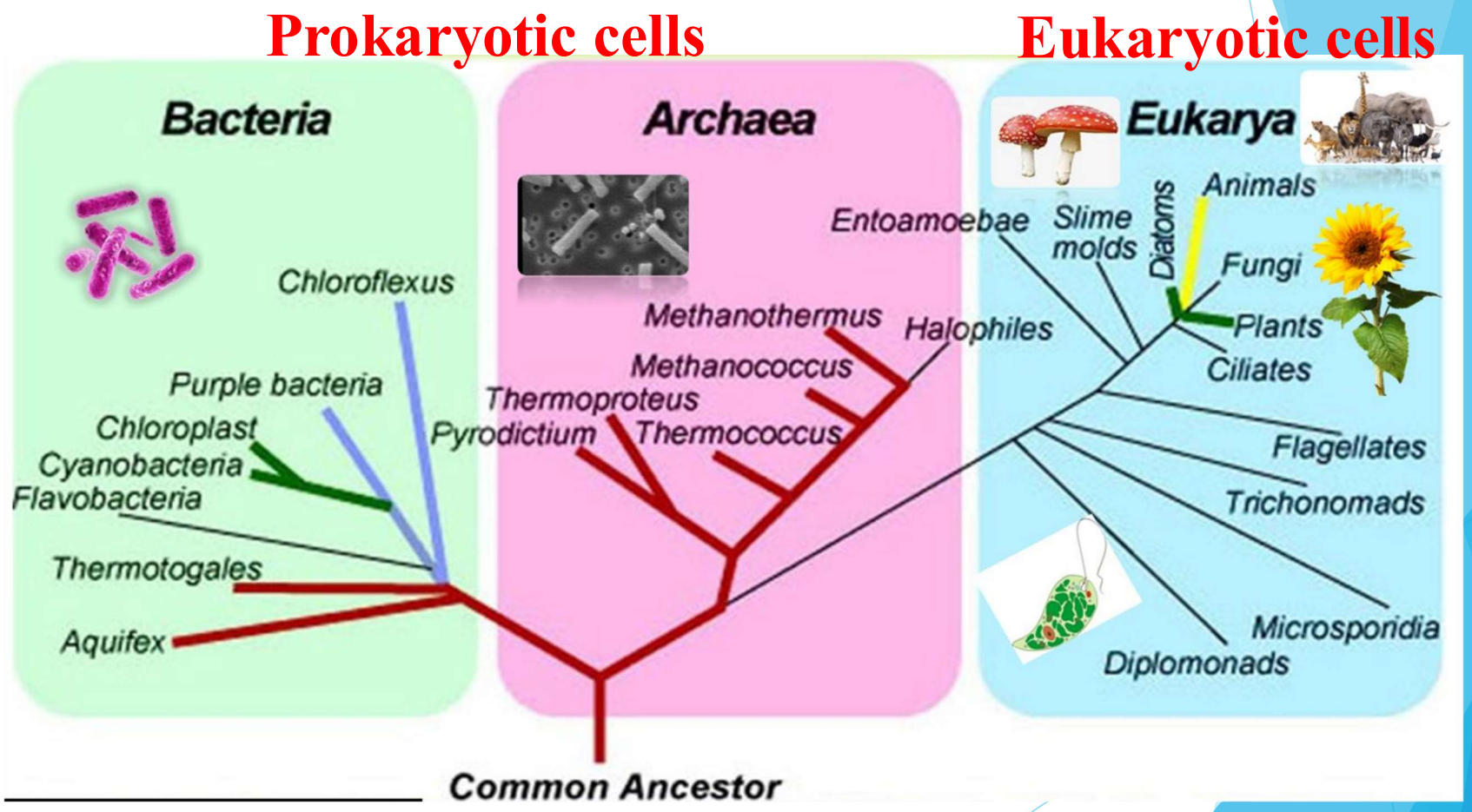

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Prokaryotic and Eukaryotic Cells

- The basic structural and functional unit of every organism is one of two types of cells: **prokaryotic** or **eukaryotic.**
- Only organisms of the domains Bacteria and Archaea consist of **prokaryotic cells**.
- Protists, fungi, animals, and plants all consist of **eukaryotic cells**.

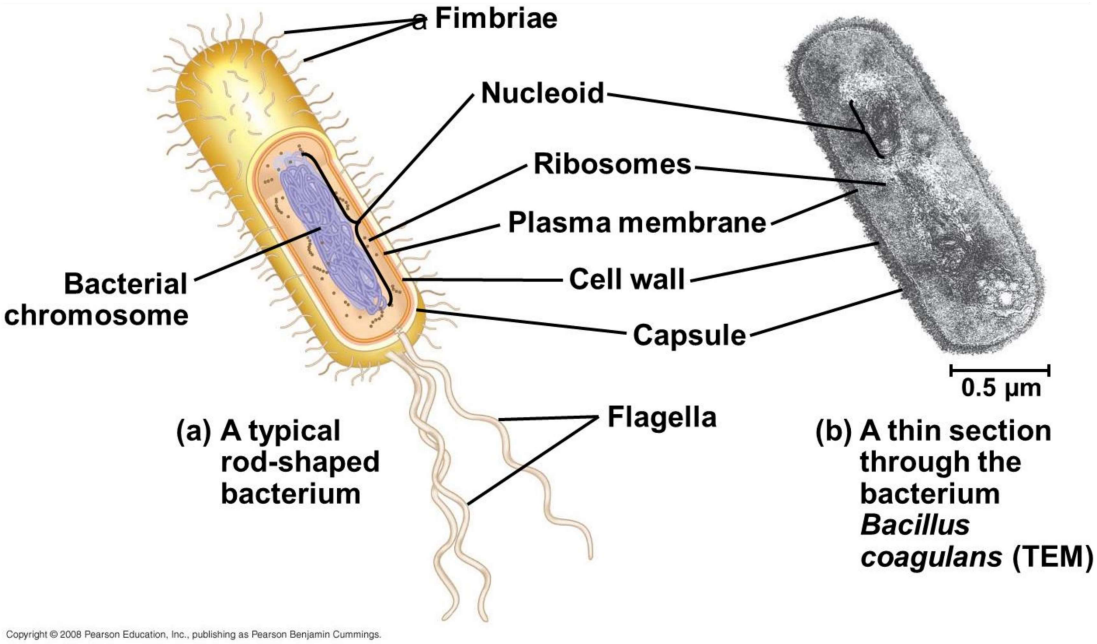


Three Domains of Life



Prokaryotic Cells

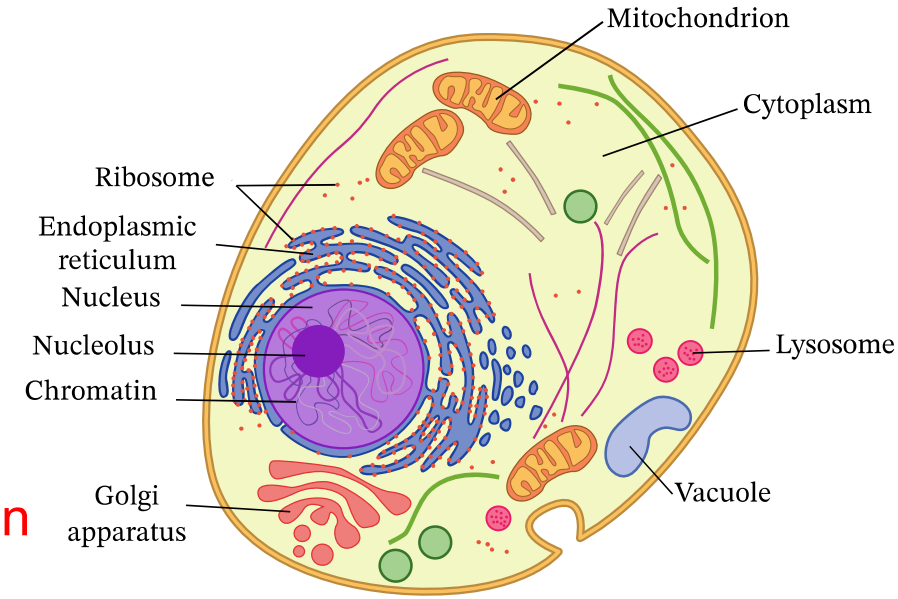
- **Prokaryotic cells** are characterized by having
  - No nucleus.
  - DNA in an unbound region called the **nucleoid**.
  - No membrane-bound organelles.
  - **Cytoplasm** bound by the plasma membrane.



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Eukaryotic Cells

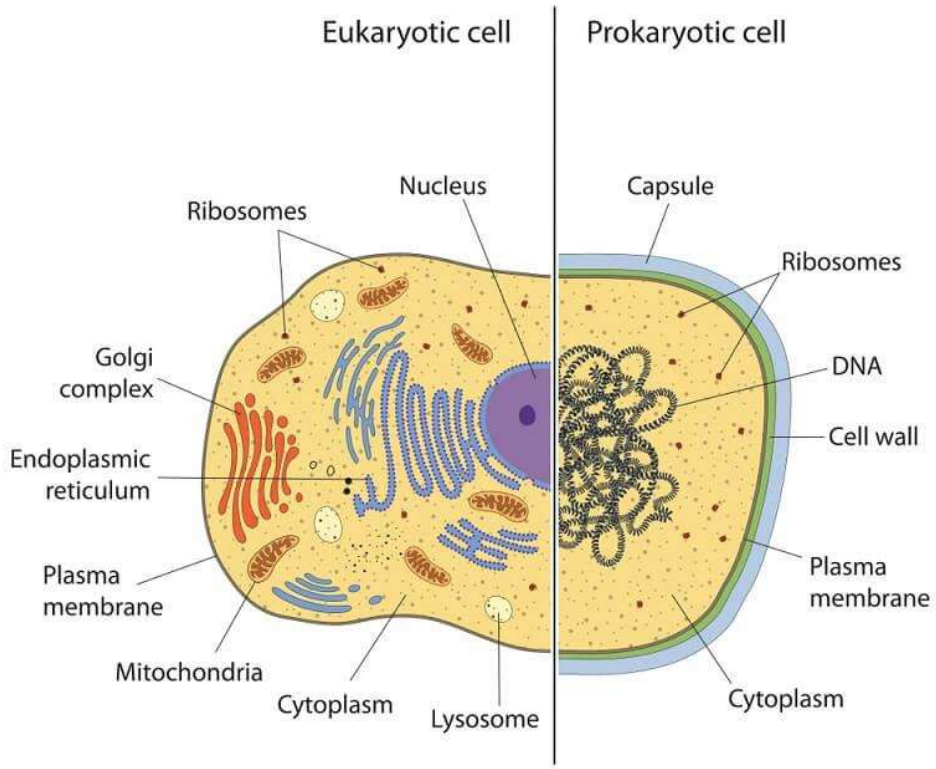
- **Eukaryotic cells** are characterized by having
  - DNA in a nucleus that is bounded by a membranous nuclear envelope.
  - Membrane-bound organelles.
  - Cytoplasm in the region between the plasma membrane and nucleus.
- Eukaryotic cells are generally much larger than prokaryotic cells.



Comparing Prokaryotic and Eukaryotic Cells

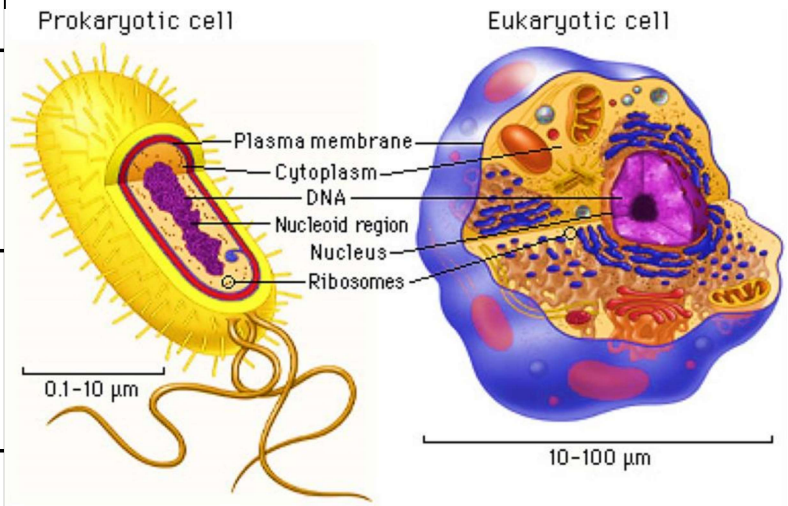
Common features between prokaryotic and eukaryotic cells of:

- Plasma membrane.
- Semifluid substance called cytoplasm (**cytosol**).
- Chromosomes (carry genes).
- Ribosomes (make proteins).



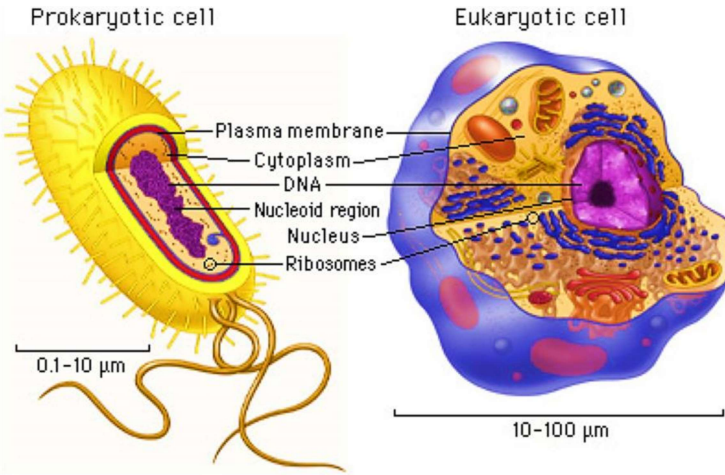
Eukaryotic VS Prokaryotic cells

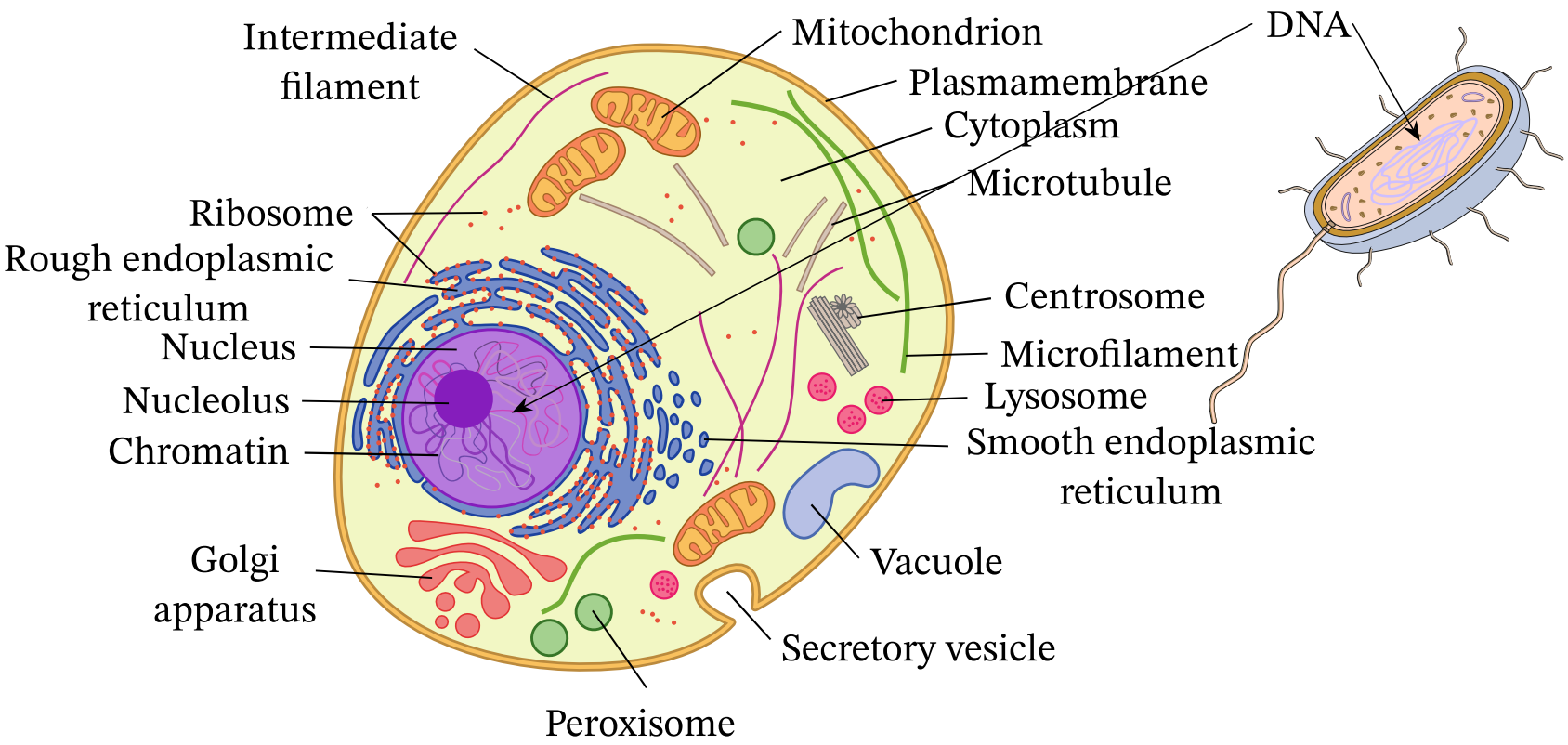
Prokaryotic Cells	Eukaryotic Cells
Nuclear region (nucleoid) is not enveloped by a nuclear membrane.	Nucleus is surrounded by a double membrane layer.
Single chromosome present.	More than one chromosome are present.
Nucleolus is absent.	Nucleolus is present.
Membrane bound organelles are absent.	Membrane bound organelles are present.



Eukaryotic VS Prokaryotic cells

Prokaryotic Cells	Eukaryotic Cells
Multiplication of cell is by fission or budding.	Cell division by mitosis or meiosis.
Cell Walls present, which are chemically complex.	Cell walls seen in only plant cells, which are chemically simpler.
Cell type is usually unicellular.	Usually multicellular cells.
Cell size is 1-10µm	Cell size 10 - 100µm.
Example: Bacteria, archaea	Example: animal cells and plant cells.

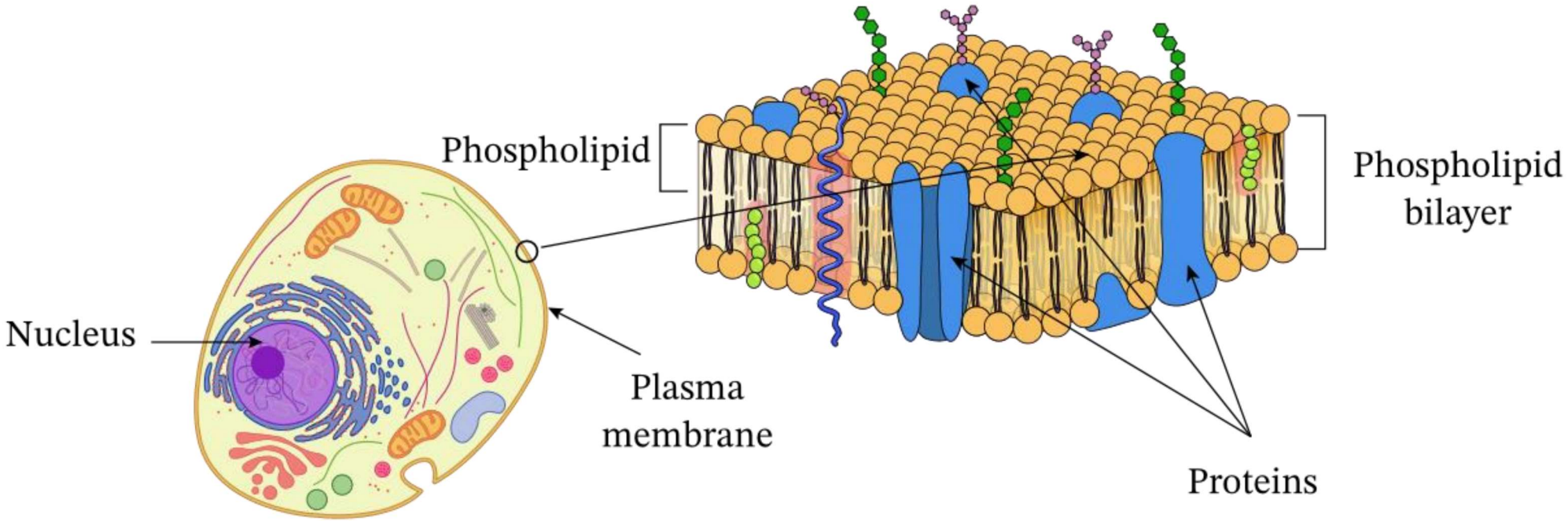



Intermediate filament
Mitochondrion
DNA
Plasmamembrane
Cytoplasm
Microtubule
Ribosome
Rough endoplasmic reticulum
Centrosome
Nucleus
Microfilament
Nucleolus
Lysosome
Chromatin
Smooth endoplasmic reticulum
Golgi apparatus
Vacuole
Secretory vesicle
Peroxisome
Eukaryotic Cell
Prokaryotic Cell

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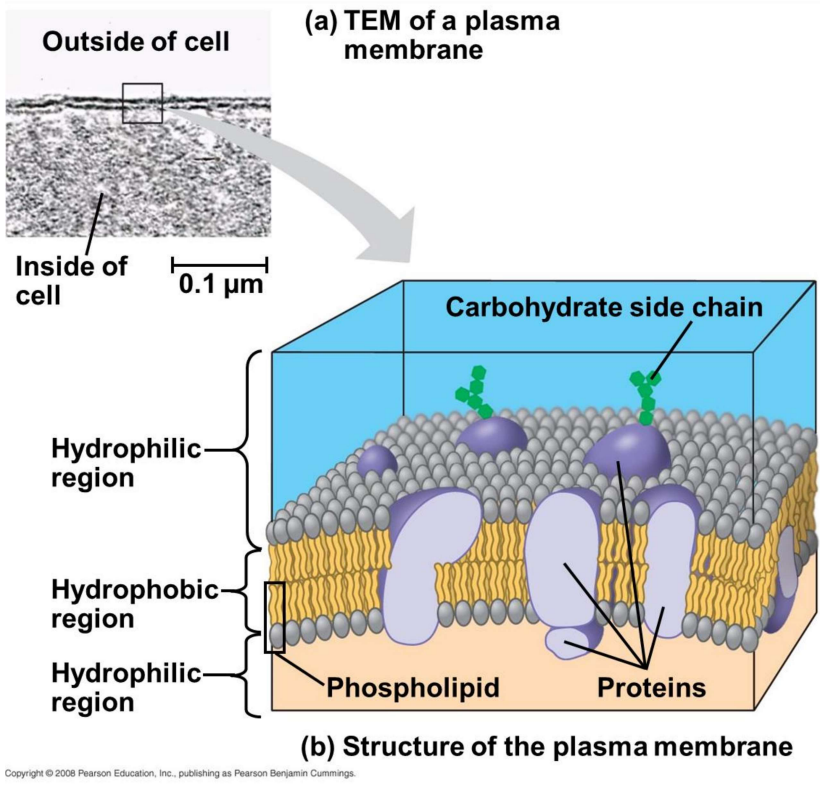
2. Membrane Structure and Function

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Phospholipid
Phospholipid bilayer
Nucleus
Plasma membrane
Proteins

Plasma Membrane

- A eukaryotic cell has internal membranes that partition the cell into organelles.
- Plant and animal cells have most of the same organelles.
- The plasma membrane is the boundary that separates the living cell from its surroundings.
- Also called **Cell membrane** is a **selective barrier** that allows sufficient passage of oxygen, nutrients, and waste to service the volume of every cell.
- Plasma membrane is made of a double layer of phospholipids.

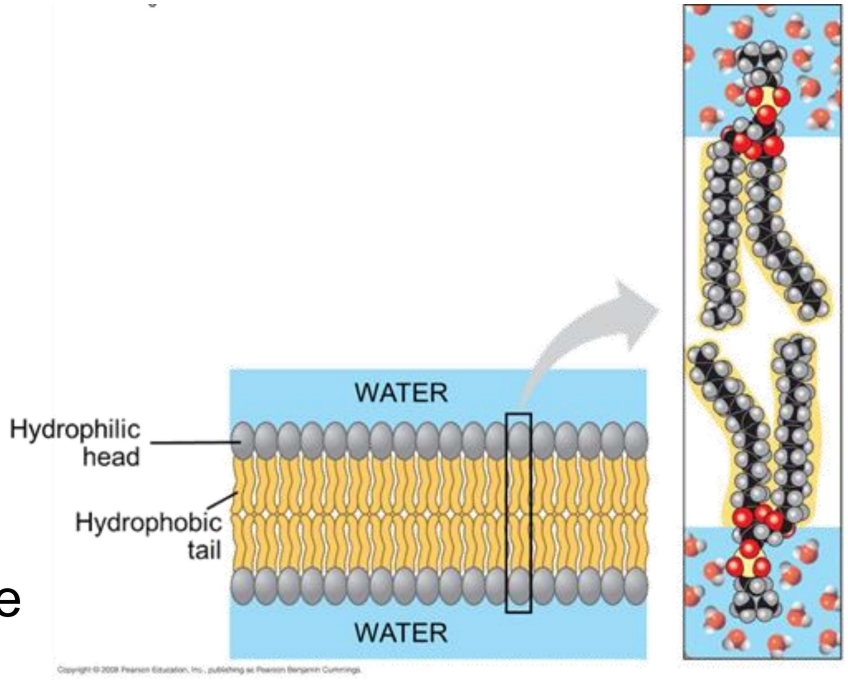


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Membrane Structure and Function

➢ Cell Membrane structure:

- Phospholipids are the most abundant lipid in the plasma membrane.
- Membranes have been chemically analyzed and found to be made of proteins and lipids.
- Phospholipids are **amphipathic molecules**, containing hydrophobic and hydrophilic regions.
- The **fluid mosaic model** states that a membrane is a fluid structure with a "mosaic" of various proteins embedded in it.



Membrane Structure and Function

Cell Membrane Functions:

- The main function of plasma membrane is that it acts as a physical barrier between the external environment and the inner cell organelles.
- Is a selectively permeable membrane.
- Osmosis.
- The plasma membrane also functions by facilitating the communication and signaling between the cells.

The Nucleus: Information Central

- The **nucleus** contains most of the cell's genes.
- The **nuclear envelope** encloses the nucleus, separating it from the cytoplasm.
- The **nuclear membrane** is a double membrane; each membrane consists of a lipid bilayer, and it contains **pores.**
- **Pores** regulate the entry and exit of molecules from the nucleus.
- In the nucleus, DNA and proteins form genetic material called **chromatin.**
- The **nucleolus** is located within the nucleus and is the site of ribosomal RNA (rRNA) synthesis.

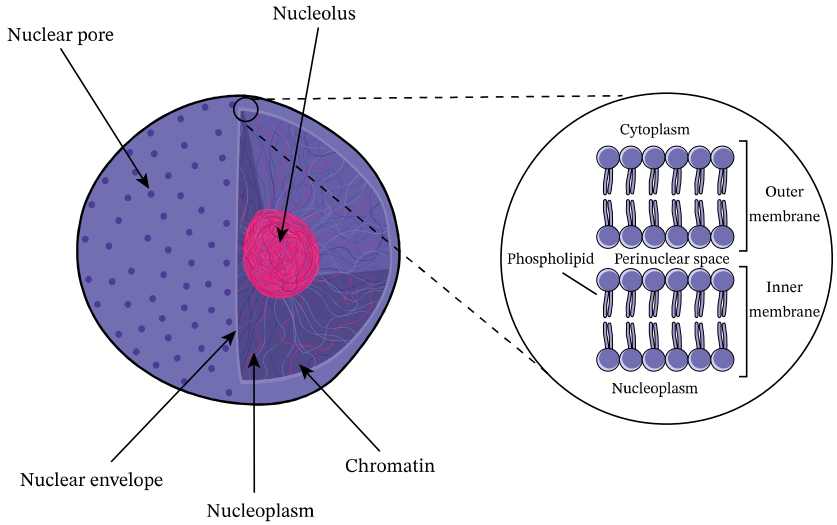
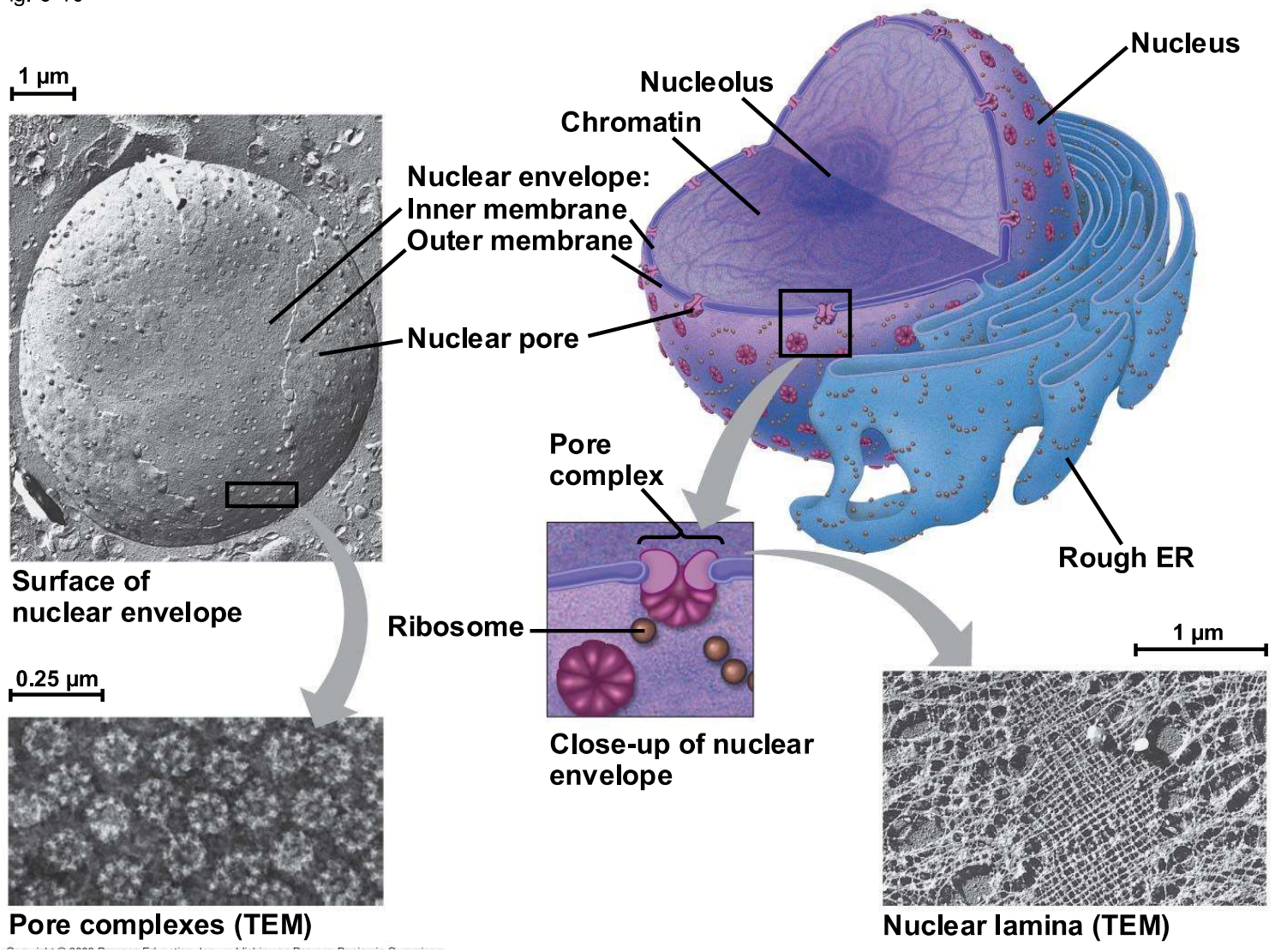
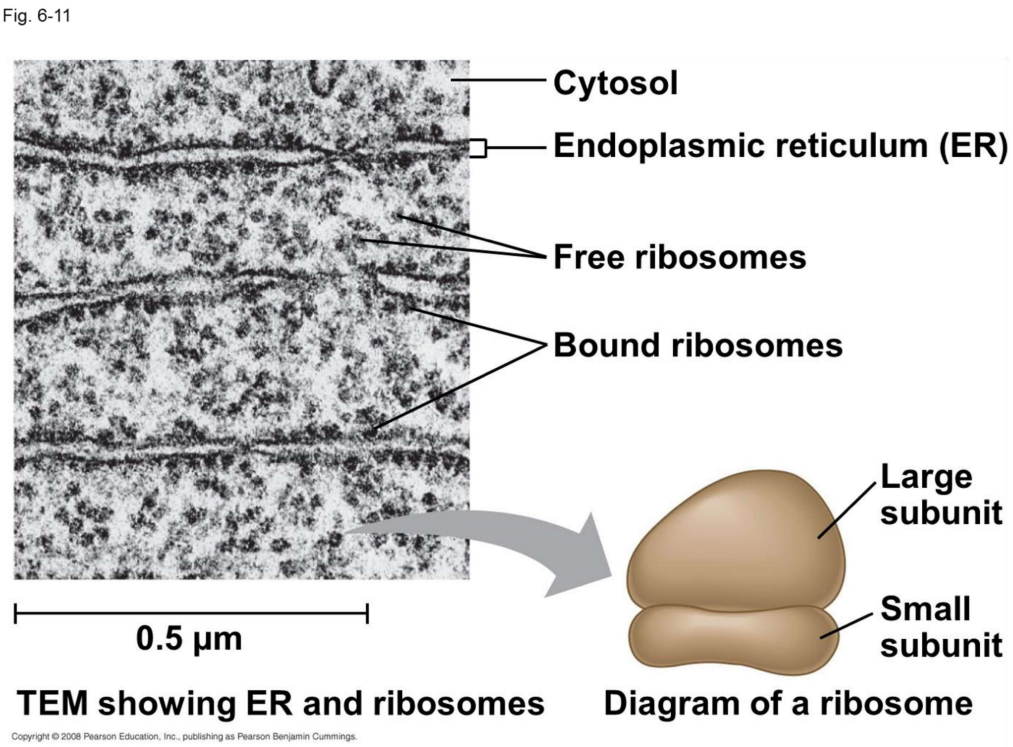


Fig. 6-10


1 µm
Nucleus
Nucleolus
Chromatin
Nuclear envelope:
Inner membrane
Outer membrane
Nuclear pore
Pore complex
Rough ER
Surface of nuclear envelope
Ribosome
1 µm
0.25 µm
Close-up of nuclear envelope
Pore complexes (TEM)
Nuclear lamina (TEM)

Ribosomes: Protein Factories

- **Ribosomes** are particles made of ribosomal RNA and protein.
- Ribosomes carry out protein synthesis in two locations:
  - In the **cytosol** (free ribosomes)
  - On the outside of the **endoplasmic reticulum** or the **nuclear envelope** (bound ribosomes)

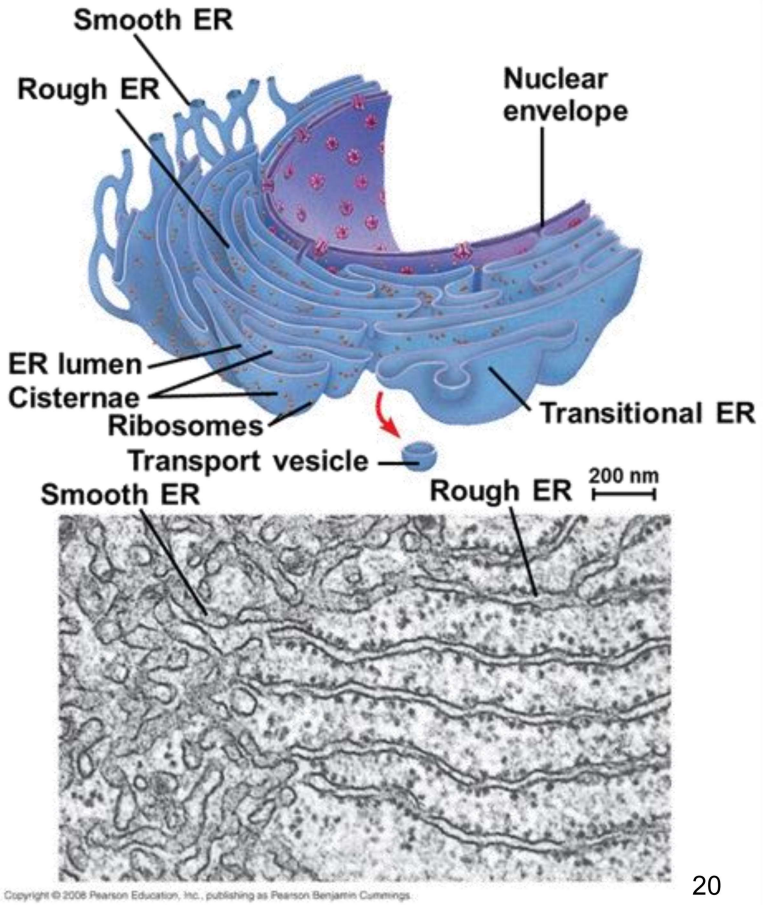


The Endoplasmic Reticulum: Biosynthetic Factory

- The **endoplasmic reticulum (ER)** accounts for more than half of the total membrane in many eukaryotic cells.
- The ER membrane is continuous with the nuclear envelope.

- There are two distinct regions of ER:

  - **Smooth ER**, which lacks ribosomes.
  - **Rough ER**, with ribosomes studding its surface.



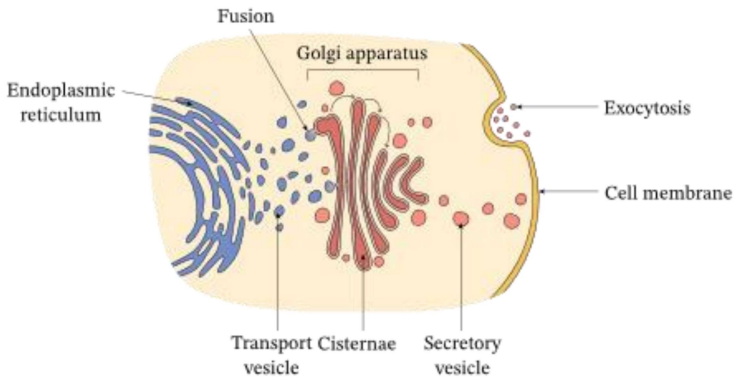
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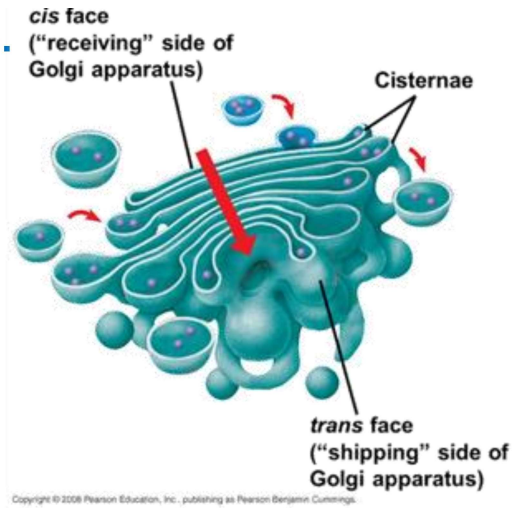
The Endoplasmic Reticulum function

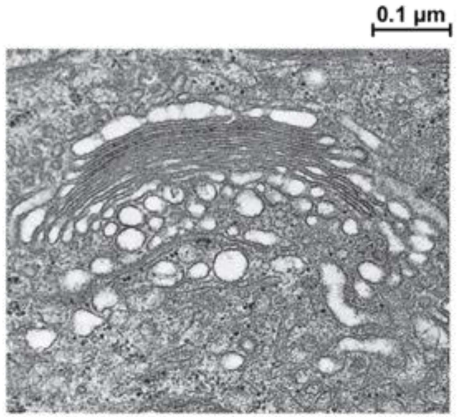
The Function	The smooth ER	The rough ER
1-	Synthesizes lipids	Distributes **transport vesicles,** proteins surrounded by membranes
2-	Metabolizes carbohydrates	secrete **glycoproteins** (proteins covalently bonded to carbohydrates)
3-	Detoxifies poison	Is a membrane factory for the cell
4-	Stores calcium	

The Golgi Apparatus: Shipping and Receiving Center

- The **Golgi apparatus** consists of flattened membranous sacs called cisternae.
- Functions of the Golgi apparatus:
  - Modifies products of the ER.
  - Manufactures certain macromolecules.
  - Sorts and packages materials into transport vesicles.





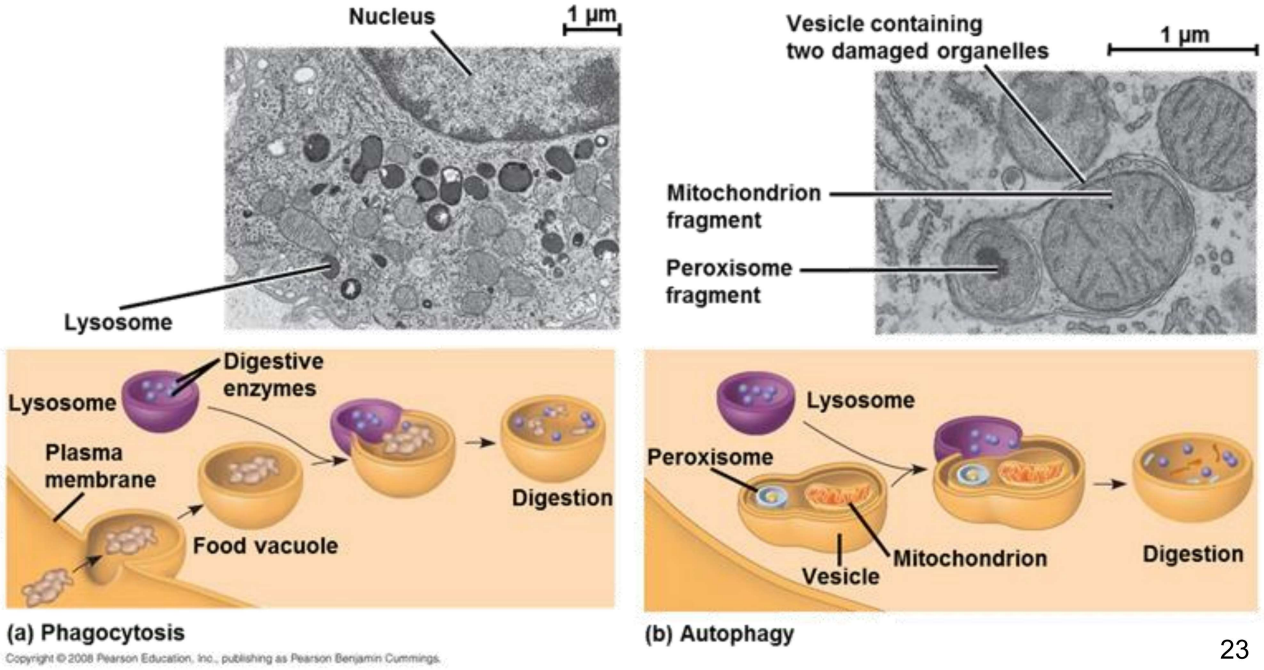


TEM of Golgi apparatus

Lysosomes: Digestive Compartments

- A **lysosome** is a membranous sac of hydrolytic enzymes that can digest macromolecules.

- The main function is digestion.
- Lysosomal enzymes can hydrolyze proteins, fats, polysaccharides, and nucleic acids.



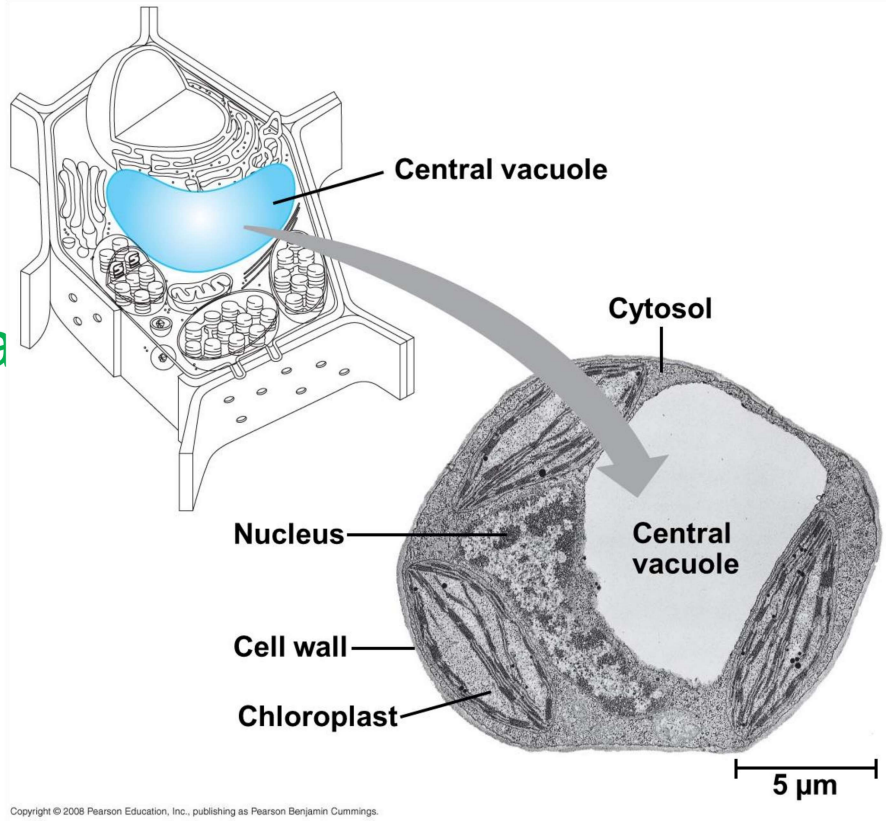
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Vacuoles: Diverse Maintenance Compartments

- A plant cell or fungal cell may have one or several vacuoles.
- The functions of the vacuole include:

- Storage, digestion, and waste removal

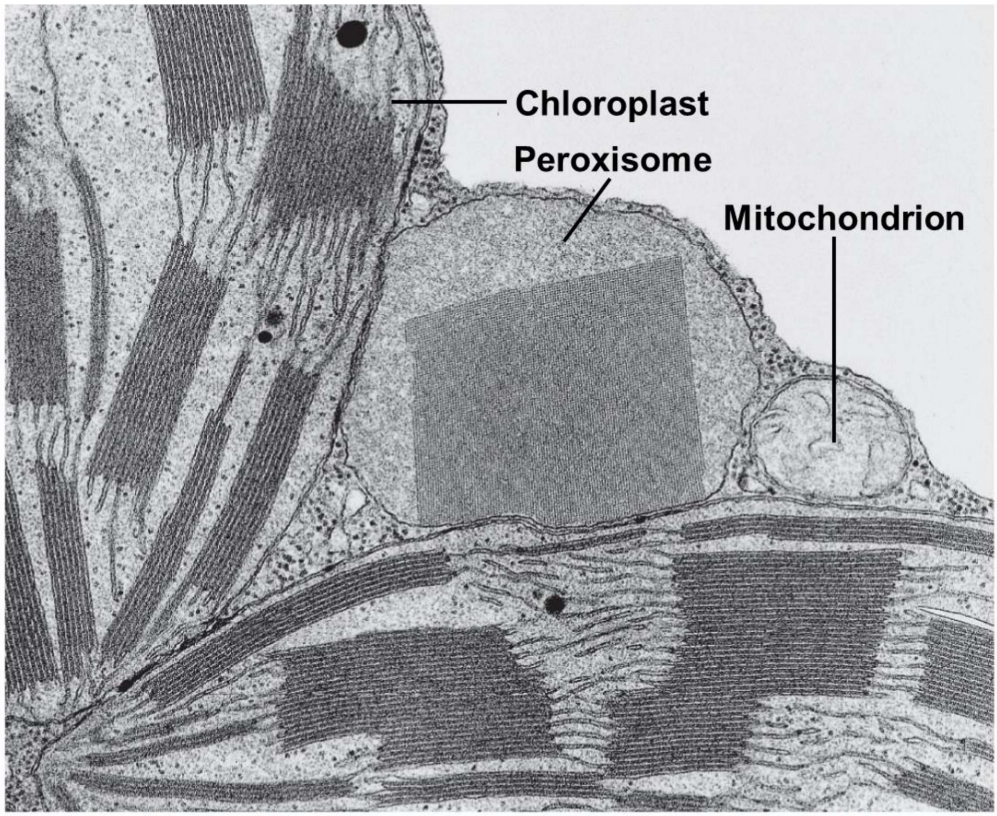
Fig. 6-15



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Mitochondria and chloroplasts change energy from one form to another

- **Mitochondria** are the sites of cellular respiration, a metabolic process that generates ATP.
- **Chloroplasts**, found in plants and algae, are the sites of photosynthesis
- **Peroxisomes** are oxidative organelles, produce hydrogen peroxide and convert it to water.

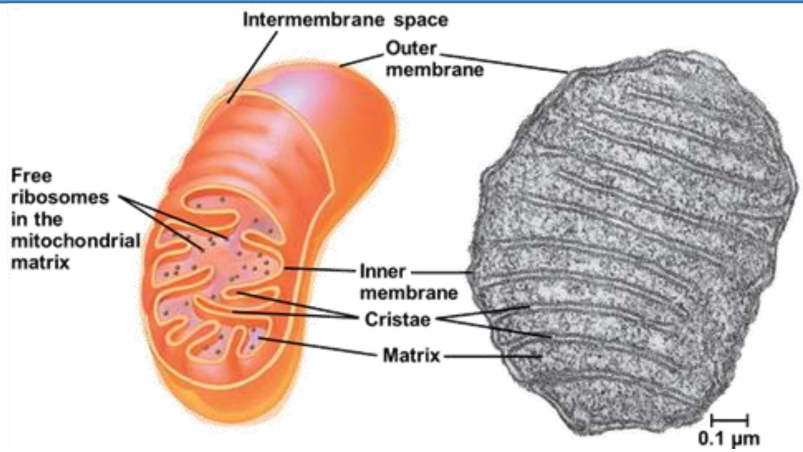


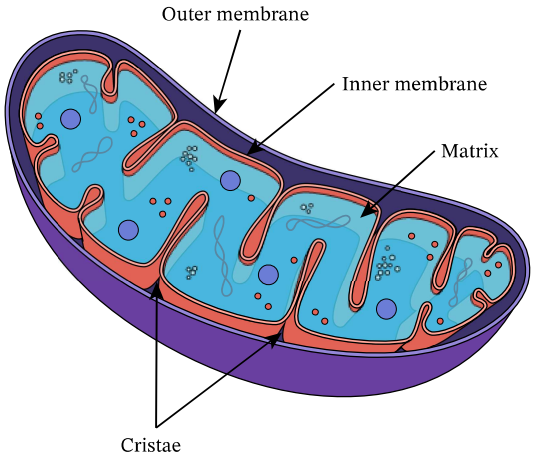
Mitochondria and chloroplasts Structures

- Mitochondria and chloroplasts Both have:
  - Have a double membrane.
  - Have proteins made by free ribosomes.
  - Contain their own DNA.

Mitochondria: Chemical Energy Conversion

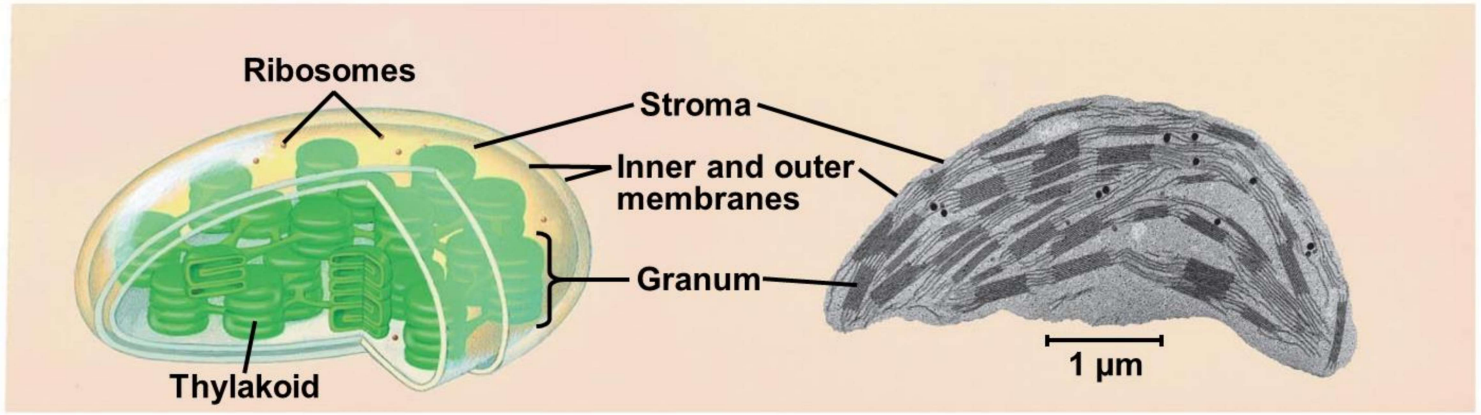
- Mitochondria are in nearly all eukaryotic cells.
- They have a smooth outer membrane and an inner membrane folded into **cristae.**
- The inner membrane creates two compartments: intermembrane space and **mitochondrial matrix.**
- Some metabolic steps of cellular respiration are catalyzed in the mitochondrial matrix.
- Cristae present a large surface area for enzymes that synthesize ATP.





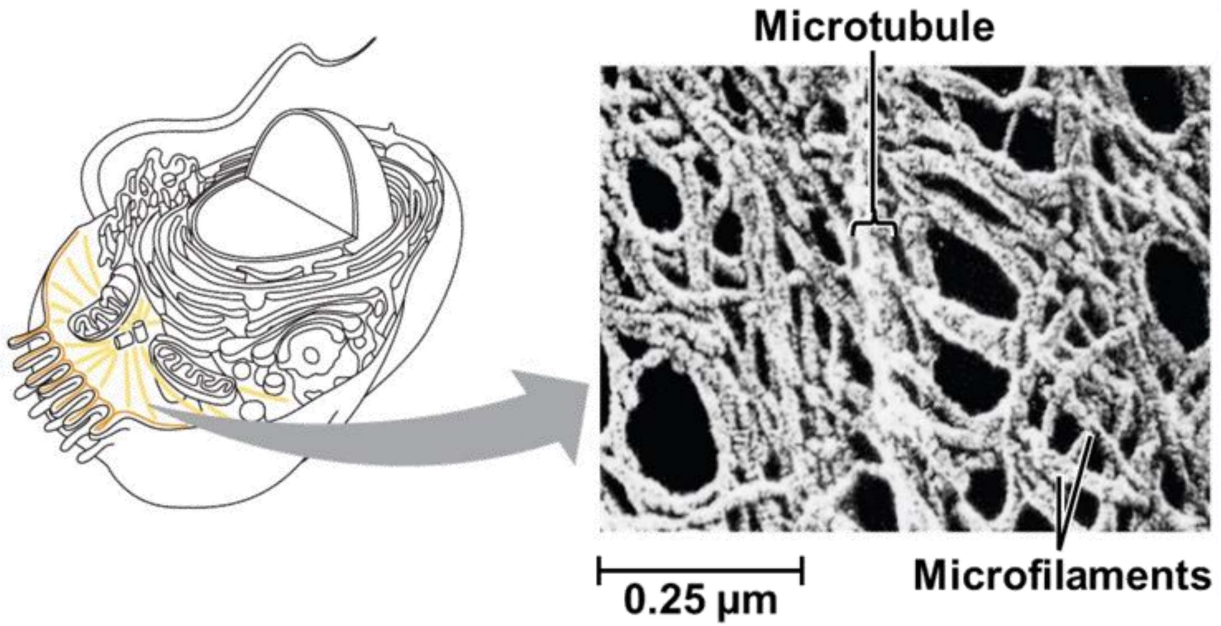
Chloroplasts: Capture of Light Energy

- The chloroplast is a member of a family of organelles called **plastids**.
- Chloroplasts contain the green pigment chlorophyll, as well as enzymes and other molecules that function in photosynthesis.
- Chloroplasts are found in leaves and other green organs of plants and in algae.



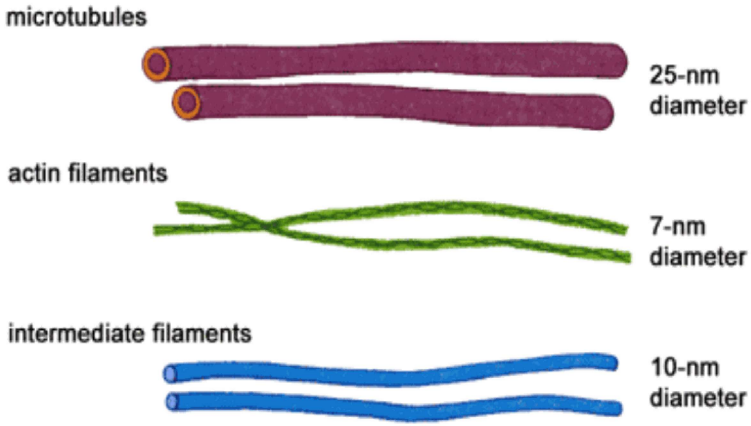
The cytoskeleton

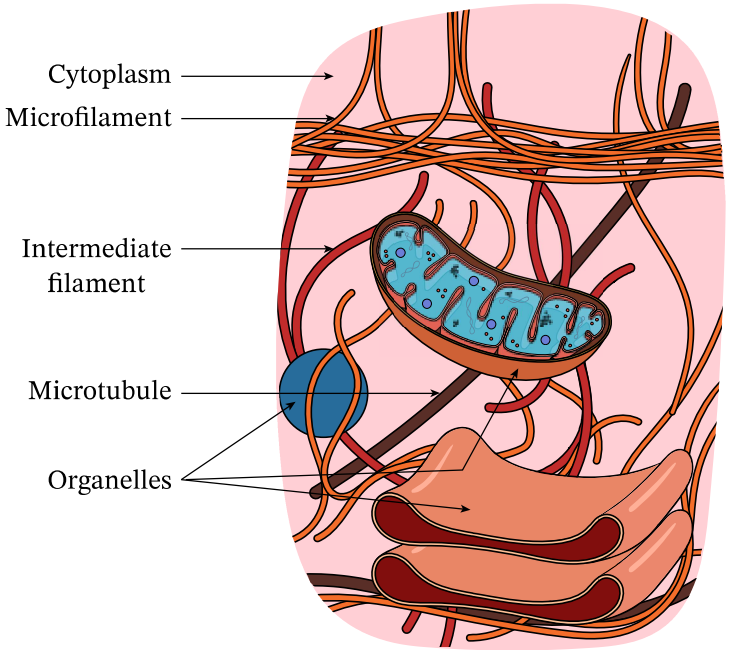
- The **cytoskeleton** is a network of fibers extending throughout the cytoplasm.
- It organizes the cell's structures and activities, anchoring many organelles.
- The roles of Cytoskeleton are Support, Motility, and Regulation.



The cytoskeleton

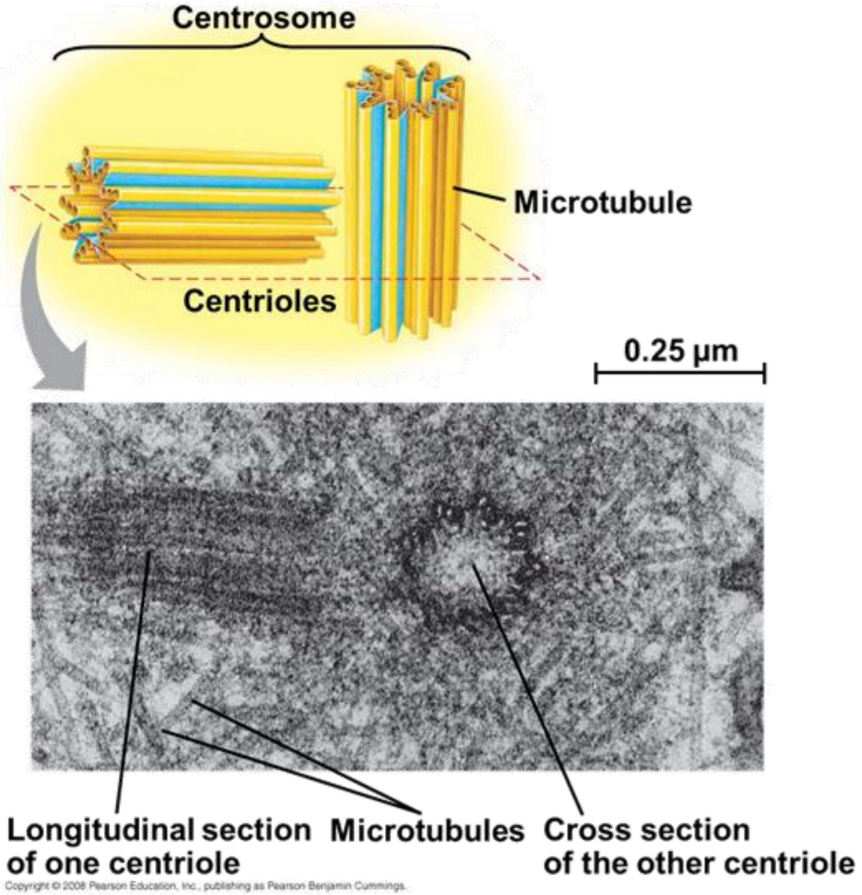
- It is composed of three types of molecular structures:
  - Microtubules are the thickest of the three components of the cytoskeleton.
  - Microfilaments also called actin filaments, are the thinnest components.
  - Intermediate filaments are fibers with diameters in a middle range .





Centrosomes and Centrioles

- In many cells, microtubules grow out from a **centrosome** near the nucleus.
- The centrosome is a microtubule-organizing center → it regulates cell motility, adhesion and polarity in interphase, and facilitates the organization of the spindle poles during mitosis.
- In animal cells, the centrosome has a pair of **centrioles**, each with nine triplets of microtubules arranged in a ring.

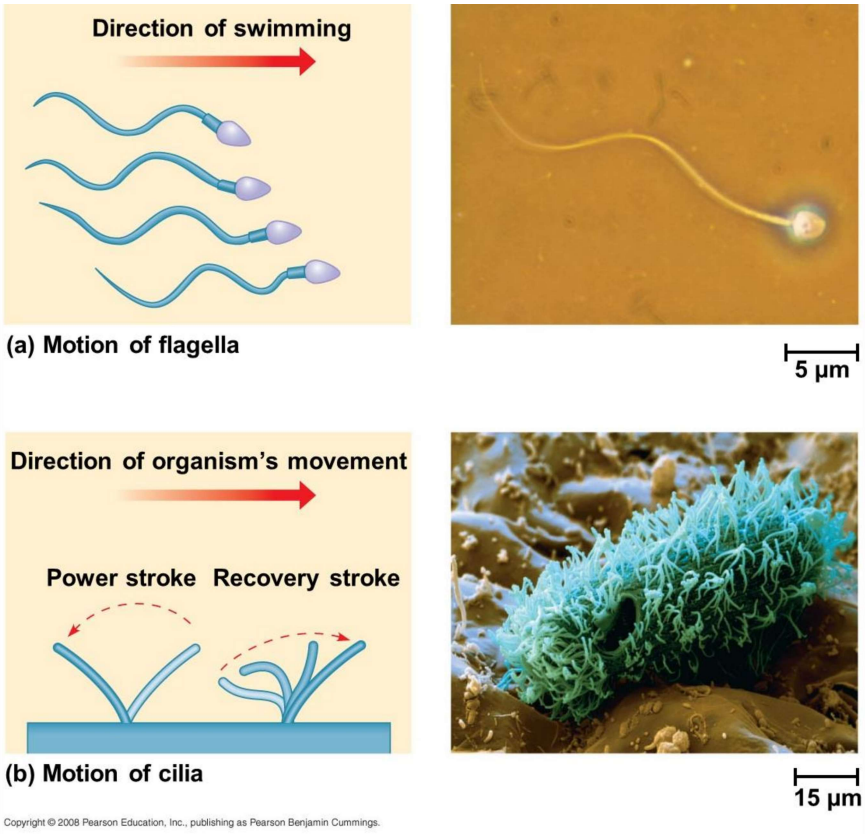


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Cilia and Flagella

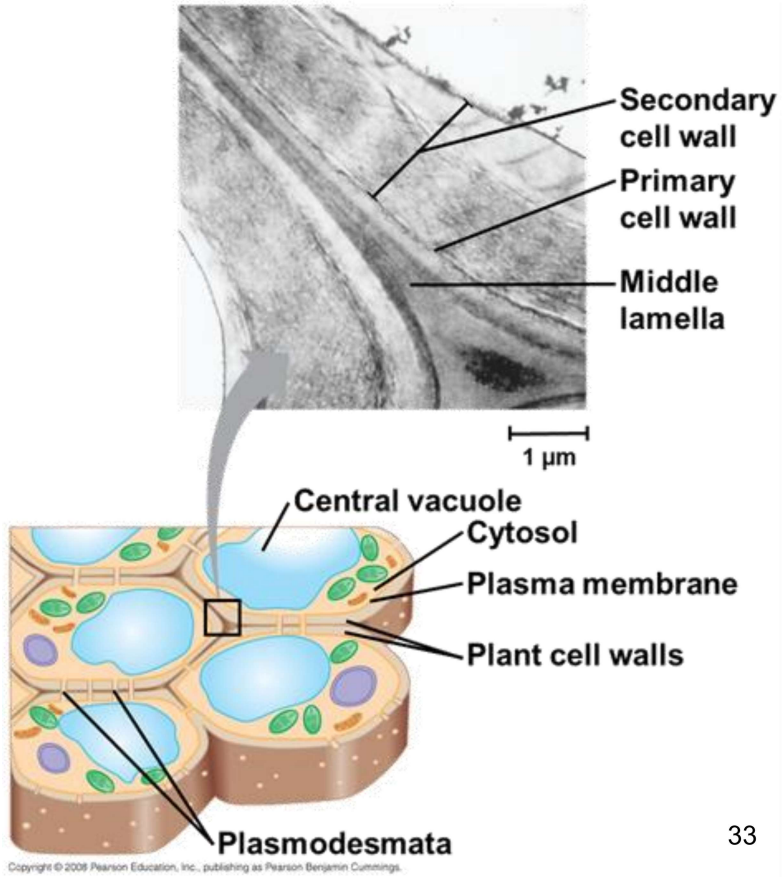
- Microtubules control the beating of **cilia** and **flagella**, locomotor appendages of some cells.

- Cilia and flagella differ in their beating patterns.

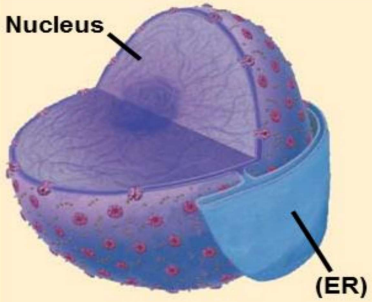
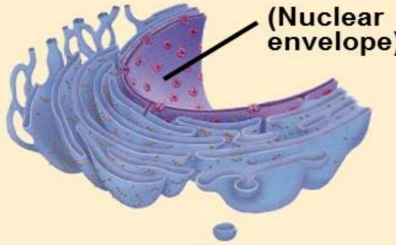
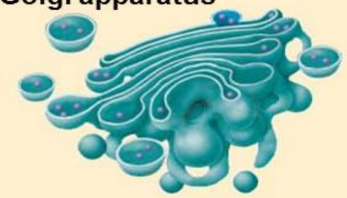


Extracellular components and connections between cells help coordinate cellular activities

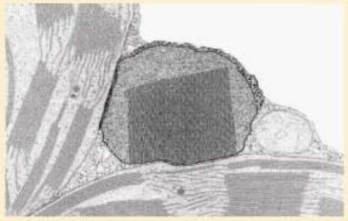
- Most cells synthesize and secrete materials that are external to the plasma membrane.
- These extracellular structures include:
  - Cell walls of plants: It protects the plant cell, maintains its shape, and prevents excessive uptake of water.
  - The extracellular matrix (ECM) of animal cells: it helps in supporting, movement, and regulation of the cells
  - Intercellular junctions: it helps in the adherence, interaction, and communication between neighboring cells



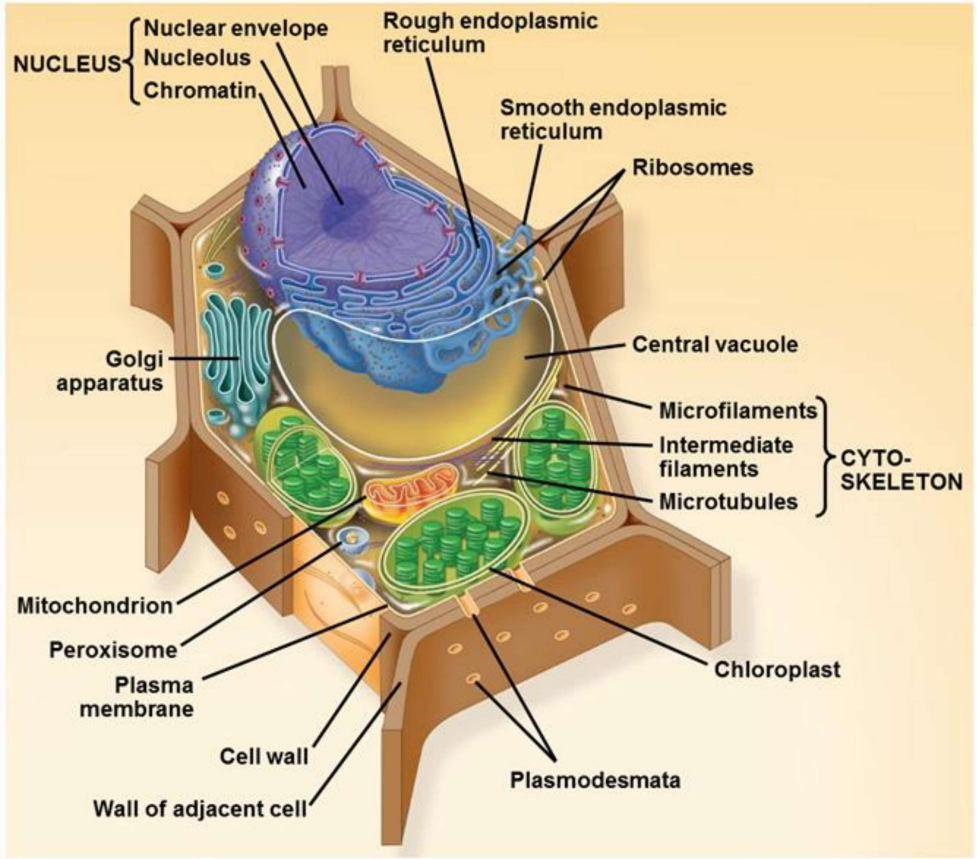
Summary of the Cell organelle

	Cell Component	Structure	Function
Concept 6.3 The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes	Nucleus  (ER)	Surrounded by nuclear envelope (double membrane) perforated by nuclear pores. The nuclear envelope is continuous with the endoplasmic reticulum (ER).	Houses chromosomes, made of chromatin (DNA, the genetic material, and proteins); contains nucleoli, where ribosomal subunits are made. Pores regulate entry and exit os materials.
	Ribosome 	Two subunits made of ribosomal RNA and proteins; can be free in cytosol or bound to ER	Protein synthesis
Concept 6.4 The endomembrane system regulates protein traffic and performs metabolic functions in the cell	Endoplasmic reticulum  (Nuclear envelope)	Extensive network of membrane-bound tubules and sacs; membrane separates lumen from cytosol; continuous with the nuclear envelope.	Smooth ER: synthesis of lipids, metabolism of carbohydrates, Ca^{2+} storage, detoxification of drugs and poisons Rough ER: Aids in sythesis of secretory and other proteins from bound ribosomes; adds carbohydrates to glycoproteins; produces new membrane
	Golgi apparatus 	Stacks of flattened membranous sacs; has polarity (*cis* and *trans* faces)	Modification of proteins, carbohydrates on proteins, and phospholipids; synthesis of many polysaccharides; sorting of Golgi products, which are then released in vesicles.

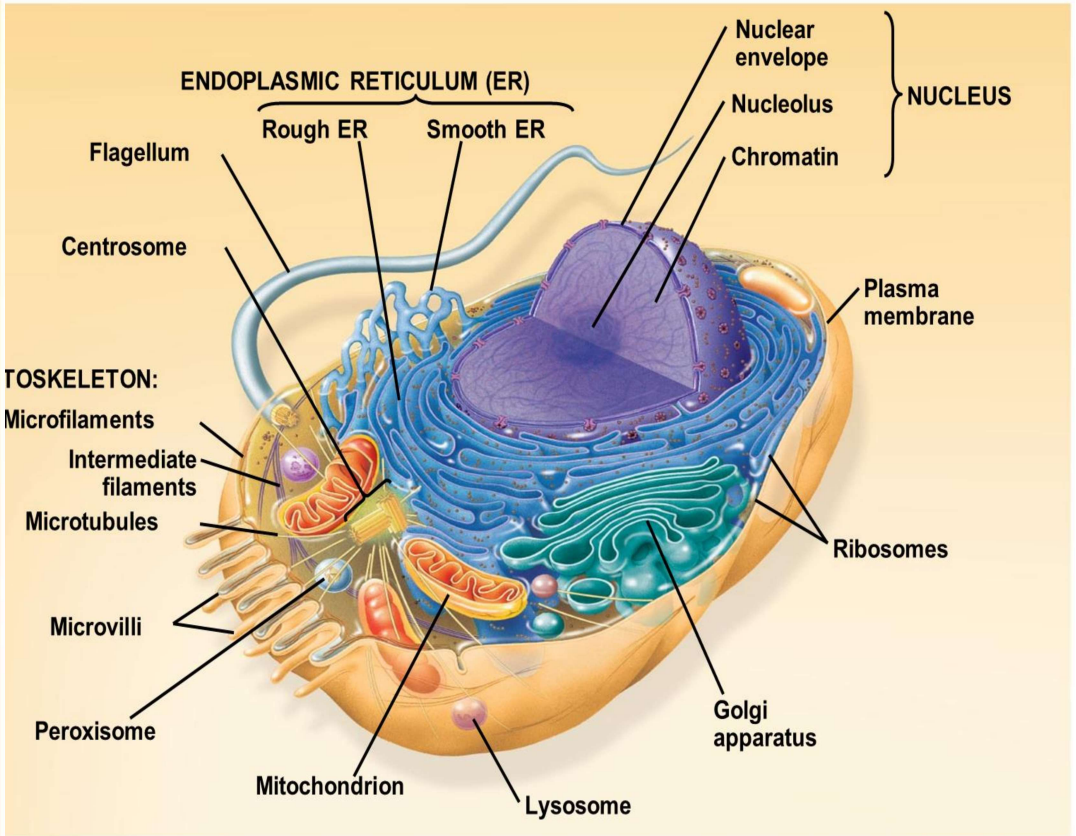
Summary of the Cell organelle

	Cell Component	Structure	Function
	Lysosome 	Membranous sac of hydrolytic enzymes (in animal cells)	Breakdown of ingested sub-stances cell macromolecules, and damaged organelles for recycling
	Vacuole 	Large membrane-bounded vesicle in plants	Digestion, storage, waste disposal, water balance, cell growth, and protection
Concept 6.5 Mitochondria and chloro-plasts change energy from one form to another	Mitochondrion 	Bounded by double membrane; inner membrane has infoldings (cristae)	Cellular respiration
	Chloroplast 	Typically two membranes around fluid stroma, which contains membranous thylakoids stacked into grana (in plants)	Photosynthesis
	Peroxisome 	Specialized metabolic compartment bounded by a single membrane	Contains enzymes that transfer hydrogen to water, producing hydrogen peroxide (H_2O_2) as a by-product, which is converted to water by other enzymes in the peroxisome

Plant and Animal Cells



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Plant Cell VS Animal cell

CELL Organelles	Plant Cell	Animal Cell
Cell Wall	Made of cellulose is present in almost all cells.	absent.
Plastids	Plastids like leucoplasts, chloroplast and chromoplasts are present.	No plastids found.
Chloroplasts	Plants cells have chloroplasts to prepare their own food.	Chloroplasts completely absent.
Vacuoles	Cell sap containing vacuoles are present.	usually absent or one or more small vacuoles are seen.
Lysosomes	Lysosomes not evident.	Lysosomes occur in cytoplasm.
Nucleus	nucleus may be located at the edge of the cell.	Usually located centrally.
Golgi bodies	Plant cells have many simpler units of golgi complex, called dictyosomes.	Animal cells have a single highly elaborate golgi complex.

Plant Cell VS Animal cell

CELL ORGANELLES	Plant Cell	Animal Cell
Centrioles	Present only in lower plant forms.	Present
Flagella	May be found in some cells.	May be found in some cells.
Cilia	Very rare	Present
Cell shape and structure	Rigid, fixes rectangular shape.	Lack rigidity, are round and irregular shape.
Starch grains	Present	Are not present.

REFERENCES

- **Campbell Biology**, 12th Edition, Author(s): Lis

- a A. Urry, Micheal L.Cain, Steven A. Wasserman, Peter V. Minorsky, Rebecca B. Orr, Neil A. Campbell, Publisher: Pearson, Year: 2020, ISBN: 9780135988046; 0135988047

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General Biology

Lecture (3): Genetics

College of Applied Sciences
Biology Department

Outline

- **Introduction into Genetics**
- **The Molecular Basis of Inheritance**
  - The Components of Nucleic Acids
  - The Structures of DNA and RNA Molecules
- **The Chromosomal Basis of Inheritance**
  - Chromosome Theory
  - Inheritance of Genes
- **The Flow of Genetic Information**

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1. Introduction into Genetics

College of Applied Sciences
Biology Department

Overview: Variations on a Theme

- Living organisms are distinguished by their ability to reproduce their own kind.
- **Genetics** is the scientific study of heredity and variation.
- **Heredity** is the transmission of traits from one generation to the next.
- **Variation** is demonstrated by the differences in appearance that offspring show from parents and siblings.

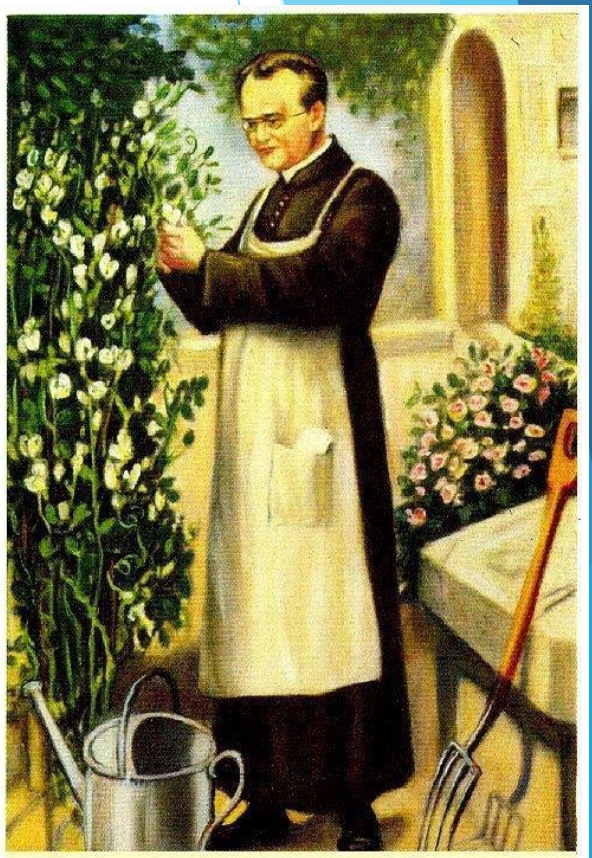
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2.The Molecular Basis of Inheritance

College of Applied Sciences
Biology Department

Mendel used the scientific approach to identify two laws of inheritance

- The "particulate" hypothesis is the idea that parents pass on discrete heritable units (genes)
- Mendel documented a particulate mechanism through his experiments with garden peas.
- Mendel discovered the basic principles of heredity by breeding garden peas in carefully planned experiments.



GREGOR MENDEL

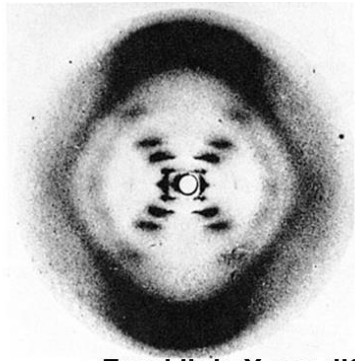
Overview: Life's Operating Instructions

- In 1953, James Watson and Francis Crick shook the world With an elegant double-helical model for the structure of deoxyribonucleic acid, or DNA.
- Watson and Crick deduced that DNA was a double helix, through observations of the X-ray crystallographic images of DNA
- The role of DNA in heredity worked out by studying bacteria and the viruses that infect them.
- DNA, the substance of inheritance and the most celebrated molecule of our time.





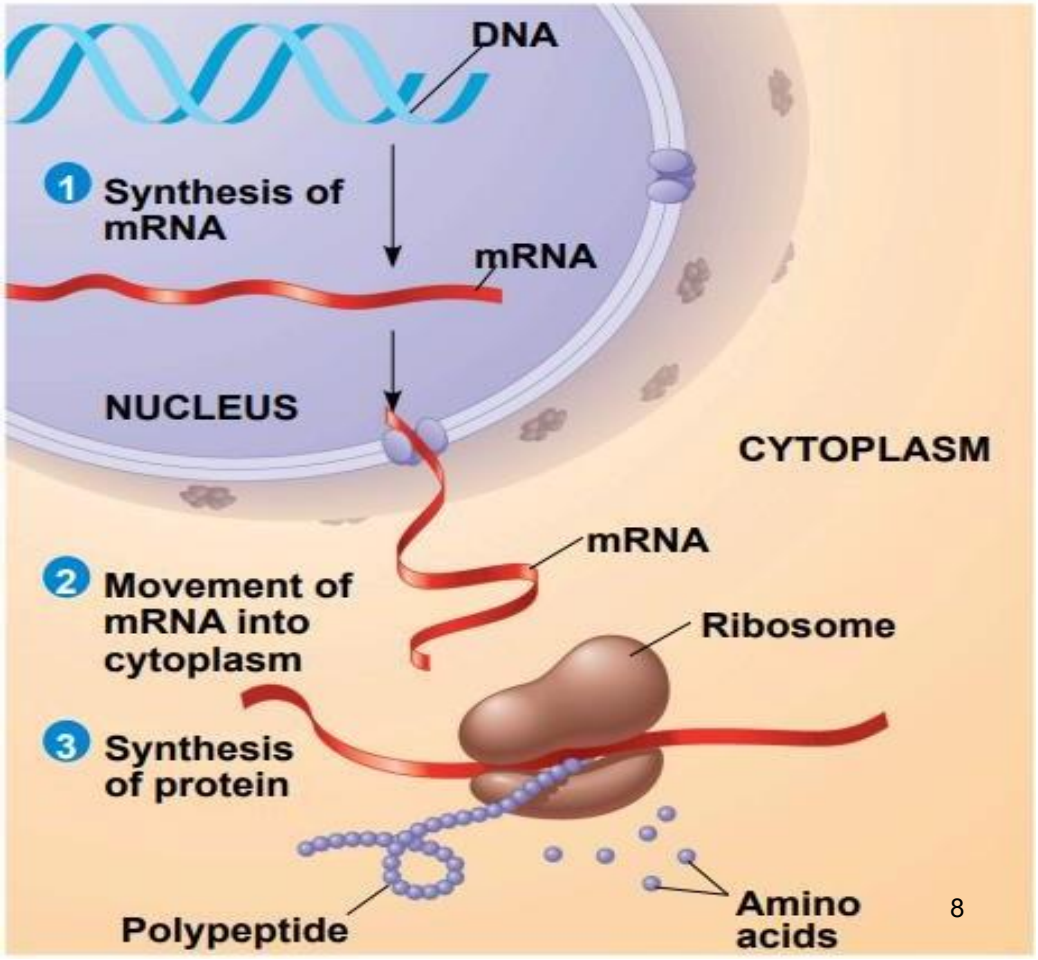
(a) Rosalind Franklin



(b) Franklin's X-ray diff Photograph of DNA

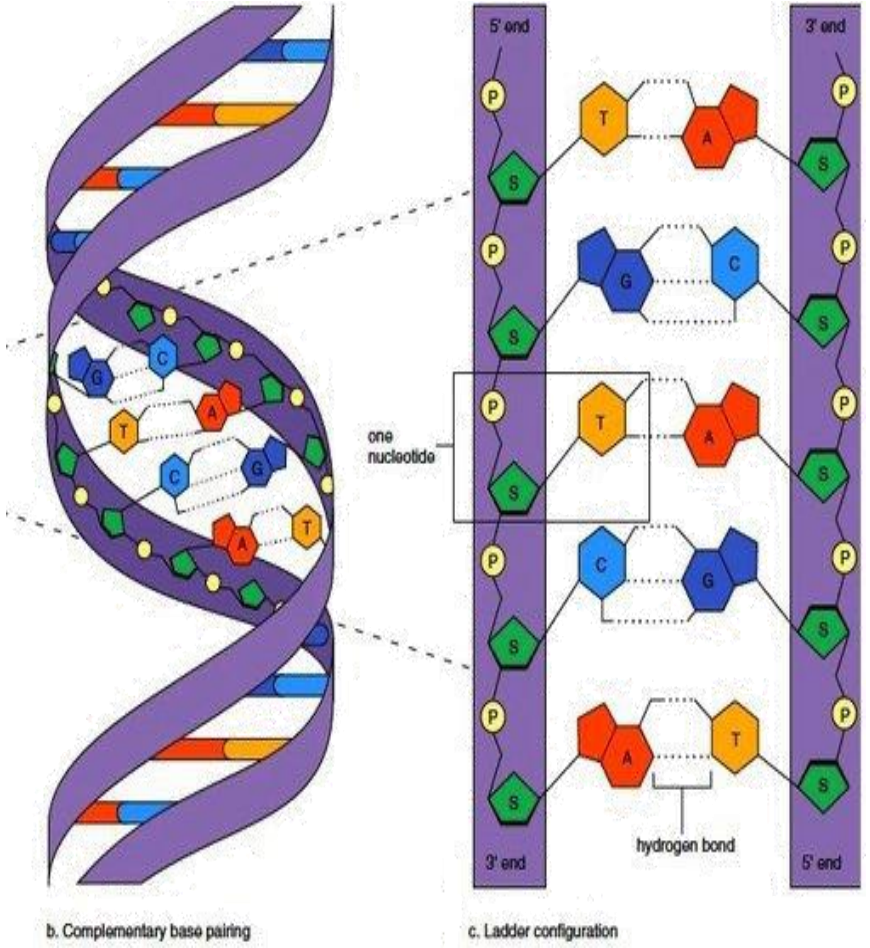
Nucleic acids store, transmit, and express hereditary information

- The amino acid sequence of a polypeptide is programmed by a unit of inheritance called a gene.
- Genes are made of DNA, a nucleic acid made of monomers called nucleotides .
- There are two types of nucleic acids:
  - Deoxyribonucleic acid (DNA)
  - Ribonucleic acid (RNA)
- DNA provides directions for its own replication.
- DNA directs synthesis of messenger RNA (mRNA) and, through mRNA, controls protein synthesis.
- Protein synthesis occurs on ribosomes.

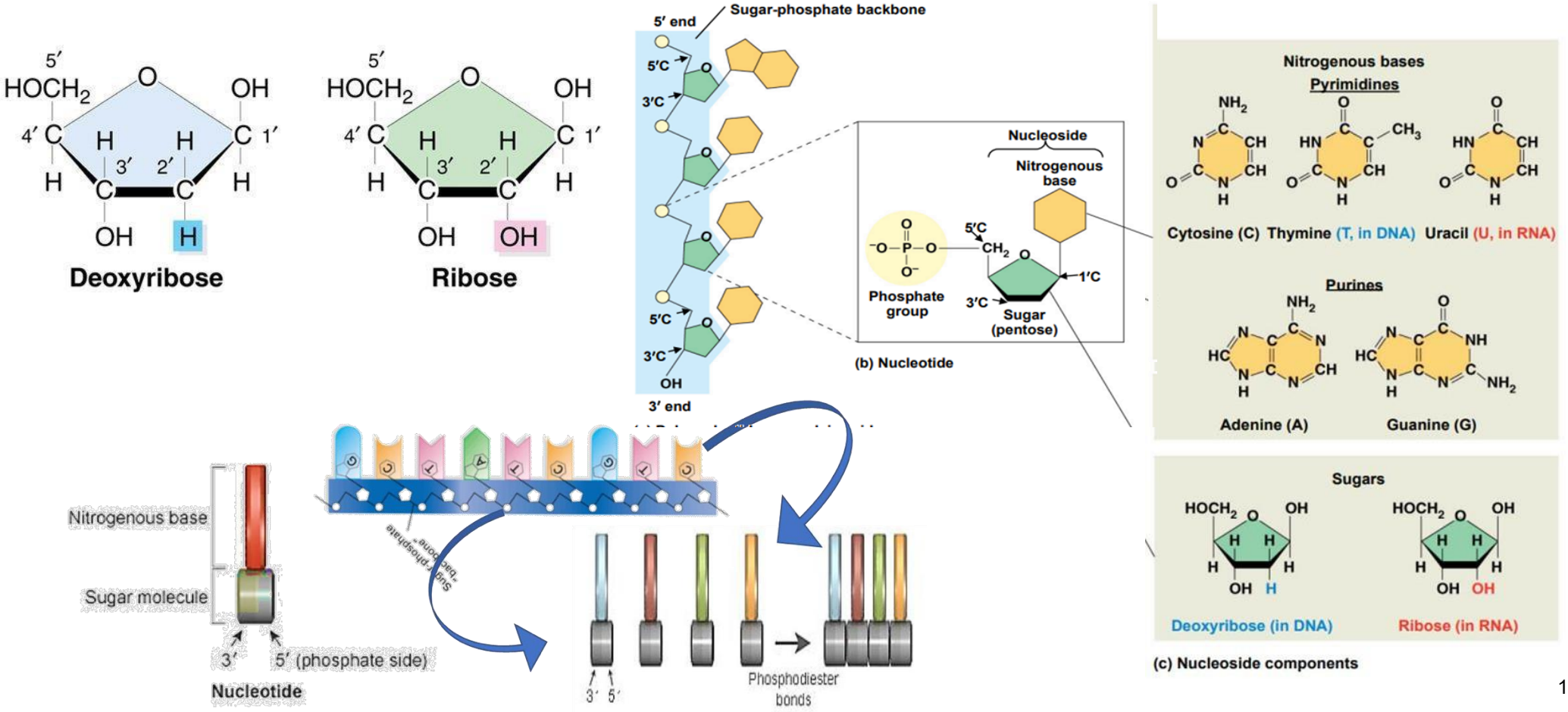


The Components of Nucleic Acids

- Nucleic acids are polymers called polynucleotides.
- Each polynucleotide is made of monomers called nucleotides.
- Each nucleotide consists of a nitrogenous base, a pentose sugar, and one or more phosphate groups.
- There are two families of nitrogenous bases
  - Pyrimidines (cytosine, thymine, and uracil)
  - Purines (adenine and guanine).
- In the DNA double helix, the two backbones run in opposite 5' to 3' directions from each other, an arrangement referred to as antiparallel.
- The nitrogenous bases in DNA pair up and form hydrogen bonds: adenine (A) always with thymine (T), and guanine (G) always with cytosine (C). Called complementary base pairing.



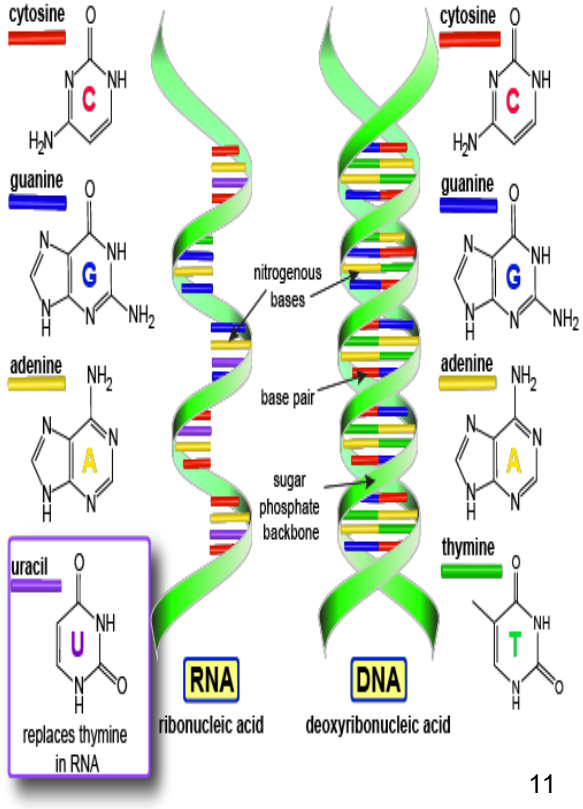
The Structures of DNA and RNA Molecules



The Structures of DNA and RNA Molecules

- RNA is slightly different from DNA in the following aspects

	DNA (Deoxyribonucleic acid)	RNA (Ribonucleic acid)
Location	Nucleus and mitochondria, chloroplast.	Nucleus and cytoplasm,
Structure	Double strand helix.	Single-strand helix.
Sugar	It contains Deoxyribose.	It contains Ribose.
Nitrogenous Bases	AT (adenine-thymine). GC (guanine-cytosine).	AU (adenine-uracil). GC (guanine-cytosine).
Length	Long with high molecular mass.	Short with low molecular mass.
Propagation	DNA is self-replicating.	RNA is synthesized from DNA.
Function	storage and transmission of genetic information.	Transfers genetic code for protein synthesis.
Type	_____	(tRNA), (rRNA), (mRNA),(snRNA)



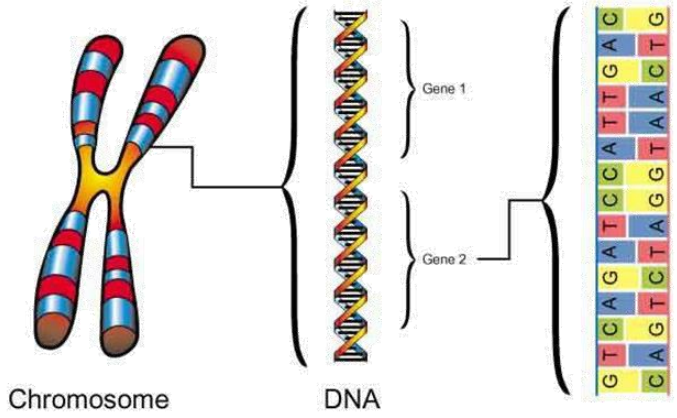
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3. The Chromosomal Basis of Inheritance

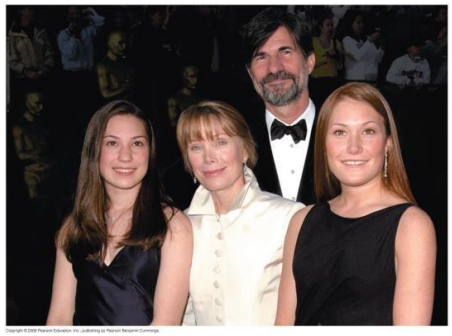
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Inheritance of Genes

- In a literal sense, children do not inherit particular physical traits from their parents.
- It is **genes** that are actually inherited.
- **Genes** are the units of heredity, and are made up of segments of DNA.
- **Genes** are passed to the next generation through reproductive cells called **gametes** (sperm and eggs).
- Each gene has a specific location called a **locus** on a certain chromosome.
- One set of chromosomes is inherited from each parent.
- Most DNA is packaged into chromosomes.

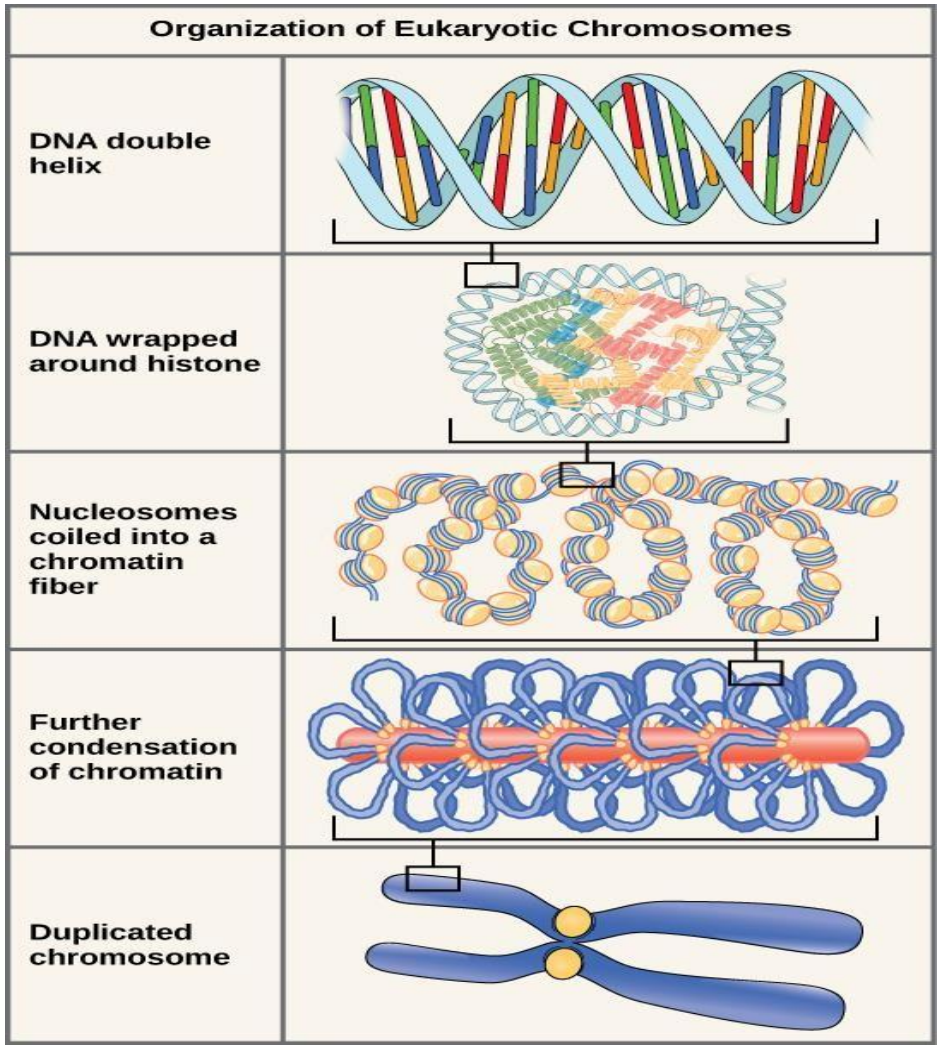


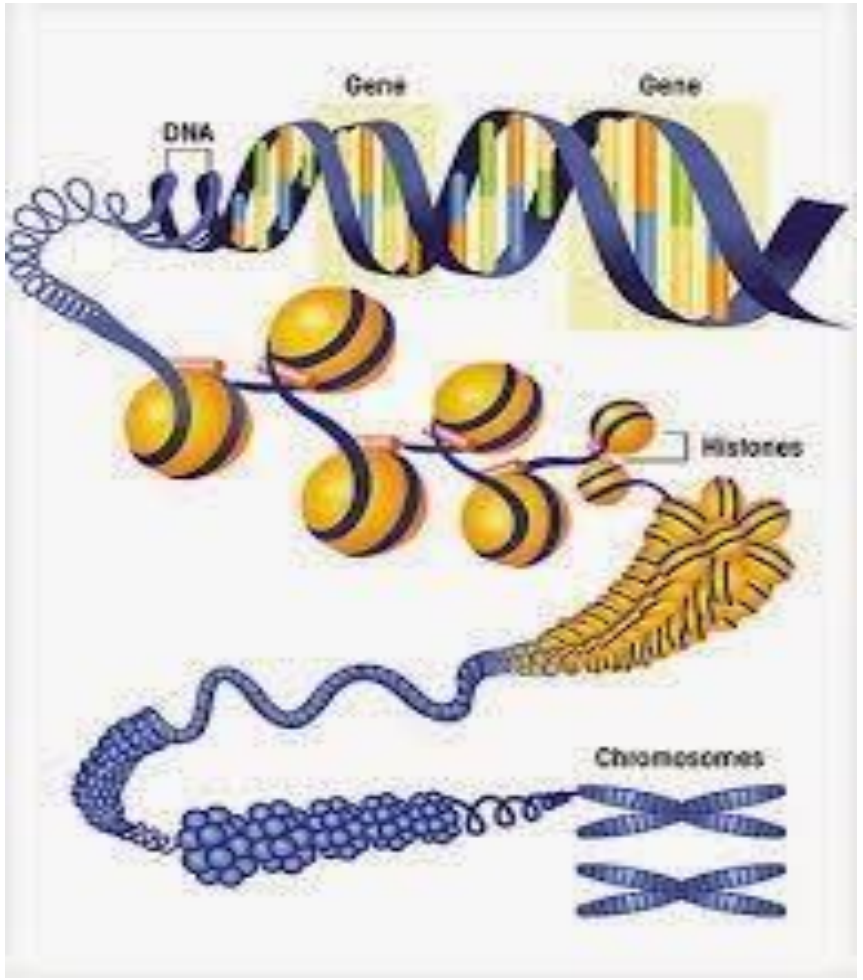
Genes



Offspring acquire genes from parents by inheriting chromosomes

DNA Packaging and Organization into Chromosomes





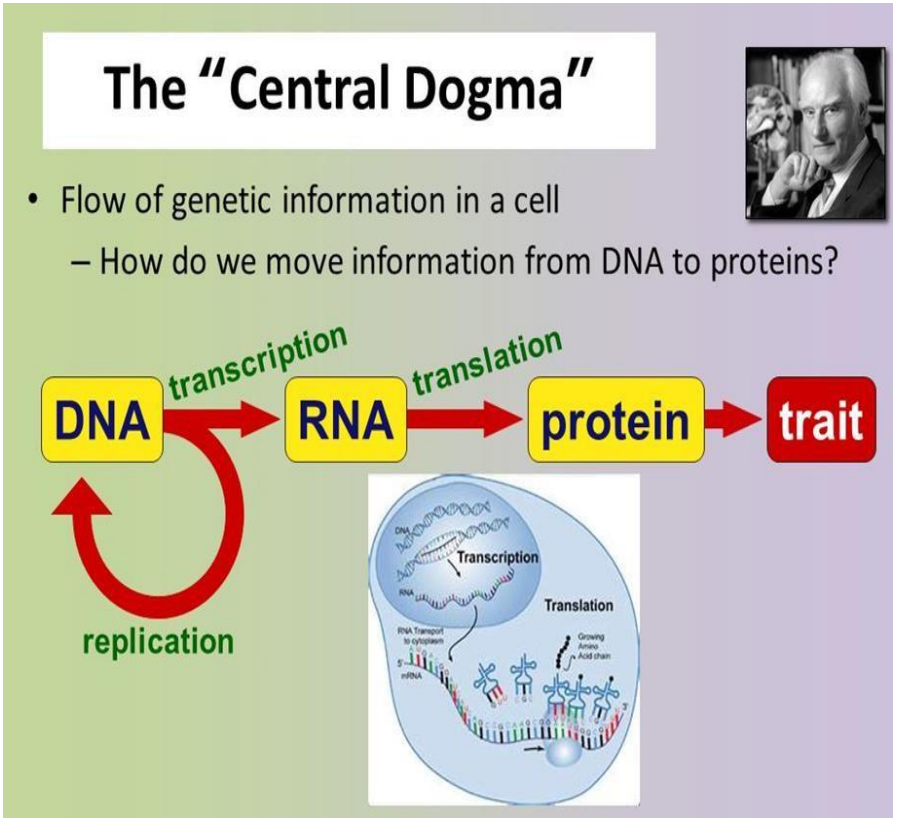
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4. The Flow of Genetic Information

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Biology Department

Overview: The Flow of Genetic Information

- **The information content of DNA** is in the form of specific sequences of nucleotides along the DNA strands.
- **The DNA inherited by an organism** leads to specific traits by dictating the synthesis of proteins.
- Cells are governed by a cellular chain of command
  DNA → RNA → protein
- The process by which DNA directs protein synthesis, called **gene expression** includes two stages, called **transcription and translation.**
- Protein are complex molecules, polypeptide are folded, and combined with other polypeptides to form a protein.



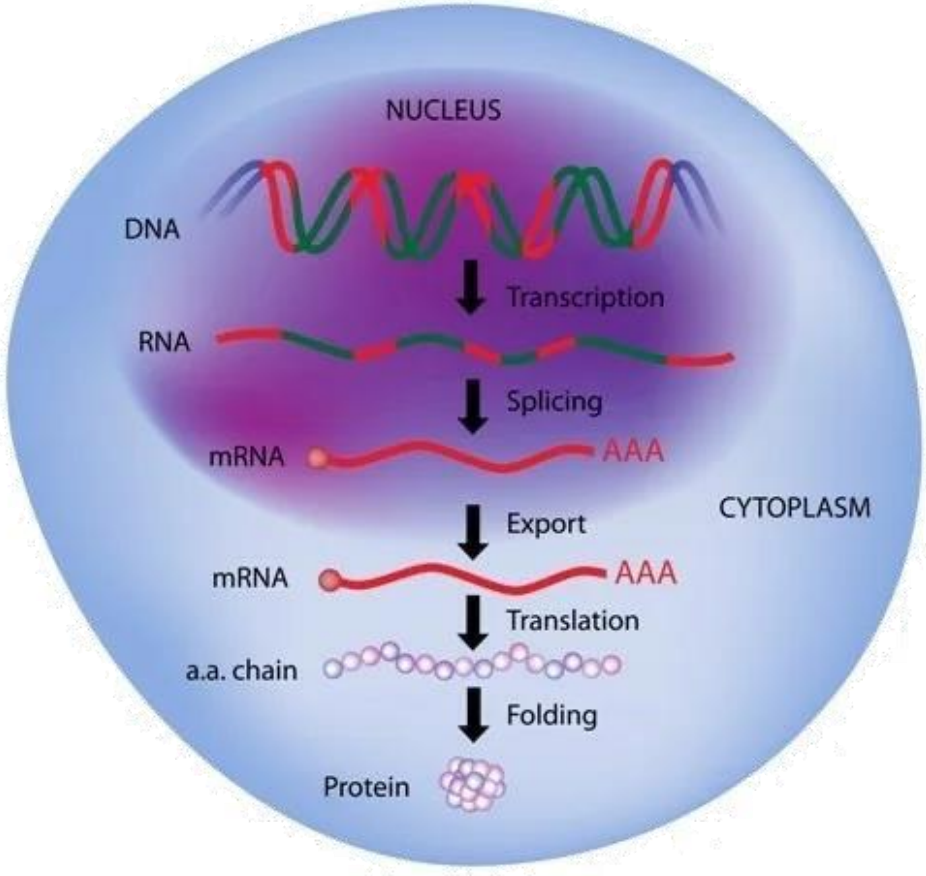
Basic Principles of Transcription and Translation

➢ Transcription:

- The first step in gene expression. It involves copying a gene's DNA sequence to make an **RNA** molecule.

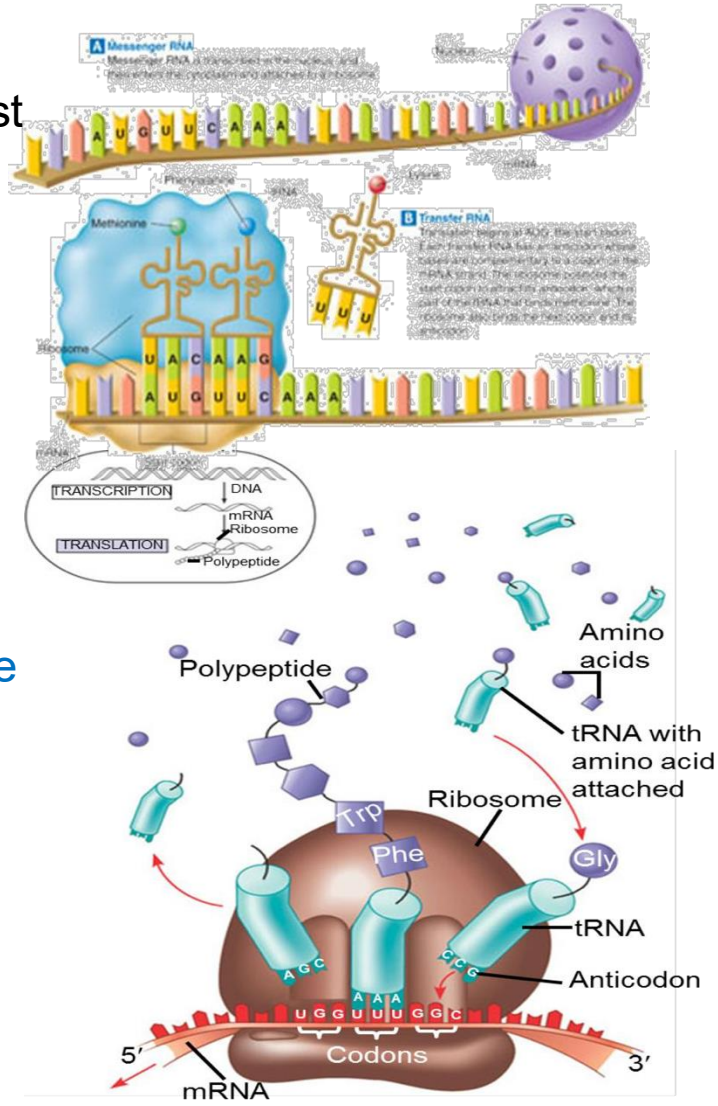
- The main enzyme involved in transcription is **RNA polymerase**, which uses a single-stranded DNA **template** to **synthesize** a **complementary strand** of **RNA**.

- **RNA polymerase** builds an **RNA** strand in the **5'** to **3'** direction by adding each **new nucleotide** to the **3' end** of the strand.



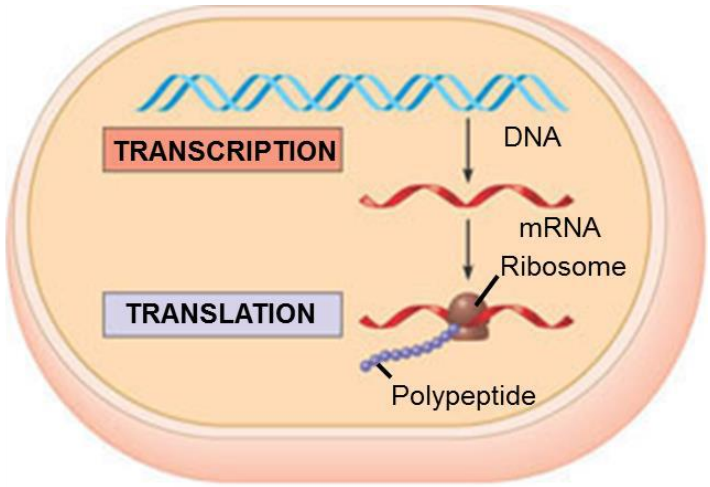
Basic Principles of Transcription and Translation

- **Translation:**
- Once the DNA has been transcribed to mRNA, the codons must be translated to the amino acid sequence of the protein.
- Protein is constructed in the cytoplasm.
- Three steps of translation:
  - Initiation: mRNA is binding with subunit of ribosome and aminoacyl-tRNA.
  - Elongation: Ribosome moves along mRNA, making polypeptide chain and extending protein.
  - Termination: Polypeptide chain is released from tRNA, and ribosome dissociates from mRNA.



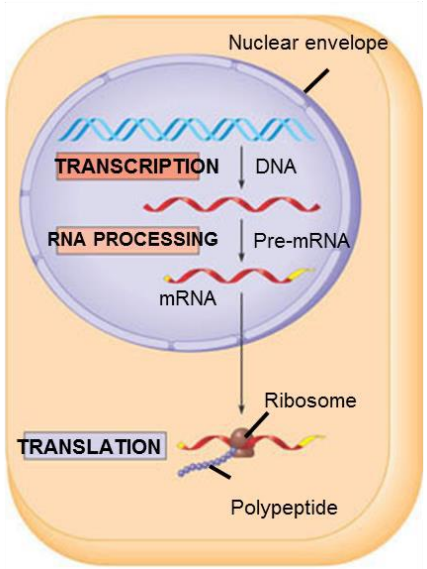
Transcription and Translation in Prokaryotes and Eukaryotes

- **In prokaryotes:**
  - Transcription and translation occur together.



(a) **Prokaryotic cell.** In a cell lacking a nucleus, mRNA produced by transcription is immediately translated without additional processing.

- **In eukaryotes:**
  - RNA transcripts are modified before becoming true mRNA



(b) **Eukaryotic cell.** The nucleus provides a separate compartment for transcription. The original RNA transcript, called pre-mRNA, is processed in various ways before leaving the nucleus as mRNA.

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- **Campbell Biology**, 12th Edition, Author(s): Lisa A. Urry, Micheal L.Cain, Steven A. Wasserman, Peter V. Minorsky, Rebecca B. Orr, Neil A. Campbell, Publisher: Pearson, Year: 2020, ISBN: 9780135988046; 0135988047.
- 1- Cell cycle https://www.youtube.com/watch?v=QVCjdNxJreE&t=279s
- 2- Mitosis https://youtu.be/7NM-UWFHG18
- 3- Meiosis https://youtu.be/jjEcHra3484
- 4- Mitosis vs. Meiosis: Side by Side Comparison https://youtu.be/zrKdz93WlVk
- 5-Mendel's experiment (monohybrid cross) | https://youtu.be/wQltEeAPtIk
- Laws of Genetics - Lesson 5 | Don't Memorise https://youtu.be/mD0Onu2ArGA
- 6- DNA transcript and translate https://www.youtube.com/watch?v=8_f-8ISZ164&t=330s
- 7- LAC operon https://youtu.be/JcKxOj6YZu4

Biological Diversity of Life Forms

– Introduction

– History of Classification

– Diversity of Life Forms: the three domains of life

Biological Diversity (Biodiversity)

Biodiversity refers to all of the variety of life that exists on Earth



Need for Classification

- People have been trying to classify the tremendous diversity of life on Earth for more than two thousand years
  - **Classification** is the process of **arranging organisms** into groups based on similar characteristics
  - **Taxonomy** is the science of **naming and classifying** organisms
  - **Systematics** **classifies** organisms and **determines their evolutionary relationships**. Systematists use fossil, molecular, and genetic data to infer evolutionary relationships.
- Classification is an important step in understanding the present diversity and past evolutionary history of life on Earth. It helps make sense of the overwhelming diversity of living things

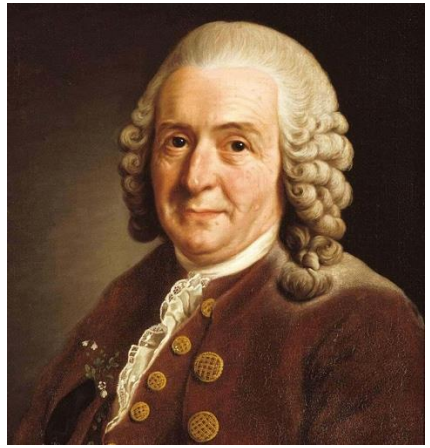
History of Classification

Linnaean Classification

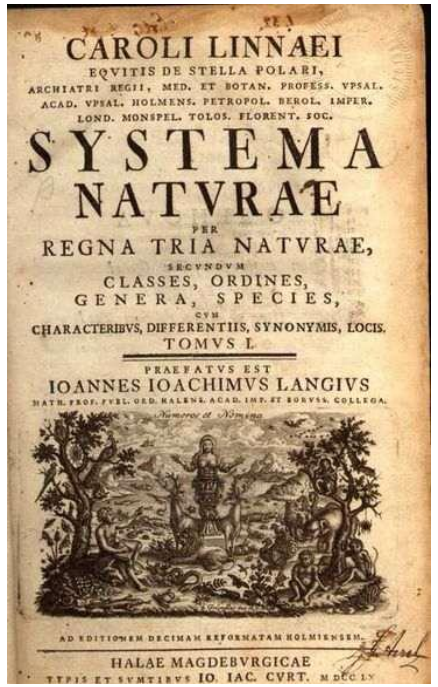
Phylogenetic Classification

1. Linnaean Classification

- All modern classification systems have their roots in the Linnaean classification system



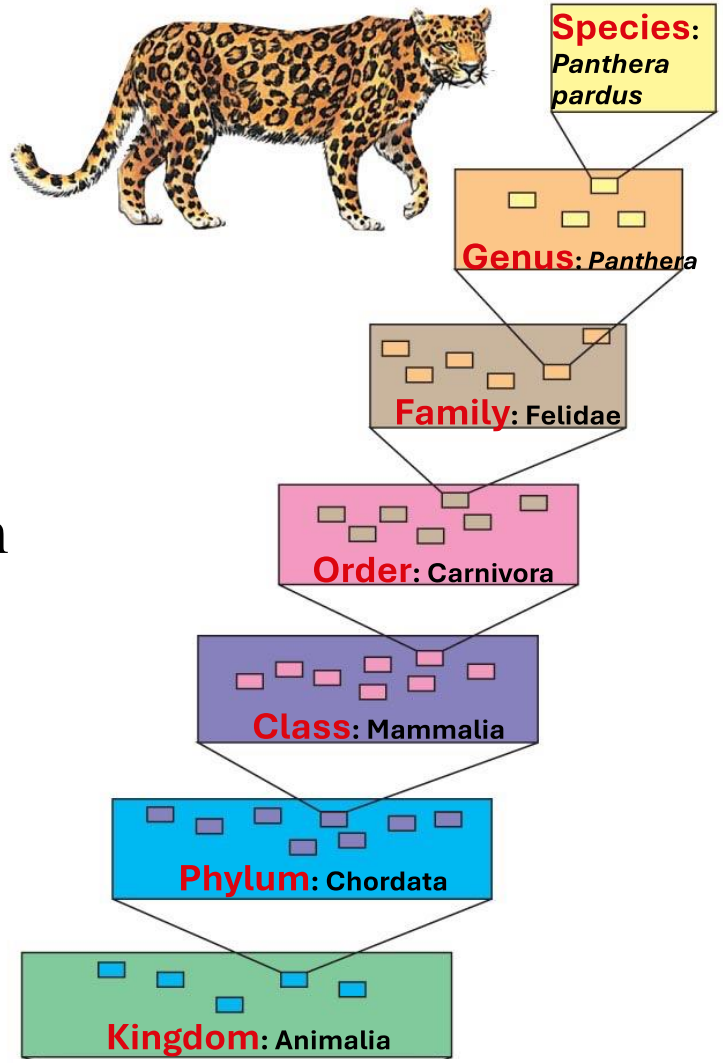
- It was developed by Swedish botanist Carolus Linnaeus in the 18th century. He published a system of taxonomy based on resemblances



- He tried to classify all living things that were known at his time. He **grouped together organisms that shared obvious morphological traits**, such as the number of legs or shape of leaves

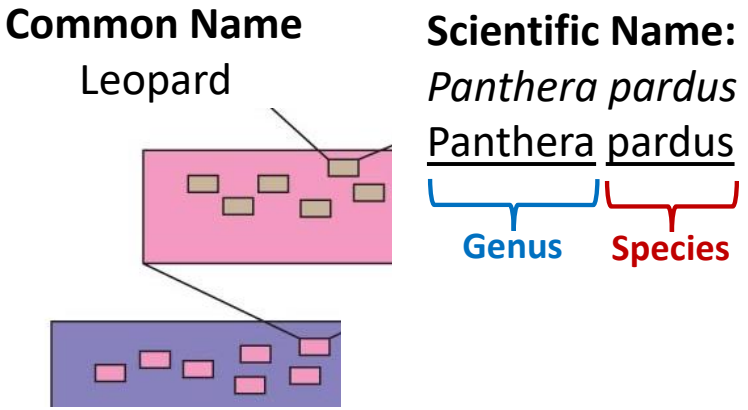
1. Linnaean Classification: Hierarchical Classification

- Linnaeus introduced a **system for grouping** species in increasingly broad categories **based on morphology** (organisms were grouped together if they looked alike)
- The taxonomic groups **from broad to narrow** are kingdom, phylum, class, order, family, genus, and species
  - The kingdom is the largest and most inclusive grouping which consists of organisms that share just a few basic similarities
  - The species is the smallest and most exclusive grouping which consists of organisms that are similar enough to interbreed
- A taxonomic unit at any level of hierarchy is called a taxon



1. Linnaean Classification: Binomial Nomenclature

- Perhaps the single greatest contribution Linnaeus made to science was his method of naming species called **binomial nomenclature**
- Binomial nomenclature gives each species a unique, **two-word Latin** name consisting of the **genus name followed by a specific species identifier**. The first letter of the genus is capitalized, and the entire species name is italicized
- Using scientific names helps scientists **avoid the confusion** that can arise when referring to an organism by its common, or everyday, name



1. Linnaean Classification: Revisions (The Domain)

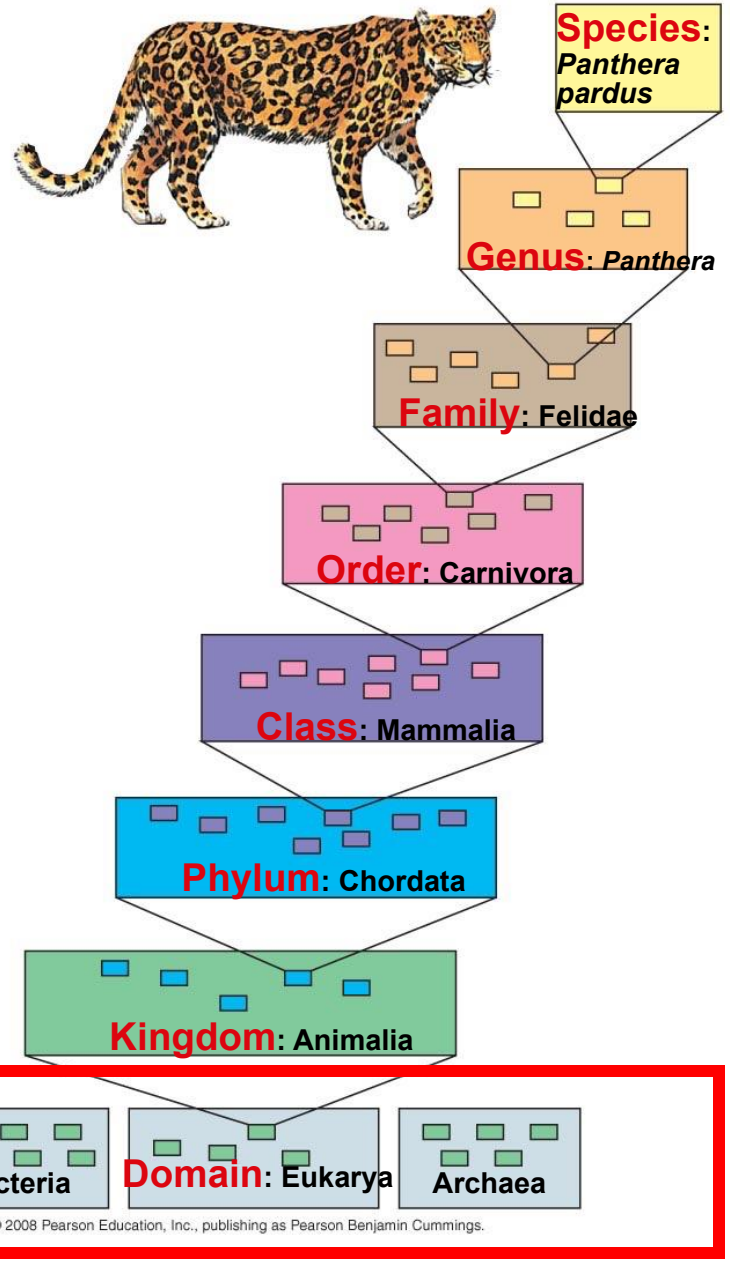
- Many changes have led to **revisions** in the original Linnaean system of classification since Linnaeus published his classification system:
  1. Many **new species** have been discovered
  2. Scientists can also now classify organisms based on their **biochemical and genetic similarities and differences** rather than just their morphology
- A major change to the Linnaean system is the **addition of a new taxon called the domain**
- The domain is a taxon that is **larger and more inclusive** than the kingdom, which includes three domains of life on Earth: Bacteria, Archaea, and Eukarya

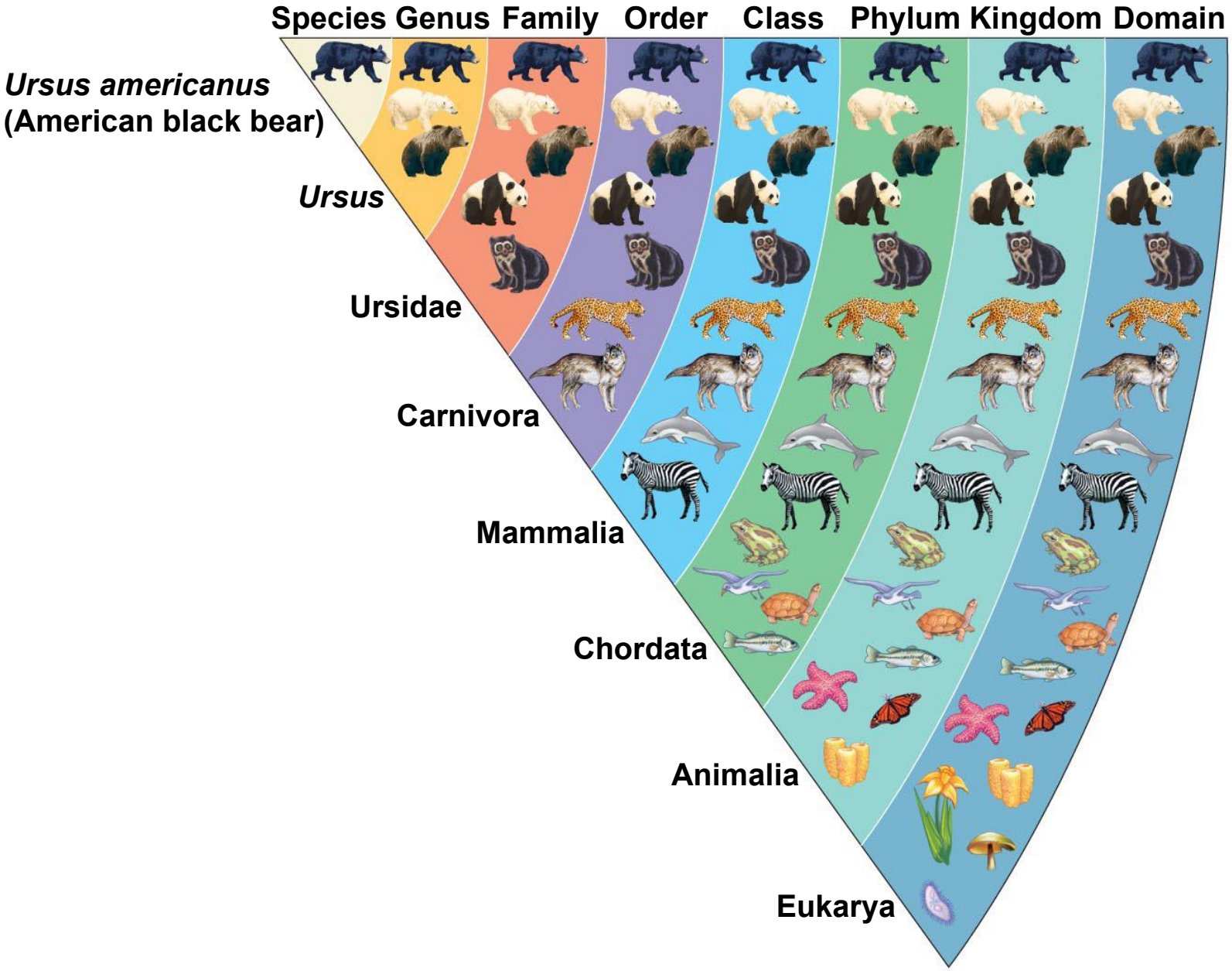
THREE DOMAINS
(Carl Woese, 1977)

ARCHAEA
(Extremophiles)
Methanogens, Halophiles, Thermoacidophiles

BACTERIA
Cyanobacteria & Eubacteria, beneficial& pathogenic

EUKARYA
(Eukaryotes)
Protista, Fungi, Plants and Animals

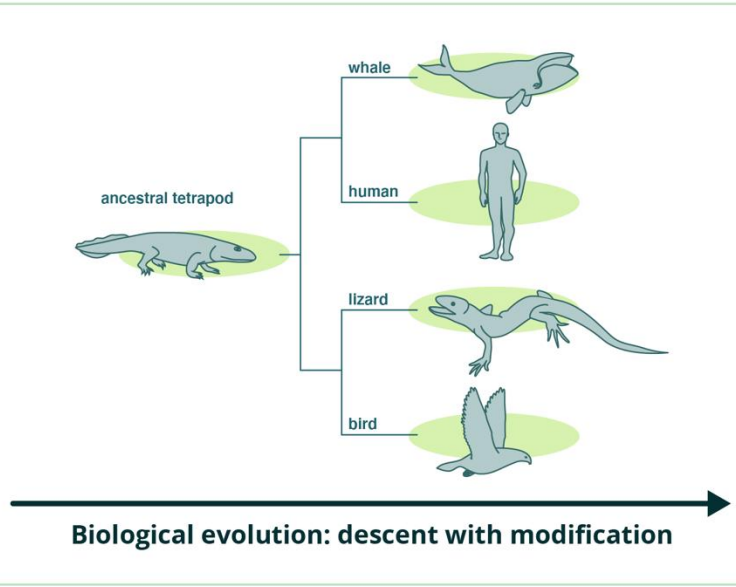



Species
Genus
Family
Order
Class
Phylum
Kingdom
Domain
Ursus americanus
(American black bear)
Ursus
Ursidae
Carnivora
Mammalia
Chordata
Animalia
Eukarya

2. Phylogenetic Classification

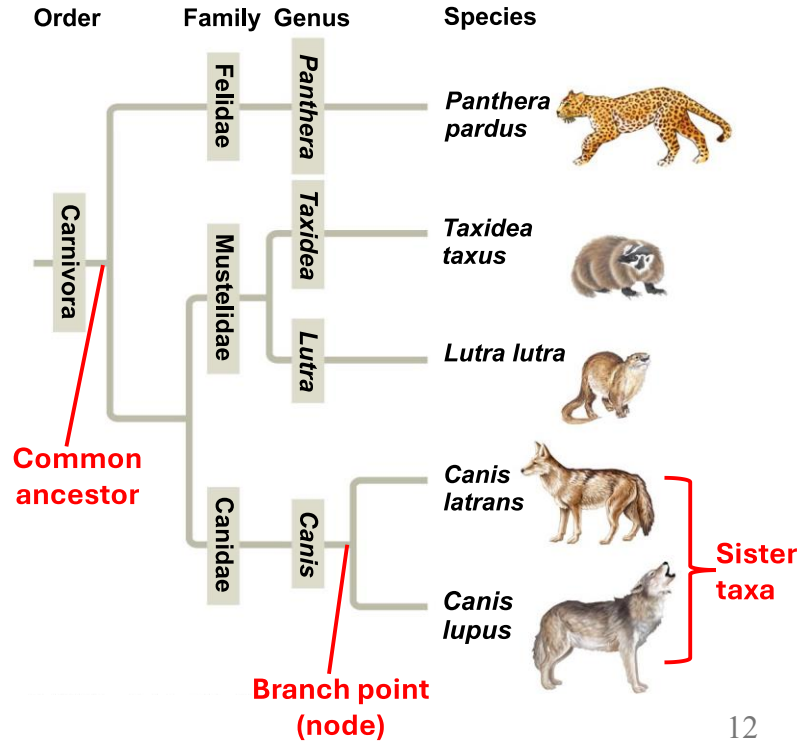
- After Darwin published his theory of evolution, scientists looked for a way to **classify organisms that took into account Phylogeny** (evolutionary relationships)
- According to Darwin's theory:
  - Evolution is descent with inherited modification
  - All life on Earth shares a common ancestor (just as you and your cousins share a common grandmother)
  - Through the process of evolution (descent with modification), this common ancestor gave rise to the diverse species that we see documented in the fossil record and around us today
  - Evolution means that we're all distant cousins: humans and oak trees, hummingbirds and whales





2. Phylogenetic Classification

- Phylogeny is the **evolutionary history** of a group of related organisms. It is represented by a phylogenetic tree
- A phylogenetic tree is a **diagram that represents evolutionary relationships** among organisms. You can interpret the degree of relationship between two organisms, and also map out the evolutionary history of life on Earth from common ancestors
- An Example: This phylogenetic tree (in your right) shows evolutionary relationships between some of the taxa within order Carnivora, itself a branch of class Mammalia. *Canis latrans* and *C. Lupus* are sister taxa that share a common ancestor. They are more related to each other than to *Lutra lutra*

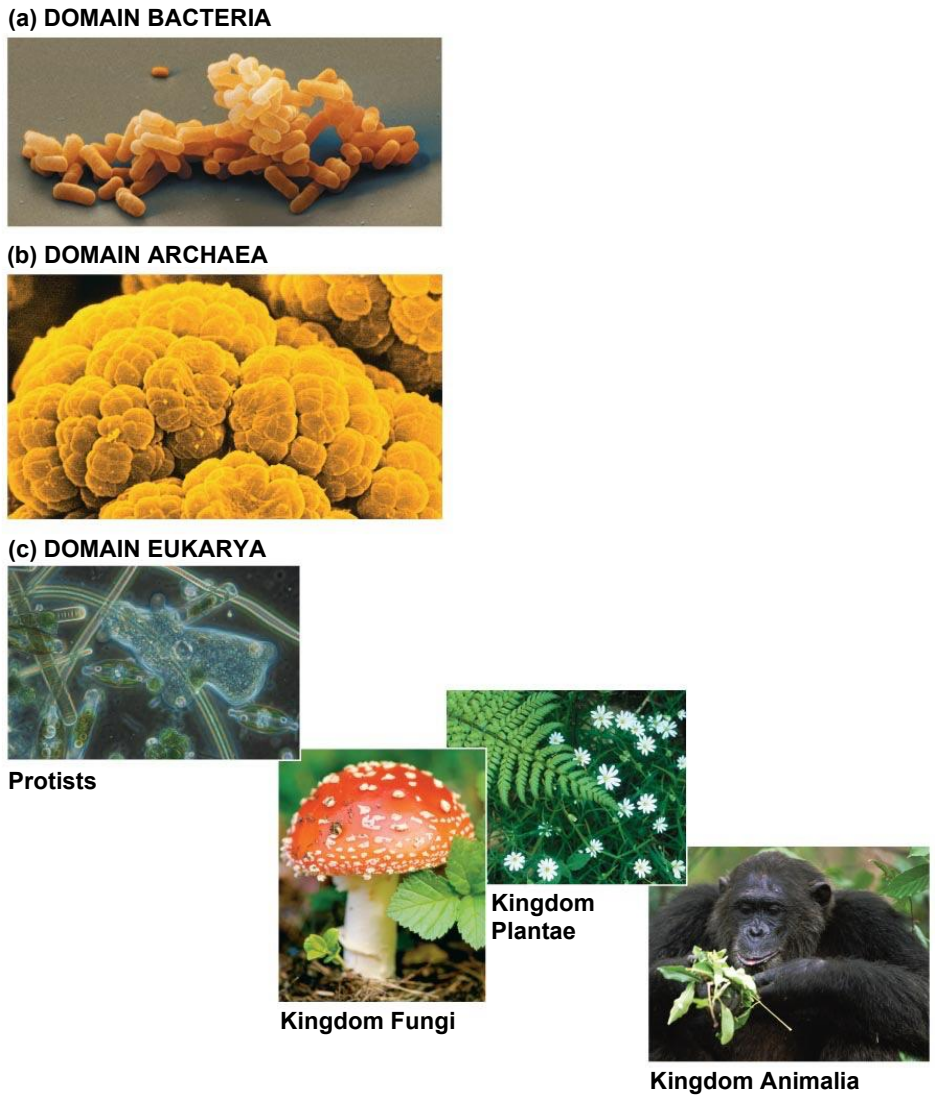


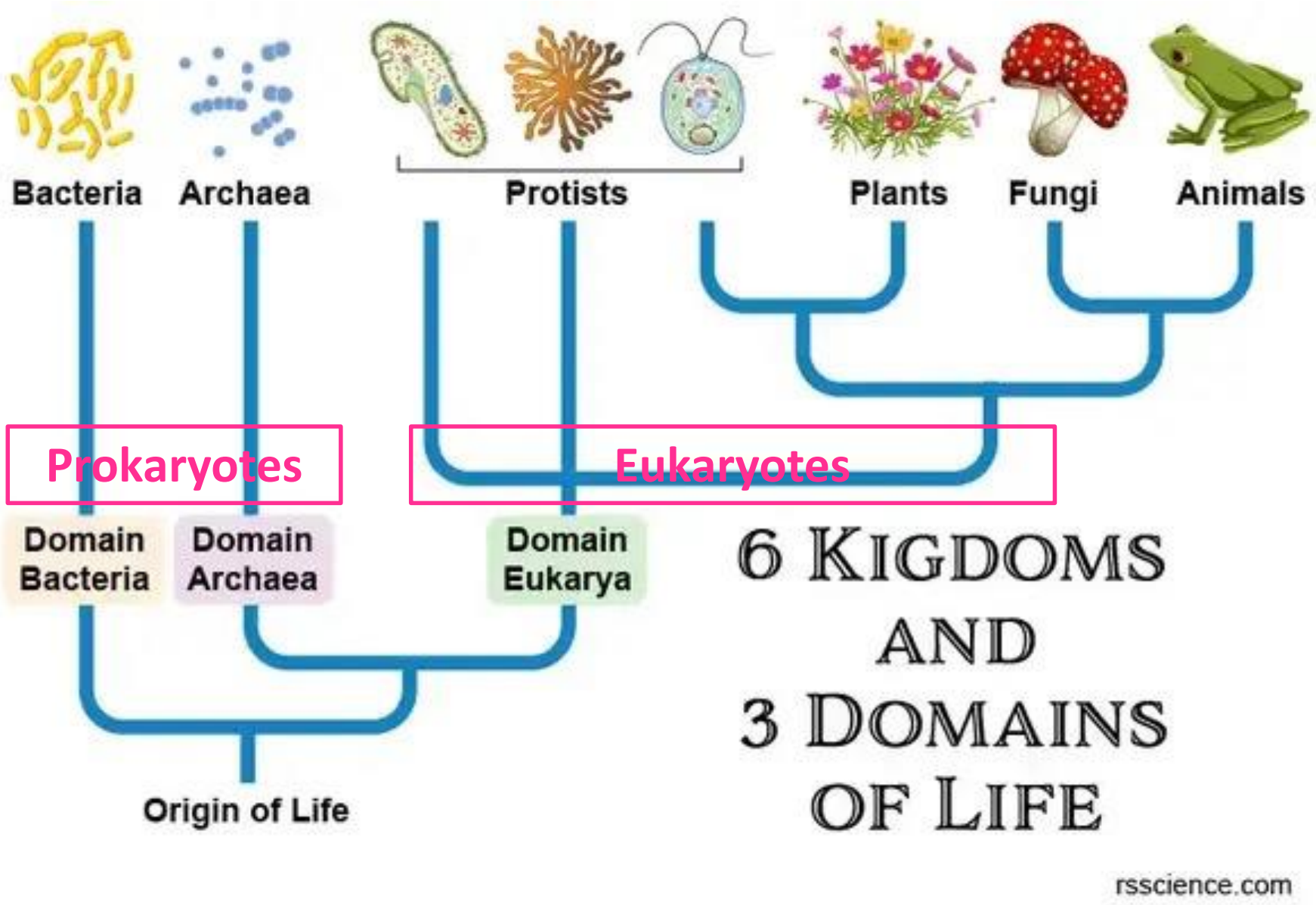
Diversity of Life Forms

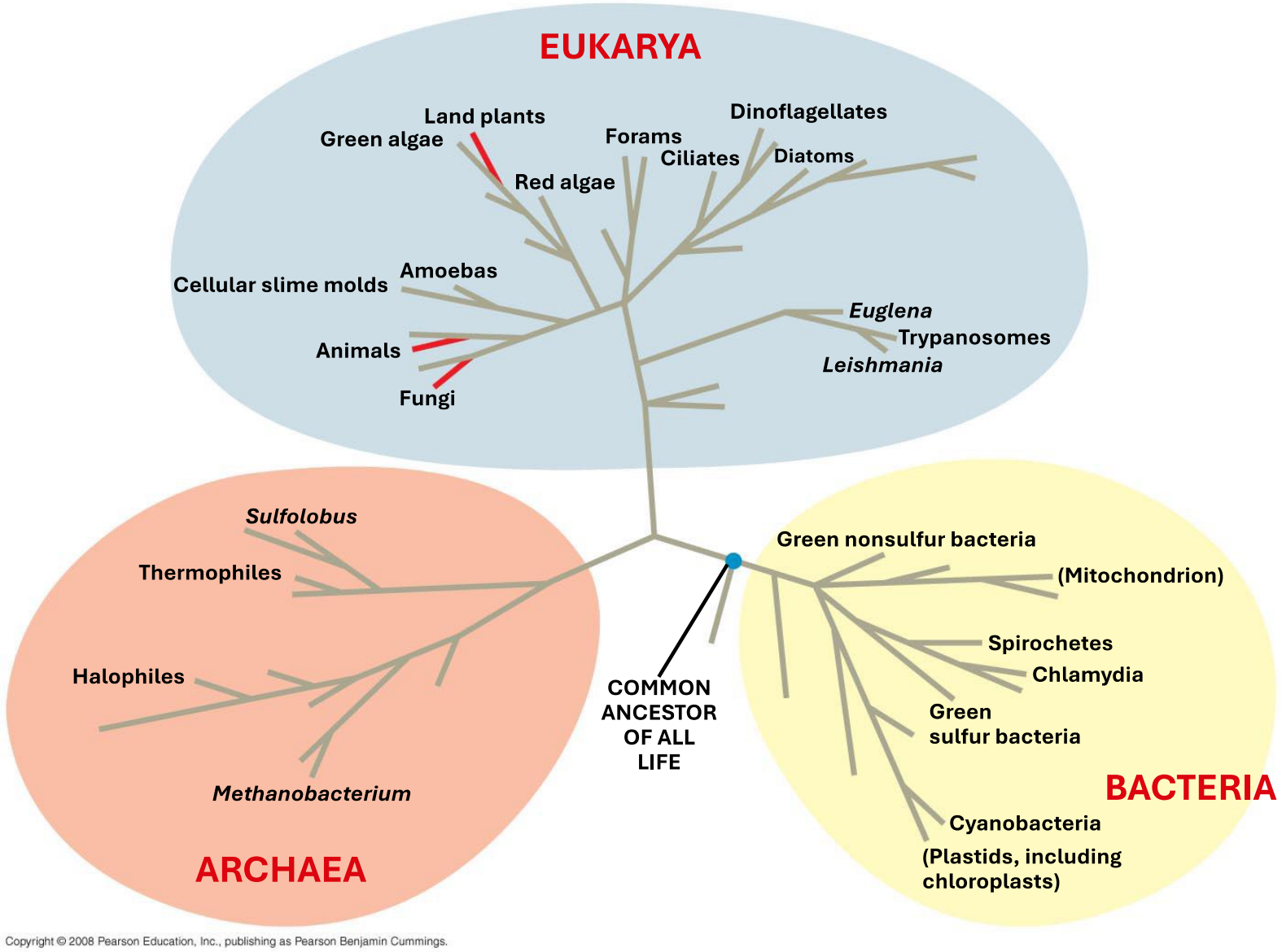
The Three Domains System

The Three Domains of Life

- Consequently, biologists have long used careful comparisons of structure, function, and other obvious features to classify forms of life into groups.
- In the last few decades, **new methods of assessing species relationships**, such as comparisons of DNA sequences, have led to a reevaluation of the classification of life
- The three-domain system is currently used:
  - **Domain Bacteria** and **domain Archaea** comprise the single-celled prokaryotes
  - **Domain Eukarya** includes all eukaryotic organisms. The Eukarya domain is made up of both single-celled and multicellular organisms This domain includes four subgroups: kingdom Plantae, kingdom Fungi, kingdom Animalia, and the protists




Bacteria
Archaea
Protists
Plants
Fungi
Animals
Prokaryotes
Eukaryotes
Domain Bacteria
Domain Archaea
Domain Eukarya
Origin of Life
6 KIGDOMS AND 3 DOMAINS OF LIFE
rsscience.com

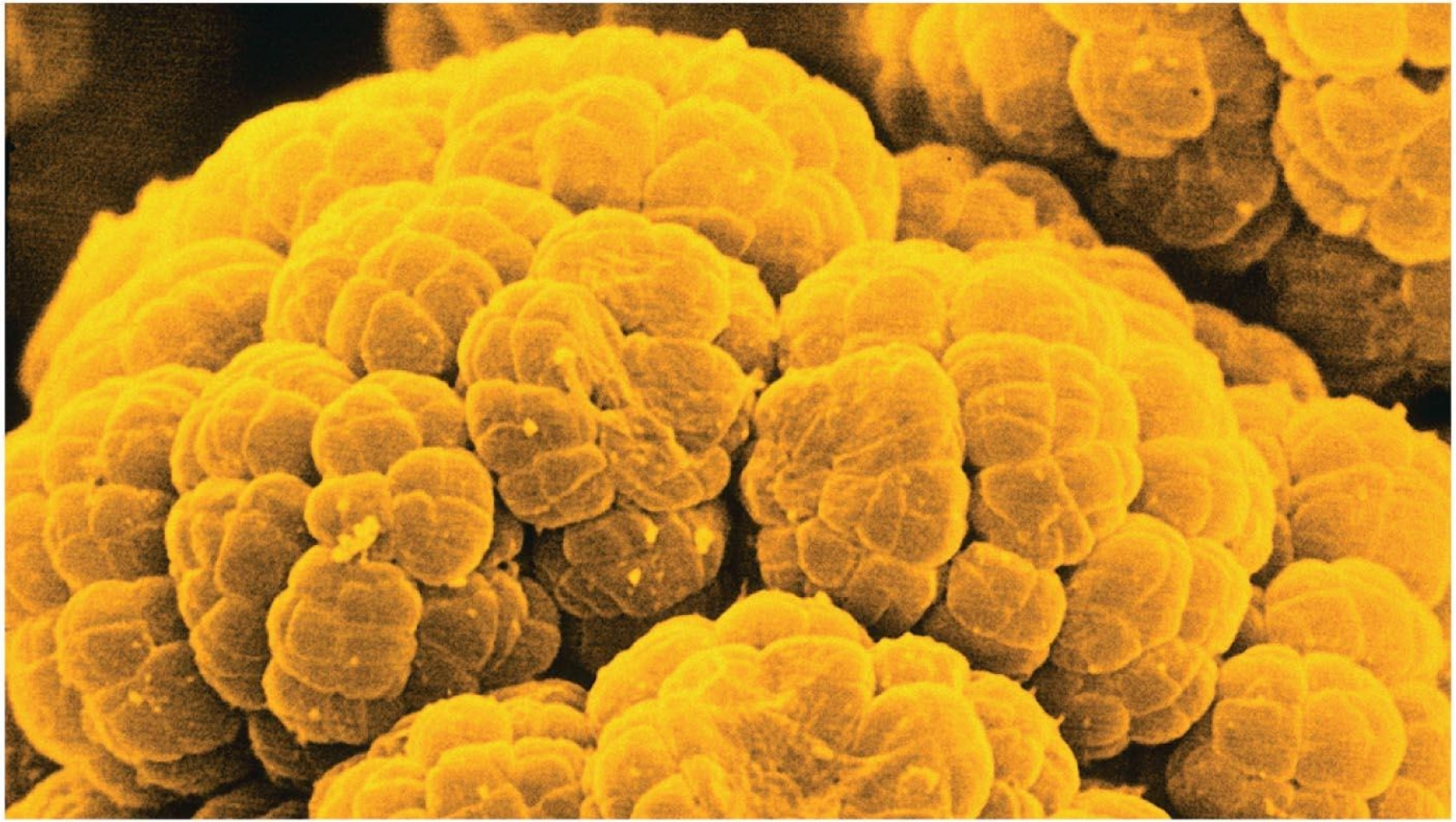


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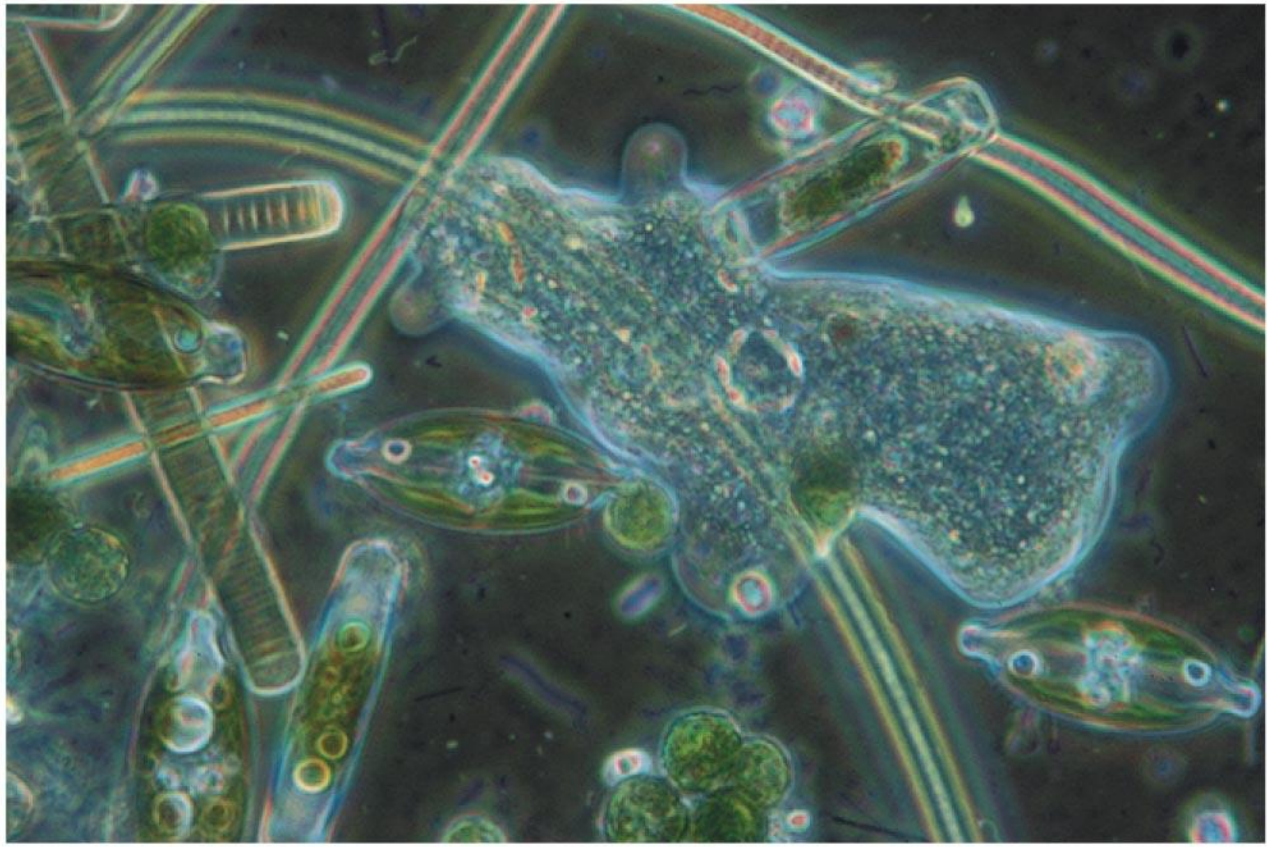
(a) DOMAIN BACTERIA .....Kingdom Bacteria

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(b) DOMAIN ARCHAEA…… Kingdom Archaea

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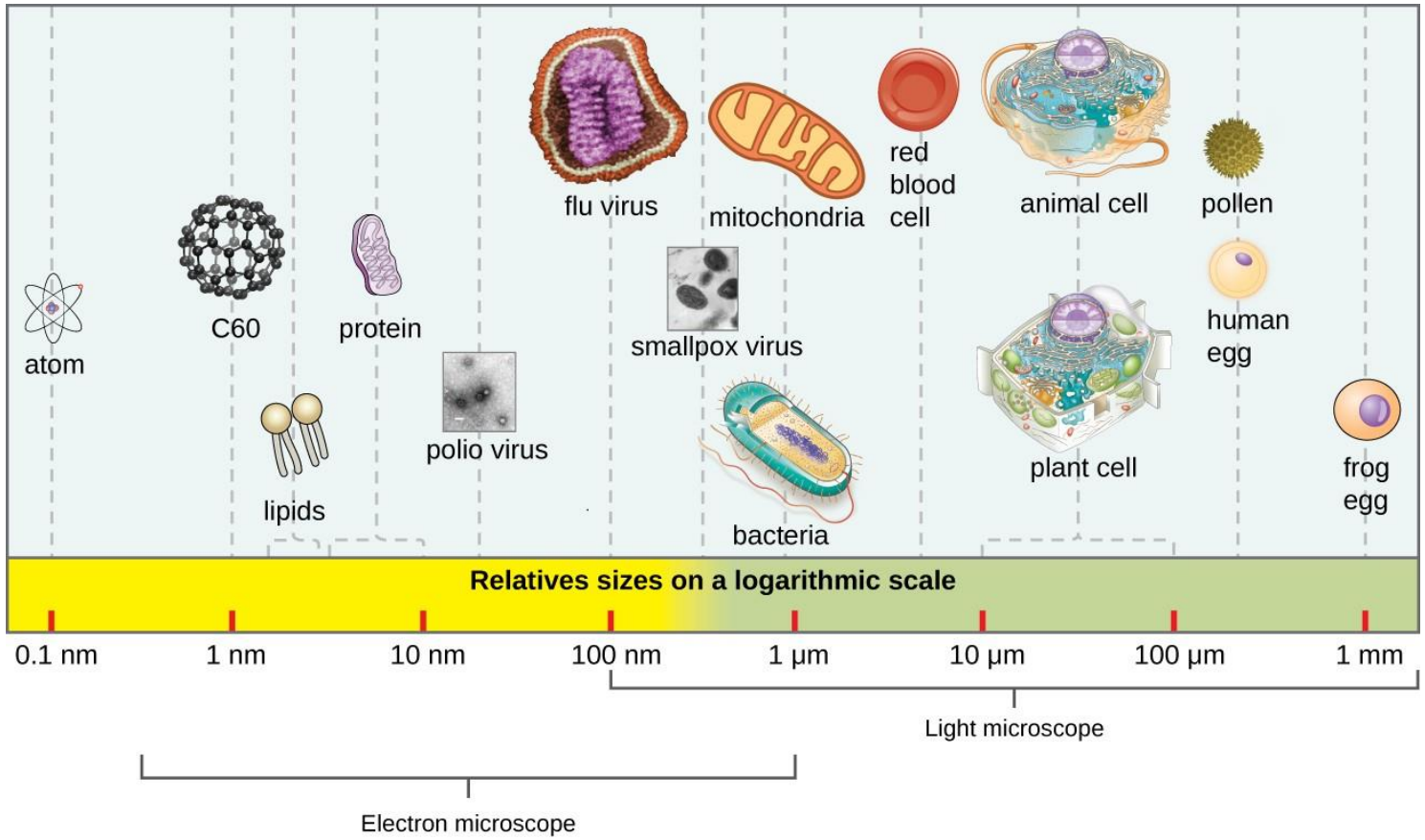
(c) DOMAIN EUKARYA…… Kingdom Animalia

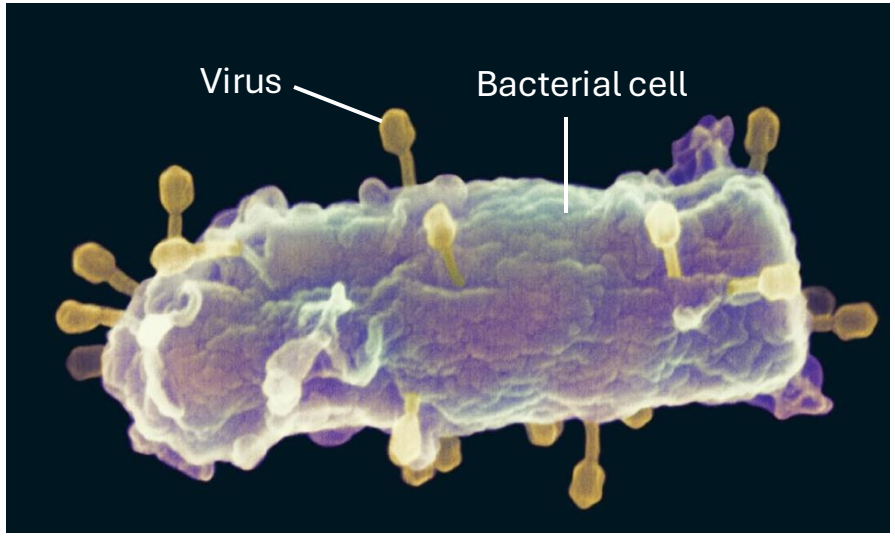
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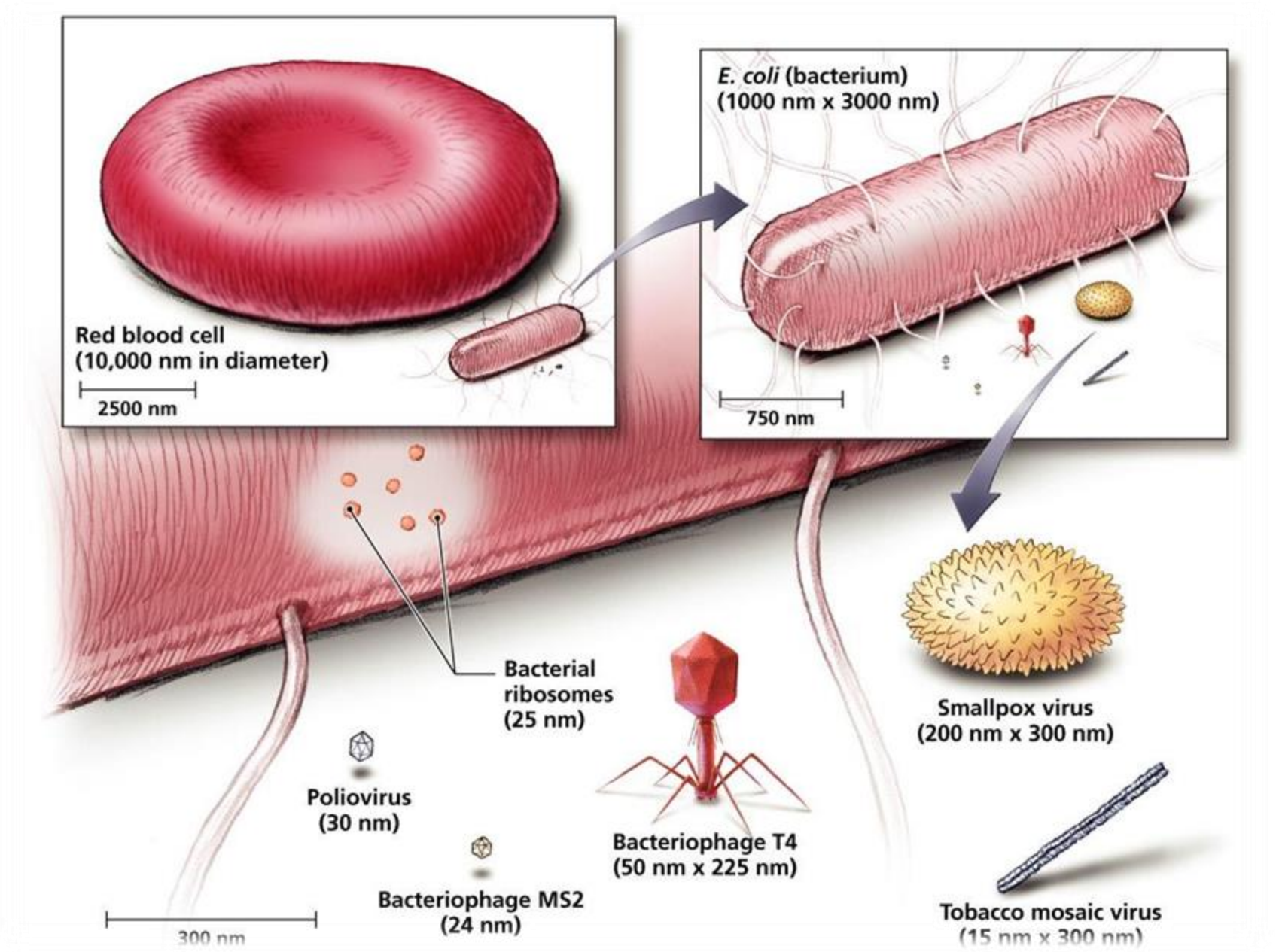
Viruses

Viruses are Tiny Ultra-Microscopic Particles

Viruses are **much smaller than prokaryotes**, ranging in size from about 20–300 nanometers (nm). They **can only be seen with an electron microscope**

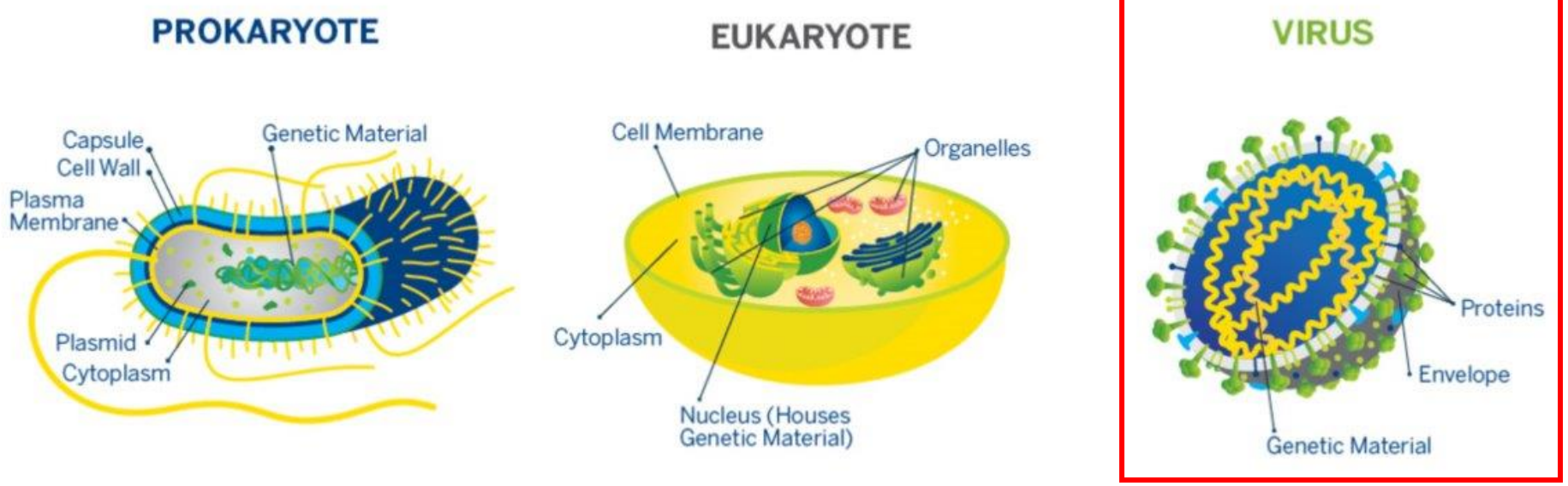





Red blood cell
(10,000 nm in diameter)
2500 nm
E. coli (bacterium)
(1000 nm x 3000 nm)
750 nm
Bacterial
ribosomes
(25 nm)
Poliovirus
(30 nm)
Bacteriophage MS2
(24 nm)
300 nm
Bacteriophage T4
(50 nm x 225 nm)
Smallpox virus
(200 nm x 300 nm)
Tobacco mosaic virus
(15 nm x 300 nm)

Viruses are Not Cells (Acellular)

- Compared with eukaryotic and even prokaryotic cells, most viruses are much **smaller and simpler** in structure
- They **lack any cellular structure;** they have no cell nucleus, organelles, or cytoplasm. They are only consisting of **nucleic acid enclosed in a protein coat and sometimes a membranous viral envelope**



Viruses Replicate only in Host Cells

- They are **obligate intercellular parasites.** They can only live and multiply within the host living cell
- Viruses are lacking the structures and metabolic machinery found in a cell, so they use **enzymes, ribosomes, and small molecules of host cells** to synthesize more viruses
- Each virus has a **host range**, a limited number of host cells that it can infect**.** They can infect **humans, plants, animals, bacteria and fungi**
- Viruses can cause a **wide variety of diseases**

Are Viruses Alive or Not?

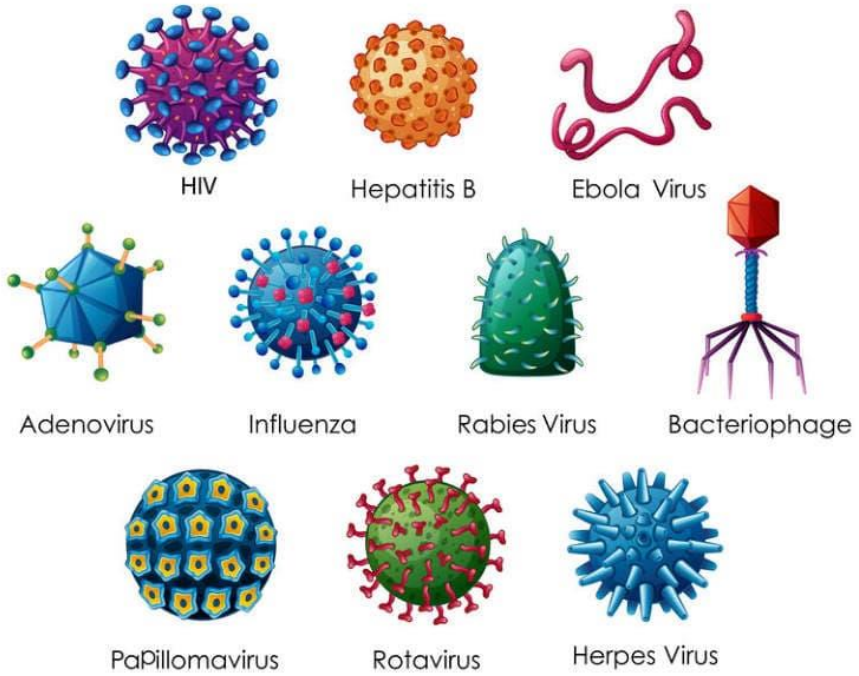
In fact, viruses exist in shady area between a living organism and a nonliving entity!!!

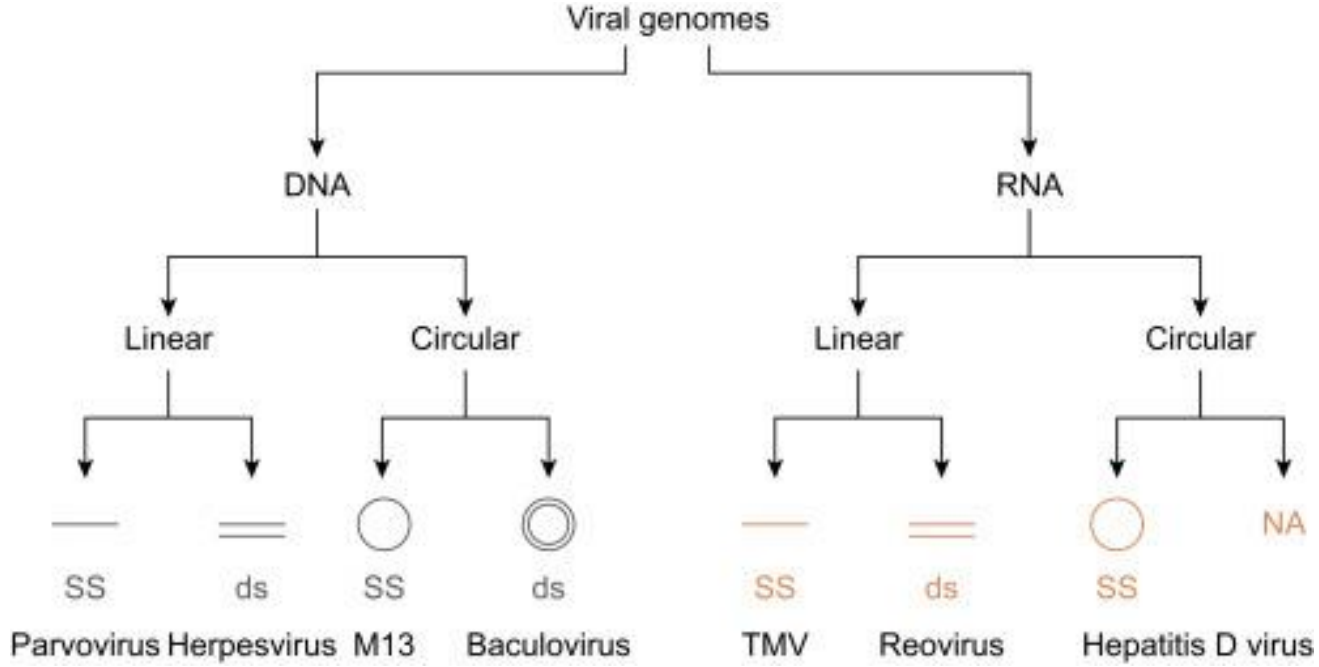
Living	Non-living
Possess genetic material either DNA or RNA	Are non-cellular
Possess a protein coat	Cannot reproduce by themselves
Can replicate (inside a living cell)	Only have one type of nucleic acid (living things have both DNA and RNA)

Diversity of Viruses

Viruses are very diverse

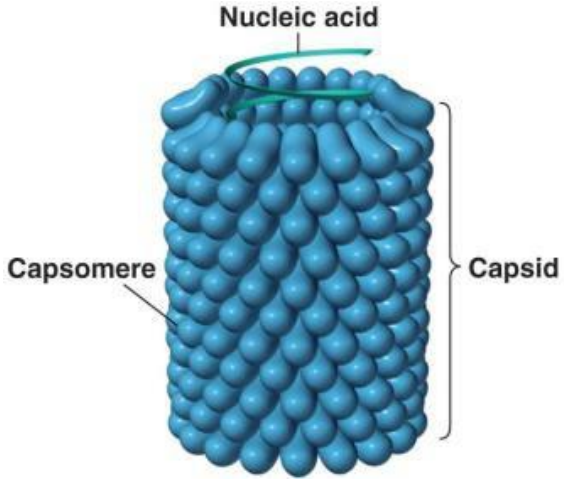
- They come in different shapes and structures
- Have different kinds of genomes
- Infect different hosts

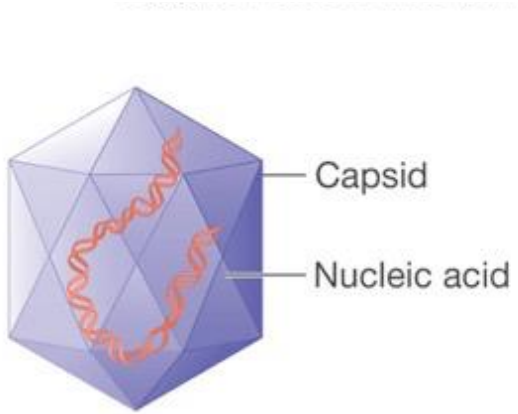


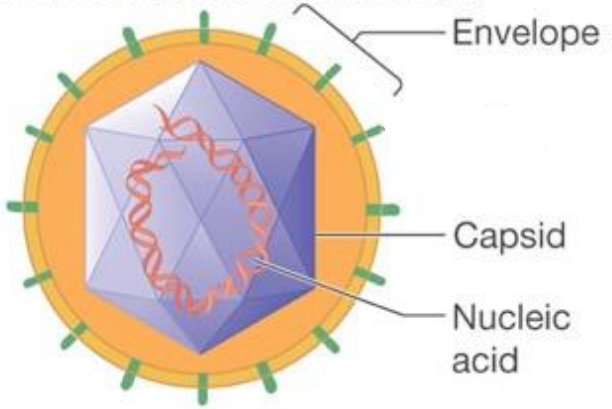


Viral Structure

- All viruses consist of:
    1. **A nucleic acid genome** made of single- or double-stranded DNA or RNA **(but not both)**
    2. **A protective protein shell, or capsid.** Capsids are built from protein subunits called **capsomeres**. A capsid can have various shapes
- Some viruses have an external membrane **envelope** surrounding the capsids of many animal viruses



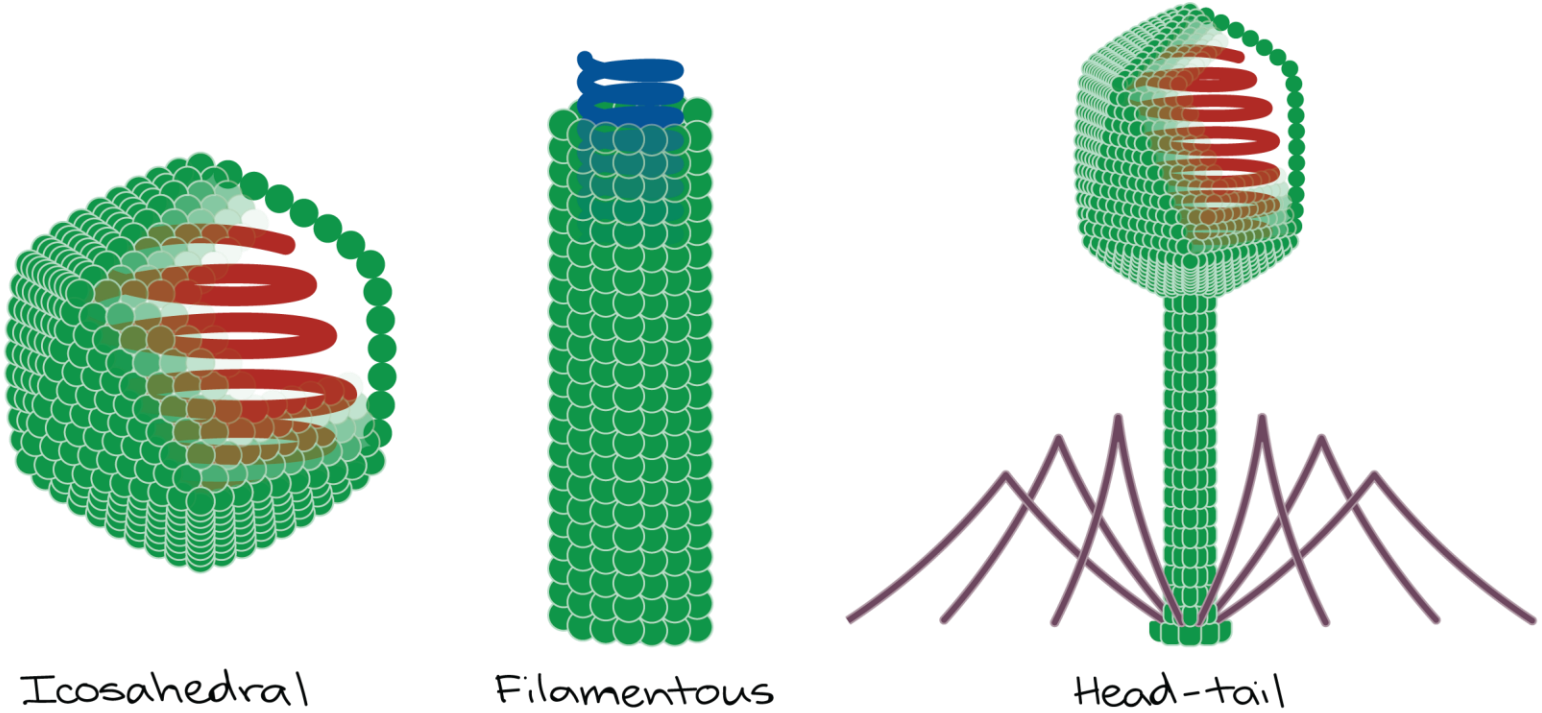


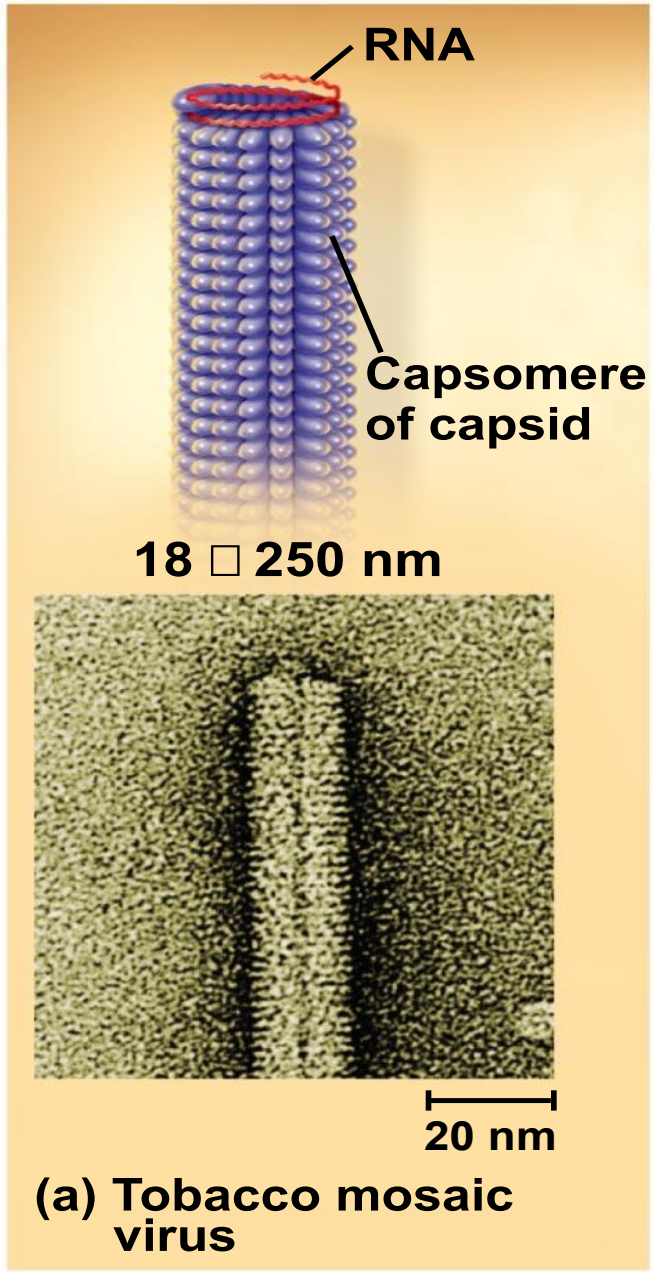


Viral Shapes

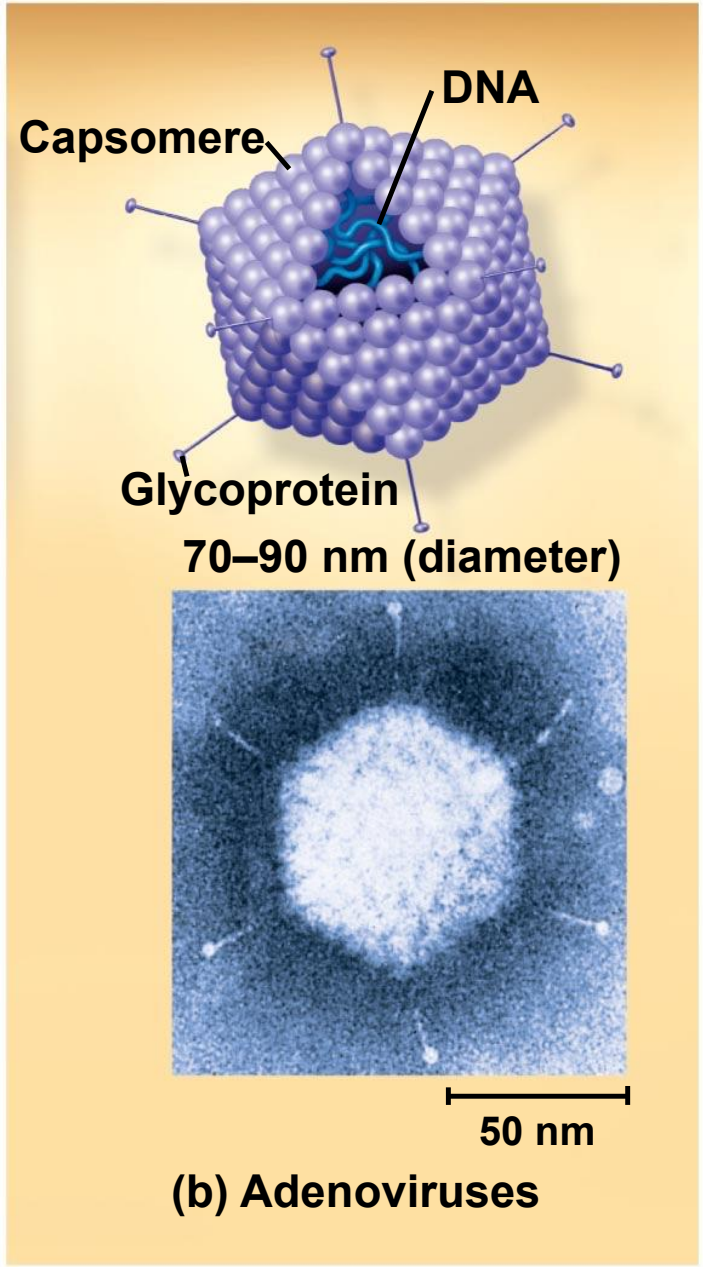
The **shape of the capsid can classify viruses into:**

1. **Icosahedral:** a polyhedral capsid with 20 triangular facets
2. **Helical/filamentous:** a long filamentous tube or rod-like structure
3. **Complex/Head-tail:** a hybrid between the helical and icosahedral shapes

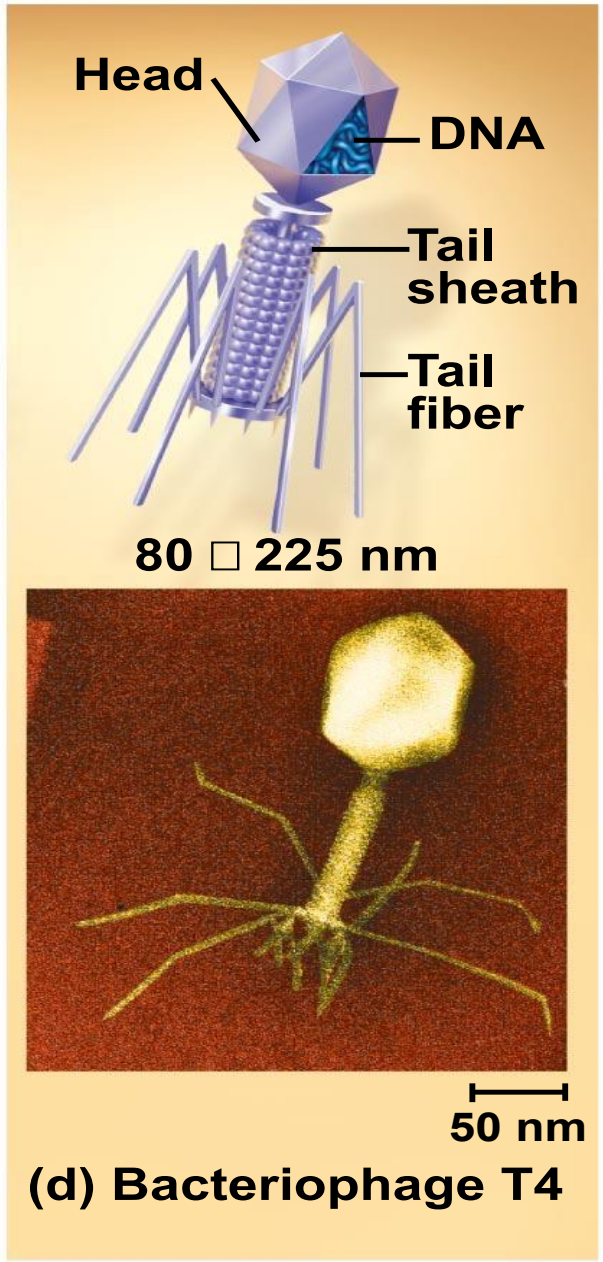




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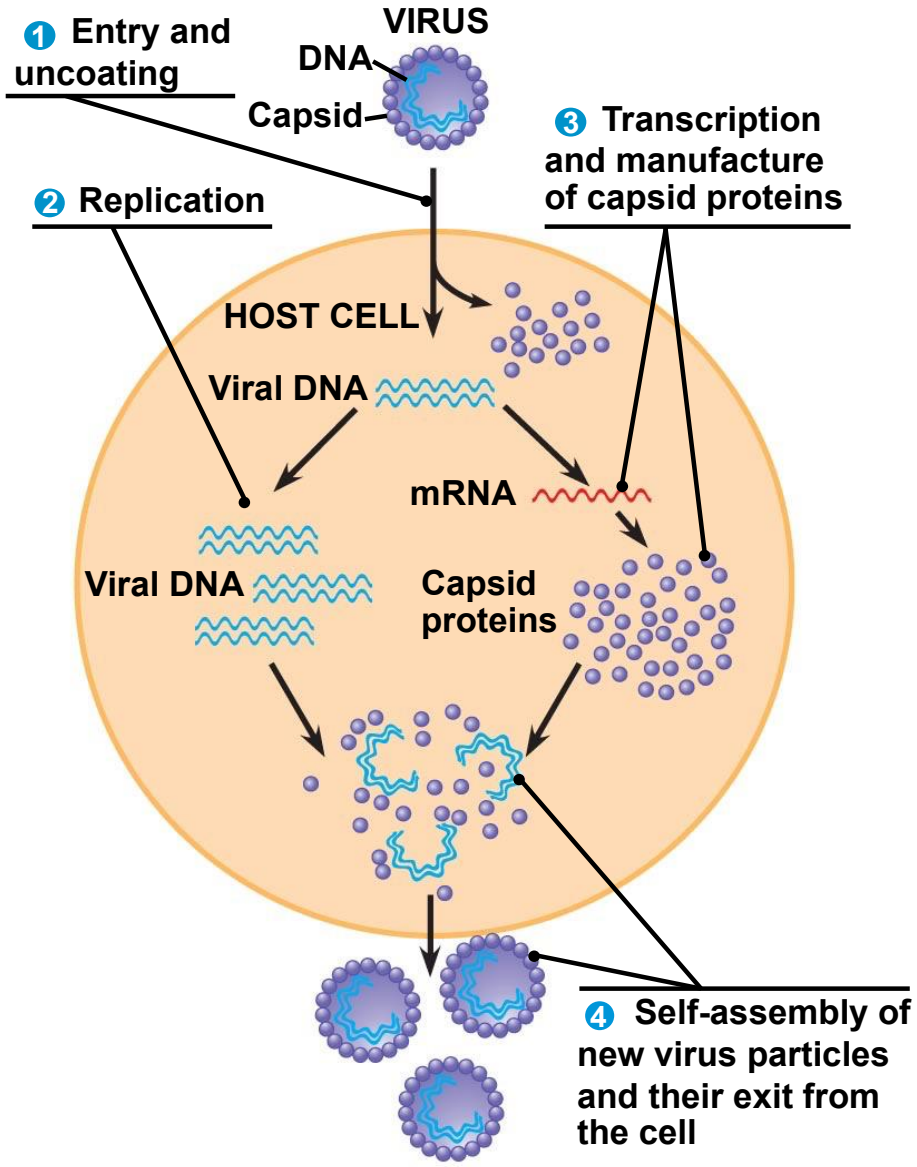
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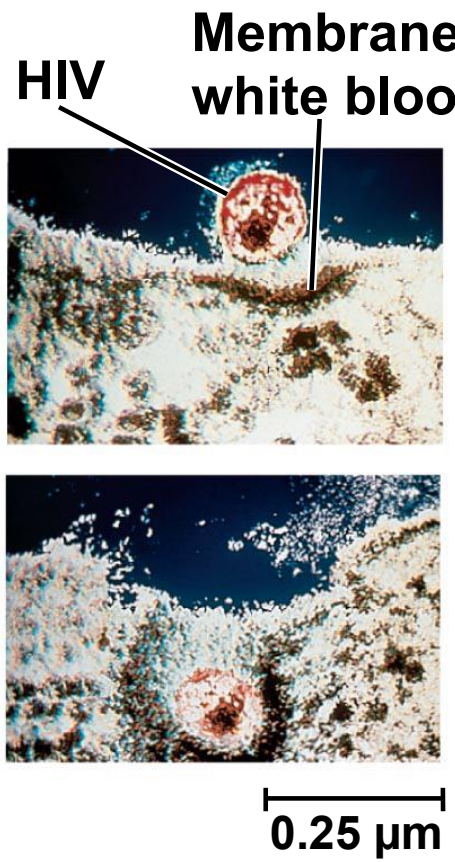


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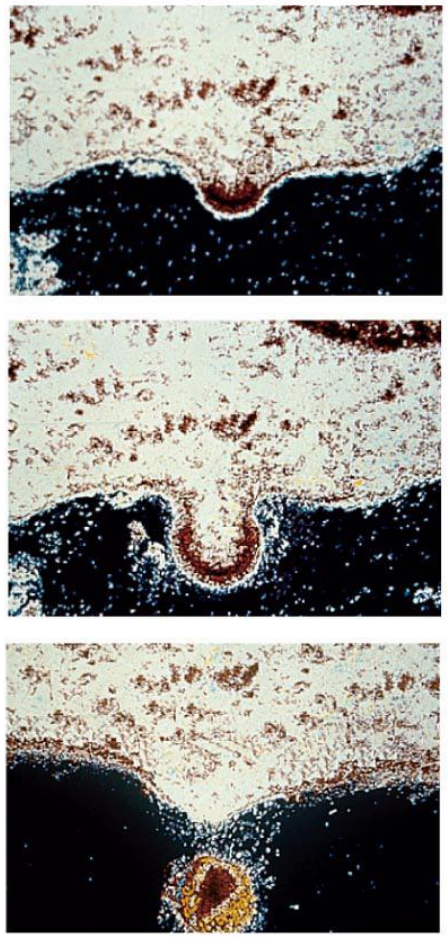
General Features of Viral Reproductive Cycles

- Once a viral genome has entered a cell, the cell begins to manufacture viral proteins
- The virus makes use of host enzymes, ribosomes, tRNAs, amino acids, ATP, and other molecules
- Viral nucleic acid molecules and capsomeres spontaneously self-assemble into new viruses





HIV entering a cell



New HIV leaving a cell

The reproductive cycle of HIV, the retrovirus that causes AIDS

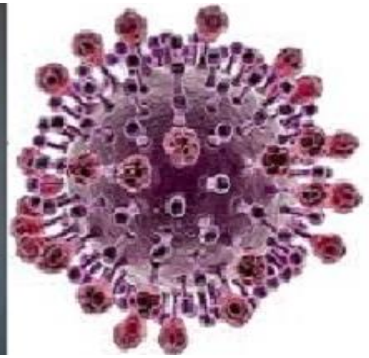
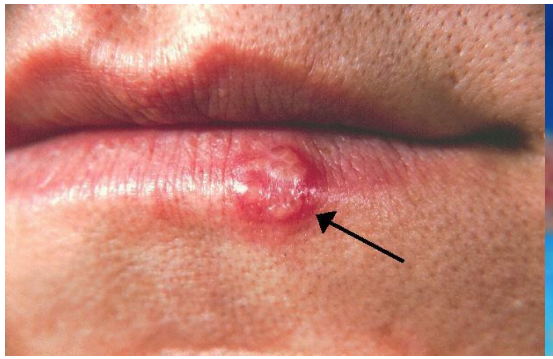
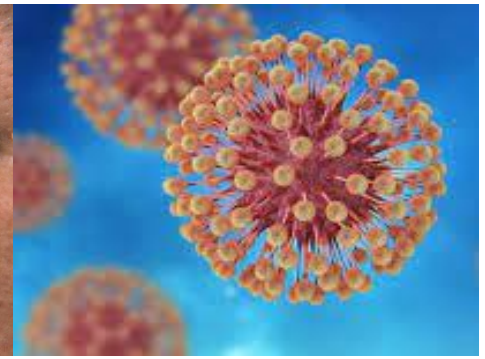
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Roles of Viruses in our Lives: 1. Cause Varaity of Diseses

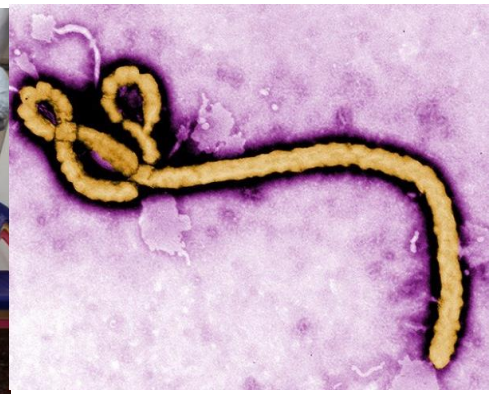
Diseases caused by viruses affect humans, agricultural crops, and livestock worldwide

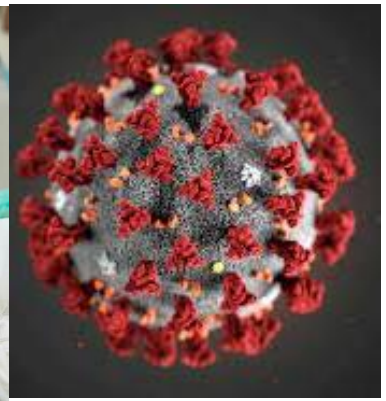
A. In Human

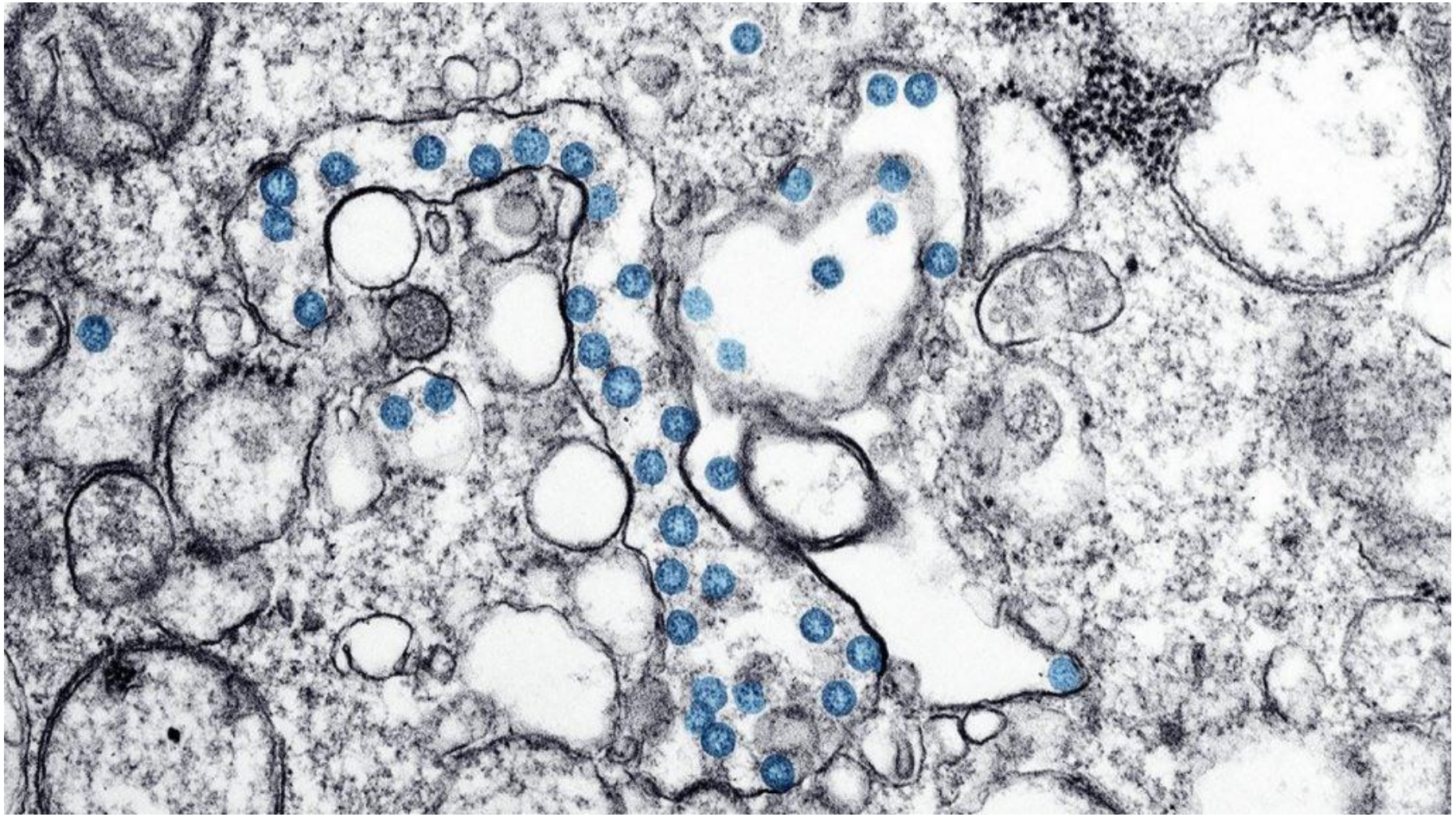
Common human diseases: Influenza and cold sore (herpes)

Serious diseases: Ebola and Covid

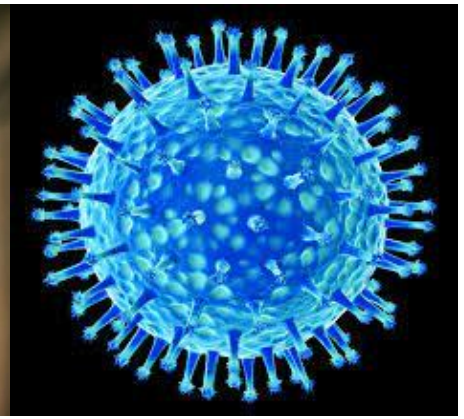
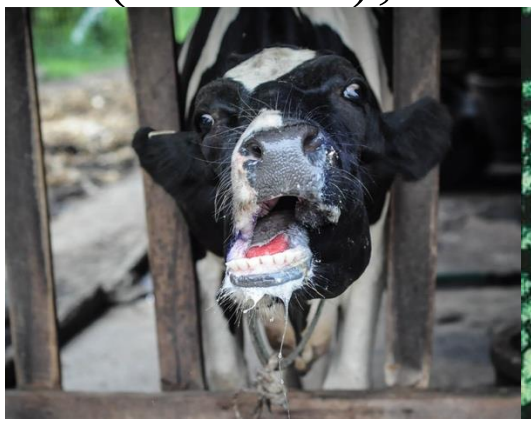
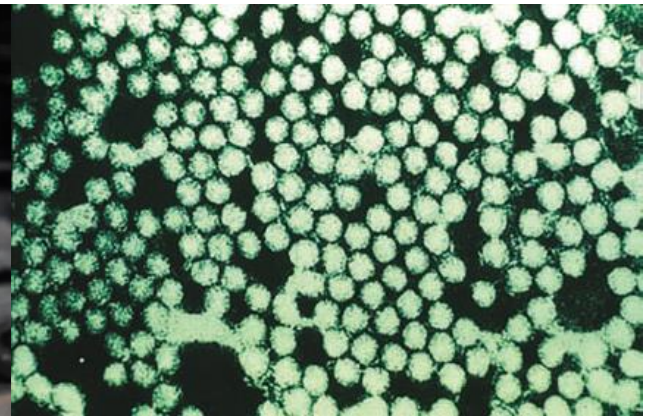




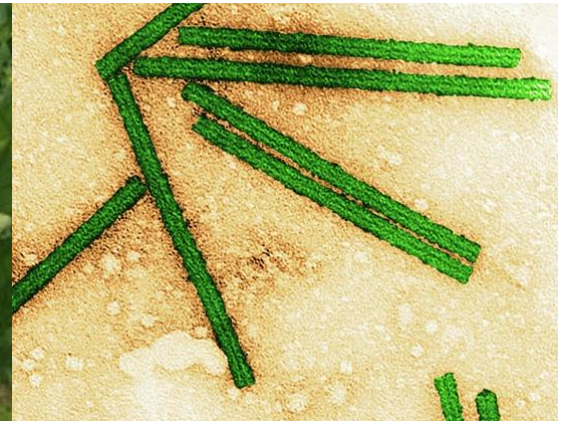
Electron microscope image of the first U.S. case of COVID-19. The spherical viral particles, colored blue, contain a cross-section of the viral genome, in the form of black dots.

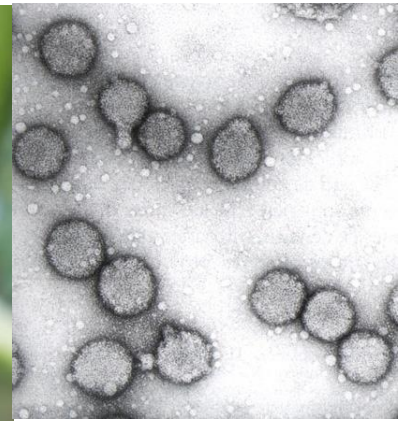
Roles of Viruses in our Lives: 1. Cause Varaity of Diseses

B. In Animals: such as Avian influenza (bird flu), and Foot and Mouth Disease

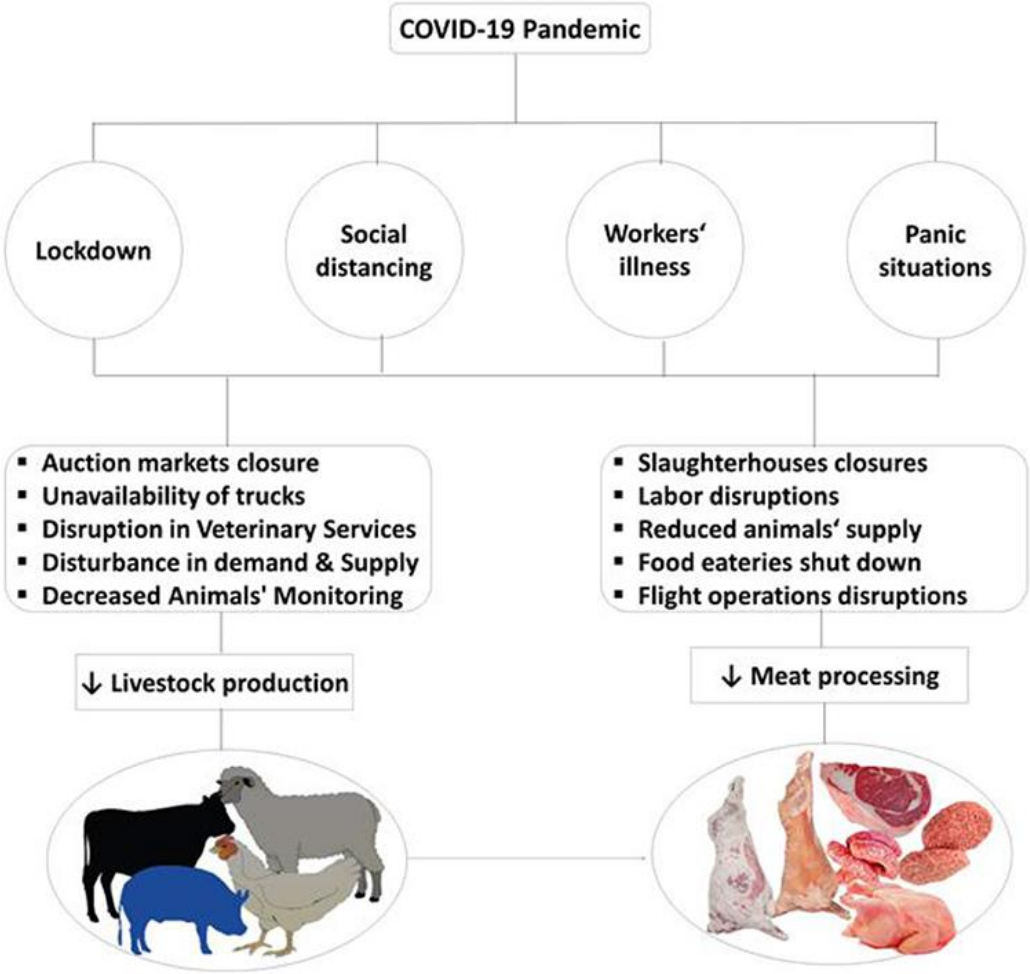
C. In plants: such as tobacco mosaic virus, and Tomato spotted wilt virus



Roles of Viruses in our Lives: 2. Economical losses

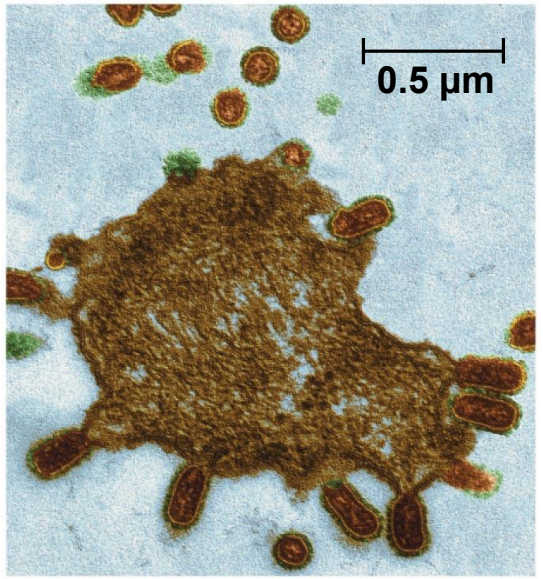
Lead to economical losses such as in livestock, agriculture and food industry





(a) The 1918 flu pandemic

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(b) Influenza A H5N1 virus

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(c) Vaccinating ducks

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Roles of Viruses in our Lives: 3. Medical Applications

A. Vaccines Production:

- **Viruses** are used to produce **vaccines** which can **prevent certain viral illnesses**
- **Vaccines** are harmless derivatives of pathogenic microbes that stimulate the immune system to mount defenses against the actual pathogen
- Viral infections **cannot be treated by antibiotics**
- **Antiviral drugs** can help to treat (stopping viral reproduction) though not cure viral infections

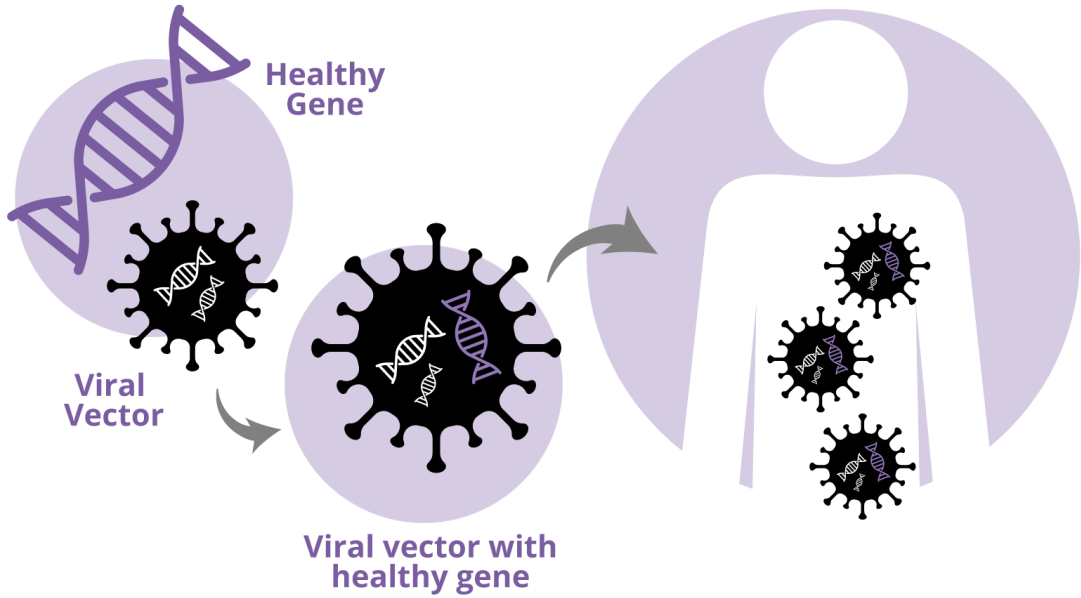


Roles of Viruses in our Lives: 3. Medical Applications

B. Gene Therapy:

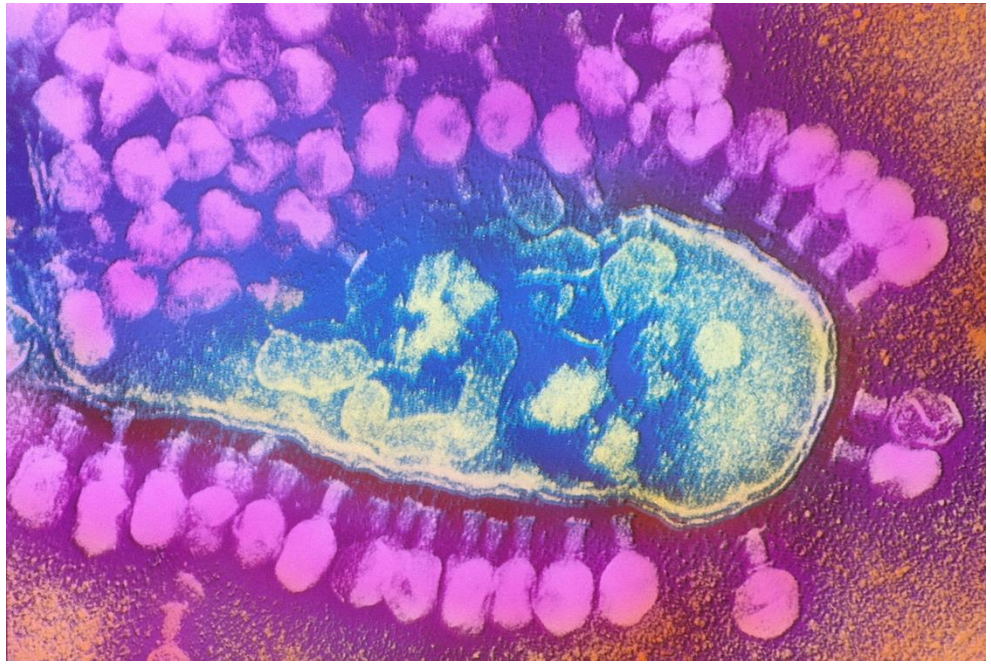
Viruses are beginning to play **major roles in medical therapies** and in advancing **medical technology**

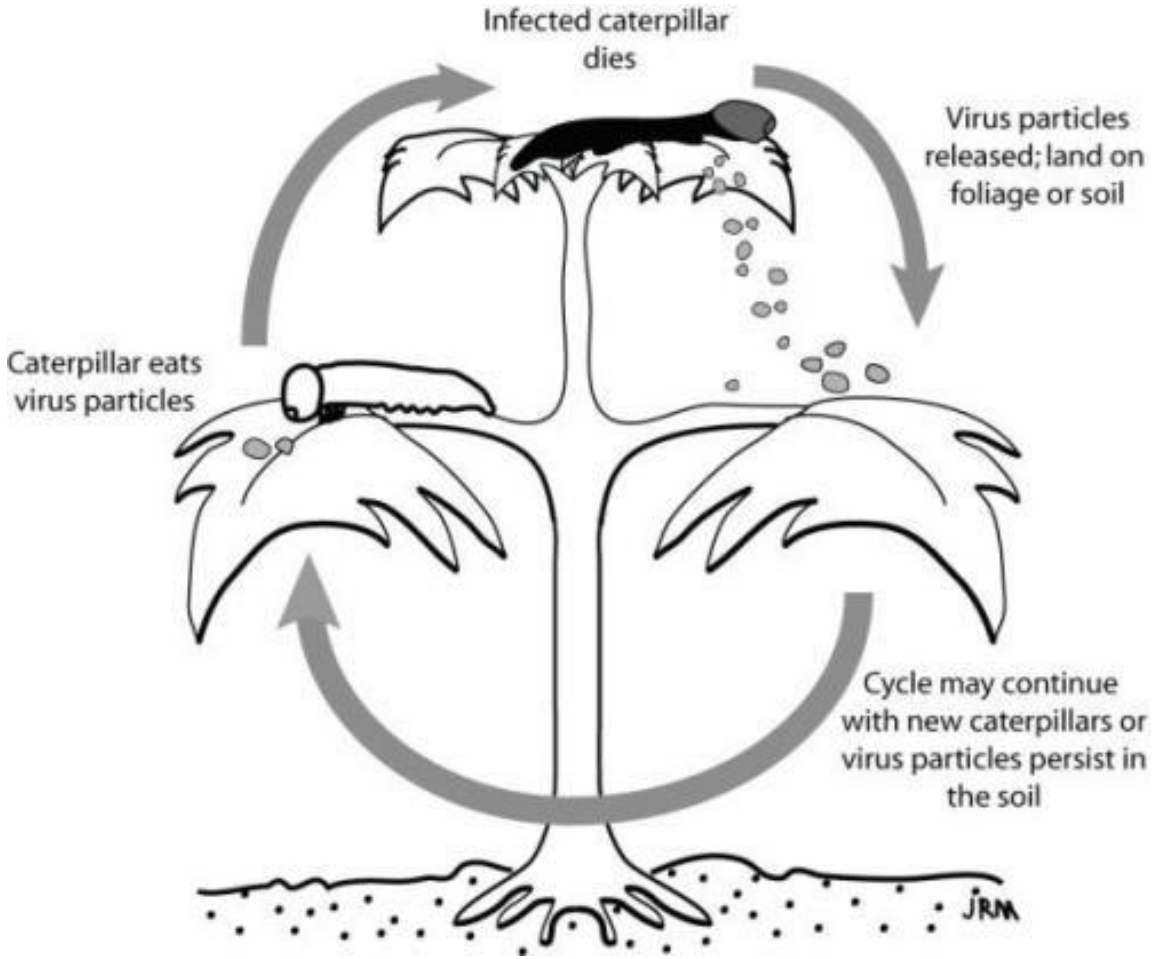
Humans now possess the technology to **reengineer natural viruses** and use them as **vectors** to combat **cancer and cure genetic diseases**



Roles of Viruses in our Lives: 4. Biological Control

Viruses play an important role in the biological control against pathogenic bacteria and insect pests





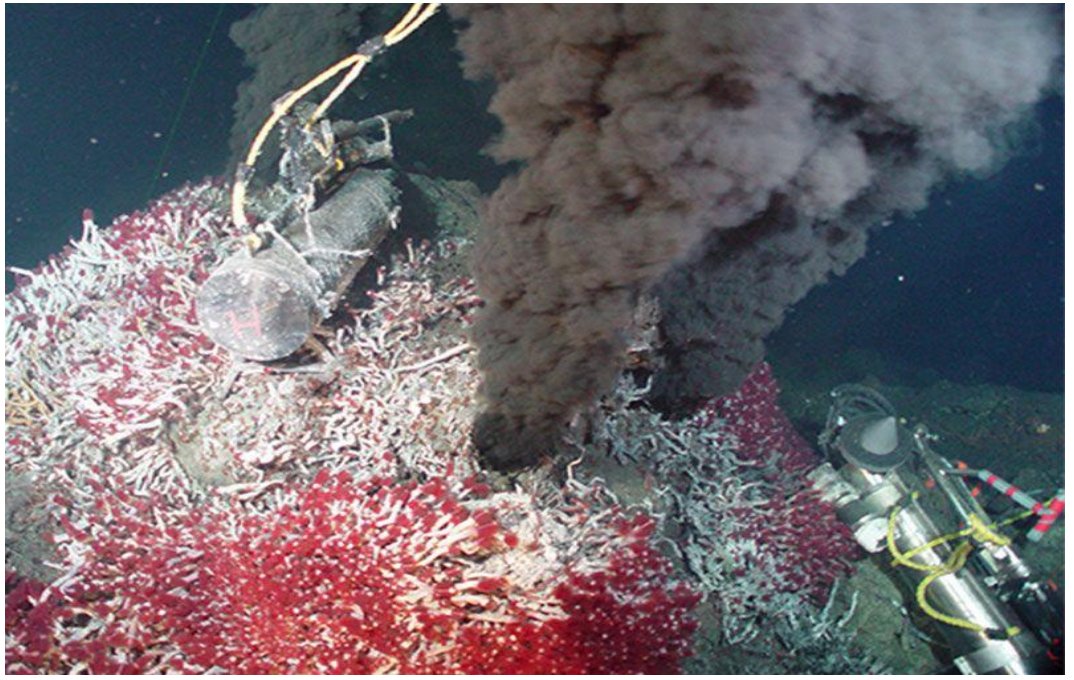
Domain Bacteria & Archaea

The Prokaryotes

- Prokaryotes thrive almost **everywhere**, including places too acidic, salty, cold, or hot for most other organisms
- There are more prokaryotes in a handful of fertile soil than the number of people who have ever lived
- **Prokaryotes** are divided into two domains: **bacteria** and **archaea**

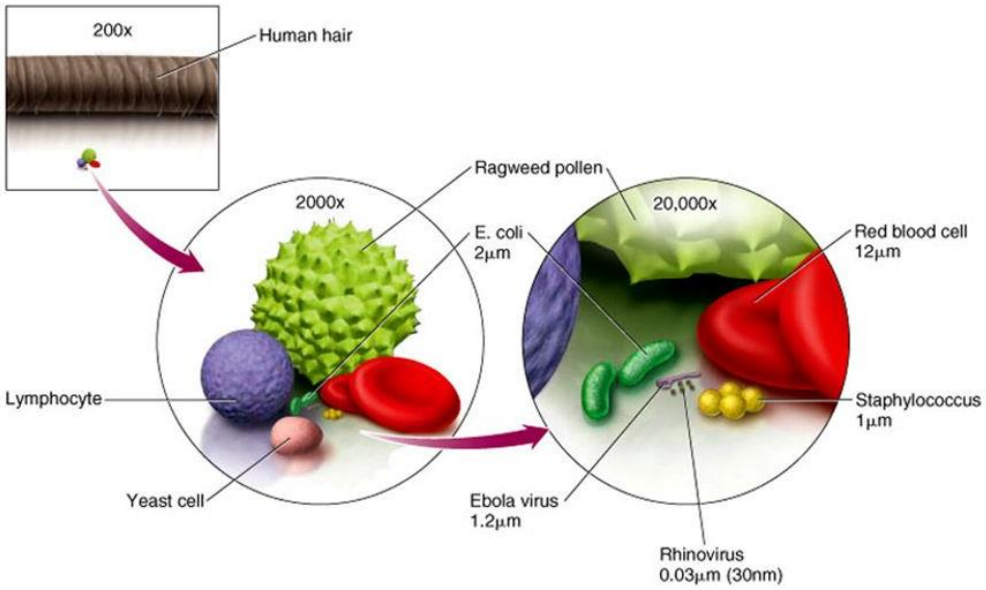


Orange and yellow colonies of thermophilic prokaryotes grow in the hot water of Yellowstone National Park's Grand Prismatic Spring

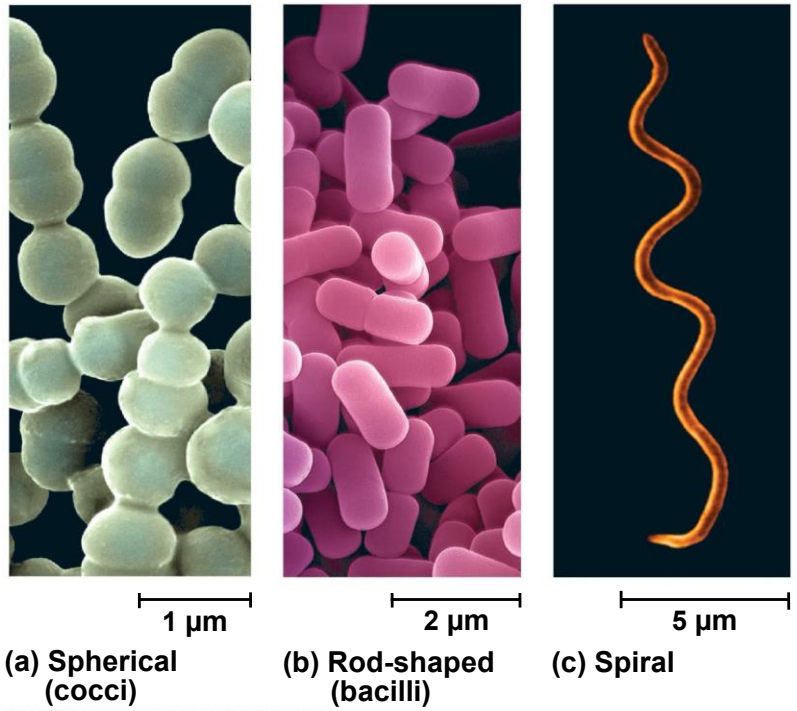


Hyperthermophilic bacteria that live on high-temperature, high-pressure hydrothermal vents in the Pacific Ocean

- Most prokaryotes are **unicellular**
- Most prokaryotic cells are **0.5–5 µm**, much smaller than the 10–100 µm of many eukaryotic cells
- Prokaryotic cells three **most common shapes** are **spheres (cocci), rods (bacilli),** and **spirals**
- Prokaryotes reproduce **asexually quickly** (some can divide every 10 min) by **binary fission**



https://learn.genetics.utah.edu/content/cells/scale/



Prokaryotic Cell Structural Organization

1. Internal structures

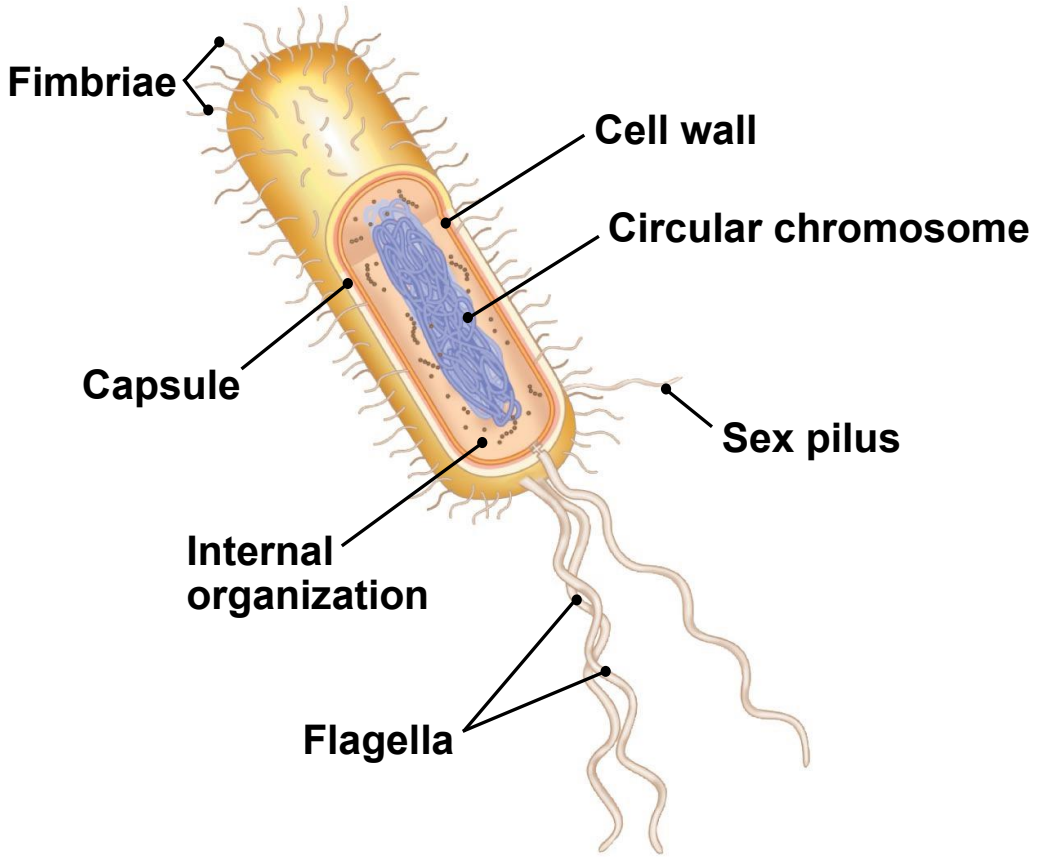
- **In all prokaryotes:** cytoplasm, chromosome, and ribosomes
- **In some prokaryotes:** plasmids and endospores

2. Cell surface (envelope)

- **In all prokaryotes:** cytoplasmic membrane and cell wall
- **In some prokaryotes:** capsule

3. External structures

- **In some prokaryotes:** flagella and pili/fimbriae



Some Distinguishable Prokaryotic cell Structures

Cell wall

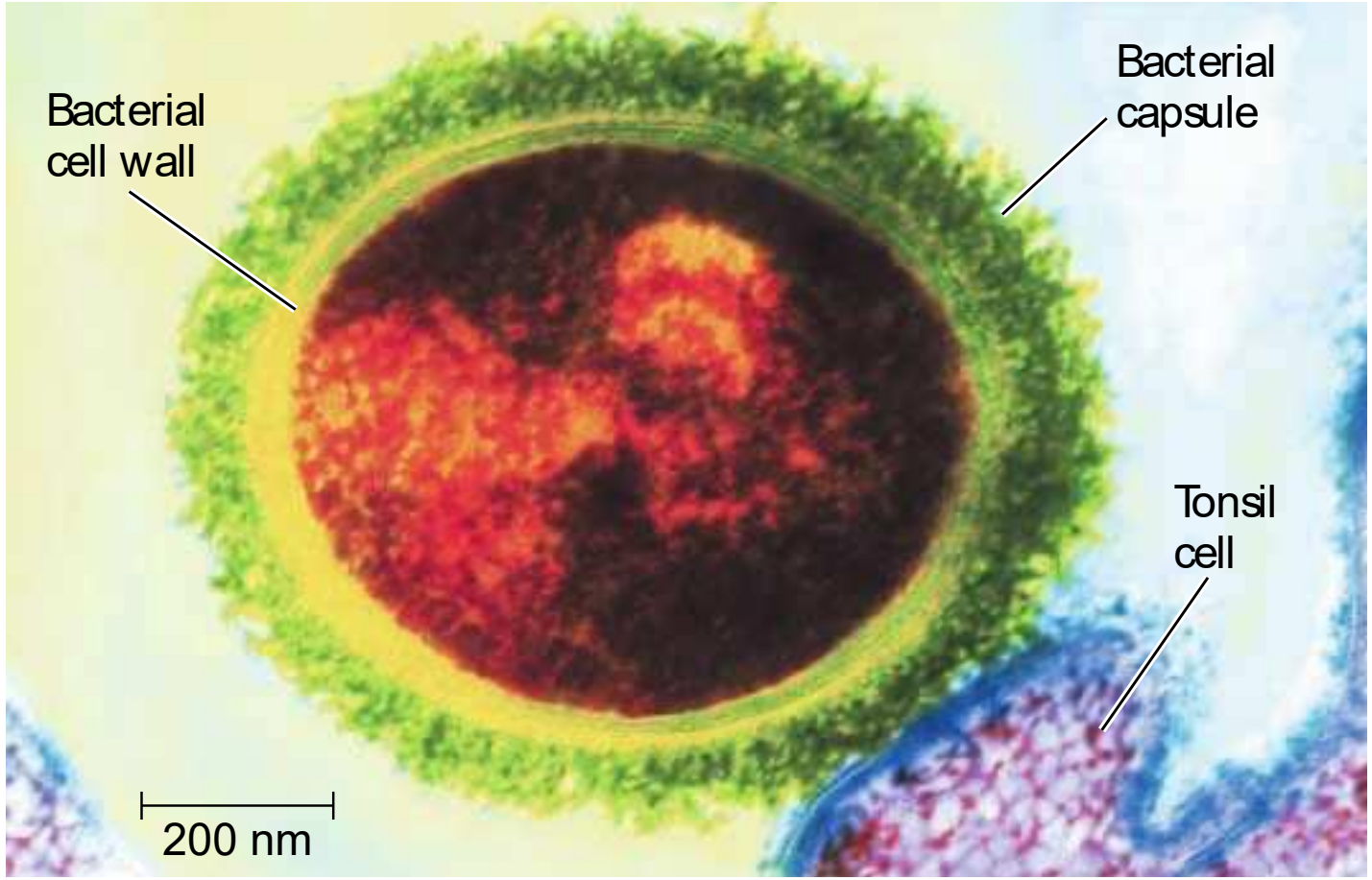
- An important feature of nearly all prokaryotic cells is their **cell wall**, which **maintains** cell shape, provides physical **protection**, and **prevents** the cell from **bursting** in a hypotonic environment
- Bacterial cell walls made of **peptidoglycan;** a network of sugar polymers cross-linked by polypeptides.

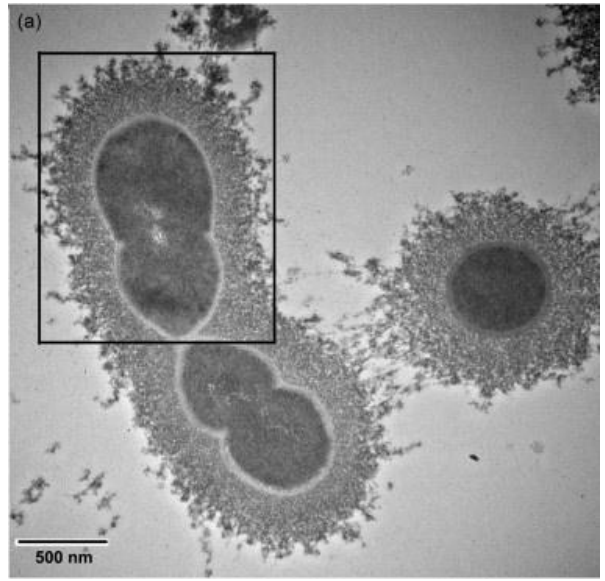
Capsule

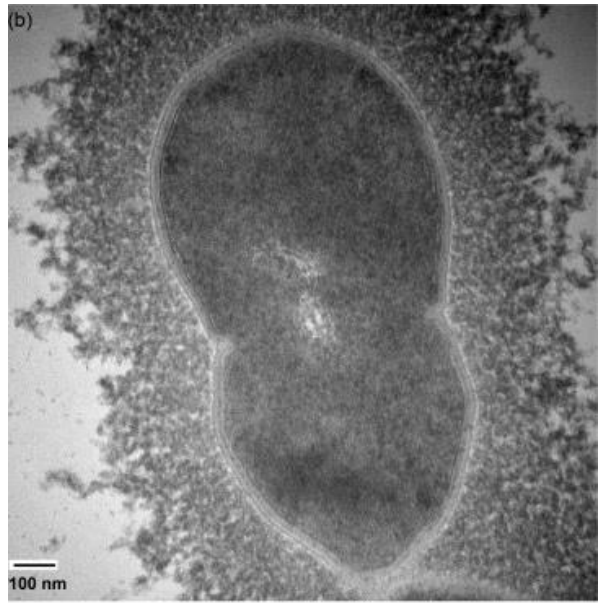
- The cell wall of many prokaryotes is surrounded by a sticky layer of polysaccharide or protein, which is called a **capsule**
- The capsule enables prokaryotes to **adhere** to their substrate or to other individuals in a colony, protect against **dehydration**, and some capsules **shield** pathogenic prokaryotes from attacks by their host's immune system

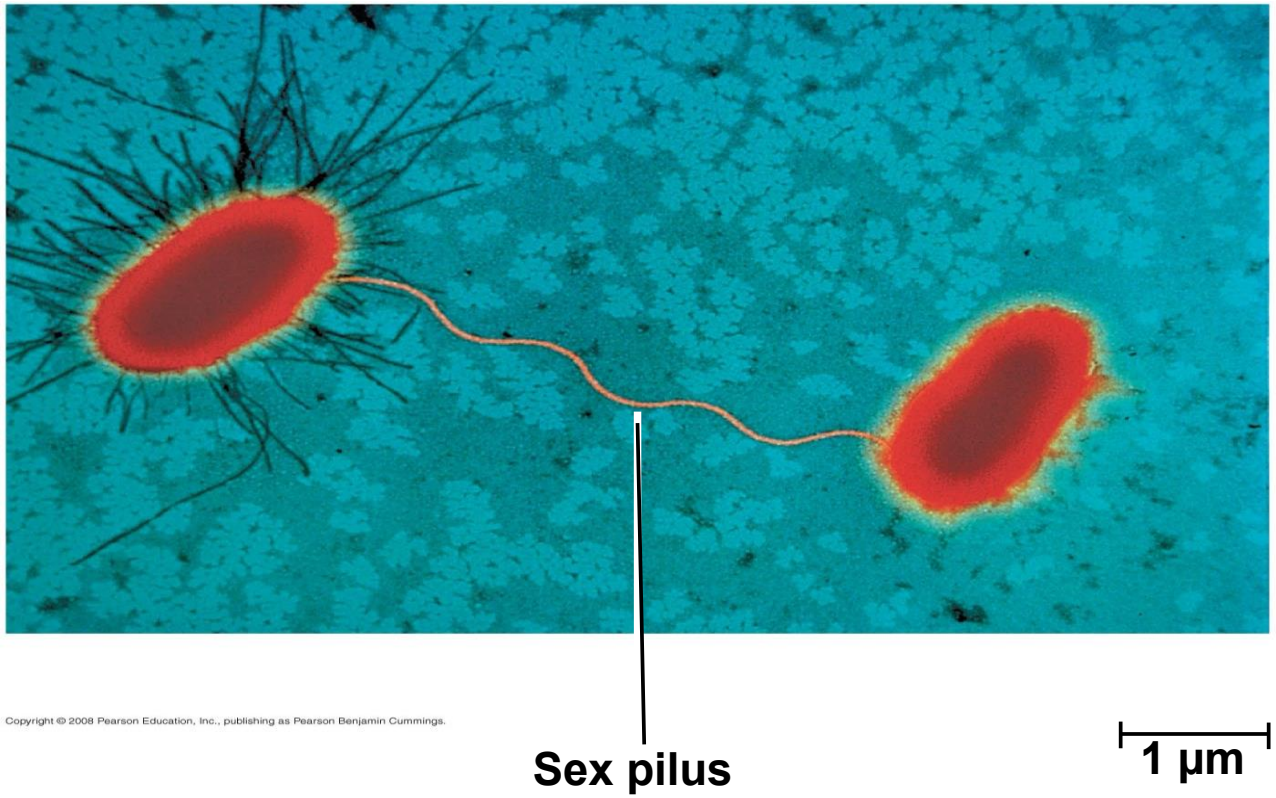
Pili/fimbriae

- Some prokaryotes have **fimbriae** (also called **attachment pili**), which allow them to **stick** to their substrate or other individuals in a colony
- **Sex pili** are longer than fimbriae and allow prokaryotes to exchange DNA by **conjugation**

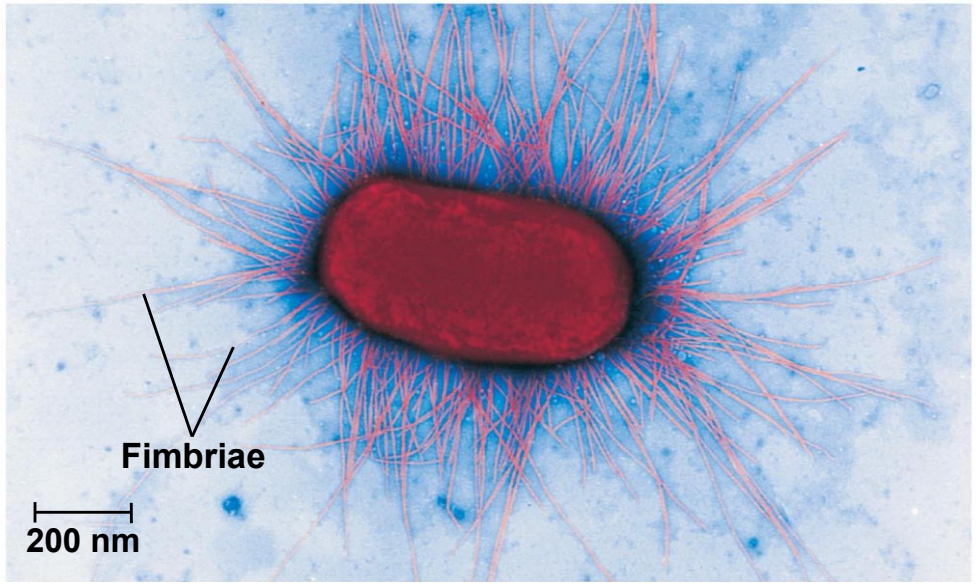

Bacterial cell wall
Bacterial capsule
Tonsil cell
200 nm

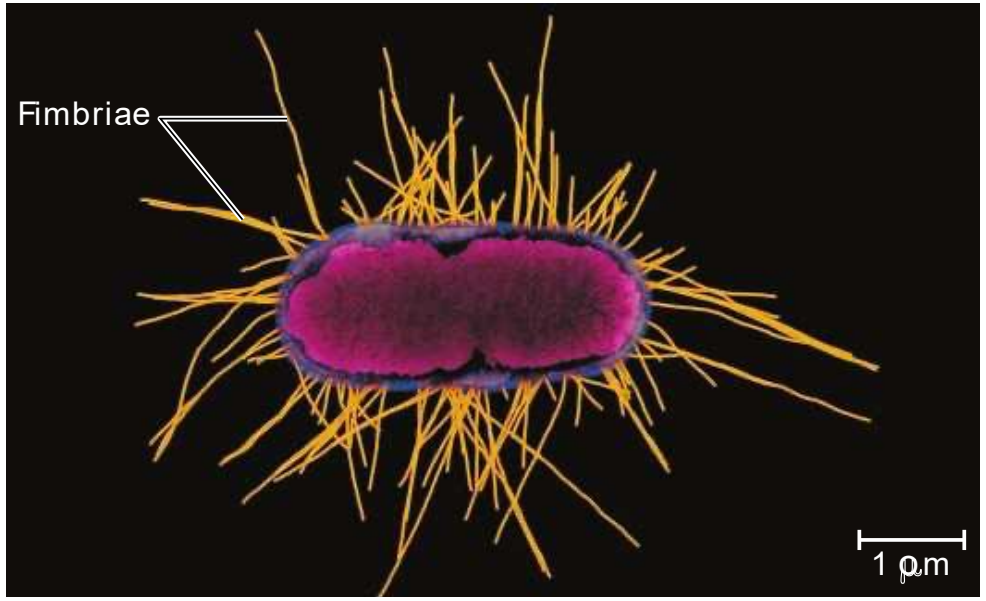

(a)
500 nm


(b)
100 nm



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Some Distinguishable Prokaryotic cell Structures

Flagella

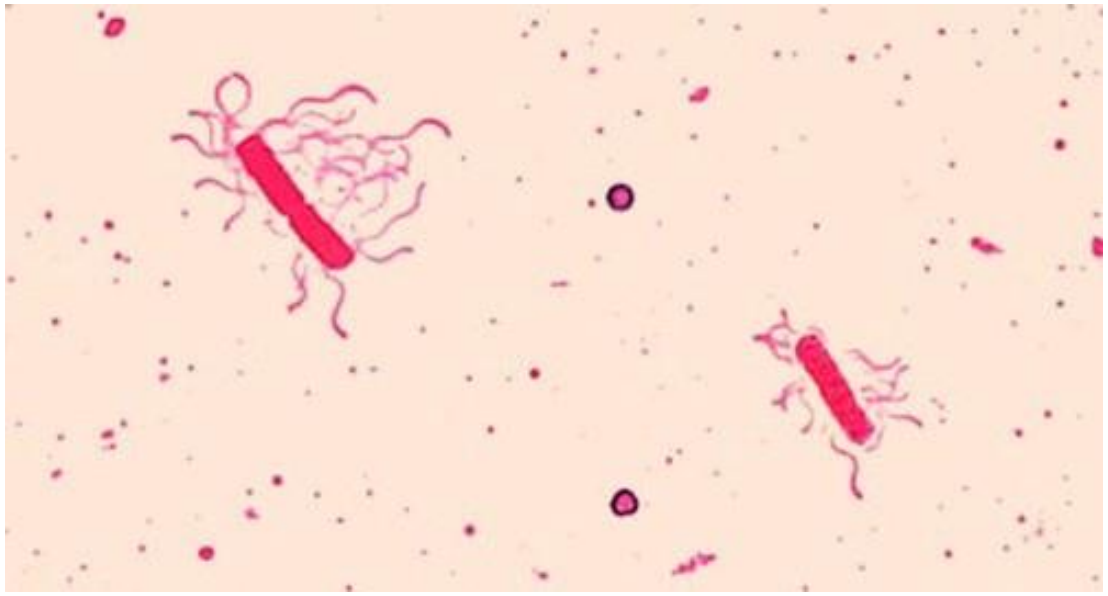
- Most **motile bacteria** move themselves by **flagella** that are structurally and functionally different from eukaryotic flagella
- They can move toward or away from a stimulus. For example, they may move toward nutrients or oxygen or away from a toxic substance

Endospores

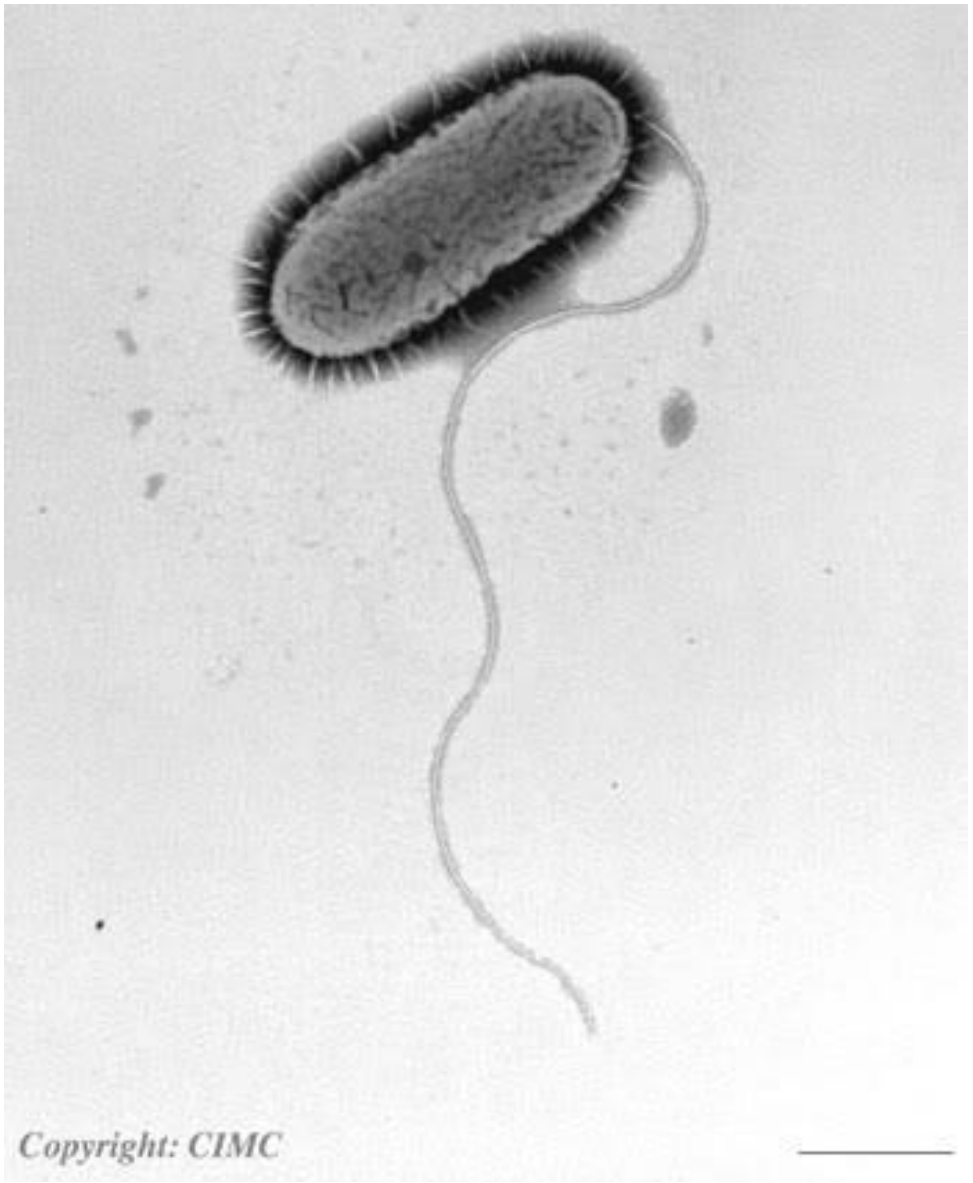
- Many prokaryotes form metabolically inactive **endospores**, which can remain **dormant** and viable in **harsh conditions** for centuries

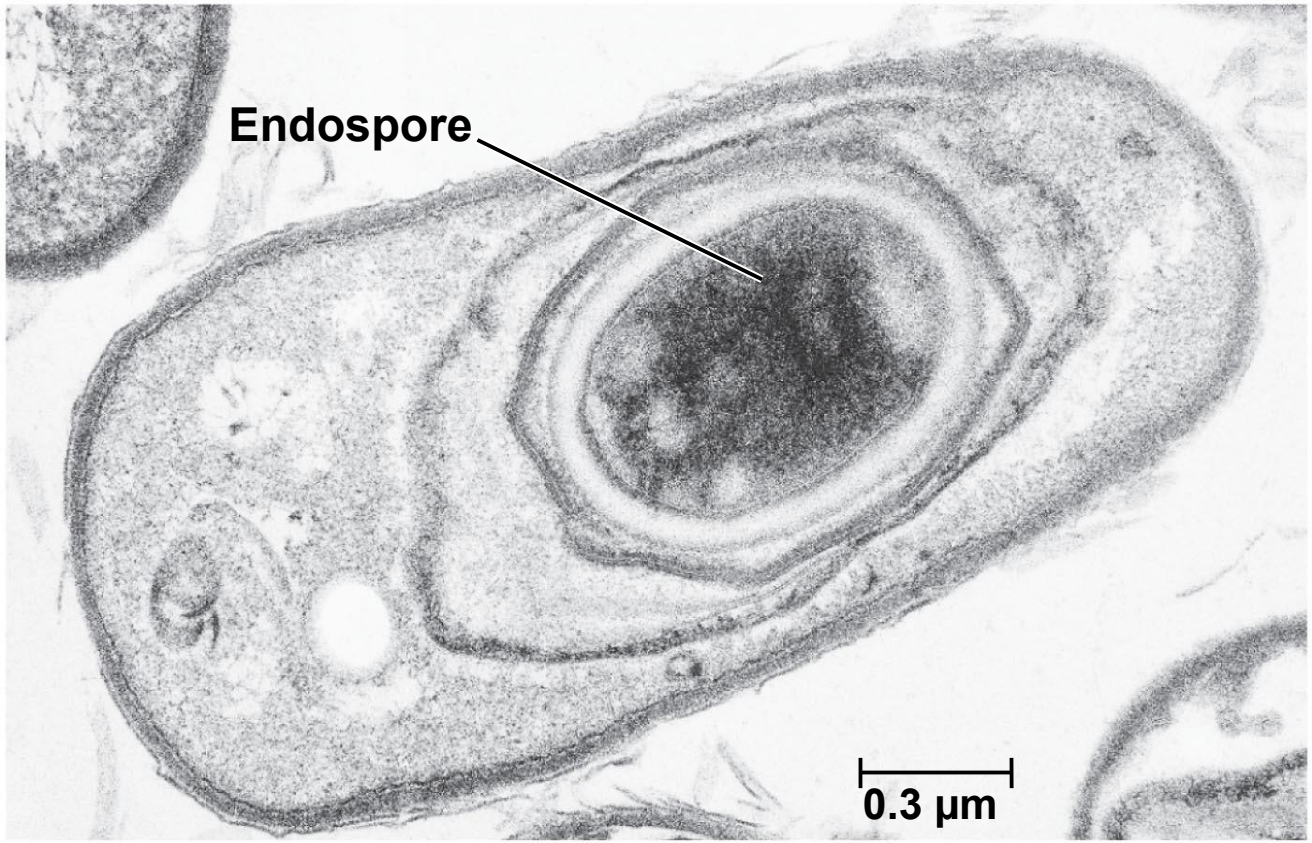
Genome

- The prokaryotic genome has **less DNA** than the eukaryotic genome
- Most of the genome consists of a **circular chromosome** that is NOT contained within a nucleus, but rather located in the irregularly shaped region known as the nucleoid
- Some species of bacteria also have smaller rings of **extra-chromosomal** DNA called **plasmids**

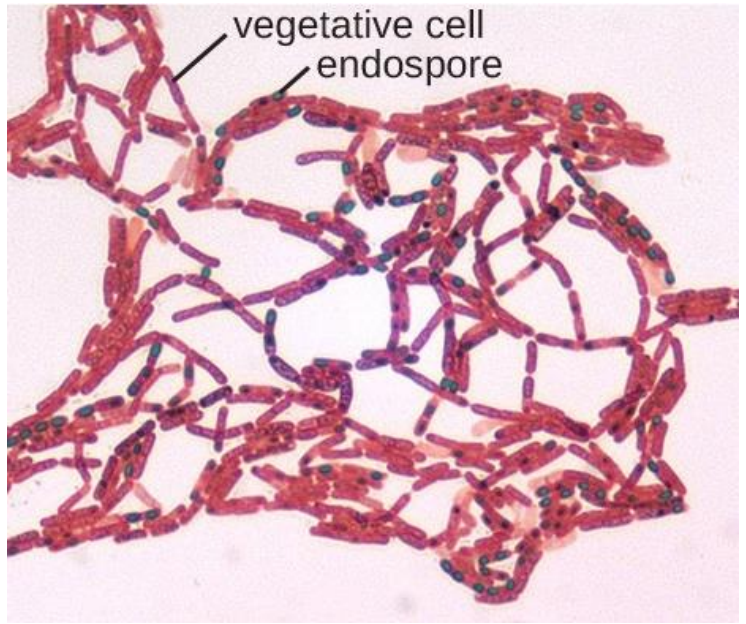


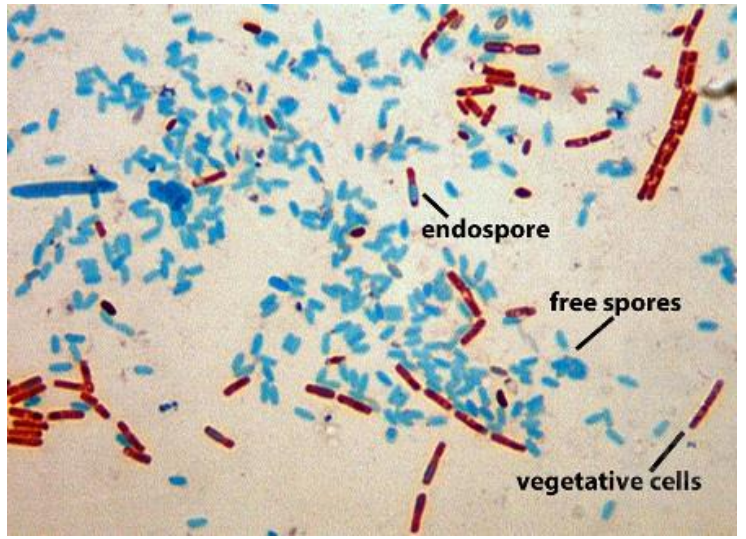


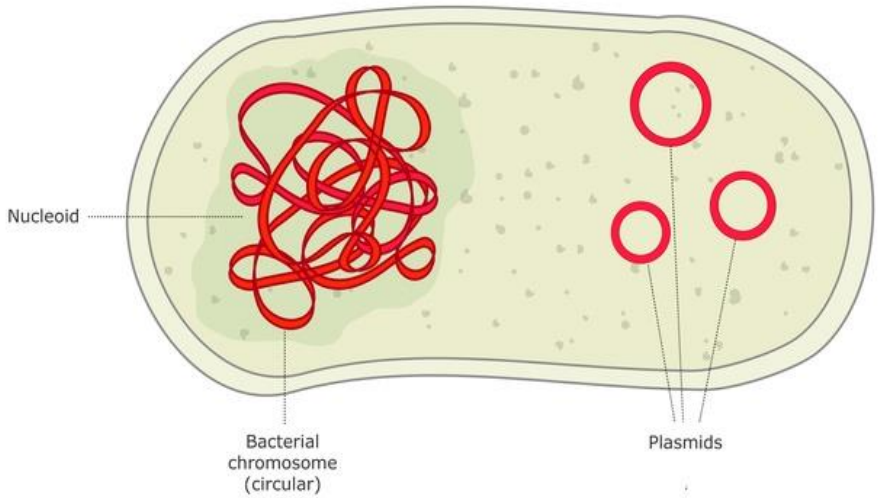

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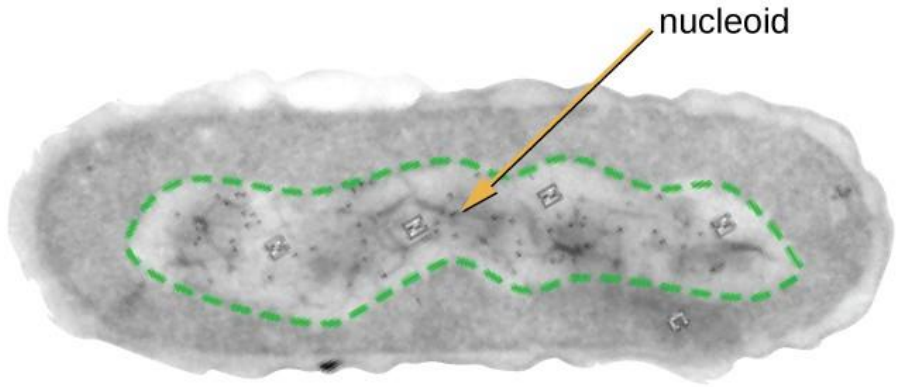


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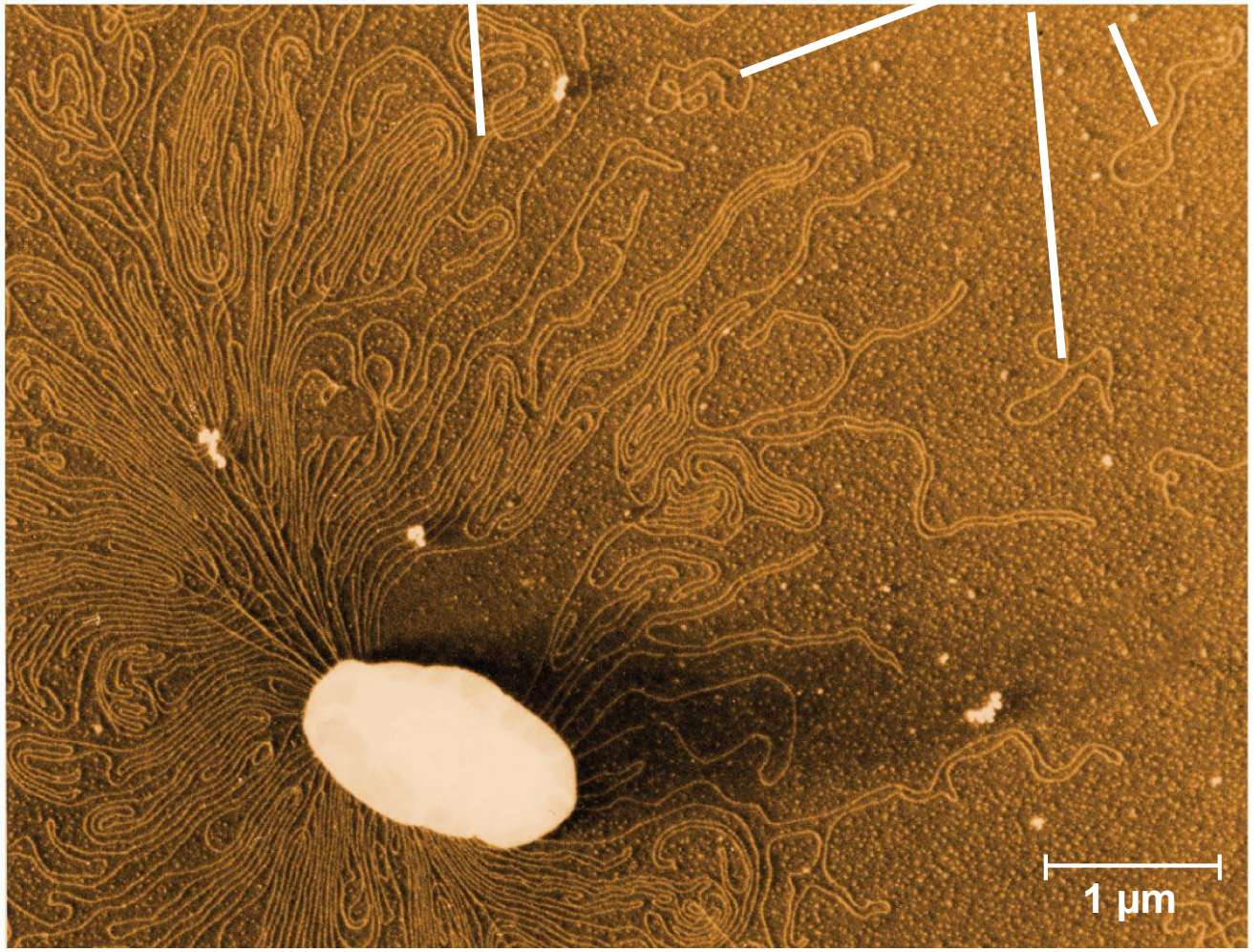




Single Circular Chromosome

Plasmids

smaller DNA rings



Nutrition in Prokaryotes

Diverse nutritional and metabolic adaptations have evolved in prokaryotes:

- **Phototrophs** obtain energy from light
- **Chemotrophs** obtain energy from chemicals
- **Autotrophs** require CO_2 as a carbon source
- **Heterotrophs** require an organic nutrient to make organic compounds

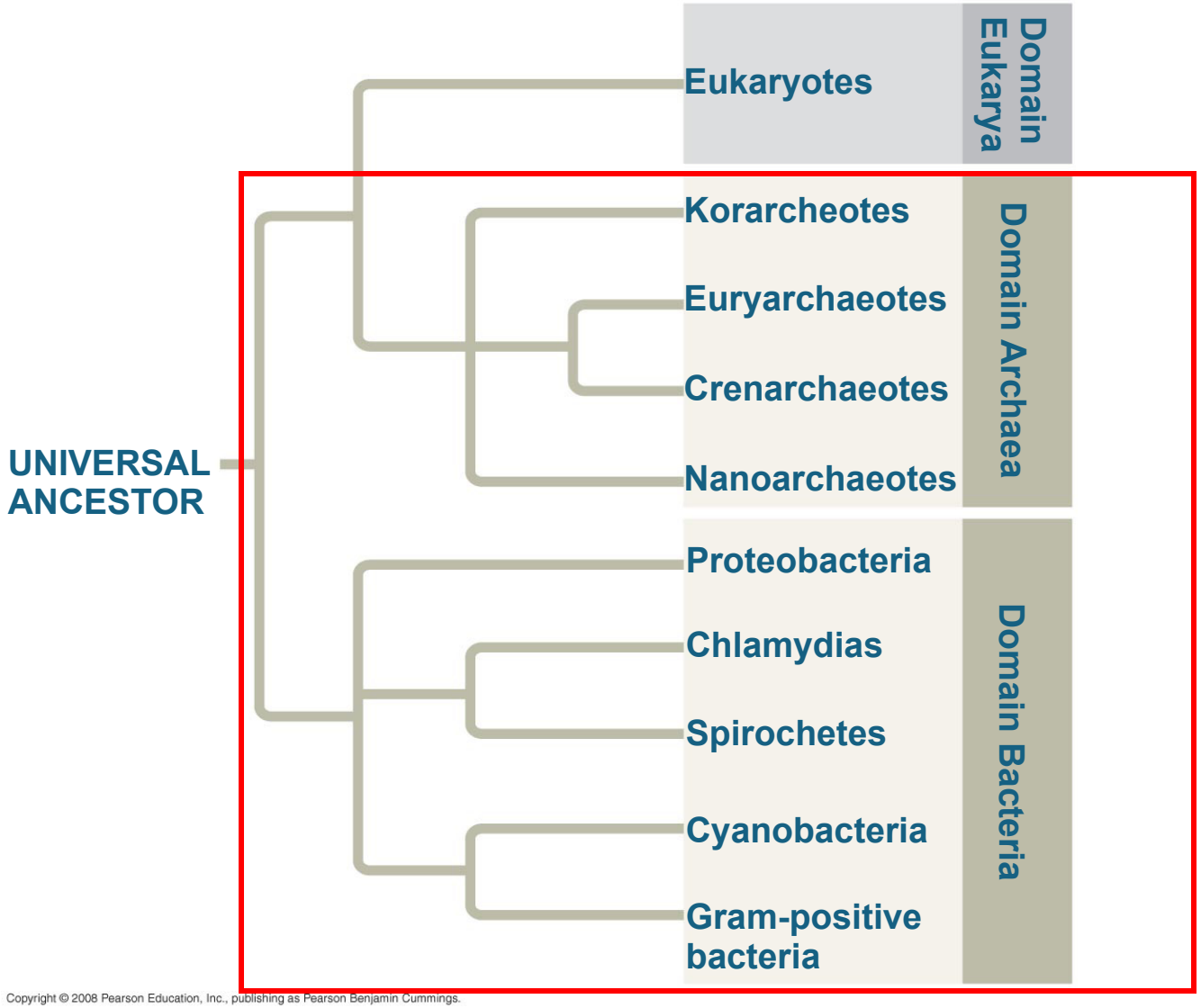
These factors can be combined to give the four major modes of nutrition: photoautotrophy, chemoautotrophy, photoheterotrophy, and chemoheterotrophy.

Table 27.1 Major Nutritional Modes

Mode of Nutrition	Energy Source	Carbon Source	Types of Organisms
Autotroph			
Photoautotroph	Light	CO_2	Photosynthetic prokaryotes (for example, cyanobacteria); plants; certain protists (for example, algae)
Chemoautotroph	Inorganic chemicals	CO_2	Certain prokaryotes (for example, *Sulfolobus*)
Heterotroph			
Photoheterotroph	Light	Organic compounds	Certain prokaryotes (for example, *Rhodobacter, Chloroflexus*)
Chemoheterotroph	Organic compounds	Organic compounds	Many prokaryotes (for example, *Clostridium*) and protists; fungi; animals; some plants

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Phylogenetic Classification of Prokaryotes

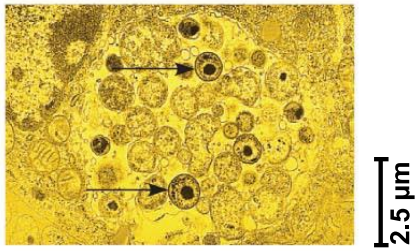


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1. Domain Bacteria

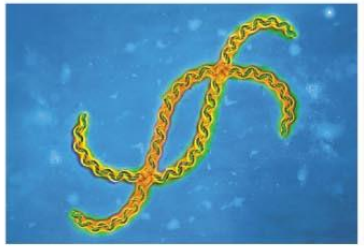
- Bacteria include the **vast majority of prokaryotes** of which **most people are aware** from the pathogenic to the beneficial species
- **Diverse nutritional types** are scattered among the major groups of bacteria as shown below:

CHLAMYDIAS



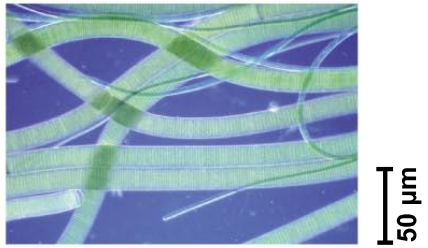
Parasitic bacteria that live within animal cells

SPIROCHETES



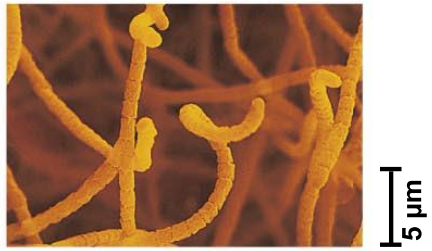
Many are free-living, but others are pathogenic parasites

CYANOBACTERIA



Photoautotrophs that generate O_2

GRAM-POSITIVE BACTERIA



Diverse group of bacteria

2. Domain Archaea

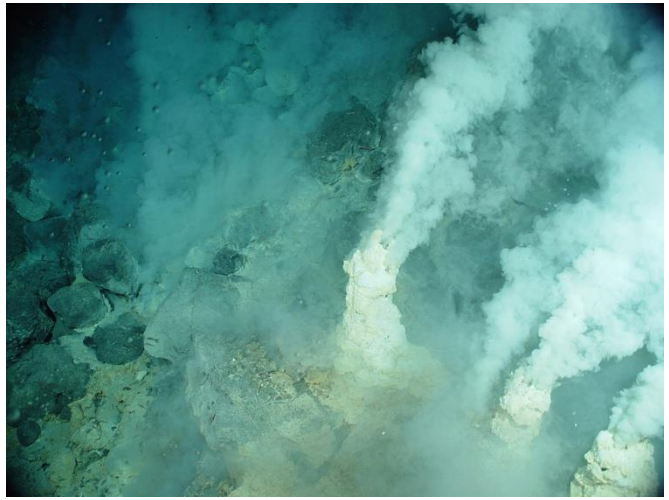
- Archaea are prokaryotes and share certain traits **with bacteria and other traits with eukaryotes**
- Archaea are famous for their **love of living in extreme environments**
- Only archaea are **known to produce methane, know as methanogens**

Spain's Rio Tinto river



Extremely acidic & Full of heavy metals

Hydrothermal vents



The surrounding water can reach over 300 °C

Deep Lake in East Antarctica



Very cold & ultra-salty

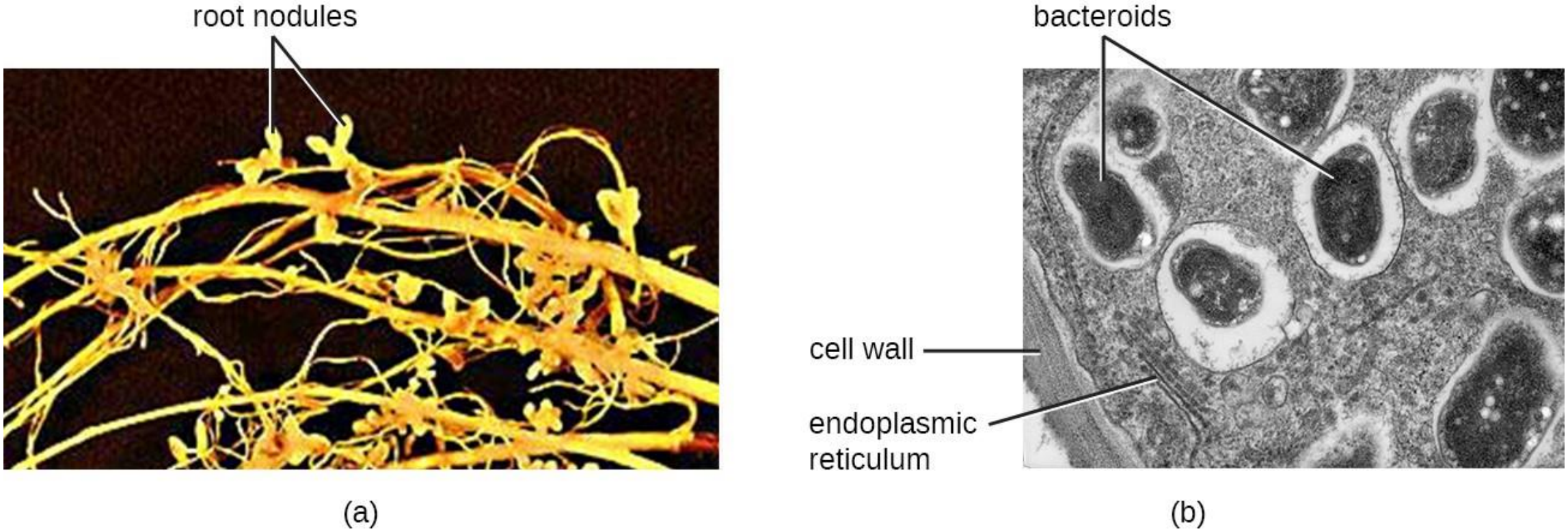
Beneficial Prokaryotes

In the environment

- **Decomposition** by **heterotrophic prokaryotes** and the synthetic activities of **autotrophic and nitrogen-fixing prokaryotes** contribute to the recycling of elements in ecosystems
- Prokaryotes play a central role in many **beneficial ecological interactions**. For instance, members of the **legume family** develop a symbiotic relationship with **Rhizobia bacteria** that operate the nitrogen fixation process

In human

People depend on mutualistic prokaryotes, including hundreds of species that live in our intestines and help digest food.



(a) Nitrogen-fixing bacteria such as *Rhizobium* live in the root nodules of legumes such as clover. (b) This micrograph of the root nodule shows bacteroids (bacterium-like cells or modified bacterial cells) within the plant cells. The bacteroids are visible as darker ovals within the larger plant cell

Beneficial Prokaryotes

In food production

They make a **wide range of food products by fermentation** such as dairy products (cheese and yogurt), meat products (sausages), and vegetable products (pickles)

In industry

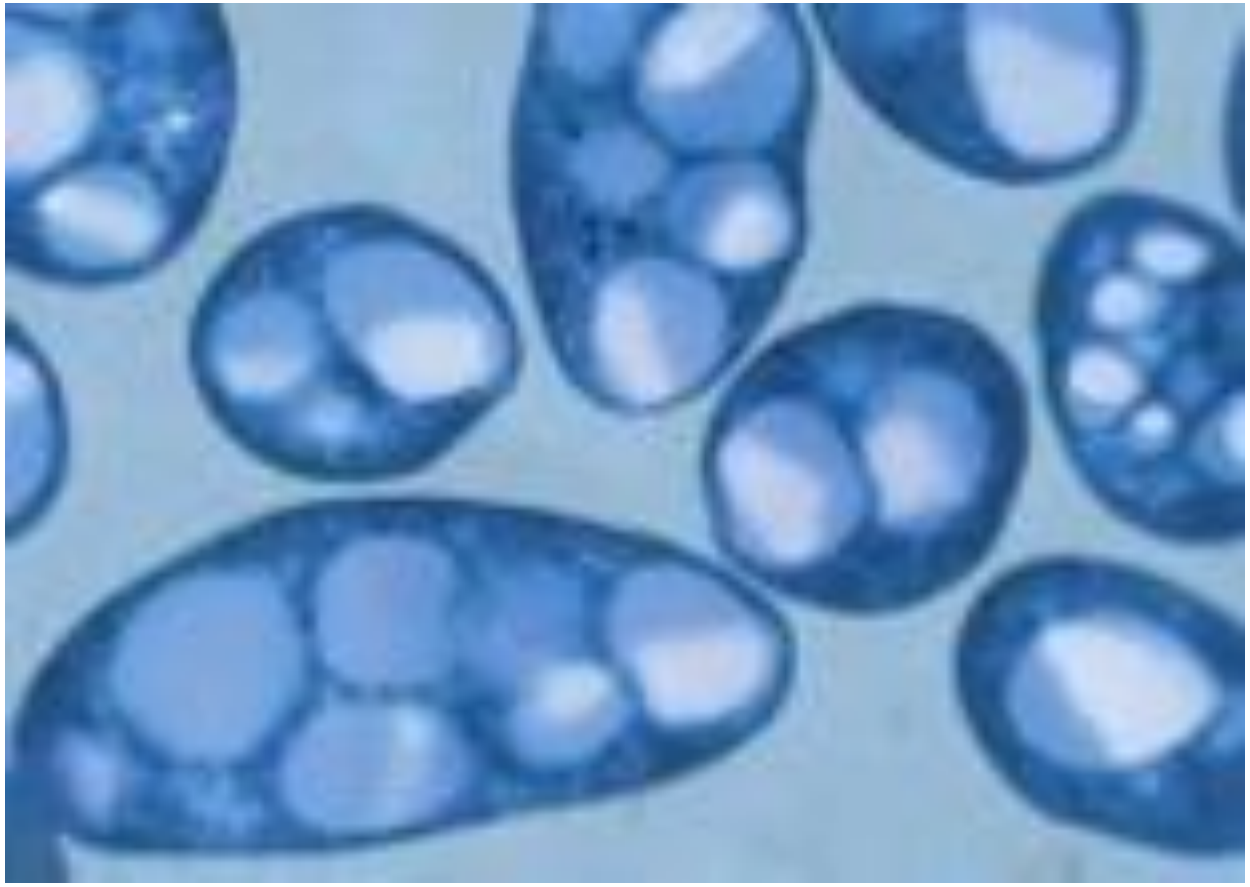
Prokaryotes can be used in **bioremediation** and **production** of plastics, vitamins, antibiotics, and other products

In Research

They are used in **molecular biology, biochemistry and genetic research**, because they **can grow quickly and are relatively easy to manipulate**. Scientists use **bacteria to study how genes and enzymes** work.



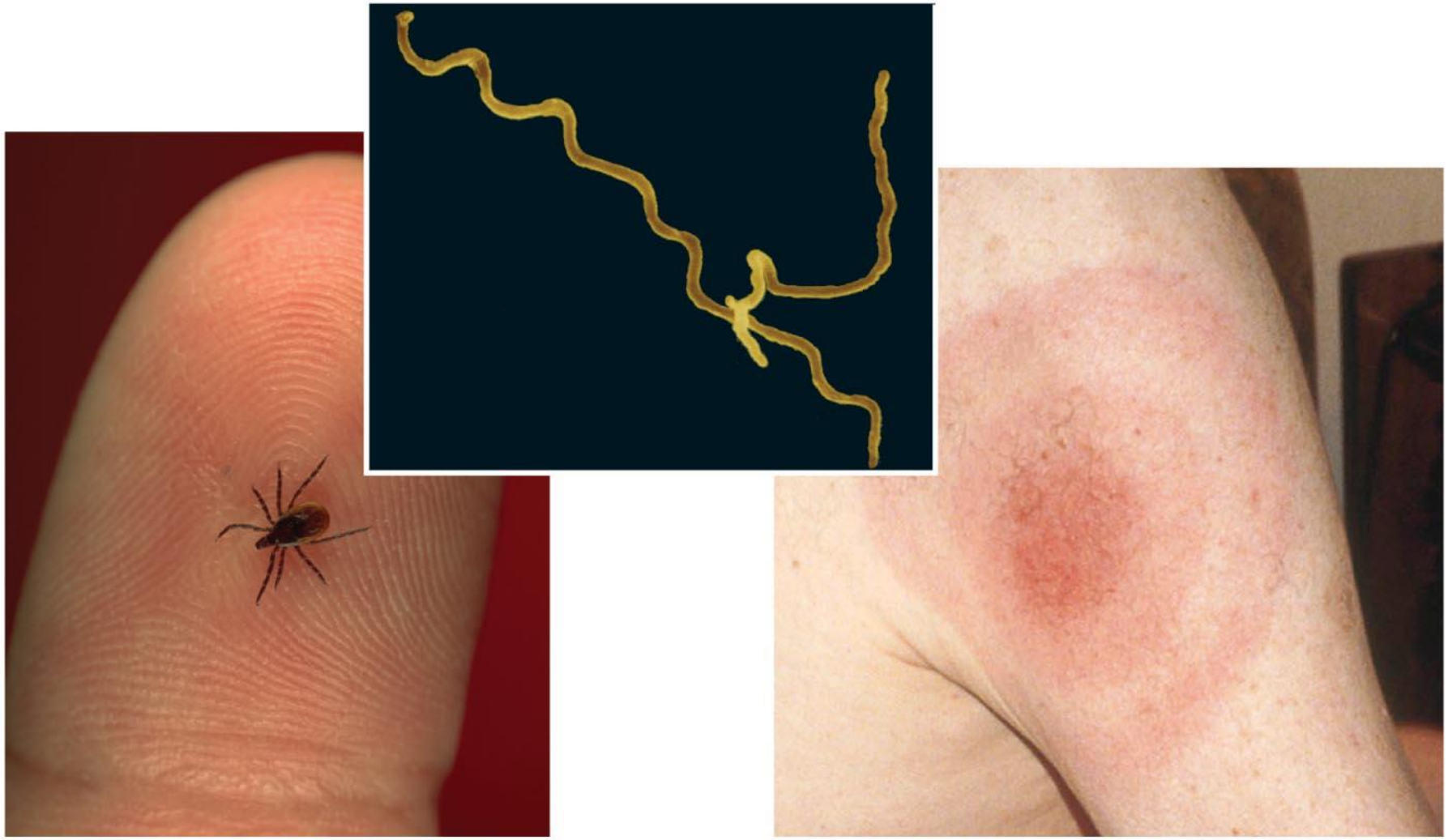
Bioremediation of an oil spill: Spraying fertilizer stimulates the growth of native bacteria that metabolize oil, increasing the speed of the breakdown process up to fivefold



Use of bacteria to produce natural plastics: Bacteria synthesizing and storing PHA (Polyhydroxyalkanoates), a component of biodegradable plastics

Harmful Prokaryotes

- Some types are pathogenic which can **cause diseases** in humans, animals or plants. Examples of human bacterial diseases are strep throat, tuberculosis, and urinary tract infections
- Their growth can **spoil different kind of food** or can pose a **serious health hazard which might lead to food poisoning** when ingested
- Some prokaryotes can **decrease the availability of nutrients in the environment**
- Many pathogenic species are potential **weapons of bioterrorism**



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Pathogens: Bacteria Causing Lyme Disease are transmitted by deer ticks

Domain Eukarya

The Fungi

- **All fungi are eukaryotic**
- Fungi are among the **most diverse and widely distributed organisms** and are of **great environmental and medical importance**
- Many fungi are **free-living in soil or water**; others form **parasitic** or **symbiotic relationships** with plants or animals



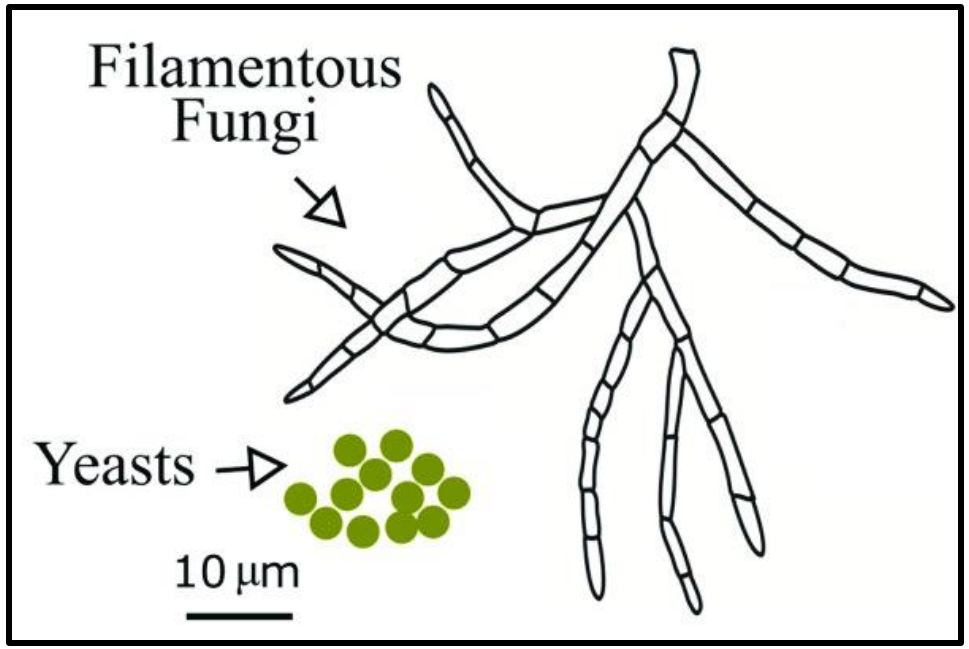


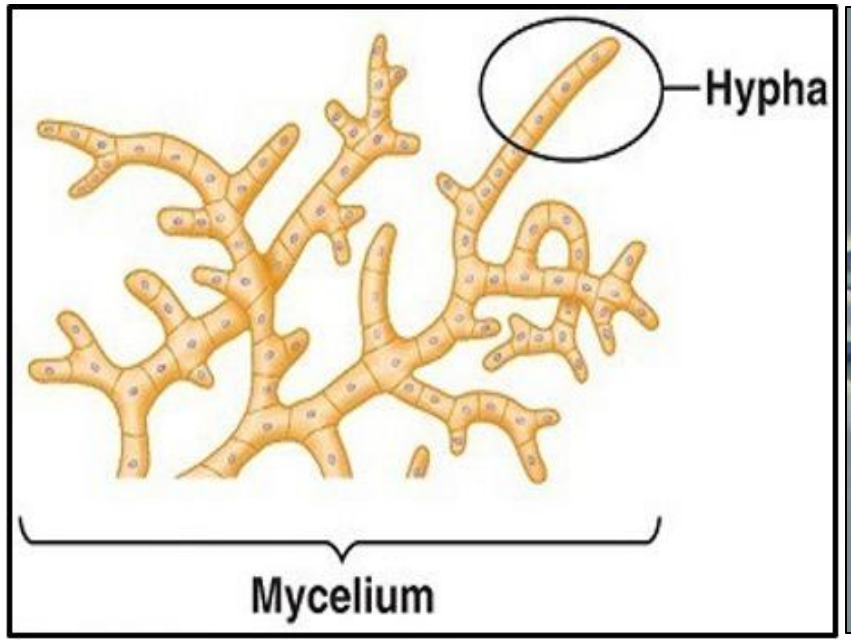


Body Shape and Structure

The **fungal body structures can be one of the following:**

1. **Multicellular filaments hyphae** branch repeatedly into a complicated network called the mycelium (most common)
2. **Unicellular (yeast-like)** are usually spherical or oval (less common)







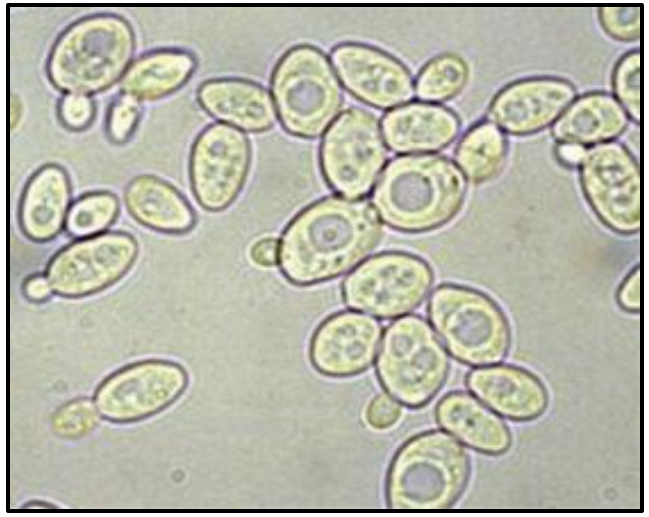
Mycelium of multicellular fungi

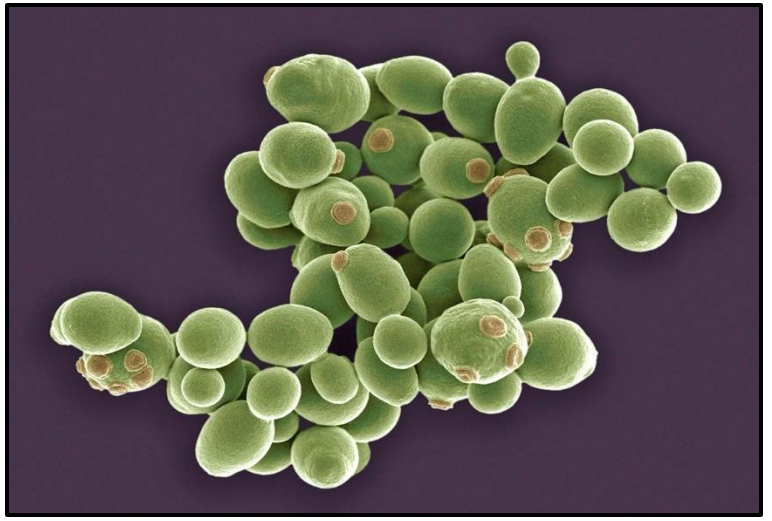


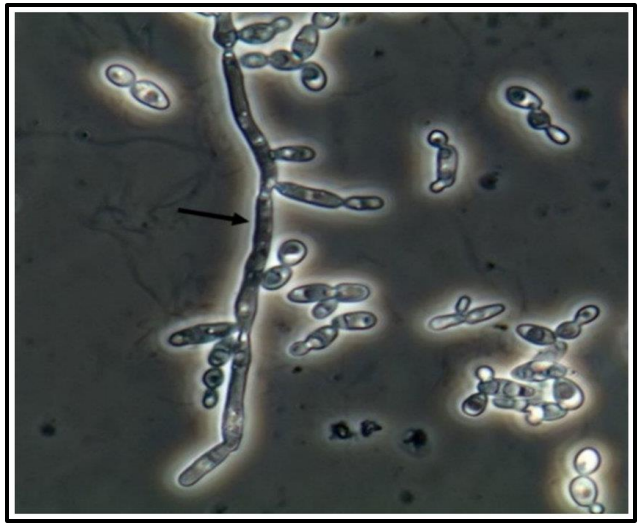


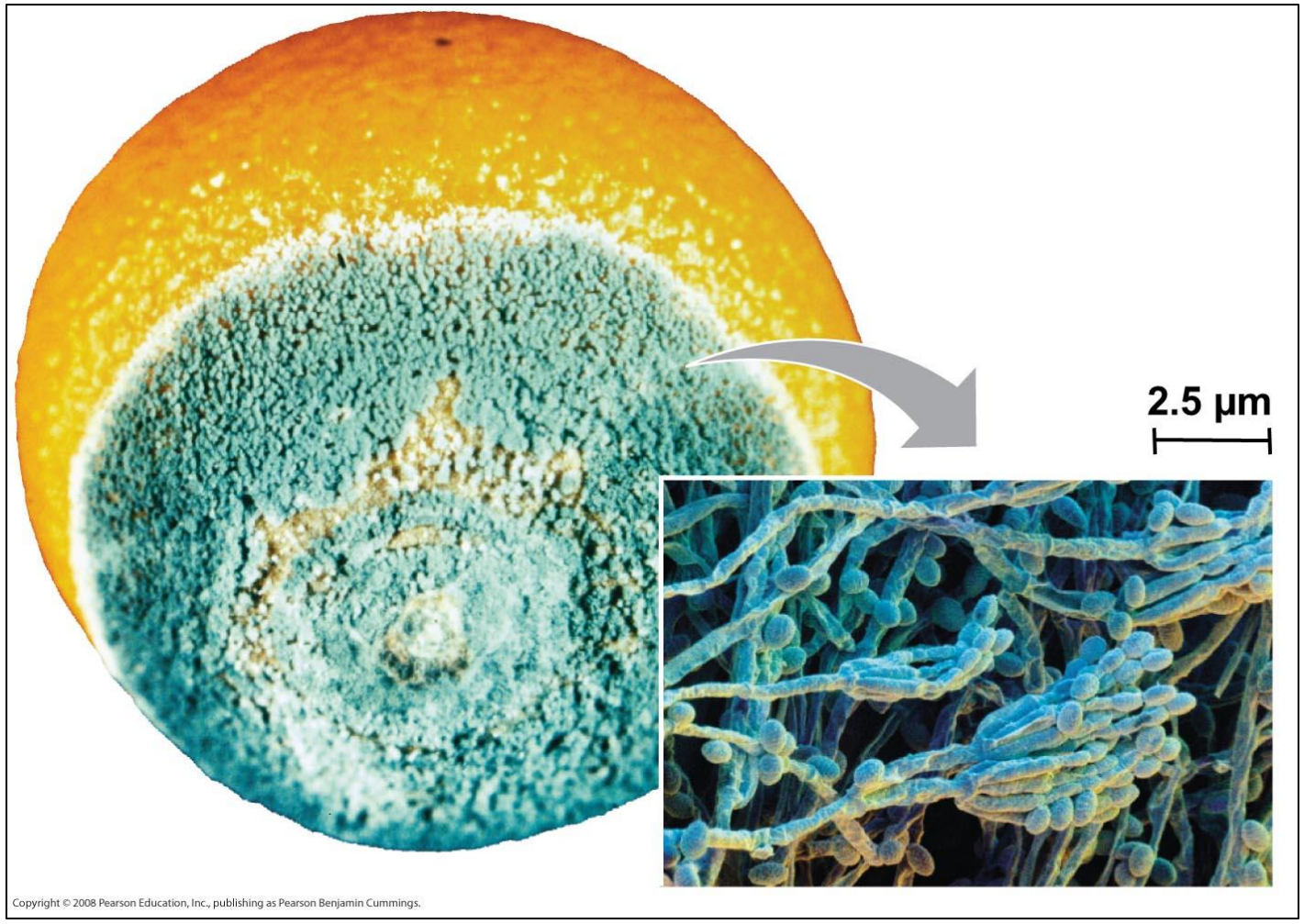


Unicellular fungi (yeast-like)

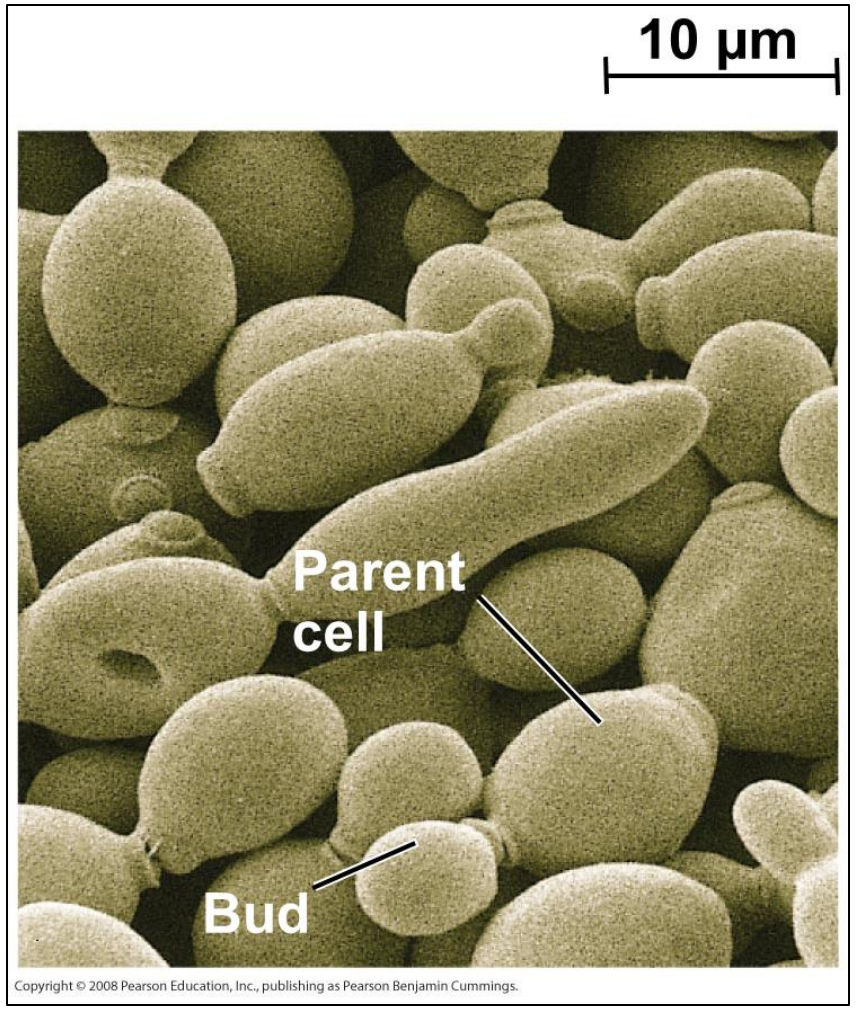








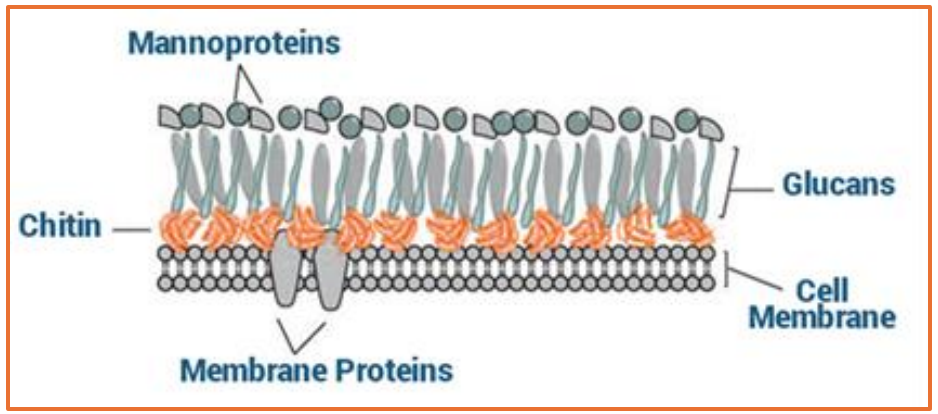
Penicillium: a mold that decomposes food

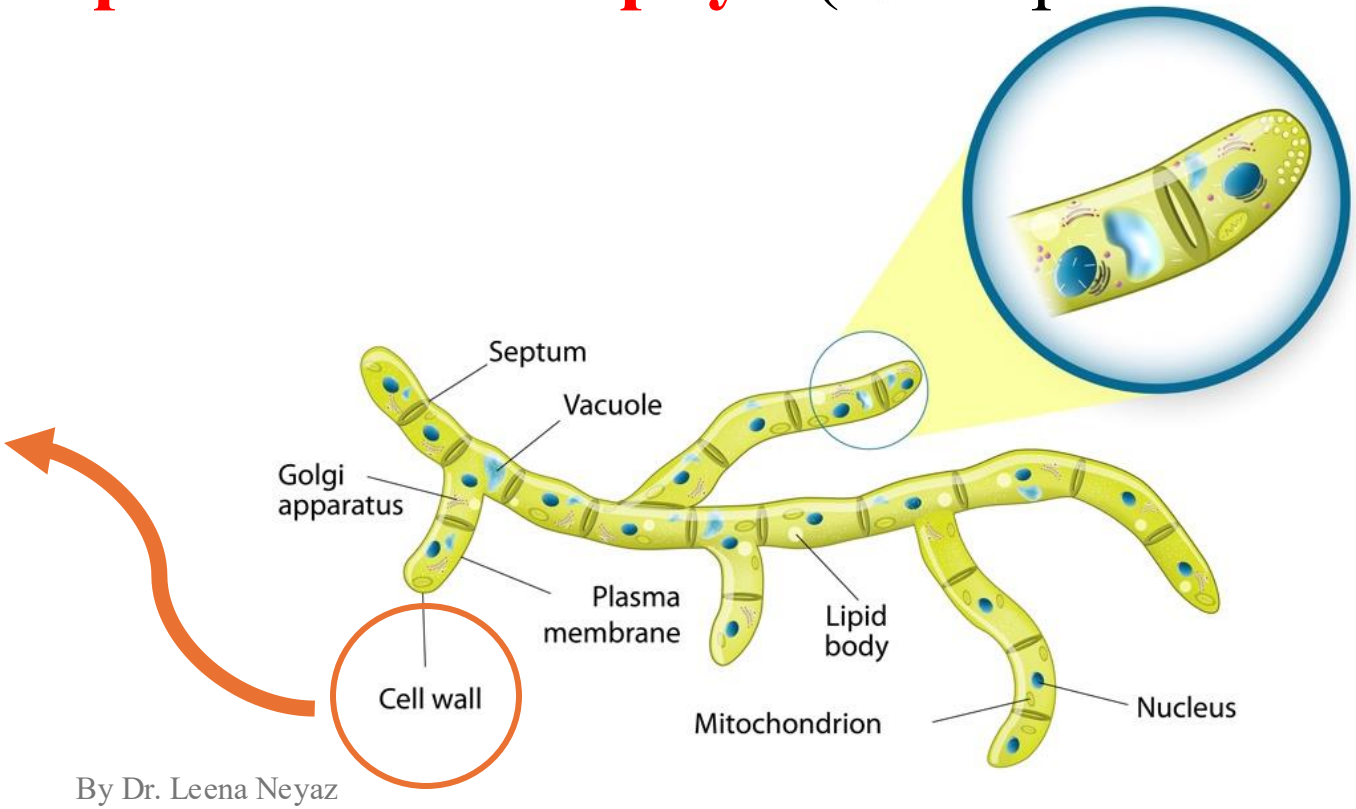


The yeast *Saccharomyces cerevisiae*

Body Shape and Structure

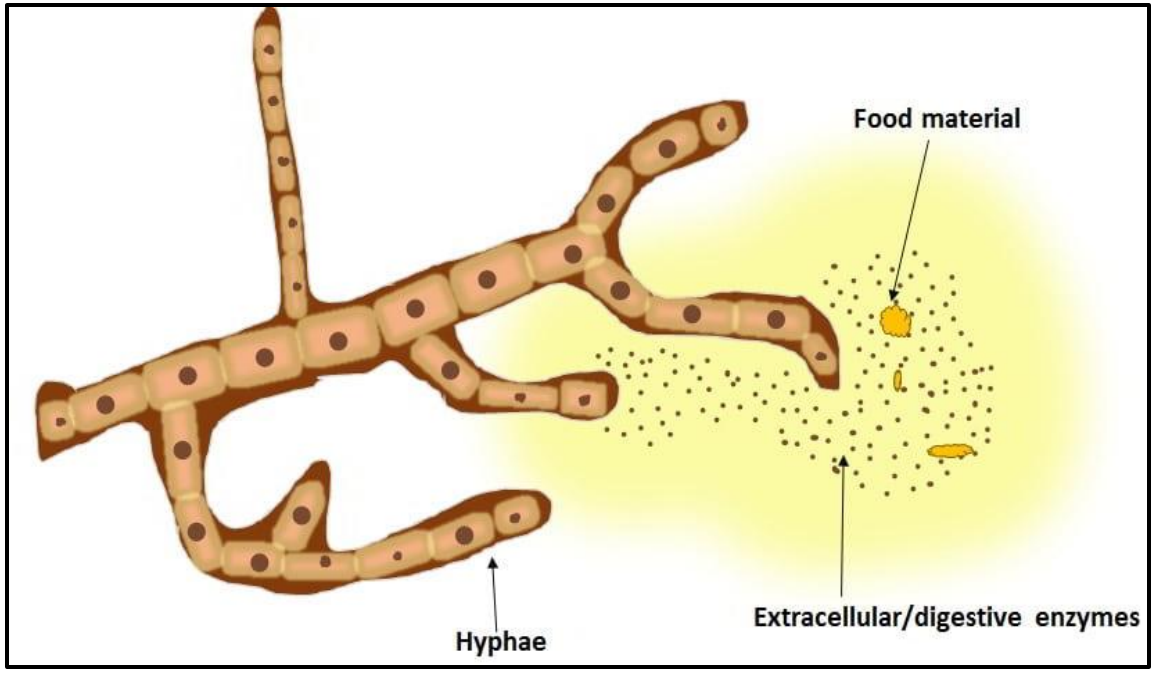
- They have a **thick cell wall made of mainly chitin** (a strong but flexible polysaccharide) to provide important **structural stability** to fungal cell walls
- Fungal cells **do not have chloroplasts or chlorophyll** (not capable of photosynthesis)
- Fungi are **non-motile**





Nutrition in Fungi

- All fungi are **heterotrophs** (not capable of photosynthesis because they lack chlorophyll)
- Fungi use **enzymes** to break down a large variety of complex molecules. The **versatility of these enzymes** contributes to **fungi's ecological success**
- They **feed by absorption (extracellular digestion);** Means they **absorb** nutrients from outside of their body



Classification of Fungi According to Nutrition

Fungi exhibit **diverse lifestyles with diverse food sources:**

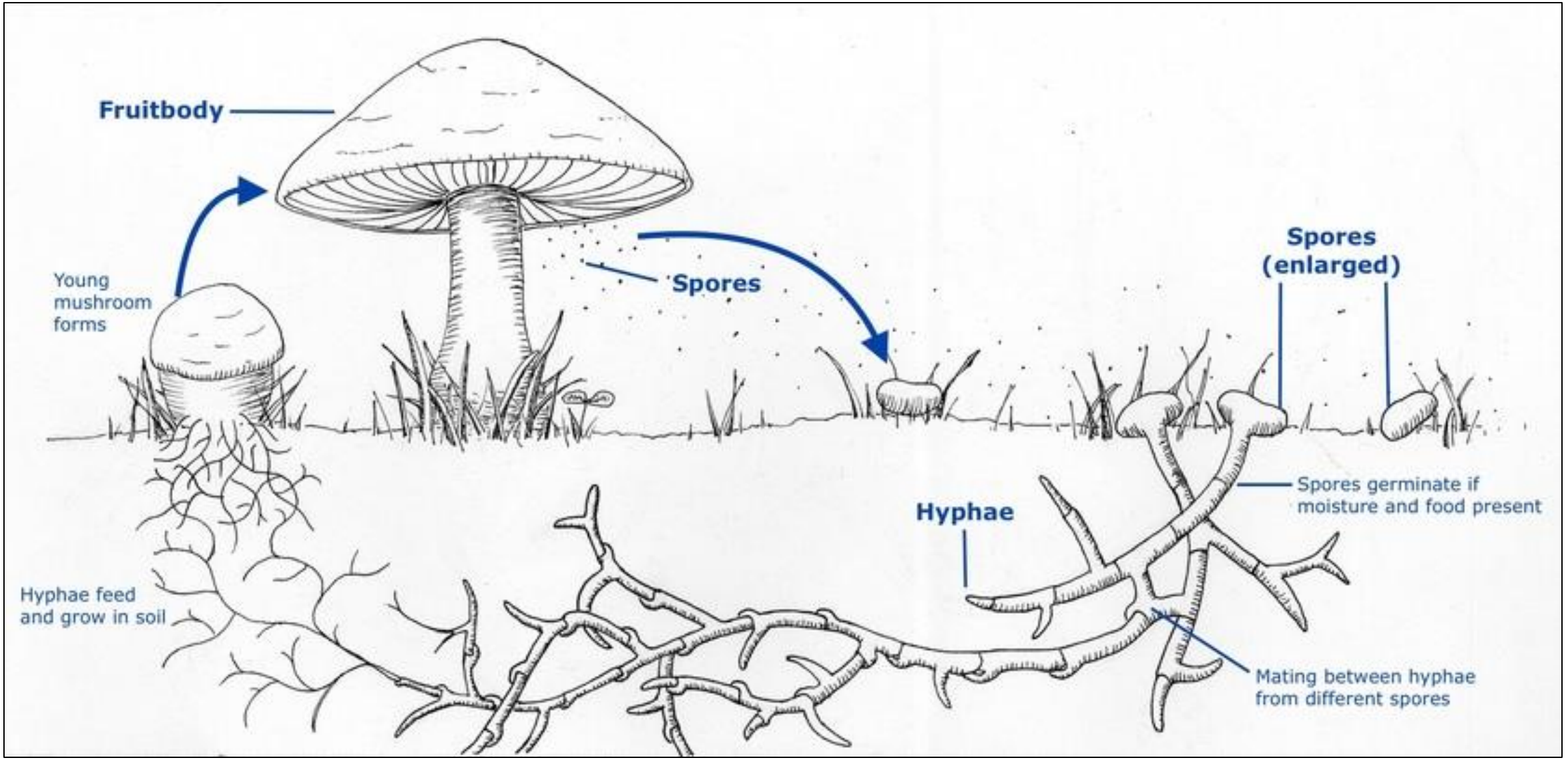
1. **Decomposers/saprophytes:** feed on **nonliving dead organic material**, such as fallen logs, animal corpses, and the wastes of organisms
2. **Parasites:** feed on **living cells of a host**. Parasites that cause disease are called **pathogens**
3. **Mutualists/ Symbionts:** fungi **live harmlessly** with other living organisms, and both **get mutually benefited**





Reproduction in Fungi

- Most fungi propagate themselves **by producing vast numbers of spores**
- Spores can be **carried long distances** by wind or water. If they land in a moist place where there is food, **they germinate producing a new mycelium**
- Some fungi form **reproductive (fruiting) structures** which can **contain spores**
- **Most fungi** can reproduce **both sexually and asexually;** others **reproduce only sexually or only asexually**
- In **both sexual and asexual** reproduction, **most fungi** produce **spores.** Fungi exhibit several types of spores, and these can be **important in classification**


Fruitbody
Young mushroom forms
Spores
Spores (enlarged)
Spores germinate if moisture and food present
Hyphae
Hyphae feed and grow in soil
Mating between hyphae from different spores

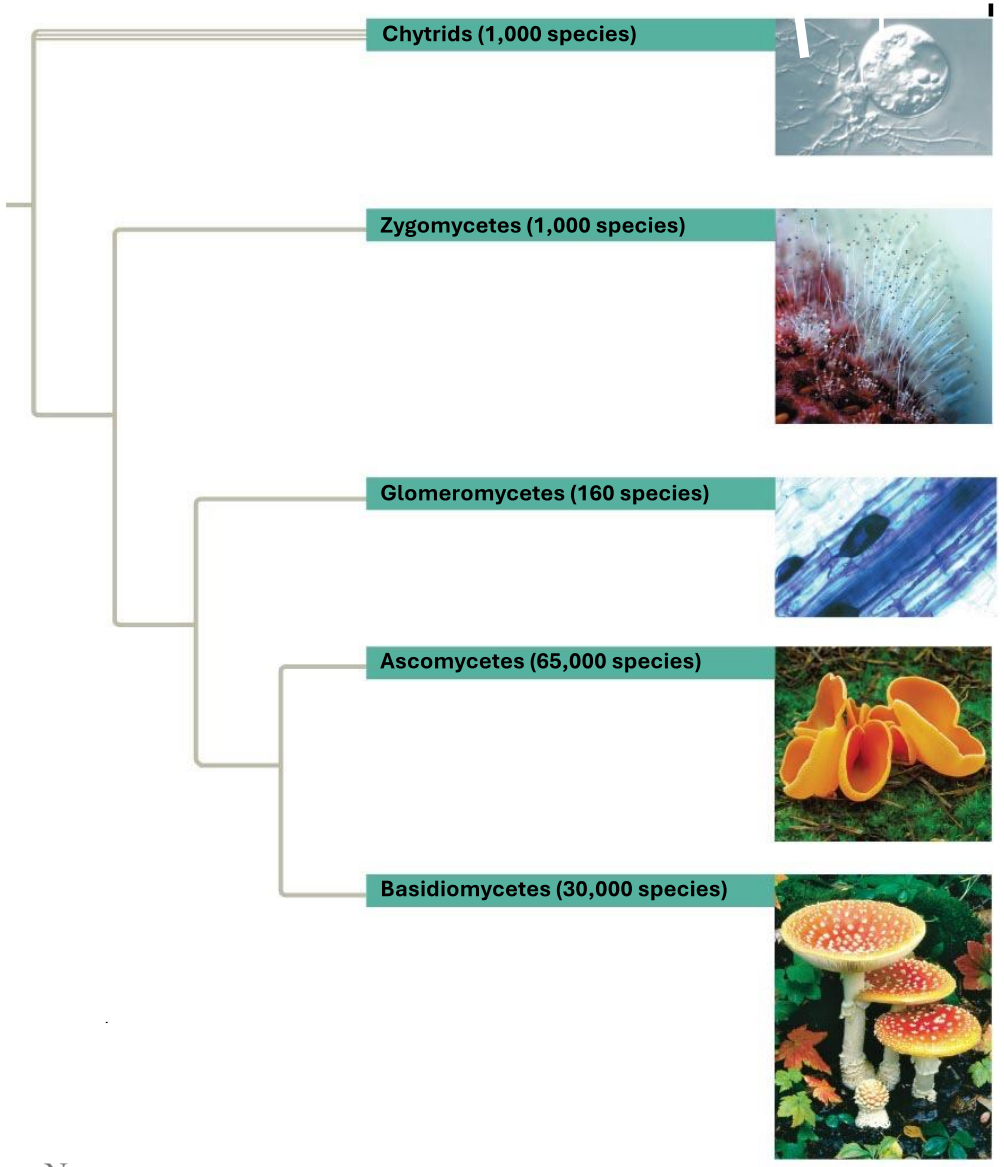




Puffballs and mushroom, the reproductive (fruiting) structures of certain fungal species, may release trillions of spores

Diversity of Fungi

Fungal Phylum	Distinguishing Features of Morphology and Life Cycles	
Chytridiomycota (chytrids)	Flagellated spores	
Zygomycota (zygote fungi)	Resistant zygosporangium as sexual stage	
Glomeromycota (arbuscular mycorrhizal fungi)	Form arbuscular mycorrhizae with plants	
Ascomycota (sac fungi)	Sexual spores (ascospores) borne internally in sacs called asci; ascomycetes also produce vast numbers of asexual spores (conidia)	
Basidiomycota (club fungi)	Elaborate fruiting body (basidiocarp) containing many basidia that produce sexual spores (basidiospores)	



Fungi play key roles in nutrient cycling

- Fungi are efficient **decomposers of organic material**, including the **cellulose and lignin of plant cell walls**. In fact, **almost any carbon-containing substrate**—even jet fuel and house paint—can be consumed by fungi
- As a result, fungi are **primarily responsible for recycling chemical elements** such as carbon, nitrogen, and other elements in the ecosystems



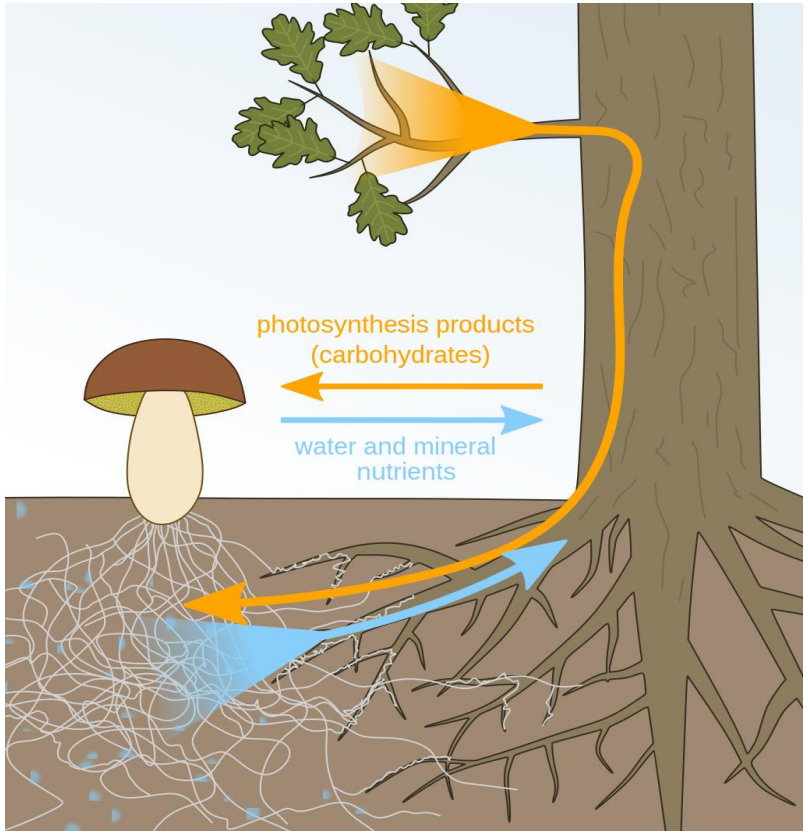


Many fungi are important decomposers of dead wood

Fungi Play Key Roles in Ecological Interactions

Fungi form **mutualistic relationships** with plants, algae, cyanobacteria, and animals. All these relationships have profound ecological effects

1. Fungus-Plant Mutualisms:
fungi & plant roots (Mycorrhizae)



2. Fungus-photosynthetic microorganism Mutualisms: fungi and algae (lichens)



Fungi Play Key Roles in Human Welfare

- About 30% of known fungal species are parasites or pathogens, **mostly on or in plants.** Some fungi that attack food crops are **toxic to humans**
- **Animals are much less susceptible** to parasitic fungi than are plants
- The general term for a fungal infection in animals (including human) is **mycosis**



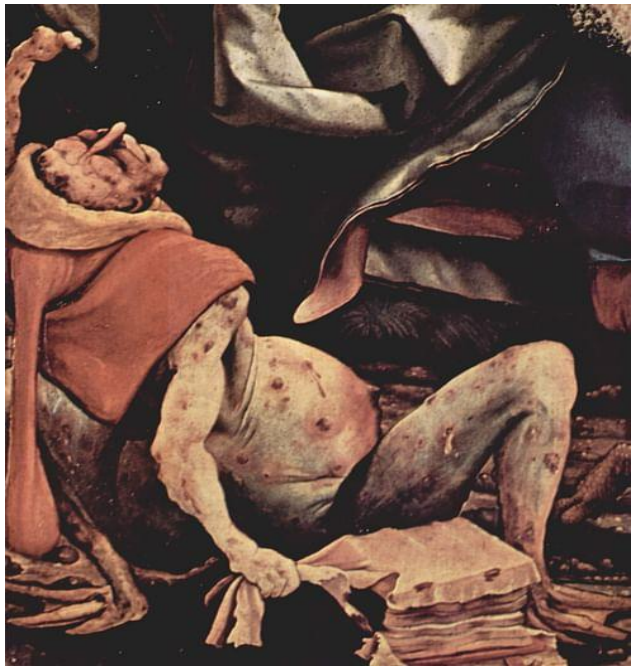
(a) Corn smut on corn



(b) Tar spot fungus on maple leaves



(c) Ergots on rye



An epidemic of ergotism (944 CE) killed up to 40,000 people in France

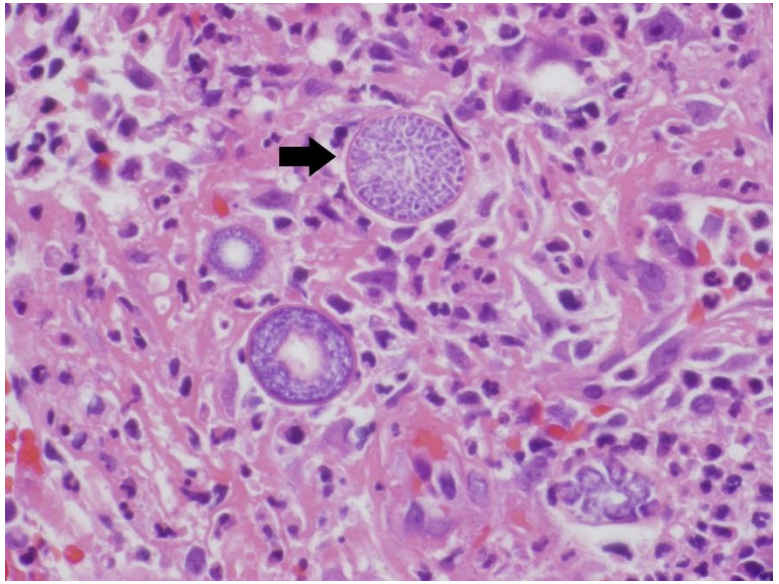




Nearly 100 species of frogs and **other amphibians** wiped out by fungal **chytrids**




Athlete's foot (left) and ringworm infections (right)



Coccidioidomycosis produces tuberculosis-like symptoms in the lungs

Practical Uses of Fungi

In Food Industry

Humans **eat** many fungi and use others to **make** cheeses, alcoholic beverages, and bread.

In Medicine

Some fungi are used to **produce antibiotics** for the treatment of bacterial infections, for example the fungi *Penicillium*.

In Research

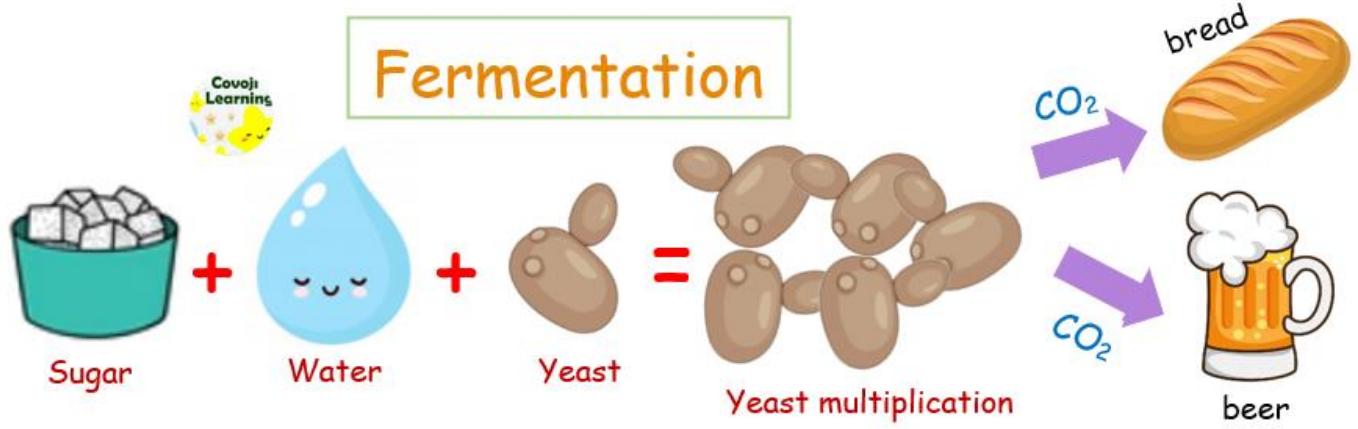
Genetic research on fungi is leading to applications in **biotechnology:** For example, insulin-like growth factor can be produced in the fungus *Saccharomyces cerevisiae*



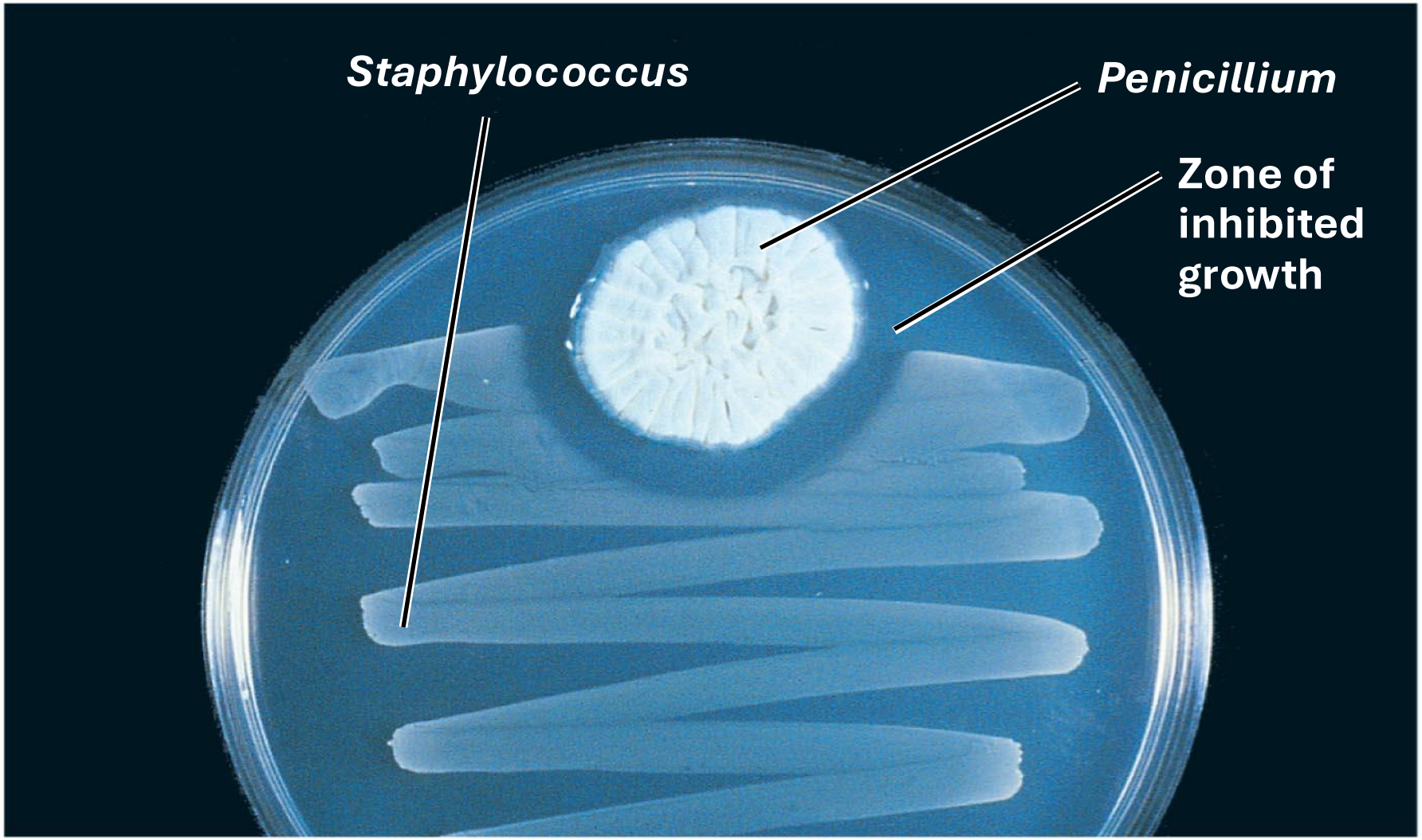





ROQUEFORT
CARLES


Fermentation
Covoji Learning
Sugar
Water
Yeast
Yeast multiplication
CO_2
bread
CO_2
beer

Fungal production of an Antibiotic: The mold penicillium produces an antibiotic that inhibits bacteria growth resulting in a clear area between the mold and the bacteria



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جامعة أم القرى
UMM AL-QURA UNIVERSITY

General Biology

Lecture (8)
Plant Form and Function

College of Applied Sciences

Biology Department

Outline

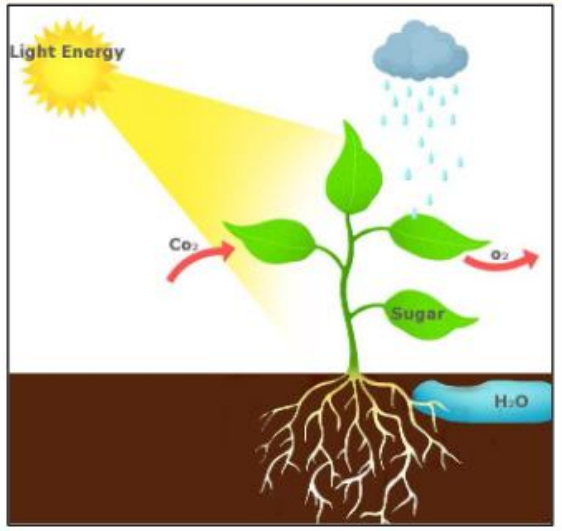
- Plant characteristics
- Highlights of plant evolution
- Plant diversity
- Seed plant structure
- Plant Function (Photosynthesis)

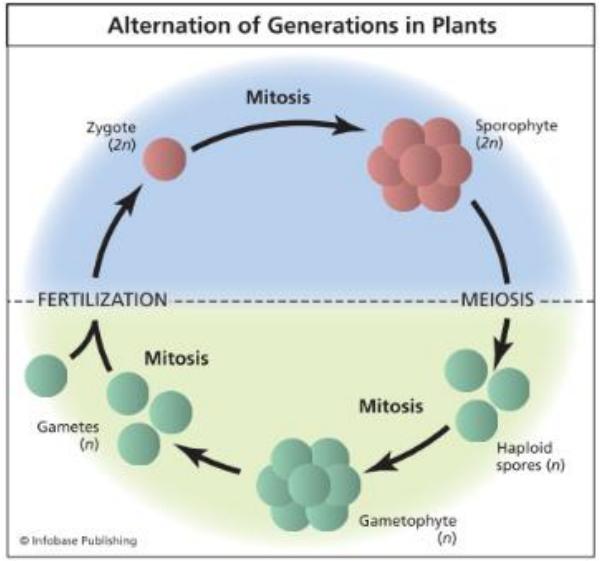
Section 1

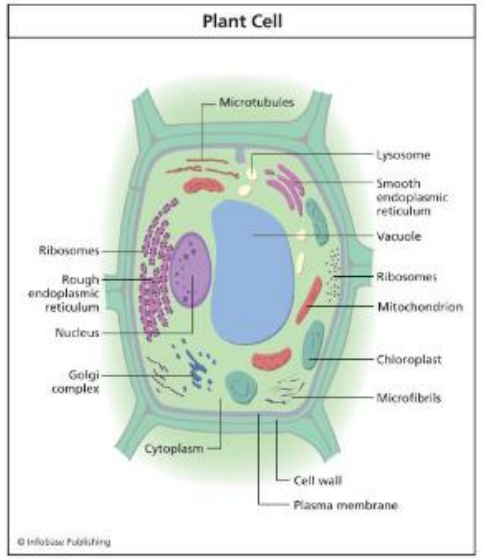
Plant diversity

Plant Characteristics

- **Autotrophic** (produce their own food by photosynthesis)
- **Non-motile**
- **Multicellular**
- **Eukaryotic** organisms
- Cell walls are composed of **cellulose**.
- Can **reproduce sexually and asexually.**
- **An alternation of generations occurs** (Gametophyte --> Sporophyte --> Gametophyte

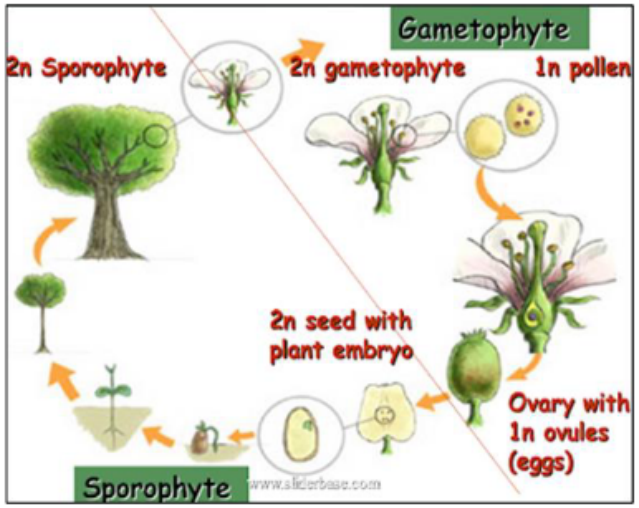


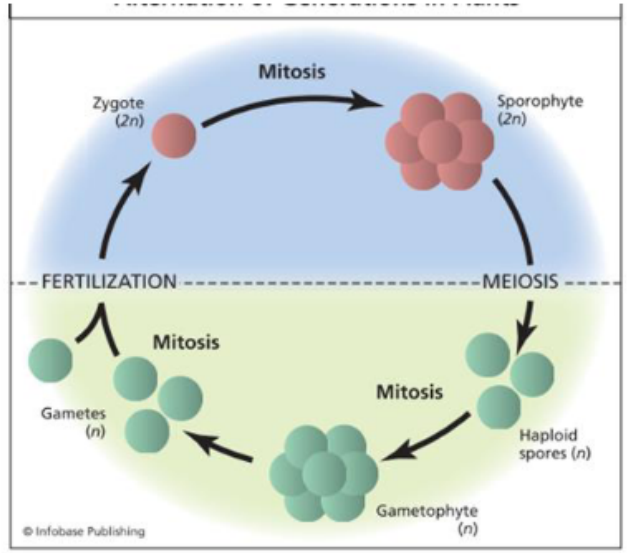




Alternation of Generations

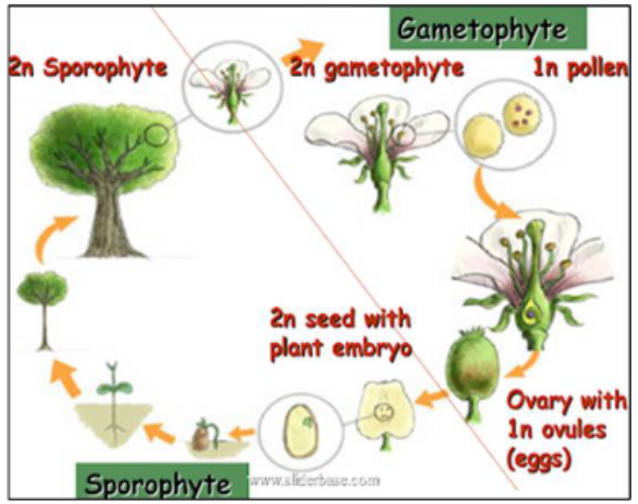
- The life cycle of any land plant has two distinct phases (**Gametophyte** and **Sporophyte**).
- The amount of time spent in each phase varies depending on the plant group.
- The first phase is called the gametophyte generation (phyte=plant, gameto=gamete).
- Gametophyte is a plant (multicellular, not just a single cell) that has a single set of chromosomes (**haploid**), which produces **gametes** via mitosis (egg and sperm cells), which are also **haploid**.

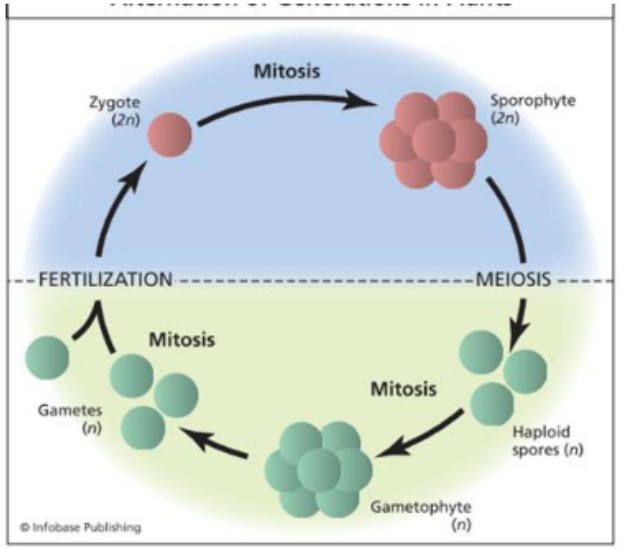




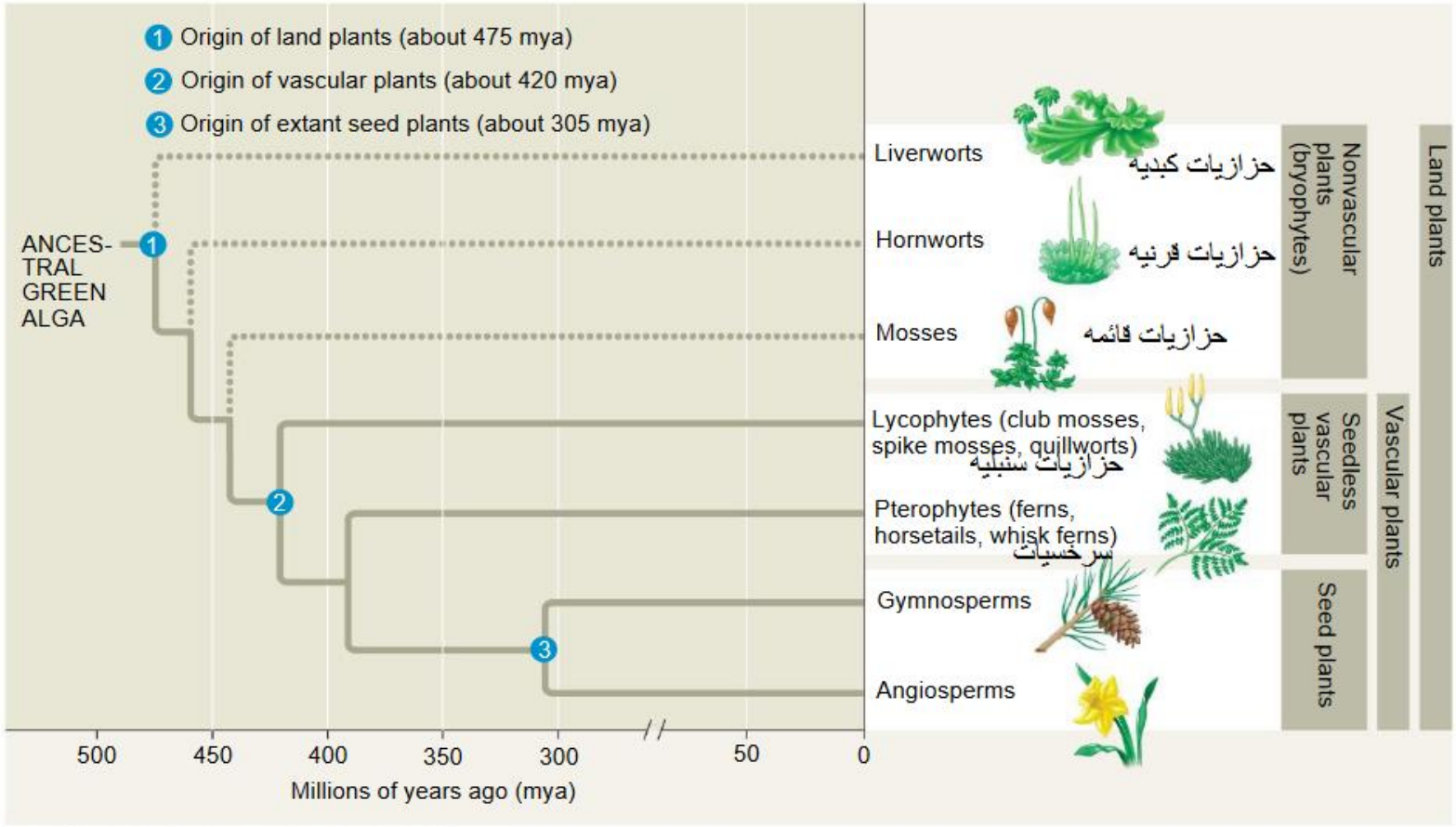
Alternation of Generations

- The second phase is called the sporophyte generation (phyte=plant, sporo=spore).
- Sporophytea is a plant (multicellular, not just a single cell) that has two sets of chromosomes (**diploid**), which is the result of the fusion of two gametes (sperm and egg), which produces **haploid spores** via **meiosis**.

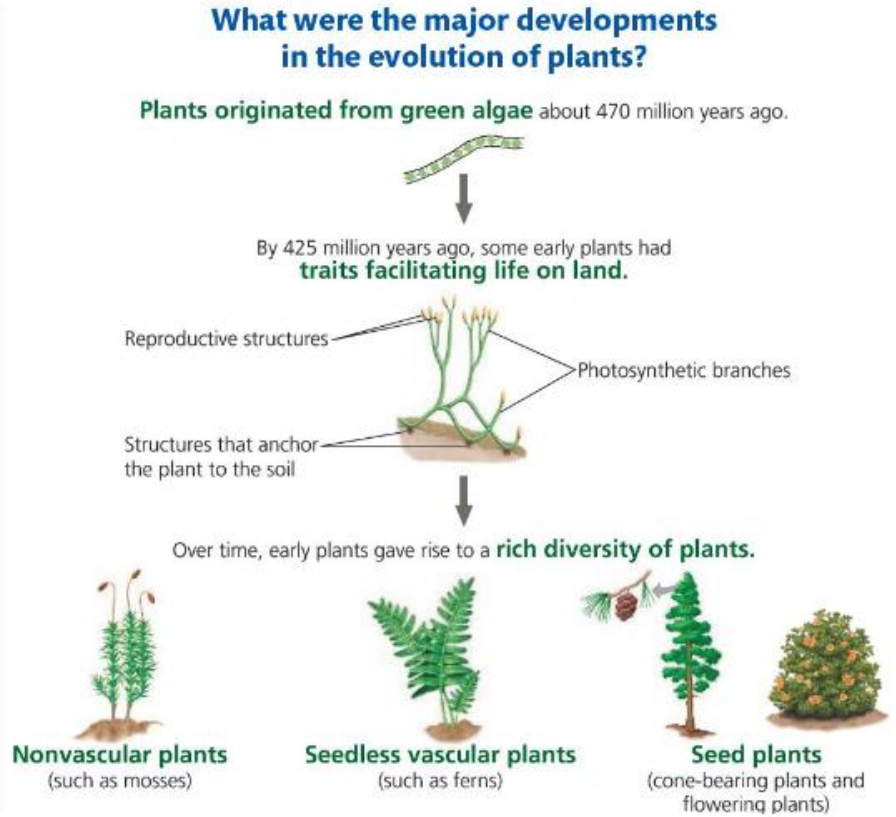




Highlights of Plant Evolution



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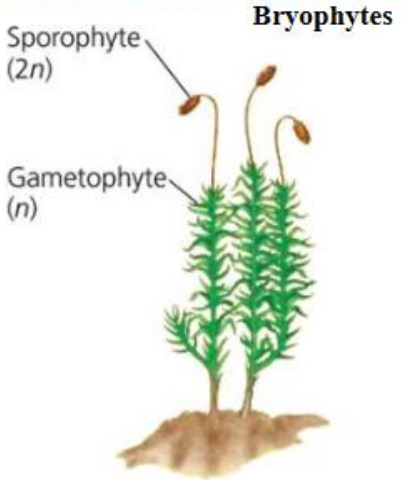
Plant diversity

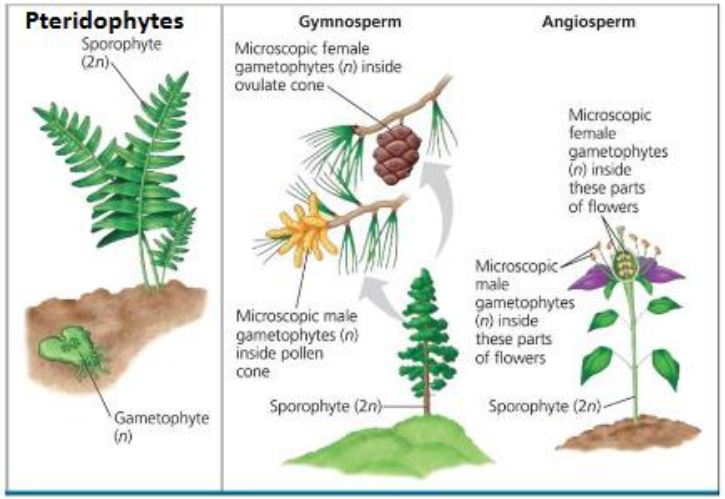




Land plants can be informally *grouped based on* the *presence or absence* of ***vascular tissue.***

Feature	Vascular Plants	Non-vascular Plants
Vascular system	They have a well-developed vascular system	They lack a specialised vascular system
Differentiation of body	They possess true roots, stem and leaves	They lack true roots, stems and leaves
Ploidy of main body	The main plant body is the diploid sporophyte	The main plant body is the haploid gametophyte
Vascular tissues	They contain complex vascular tissues, i.E. Xylem and phloem	They lack xylem and phloem
Size	They may grow very tall	They are small in size
Fertilisation	They may or may not require water for fertilisation	They require water for fertilisation
Examples	Pteridophytes, gymnosperms and angiosperms	Bryophytes





Section 2

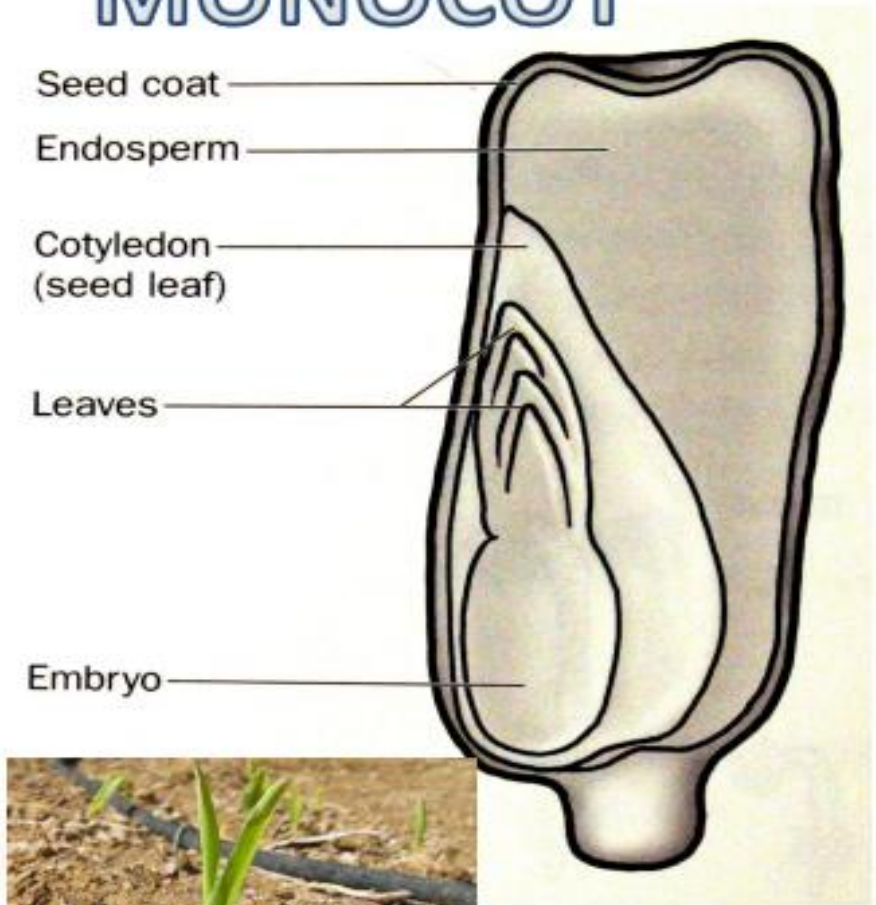
Plant Form

Seeds and Mature seed structure

- **Seed** is a **small embryonic** plant in the **dormancy state**, that produce of sexual reproduction in flowering plants.
- **Mature seed structure:**
  1. Seed coat (testa)
  2. Embryo
  3. Cotyledons

SEEDS

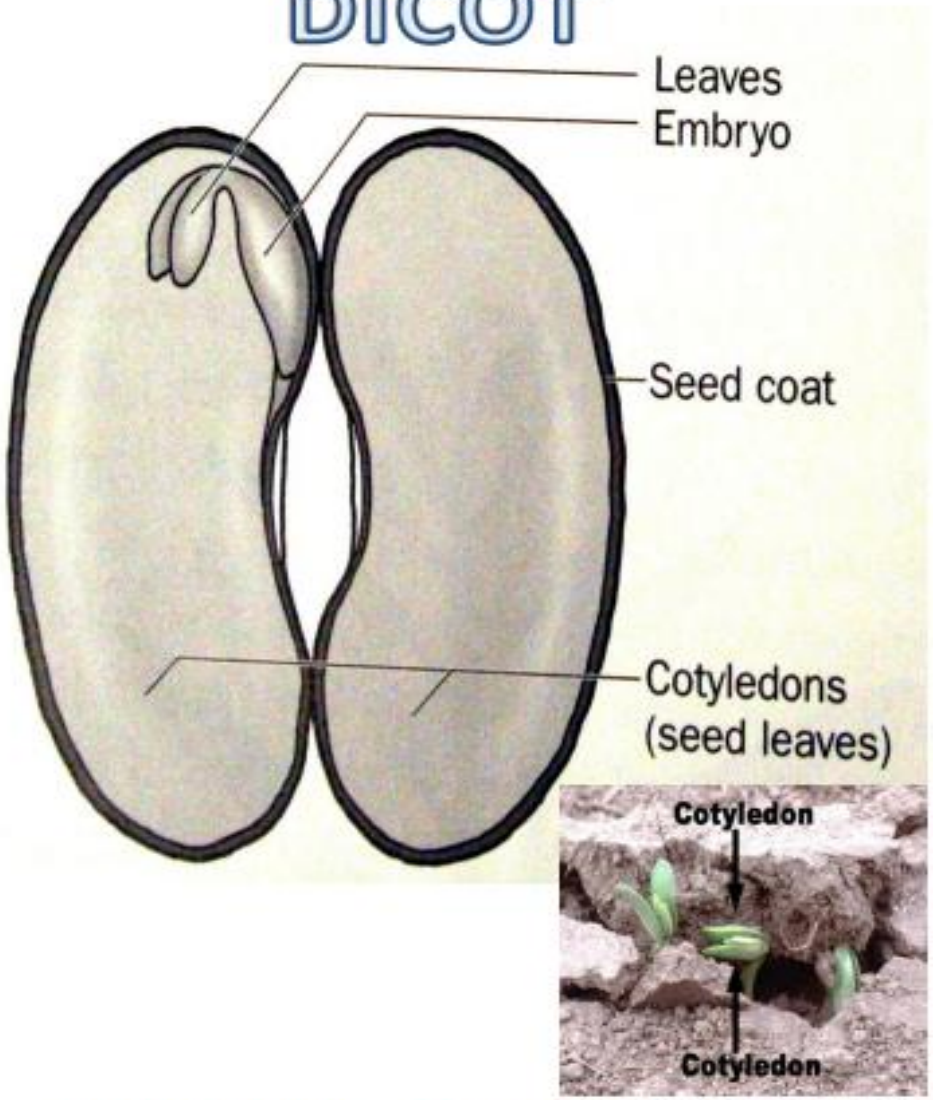
MONOCOT





Scientific name : ***Zea mays***

DICOT

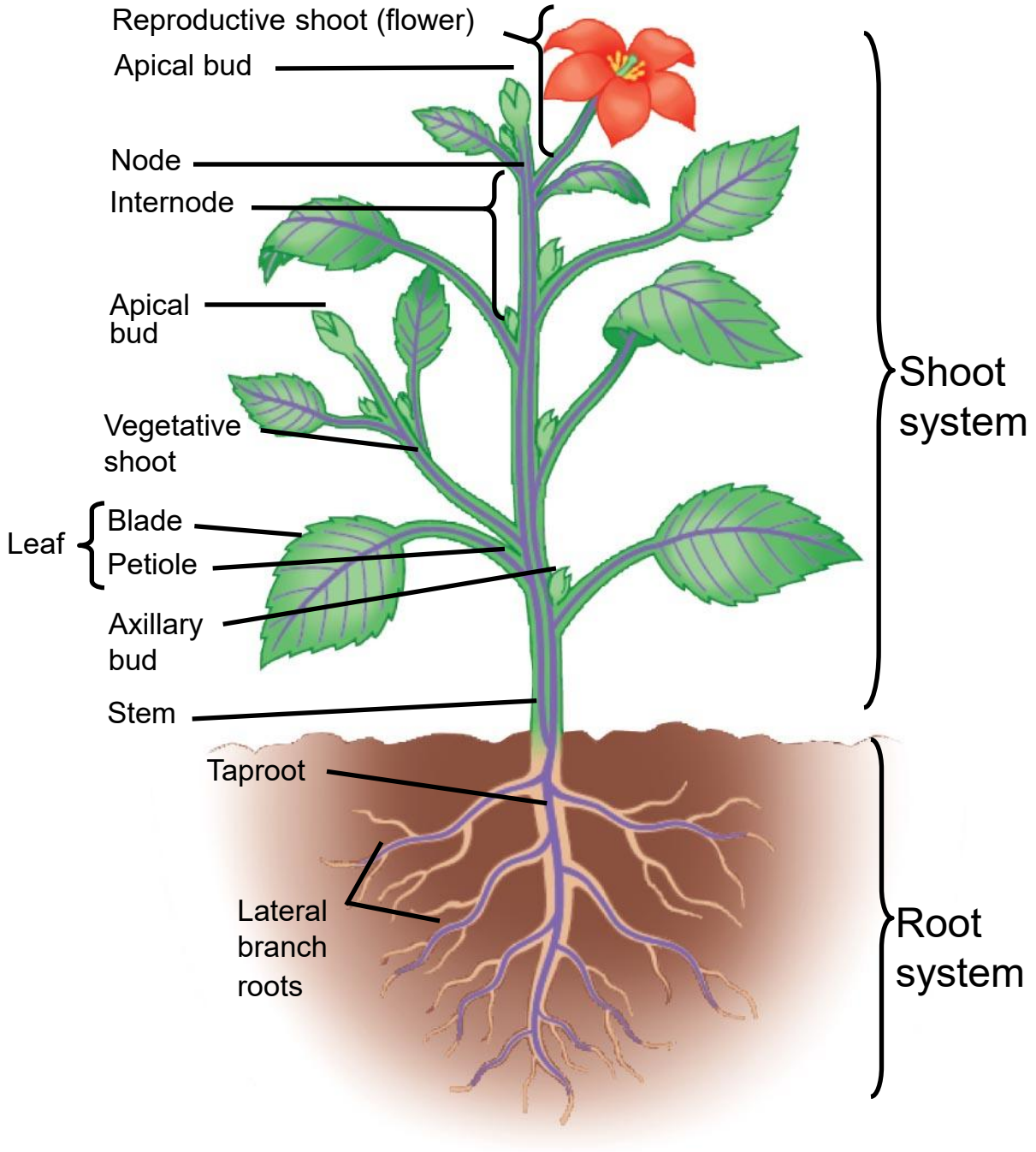


Scientific name : ***Phaseolus lunatus***

The Plant Structure

- **Three** basic organs evolved**: roots, stems, and leaves.**
- They are organized into a **root system** and a **shoot system:**
- **Roots** rely on sugar produced by photosynthesis in the ***Shoot system***.
- **Shoots** rely on water and minerals absorbed by the ***Root system***.

Flowering Plant Morphology



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The Root

- **Root:** an **underground** portion of Plant.

- **Types of Root:**
  - one main vertical root (Tap root) consists of lateral roots and root hairs.
  - Adventitious roots arise from stems or leaves

Functions of the root system

1. Responsible for **anchoring** and **support** the plant in the soil.
2. Roots **absorb** water and dissolved nutrients or solutes (nitrogen, phosphorous, magnesium, boron, etc.) needed for normal growth, development, photosynthesis, and reproduction.
3. In some plants, roots have become adapted for specialized functions ex: **storage**..

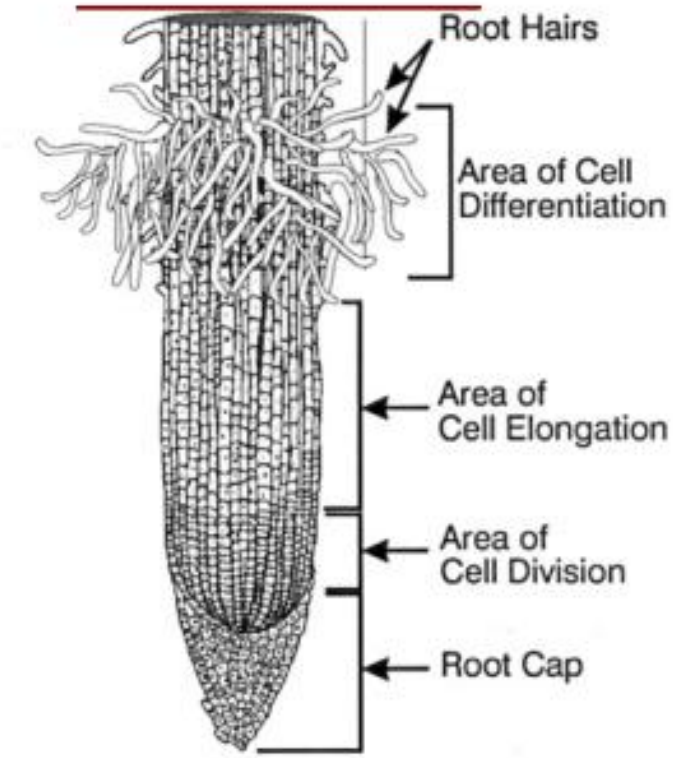
Zones of the Root - External Anatomy

1. Meristematic zone

- Root cap
- Region of cell division

2. Elongation zone

3. Maturation (or differentiation) **zone**



Many plants have modified roots



Prop roots



Storage roots



"Strangling" aerial roots



Pneumatophores

Buttress roots

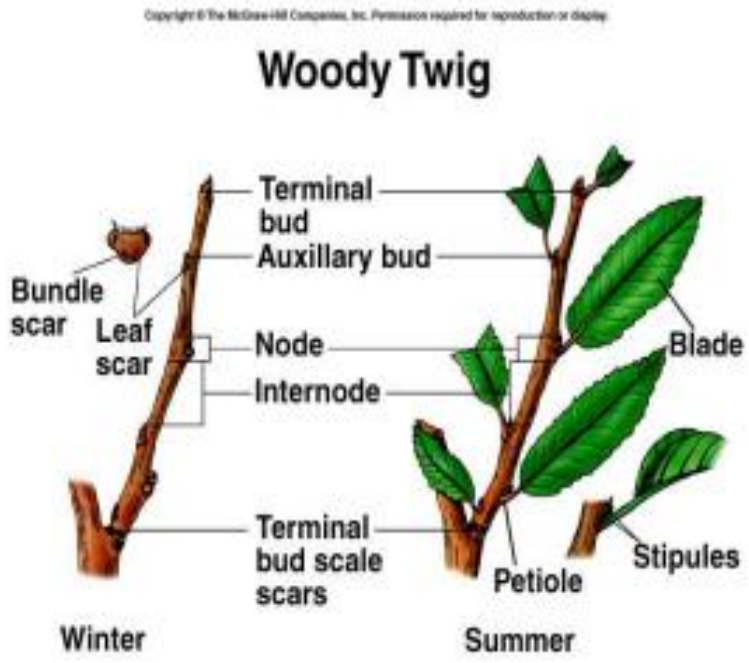


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The Stem

- **Stem**: **aboveground** portion of shoot, bearing leaves.

- **Divided into:**
  - Nodes (where leaves attach)
  - Internodes (where no leaves attached)



Functions of the Stem

1. **Support** of leaves, flowers, fruits
2. **Conduction** of water, minerals, sugars, etc.
3. **Photosynthesis**
4. **Storage**
5. **Defence**

Many Plants have Modified Stems

▼ Rhizomes



▶ Bulbs



▶ Stolons





◀ Tubers

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The leaf and Leaf Functions

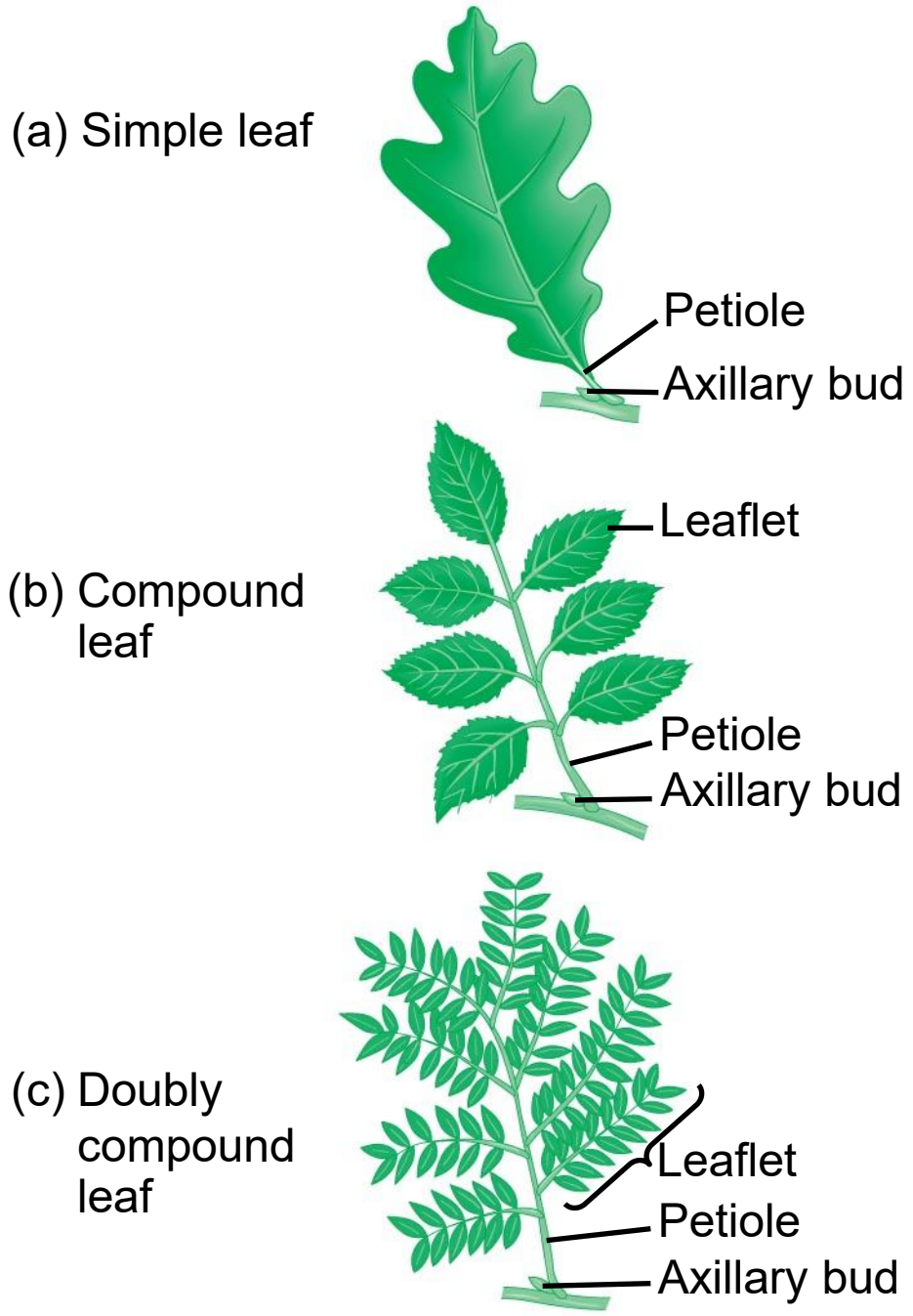
The leaf is the most important vegetative organ of the plant.

It is generally green flat body, have phototropism.

Leaf Functions:

- **Photosynthesis**
- **Gaseous Exchange**
- **Transpiration**, **Absorption** and **Reproduction**…etc

Simple vs. Compound Leaves



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Some plant species have evolved* modified leaves *that serve various functions

Tendrils
cling



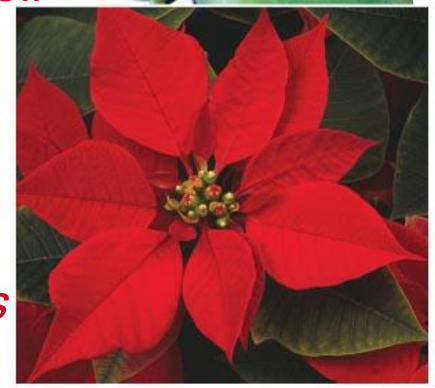


Spines *"prickly" Photosynthesis is carried out mainly by the fleshy stems*



Storage Leaves *succulent plant leaves store water*

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



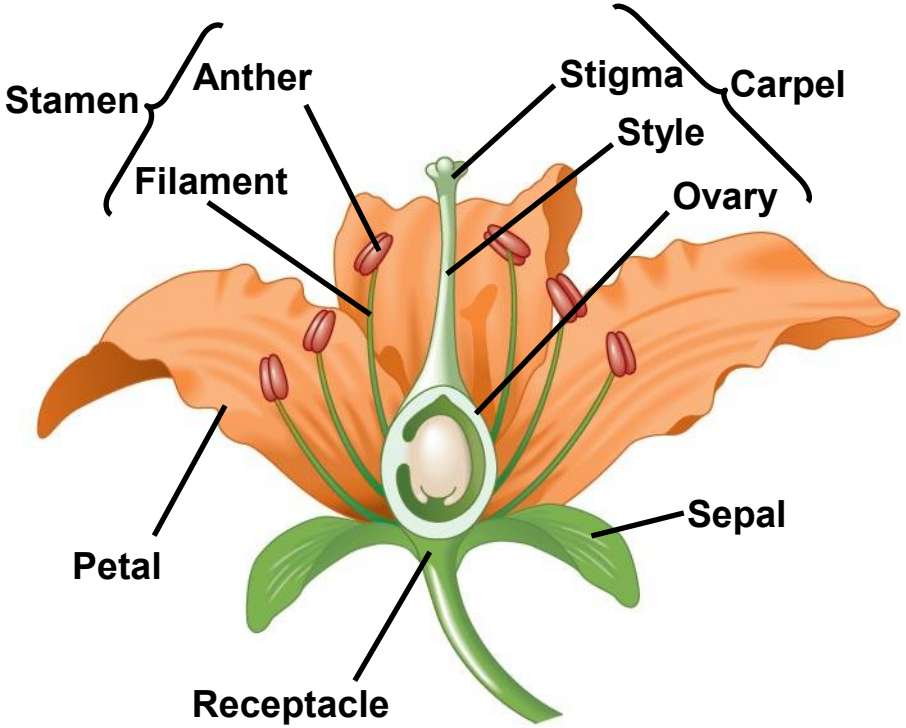
Bracts
Look like petals
Attract pollinators

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Flower Structure and Function

- **Flowers** are the reproductive shoots of the angiosperm sporophyte.
- **Flowers consist** of **four** floral organs: **sepals**, **petals**, **stamens**, and **carpels**.
- A **stamen** consists of a filament topped by an anther with pollen sacs that produce pollen.
- A **carpel** / pistil has a long style with a stigma on which pollen may land.
- At the base of the style is an ovary containing one or more ovules.

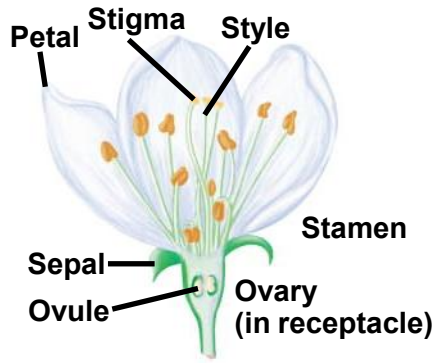
Flower Structure



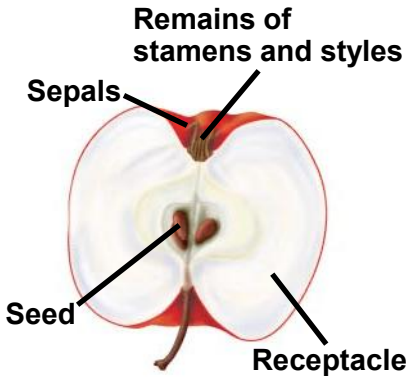
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Fruit Structure and Function

- A **fruit** develops from the ovary.
- It **protects** the enclosed **seeds** and aids in seed dispersal by wind or animals.
- A **fruit may be classified** as:
  - dry, if the ovary dries out at maturity
  - fleshy, if the ovary becomes thick, soft, and sweet at maturity.



Apple flower



Apple fruit

(d) Accessory fruit

Section 3

Plant Function (Photosynthesis)

Overview: The Process That Feeds the Biosphere

- Plants need food to respire, grow and reproduce. Unlike animals, plants are able to make their own food by the process of photosynthesis.
- Almost all plants are photoautotrophs, using the energy of sunlight to make organic molecules from H_2O and CO_2
- Photosynthesis occurs in plants, algae, certain other protists, and some prokaryotes.
- These organisms feed not only themselves but also most of the living world.

Photosynthesis occurs in plants, algae, certain other protists, and some prokaryotes

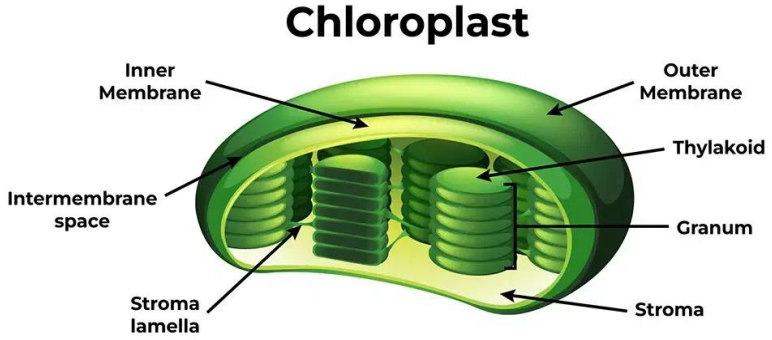


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Chloroplasts: The Sites of Photosynthesis in Plants

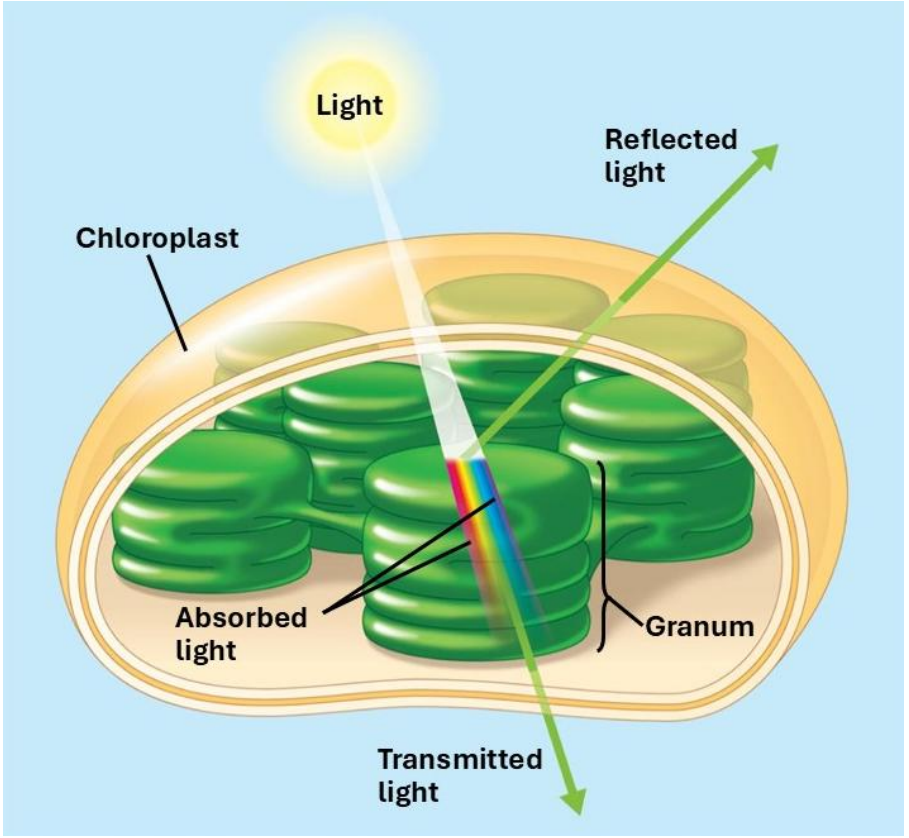
- Chloroplasts are small organelles inside the cells of plants and algae.
- They absorb light to make sugar in a process called photosynthesis.
- The sugar can be stored in the form of starch.
- Chloroplasts contain the chlorophyll, which absorbs sunlight for photosynthesis.
- The chlorophyll is in the membranes of **thylakoids** (connected sacs in the chloroplast); thylakoids may be stacked in columns called grana.
- Chloroplasts also contain **stroma**, a dense fluid
- Photosynthesis can be summarized as the following equation:

$$6\ CO_2 + 12\ H_2O + \text{Light energy} \rightarrow C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$$



Photosynthetic Pigments(Light Receptors)

- Visible light consists of wavelengths (including those that drive photosynthesis) that produce colors we can see.
- Pigments are substances that absorb visible light.
- Different pigments absorb different wavelengths.

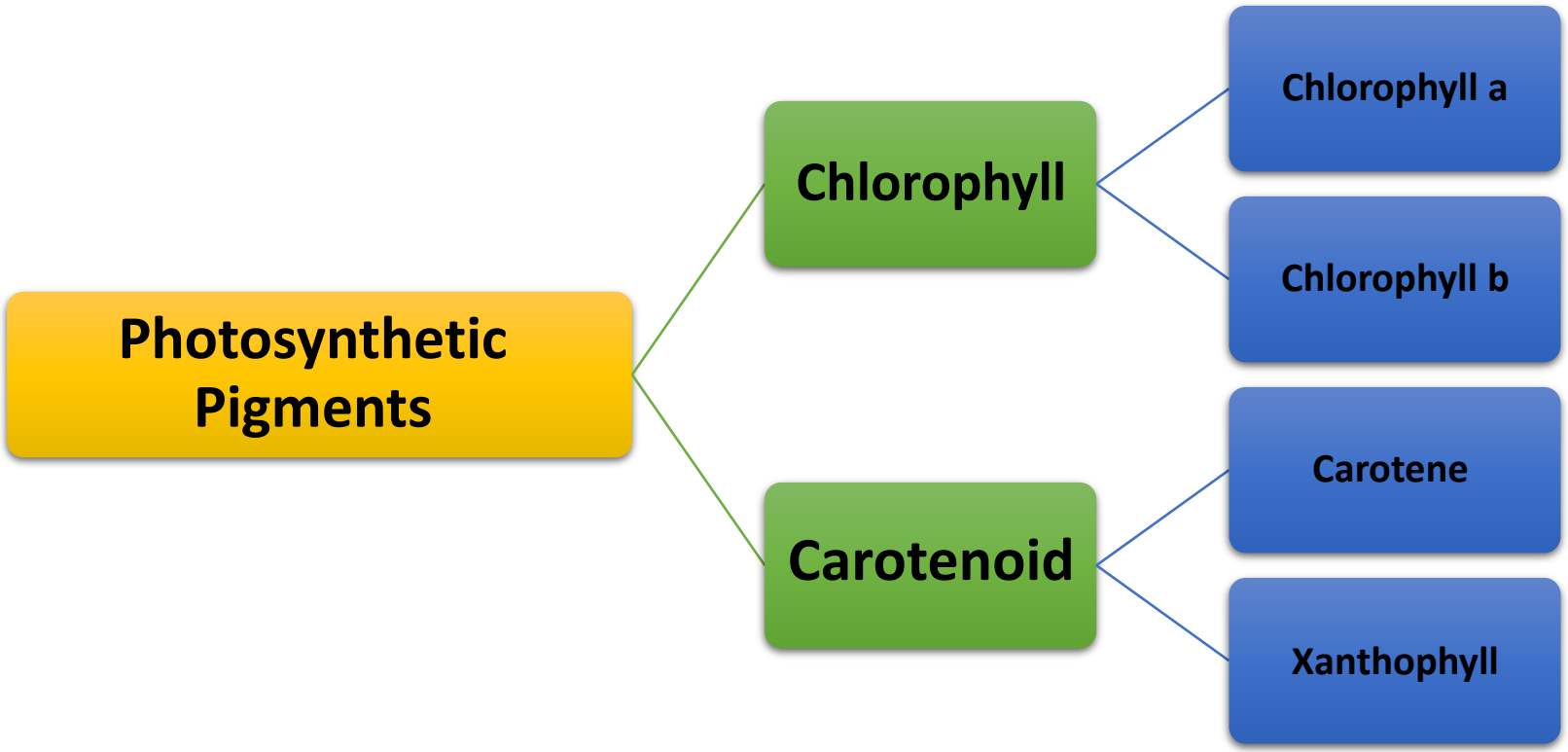


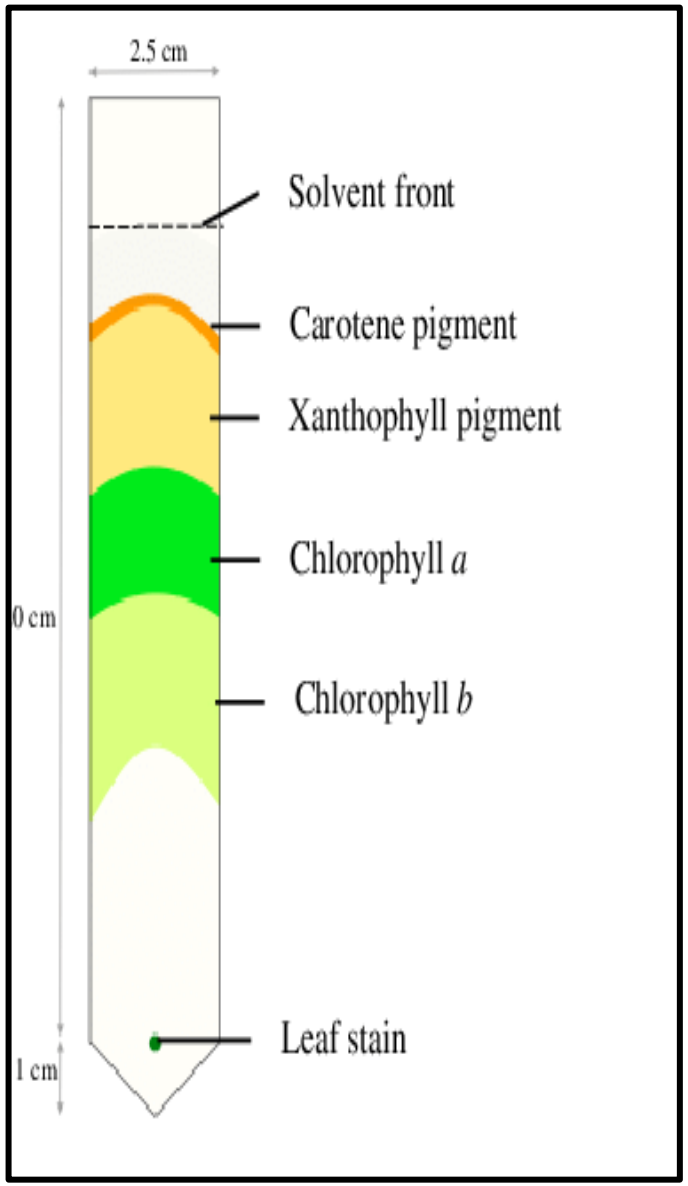
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Photosynthetic Pigments(Light Receptors)

- **Chlorophyll a** is the most abundant and important photosynthetic pigment. It is the **primary pigment** for Photosynthesis.
- The other photosynthetic pigments are called **accessory pigments, such as; Chlorophyll b and Carotenoid (Carotene & Xanthophyll)**
- They enables the plant to absorb sunlight of greater range of wavelength.
- They protect chlorophyll a from destruction by absorbing excessive sunlight

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Photosynthetic Pigments

References

Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., Orr, R. B., & Campbell, N. A. (2020). Campbell Biology, 12th Edition (12th ed.). Pearson.

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UMM AL-QURA UNIVERSITY

General Biology

Lecture (6):

Plant Form and Function

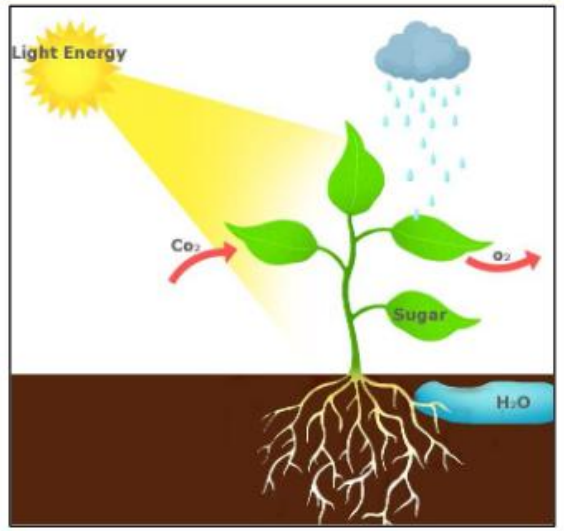
College of Applied Sciences
Biology Department

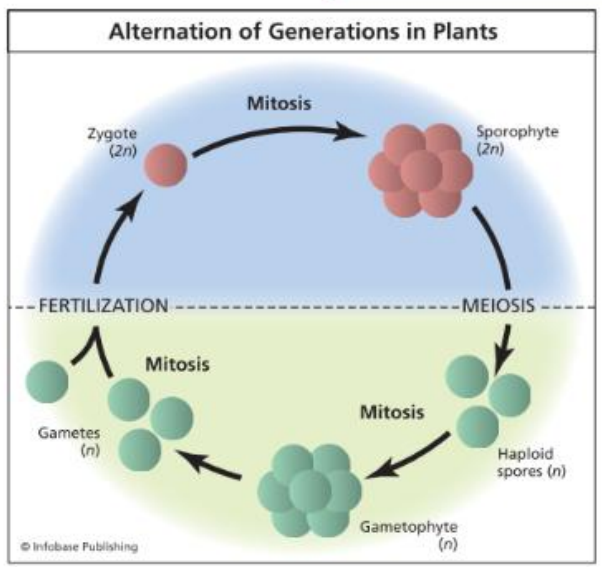
Outline

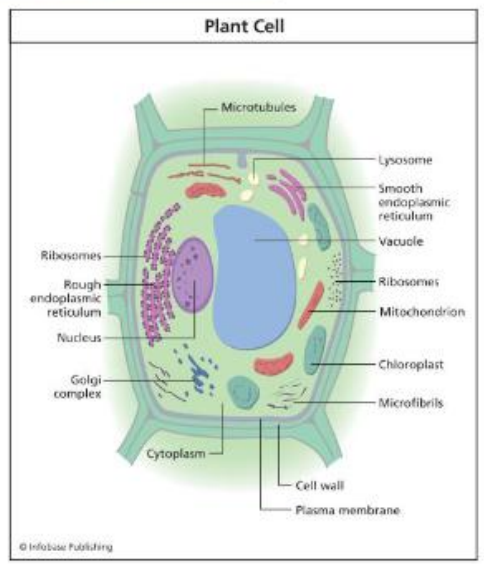
- Plant Characteristics
- Highlights of Plant Evolution
- Plant diversity
- Seed Plant structure [*seed, root, stem, leaf, flower, fruit*)
- Plant Nutrition and Soil Structure [*macronutrients micronutrients, soil, fertilizers*]
- Plant Responses to Internal and External Signals

Plant Characteristics

- **Autotrophic** (produce their own food by photosynthesis)
- **Non-motile**
- **Multicellular**
- **Eukaryotic** organisms
- Cell walls are composed of **cellulose**.
- Can **reproduce sexually and asexually.**
- **An alternation of generations occurs** (Gametophyte --> Sporophyte --> Gametophyte

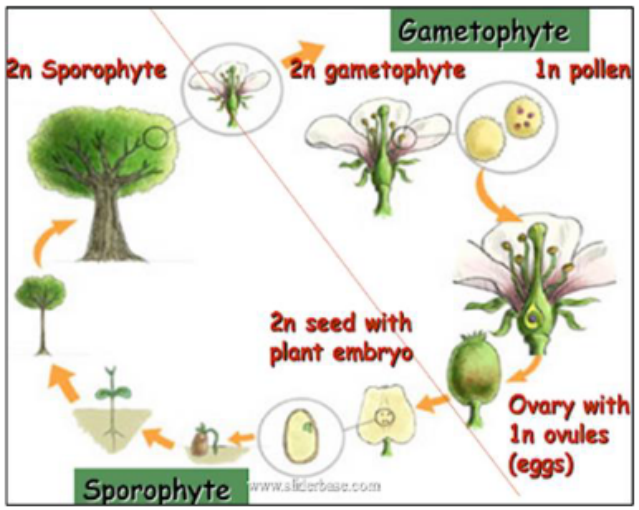


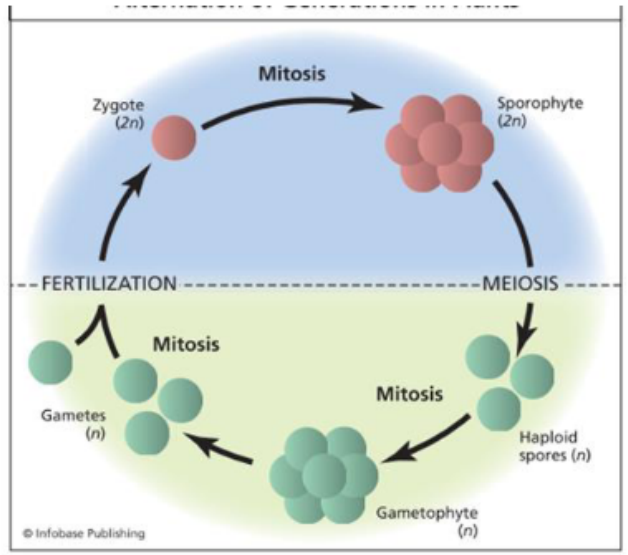




Alternation of Generations

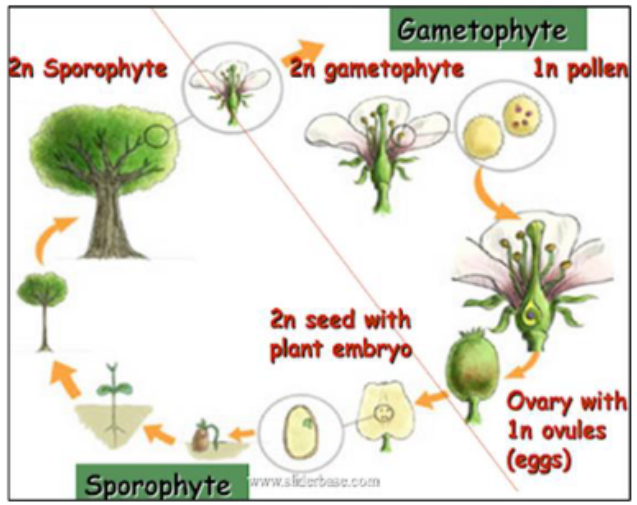
- The life cycle of any land plant has two distinct phases (**Gametophyte** and **Sporophyte**).
- The amount of time spent in each phase varies depending on the plant group.
- The first phase is called the gametophyte generation (phyte=plant, gameto=gamete).
- Gametophyte is a plant (multicellular, not just a single cell) that has a single set of chromosomes (**haploid**), which produces **gametes** via mitosis (egg and sperm cells), which are also **haploid**.

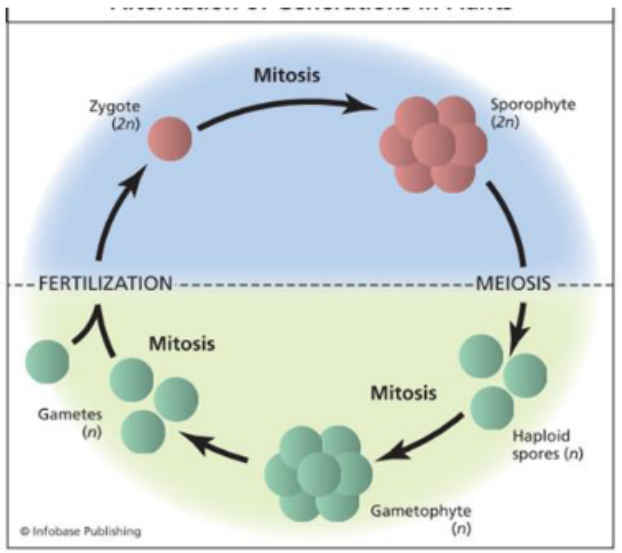




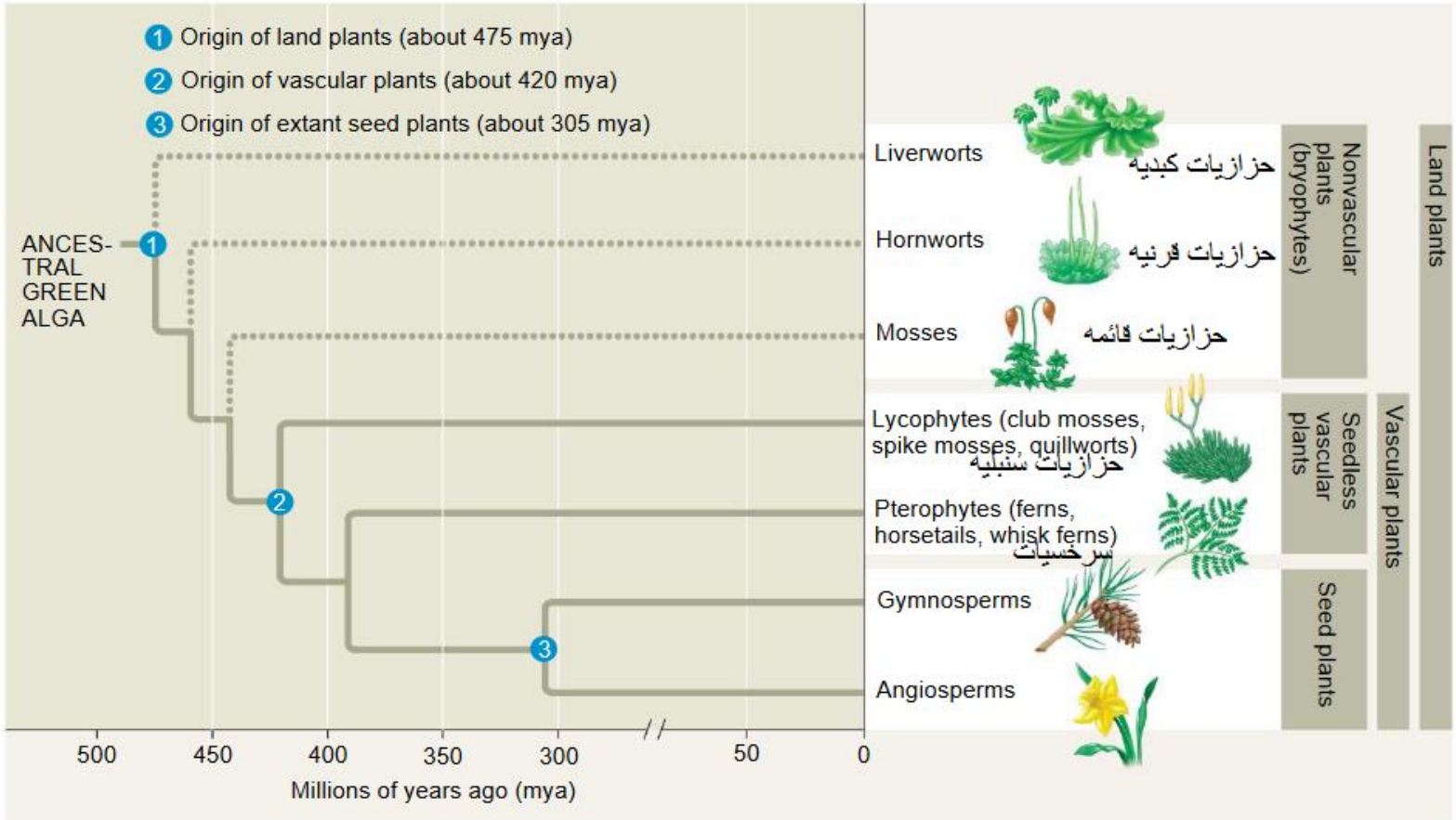
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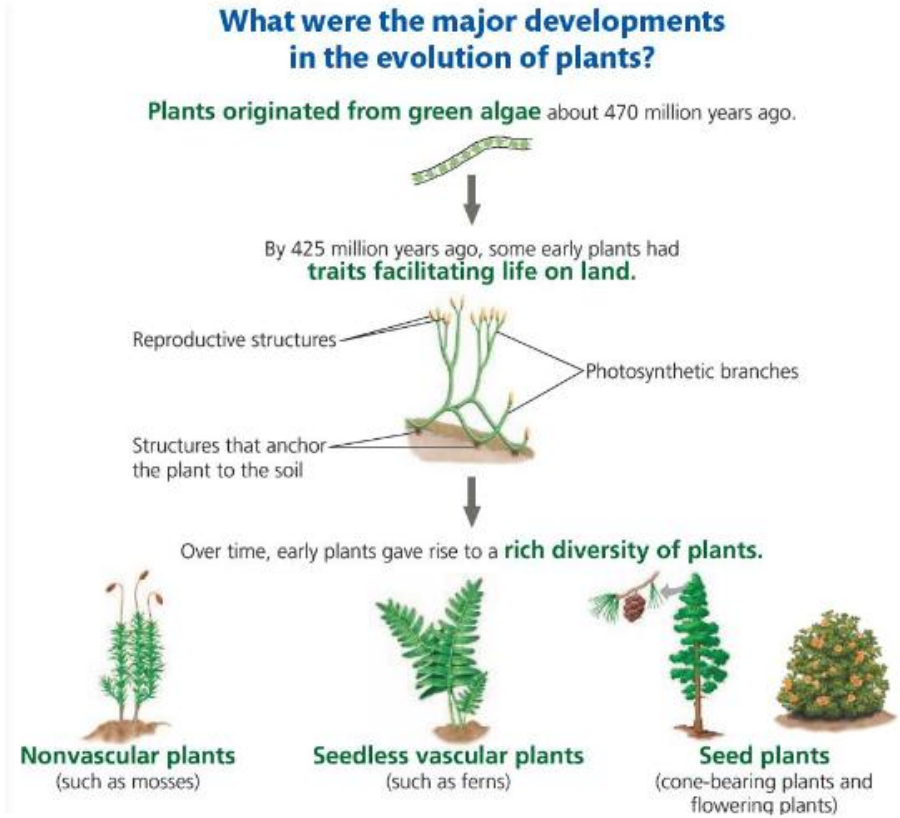




Highlights of Plant Evolution



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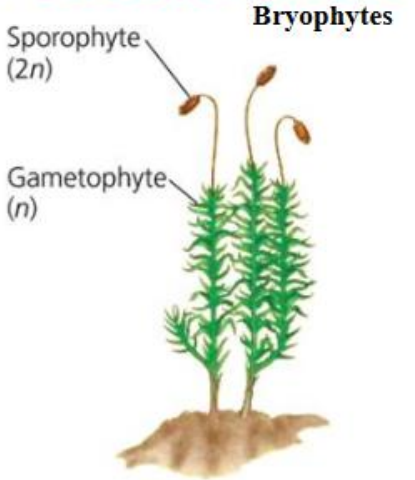
Plant diversity

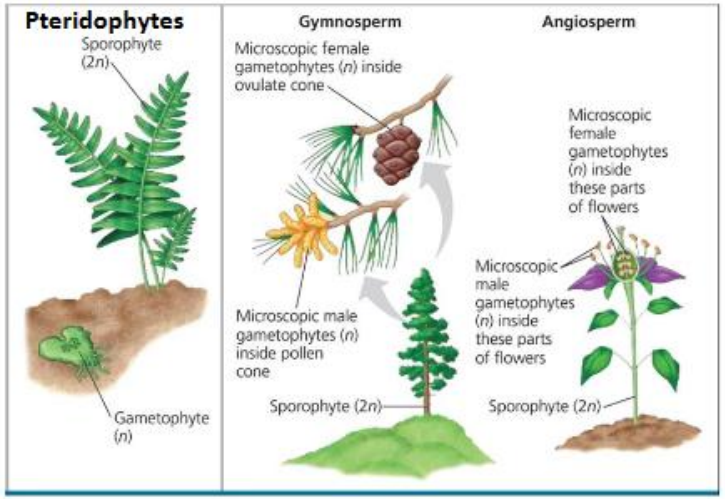




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Seed plants

College of Applied Sciences

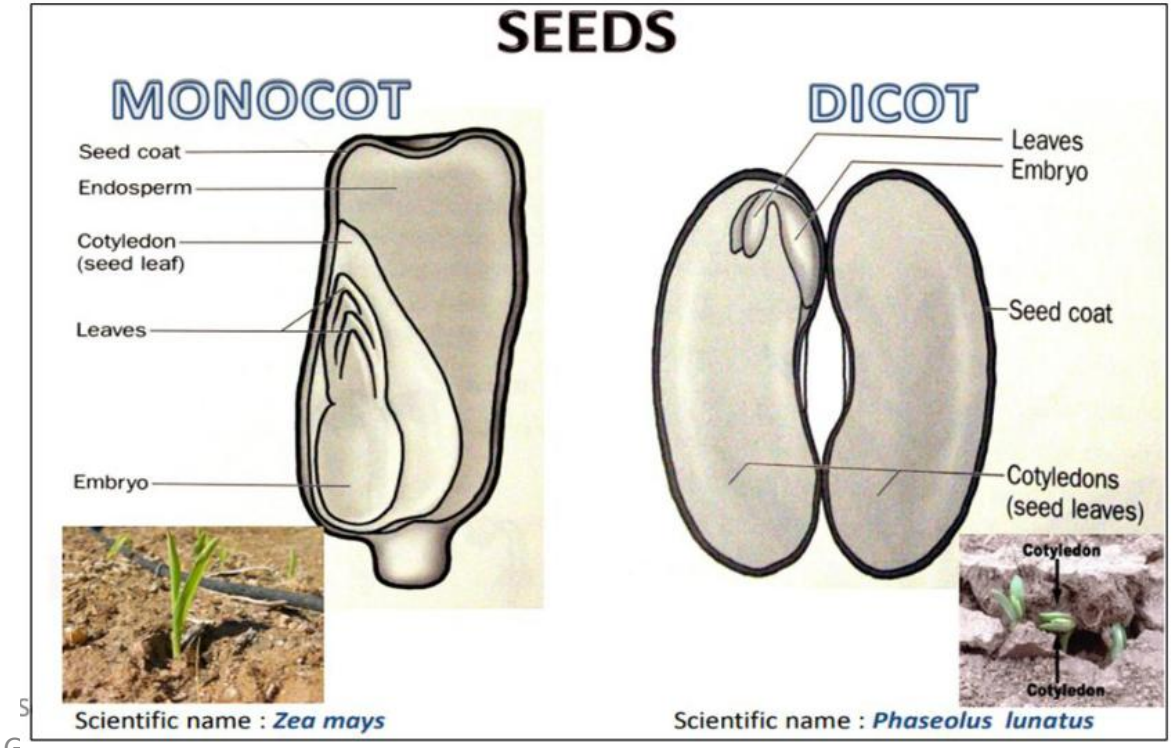
Biology Department

Seeds and Mature seed structure

- **Seed** is a **small embryonic** plant in the **dormancy state**, that produce of sexual reproduction in flowering plants.

- **Mature seed structure:**

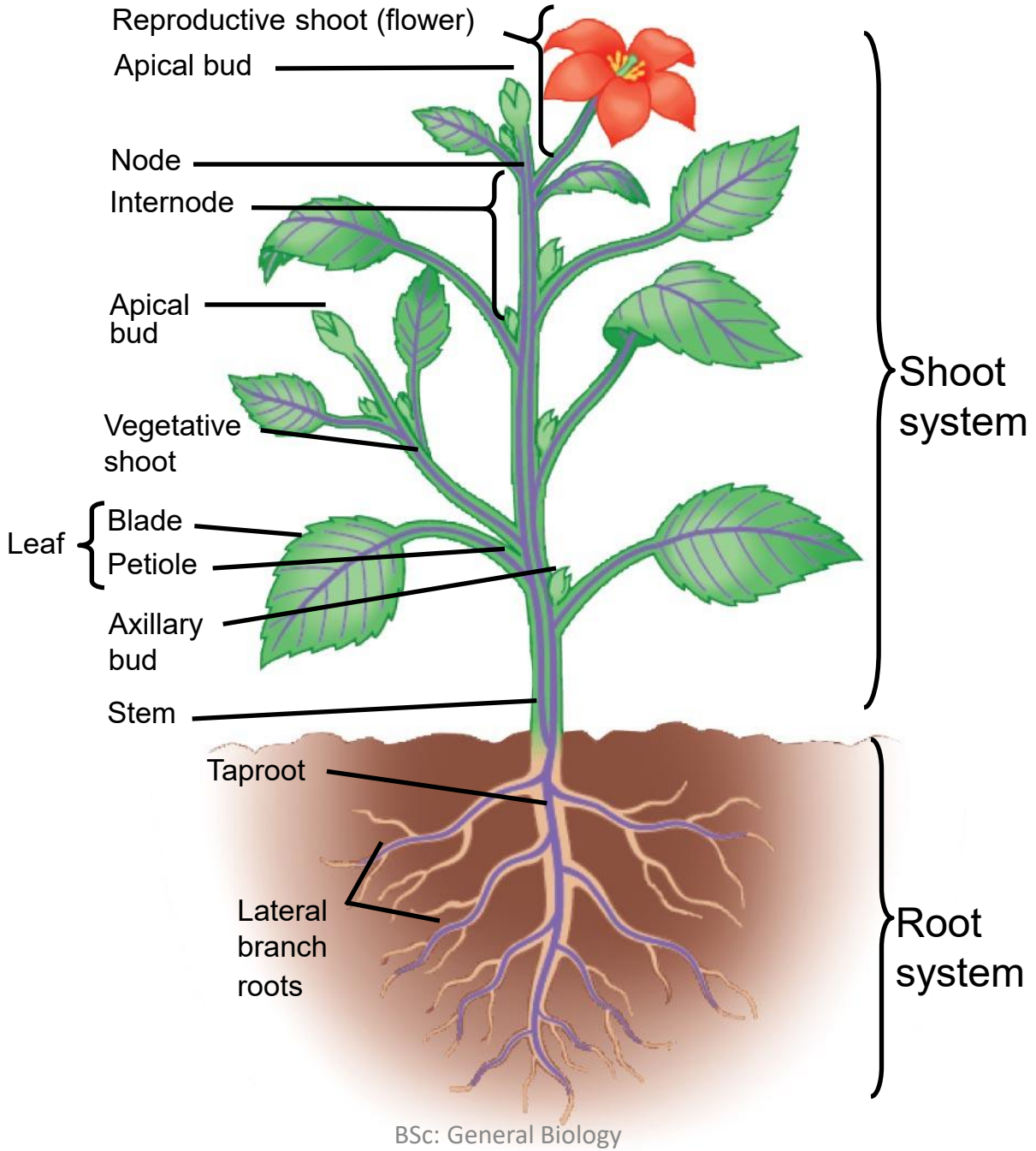
  1. Seed coat (testa)
  2. Embryo
  3. Cotyledons



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- **Shoots** rely on water and minerals absorbed by the ***Root system***.

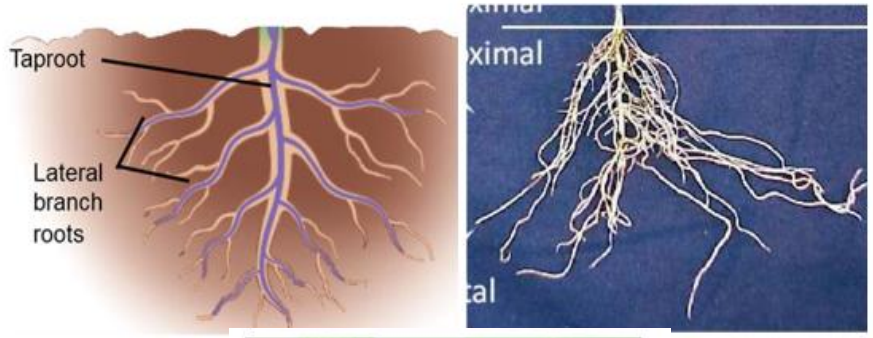
Flowering Plant Morphology



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The Root

- **Root:** an **underground** portion of Plant.



- **Types of Root:**
  - one main vertical root (Tap root) consists of lateral roots and root hairs.
  - Adventitious roots arise from stems or leaves



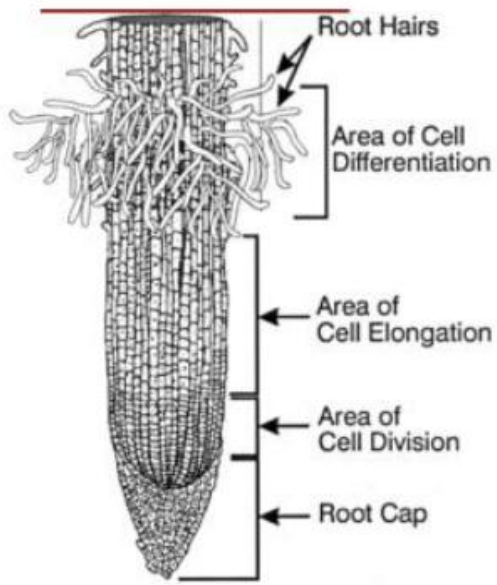
Zones of the Root - External Anatomy

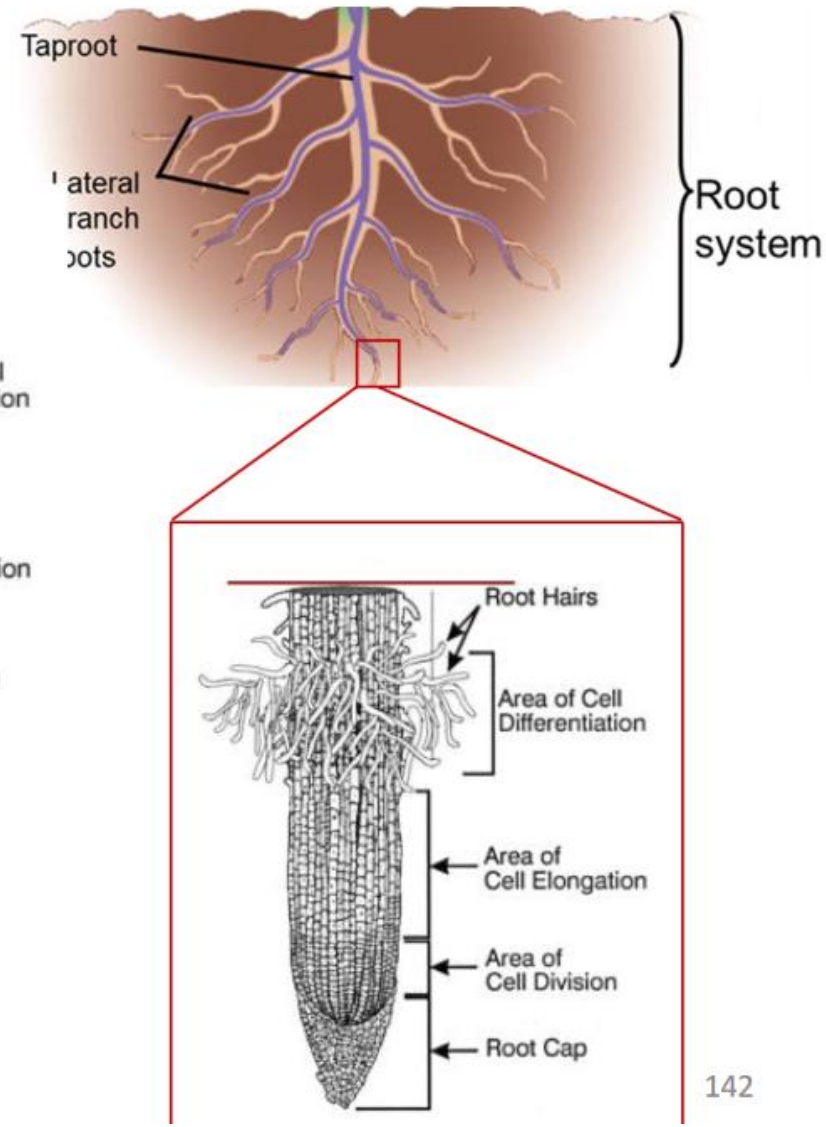
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- Root cap
- Region of cell division

2. Elongation zone

3. Maturation (or differentiation) **zone**





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Many plants have modified roots



Prop roots



Storage roots



"Strangling" aerial roots



Pneumatophores

Buttress roots

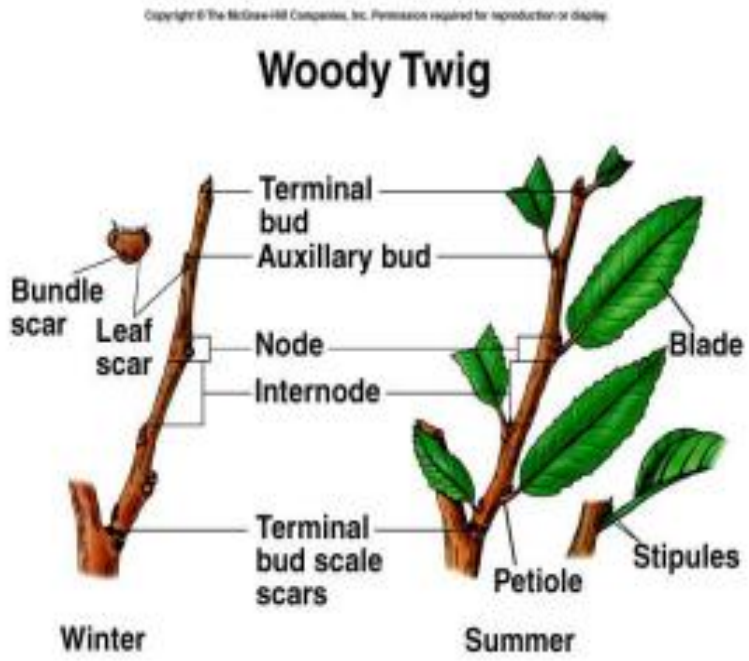


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The Stem

- **Stem**: **aboveground** portion of shoot, bearing leaves.

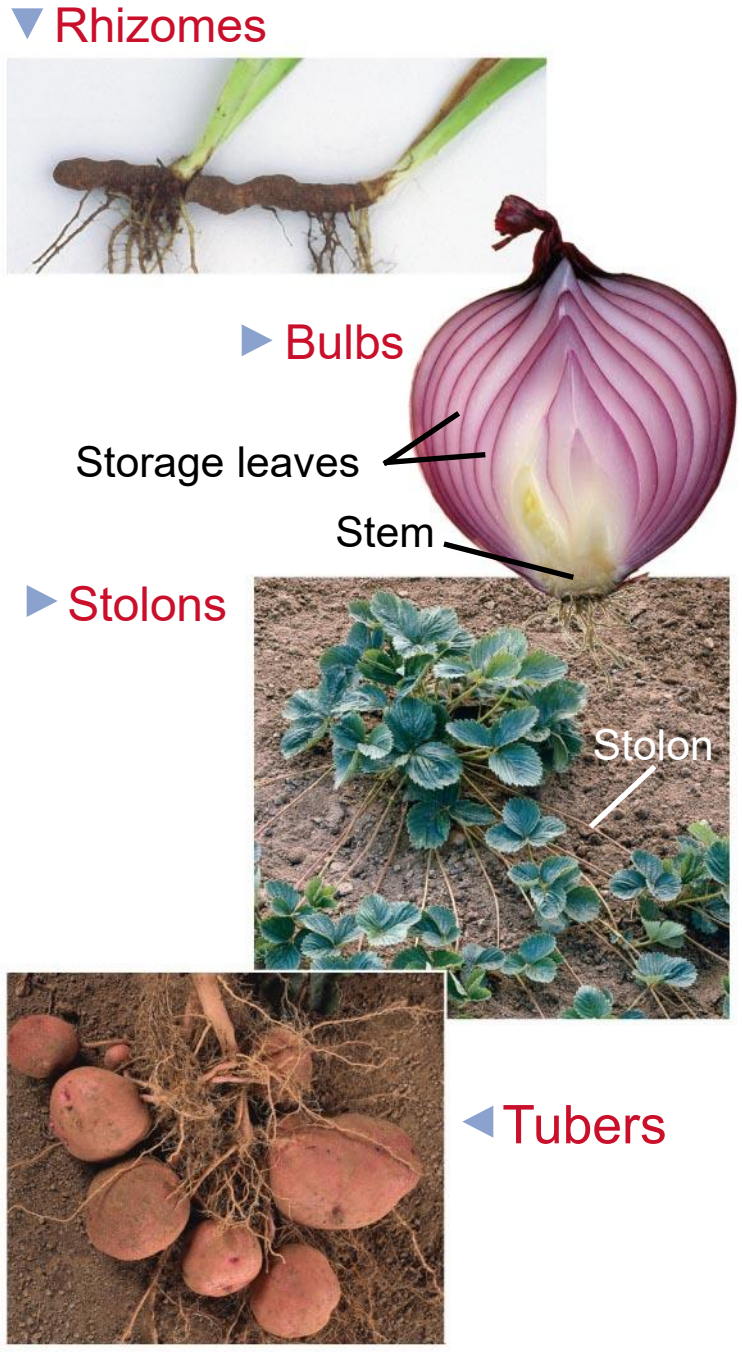
- **Divided into:**
  - Nodes (where leaves attach)
  - Internodes (where no leaves attached)



Functions of the Stem

1. **Support** of leaves, flowers, fruits
2. **Conduction** of water, minerals, sugars, etc.
3. **Photosynthesis**
4. **Storage**
5. **Defence**

Many Plants have Modified Stems



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The leaf and Leaf Functions

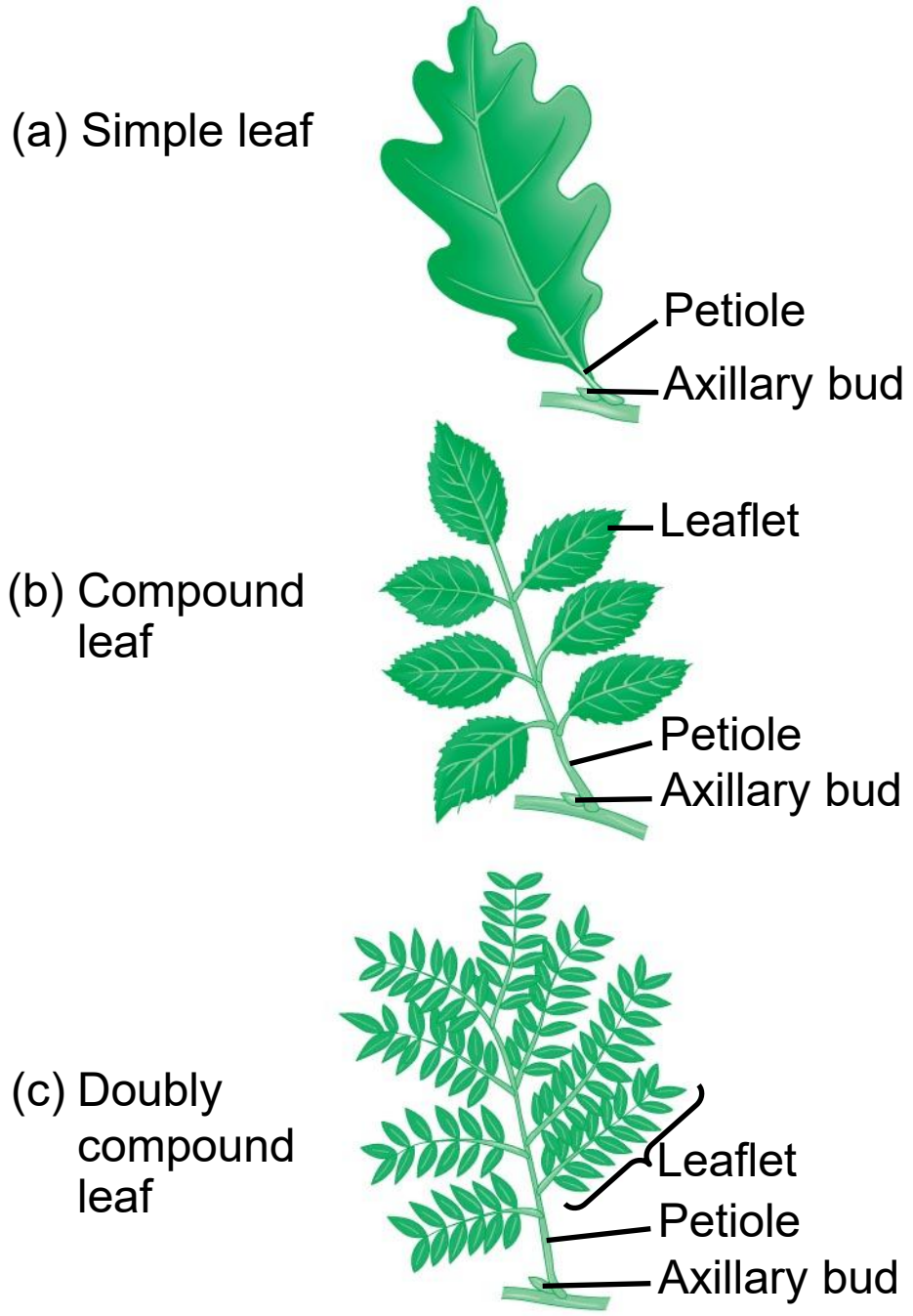
The leaf is the most important vegetative organ of the plant.

It is generally green flat body, have phototropism.

Leaf Functions:

- **Photosynthesis**
- **Gaseous Exchange**
- **Transpiration**, **Absorption** and **Reproduction**…etc

Simple vs. Compound Leaves



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Some plant species have evolved* modified leaves *that serve various functions

Tendrils
cling



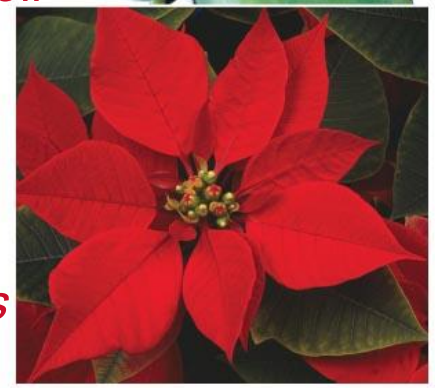


Spines *"prickly" Photosynthesis is carried out mainly by the fleshy stems*



Storage Leaves *succulent plant leaves store water*

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



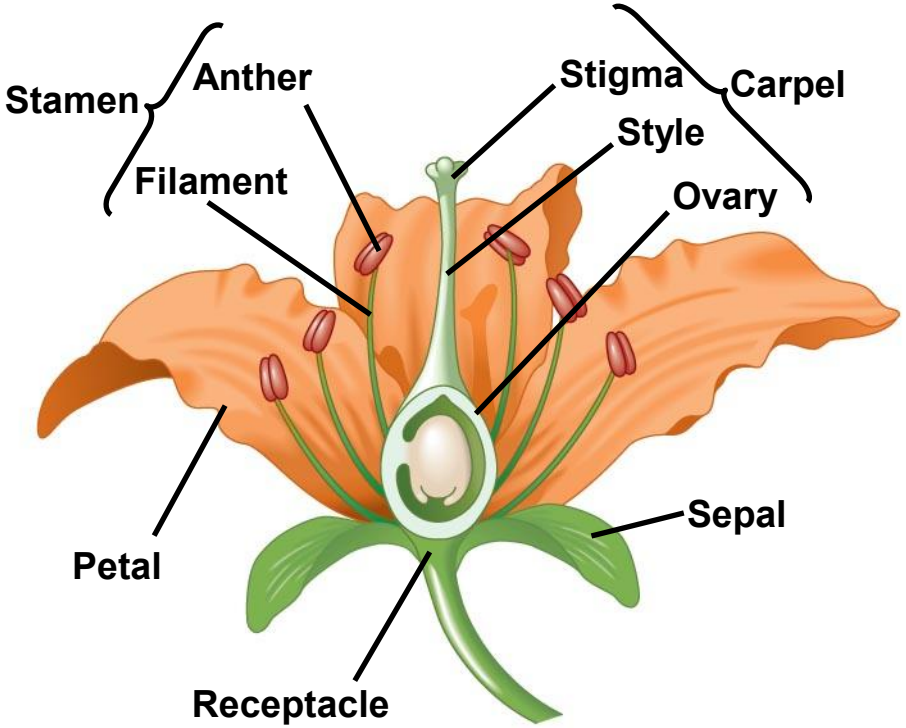
Bracts
Look like petals
Attract pollinators

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Flower Structure and Function

- **Flowers** are the reproductive shoots of the angiosperm sporophyte.
- **Flowers consist** of **four** floral organs: **sepals**, **petals**, **stamens**, and **carpels**.
- A **stamen** consists of a filament topped by an anther with pollen sacs that produce pollen.
- A **carpel** / pistil has a long style with a stigma on which pollen may land.
- At the base of the style is an ovary containing one or more ovules.

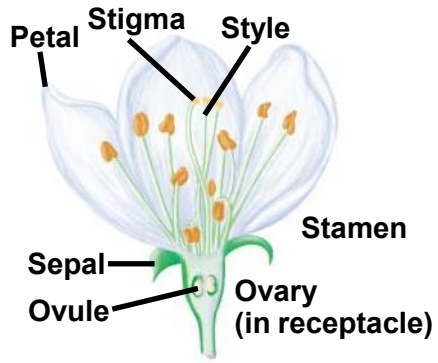
Flower Structure



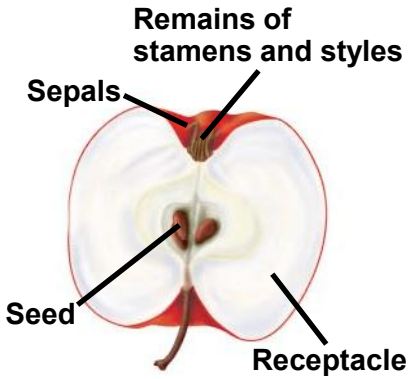
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Fruit Structure and Function

- A **fruit** develops from the ovary.
- It **protects** the enclosed **seeds** and aids in seed dispersal by wind or animals.
- A **fruit may be classified** as:
  - dry, if the ovary dries out at maturity
  - fleshy, if the ovary becomes thick, soft, and sweet at maturity.



Apple flower



Apple fruit

(d) Accessory fruit

Plant Nutrition and Soil structure

College of Applied Sciences

Biology Department

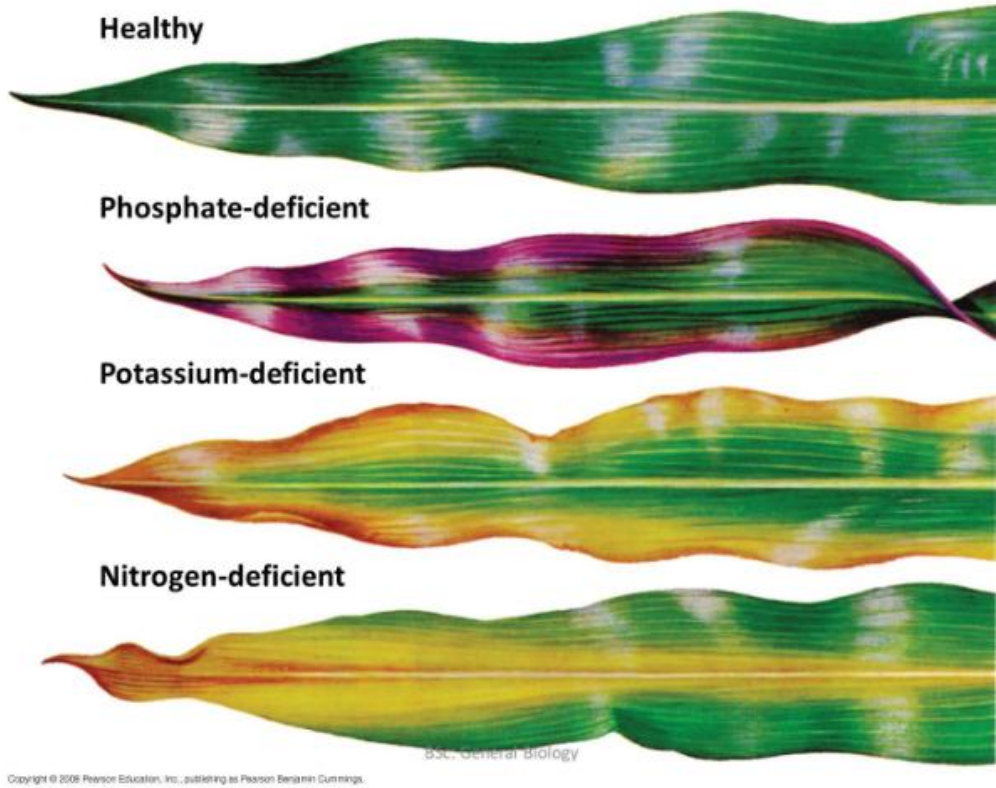
Plant Nutrition

- Plants derive most of their organic mass from the CO_2 of air, but they also depend on soil nutrients such as water and minerals.
- The inorganic substances in plants contain more than **50 chemical elements**.
- In studying the chemical composition of plants, we must distinguish elements that are **essential** from those that are **merely present** in the plant.
- A **Chemical element** is considered an **essential element** if it is **required** for a plant to complete its life cycle.

Plants require elements to complete their life cycle

- **Nine** of the **Essential elements** are called **Macronutrients** because plants **require** them in relatively large amounts.

- The **Macronutrients** are carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, calcium, and magnesium.

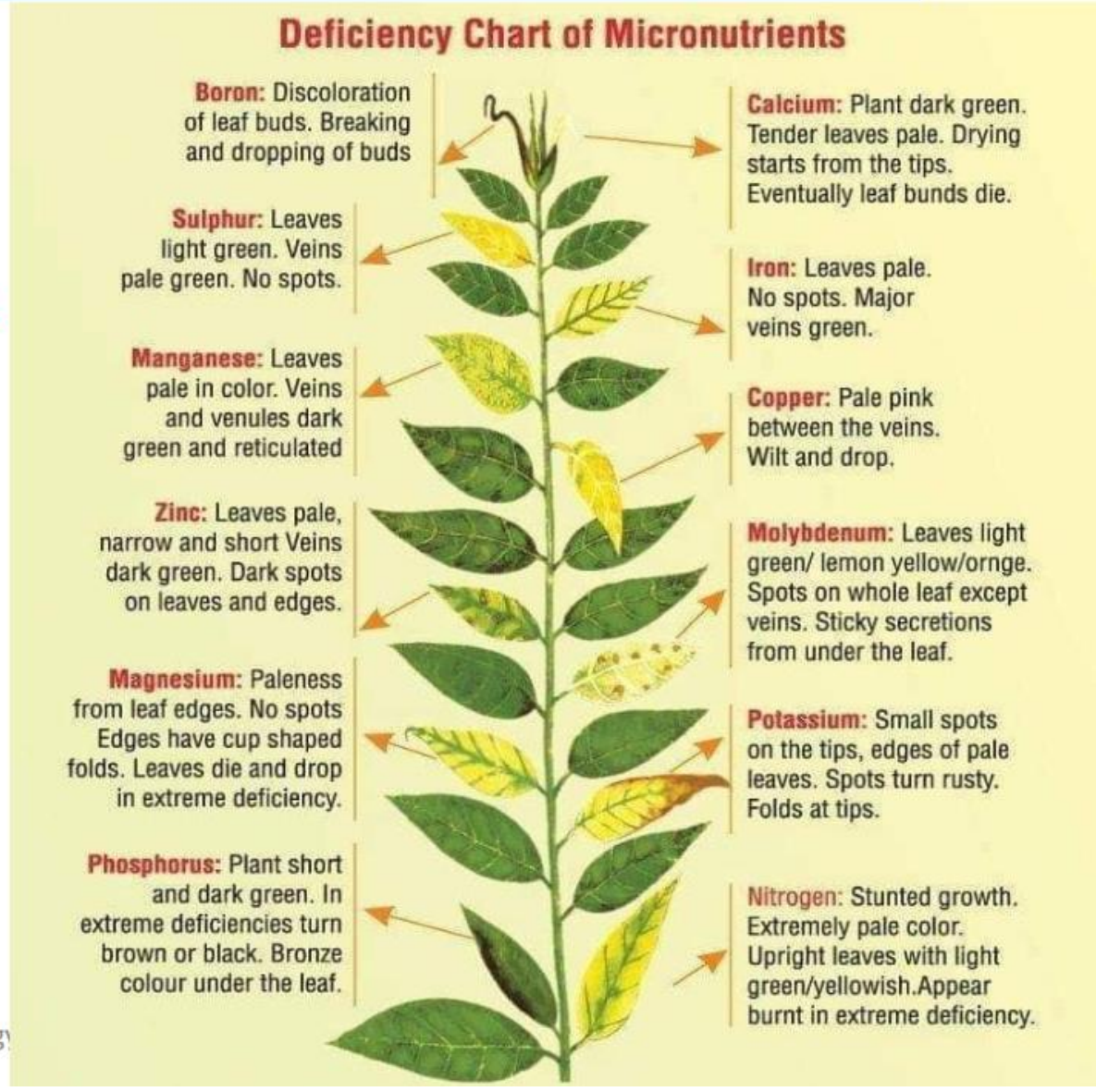


The most common mineral deficiencies, as seen in maize leaves

Plants require elements to complete their life cycle

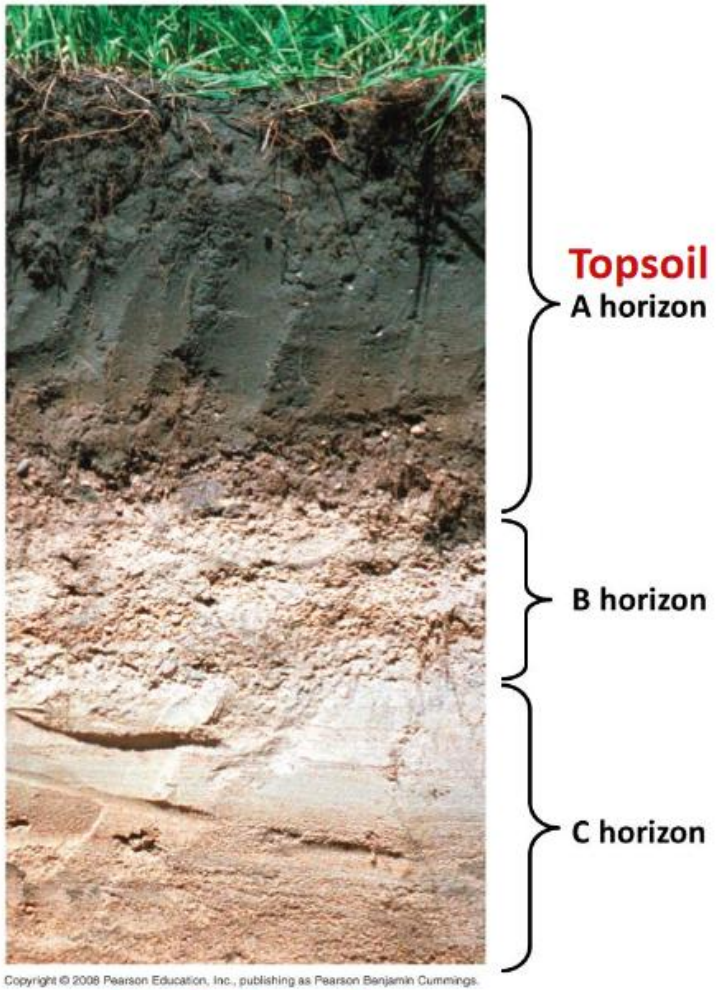
- **Eight** of the **essential elements** are called **Micronutrients** because plants need them in very small amounts.

- These are chlorine, iron, manganese, boron, zinc, copper, nickel, and molybdenum.



Soil and Soil Structure

- Healthy soils improve plant growth by enhancing plant **nutrition.**
- **Topsoil** consists of mineral particles, living organisms, and humus = the decaying organic material.
- **Soil particles** are **classified** by **size**; from largest to smallest, they are called sand, silt, and clay.
- **Soil particle size** affects the availability of water, oxygen, and minerals in the soil.



Soil horizons

Fertilization

- **Fertilization replaces** mineral nutrients that have been **lost** from the soil.
- **Commercial fertilizers** are enriched in nitrogen, phosphorus, and potassium.
- **Organic fertilizers** are composed of manure, fishmeal, or compost.



Organic fertilizers | Commercial fertilizers

Section 4

Plant Responses to Internal and External Signals

Plant hormones help coordinate growth, development, and responses to stimuli

- **Hormones** are chemical **signals** that **coordinate** different parts of an organism.
- Any response resulting in curvature of organs toward or away from a stimulus is called a **tropism** = **a growth response**.
- **Tropisms** are often caused by **hormones**.

Plant Hormones

- In general, **hormones control** plant growth and development by affecting the division, elongation, and differentiation of cells.

- **Plant hormones** are **produced** in **very low concentration**, but a minute amount can greatly affect growth and development of a plant organ.

Table 39.1 Overview of Plant Hormones

Hormone	Where Produced or Found in Plant	Major Functions
Auxin (IAA)	Shoot apical meristems and young leaves are the primary sites of auxin synthesis. Root apical meristems also produce auxin, although the root depends on the shoot for much of its auxin. Developing seeds and fruits contain high levels of auxin, but it is unclear whether it is newly synthesized or transported from maternal tissues.	Stimulates stem elongation (low concentration only); promotes the formation of lateral and adventitious roots; regulates development of fruit; enhances apical dominance; functions in phototropism and gravitropism; promotes vascular differentiation; retards leaf abscission.
Cytokinins	These are synthesized primarily in roots and transported to other organs, although there are many minor sites of production as well.	Regulate cell division in shoots and roots; modify apical dominance and promote lateral bud growth; promote movement of nutrients into sink tissues; stimulate seed germination; delay leaf senescence.
Gibberellins	Meristems of apical buds and roots, young leaves, and developing seeds are the primary sites of production.	Stimulate stem elongation, pollen development, pollen tube growth, fruit growth, and seed development and germination; regulate sex determination and the transition from juvenile to adult phases.
Brassinosteroids	These compounds are present in all plant tissues, although different intermediates predominate in different organs. Internally produced brassinosteroids act near the site of synthesis.	Promote cell expansion and cell division in shoots; promote root growth at low concentrations; inhibit root growth at high concentrations; promote xylem differentiation and inhibit phloem differentiation; promote seed germination and pollen tube elongation.
Abscisic acid (ABA)	Almost all plant cells have the ability to synthesize abscisic acid, and its presence has been detected in every major organ and living tissue; may be transported in the phloem or xylem.	Inhibits growth; promotes stomatal closure during drought stress; promotes seed dormancy and inhibits early germination; promotes leaf senescence; promotes desiccation tolerance.
Ethylene	This gaseous hormone can be produced by almost all parts of the plant. It is produced in high concentrations during senescence, leaf abscission, and the ripening of some types of fruits. Synthesis is also stimulated by wounding and stress.	Promotes ripening of many types of fruit, leaf abscission, and the triple response in seedlings (inhibition of stem elongation, promotion of lateral expansion, and horizontal growth); enhances the rate of senescence; promotes root and root hair formation; promotes flowering in the pineapple family.

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جامعة أم القرى
UMM AL-QURA UNIVERSITY

General Biology
Lecture (10) & (11)
Animal Form and Function

College of Science

Biology Department

OUTLINE

- Basic Principles of Animal Form and Function
- Animal Nutrition
- Circulation and Gas Exchange
- The Immune System
- Animal Reproduction
- Animal Development
- Animal Behavior



How do animals regulate their internal state even in changing or harsh environments?

Adaptations in form, function, and behavior help maintain an animal's internal environment. For example, three adaptations that help penguin stay warm :

Form (anatomy): An insulating layer of fat (blubber) reduces heat loss from most of the penguin's body (blue body areas in this thermal image).





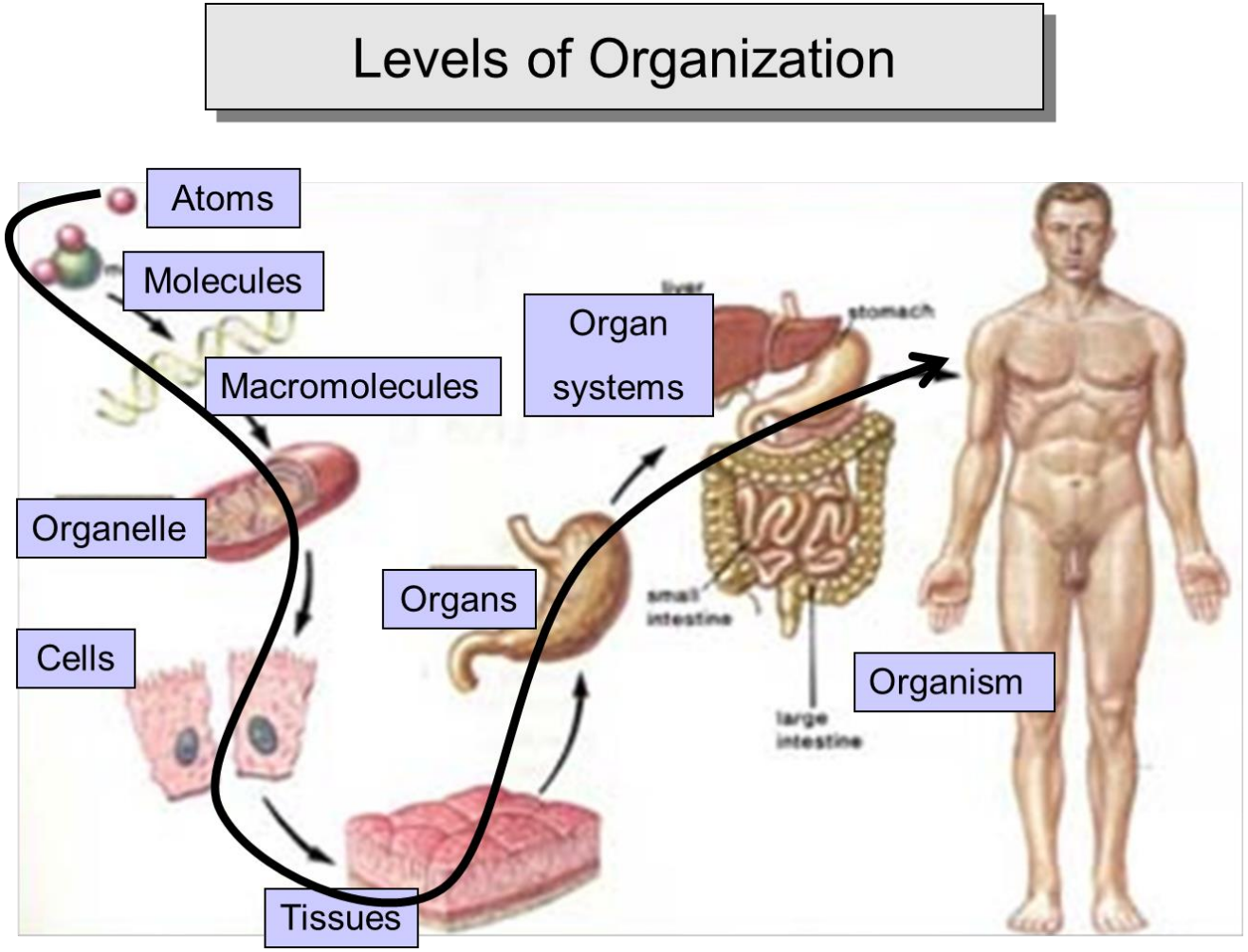
Function (physiology): Rapid cycles of muscle contraction and relaxation during shivering produce heat at a cellular level



Behavior: By packing together in groups of up to several thousand, Emperor penguins greatly reduce their exposure to wind and cold.

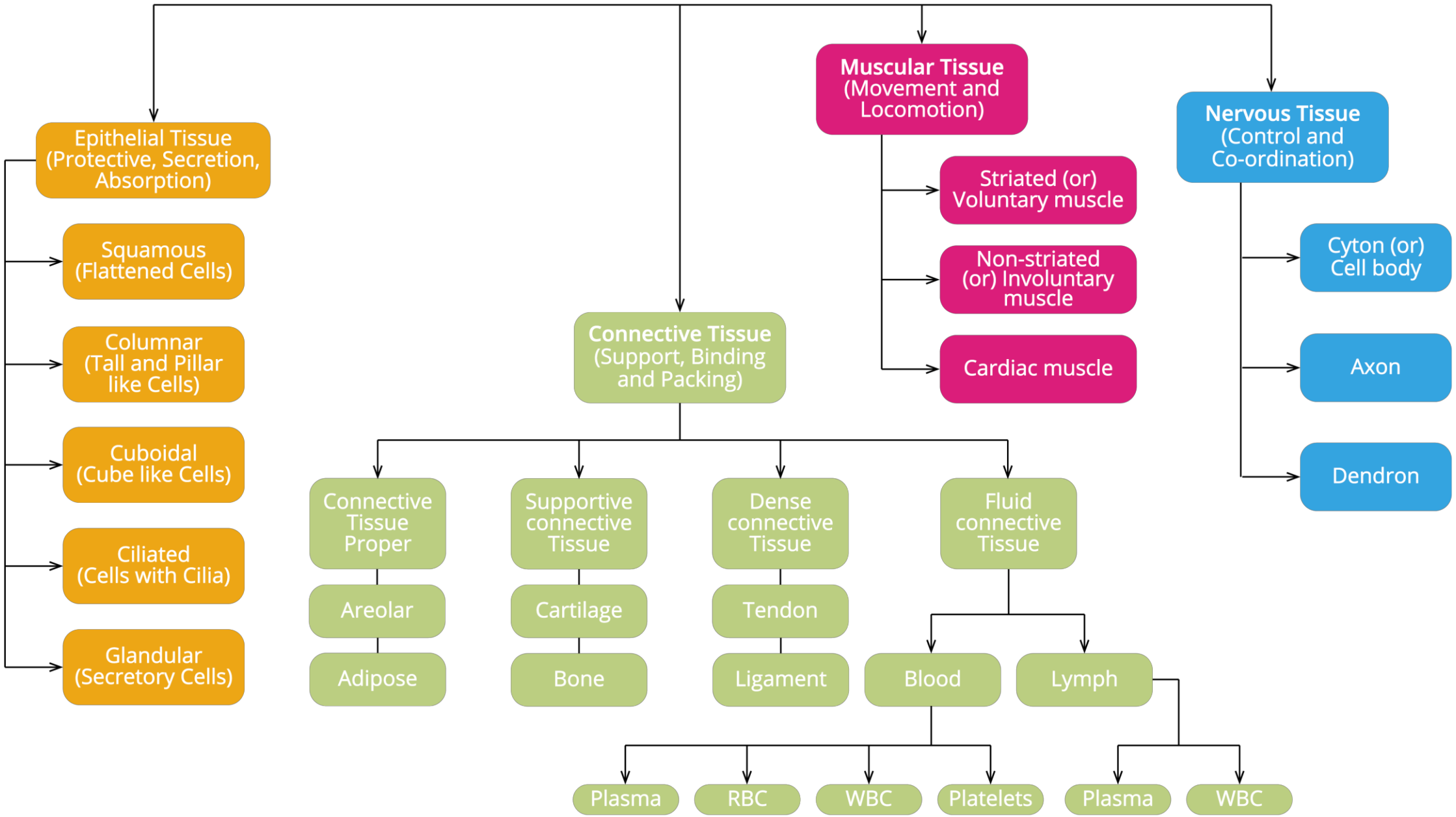
Hierarchical Organization of Body Plans

- In vertebrates, *the space between cells* is filled with *interstitial fluid*, which allows for the movement of material into and out of cells.
- A complex body plan helps an animal in a variable environment to maintain a relatively stable internal environment.
- Most animals are composed of specialized cells organized into tissues that have different functions.
- Tissues make up organs, which together make up organ systems.

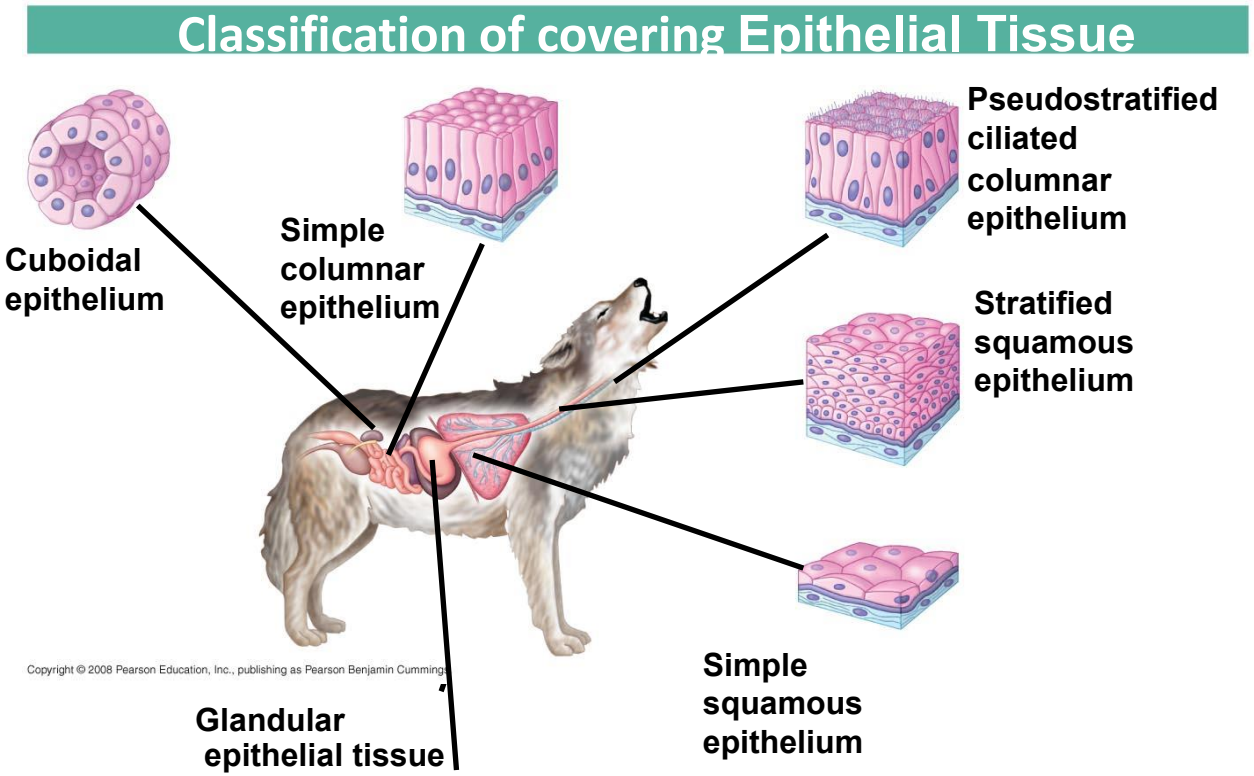


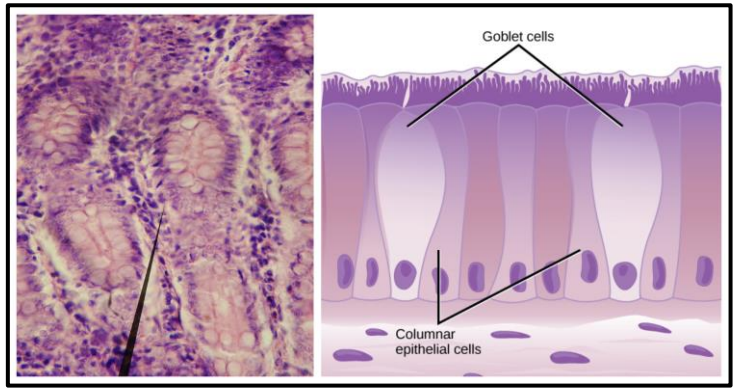
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CLASSIFICATION OF ANIMAL TISSUES



Epithelial Tissue





1.The covering epithelial tissue:

- ✓ **Based on the epithelial layers**

1. Simple - Single layer
2. Stratified - More than one layer
3. Ciliated - Cells with cilia

- ✓ **Based on the cell shapes**

1. Squamous - Flat
2. Cuboidal - Cube
3. Columnar – Rectangular

2.Glandular epithelial tissue:

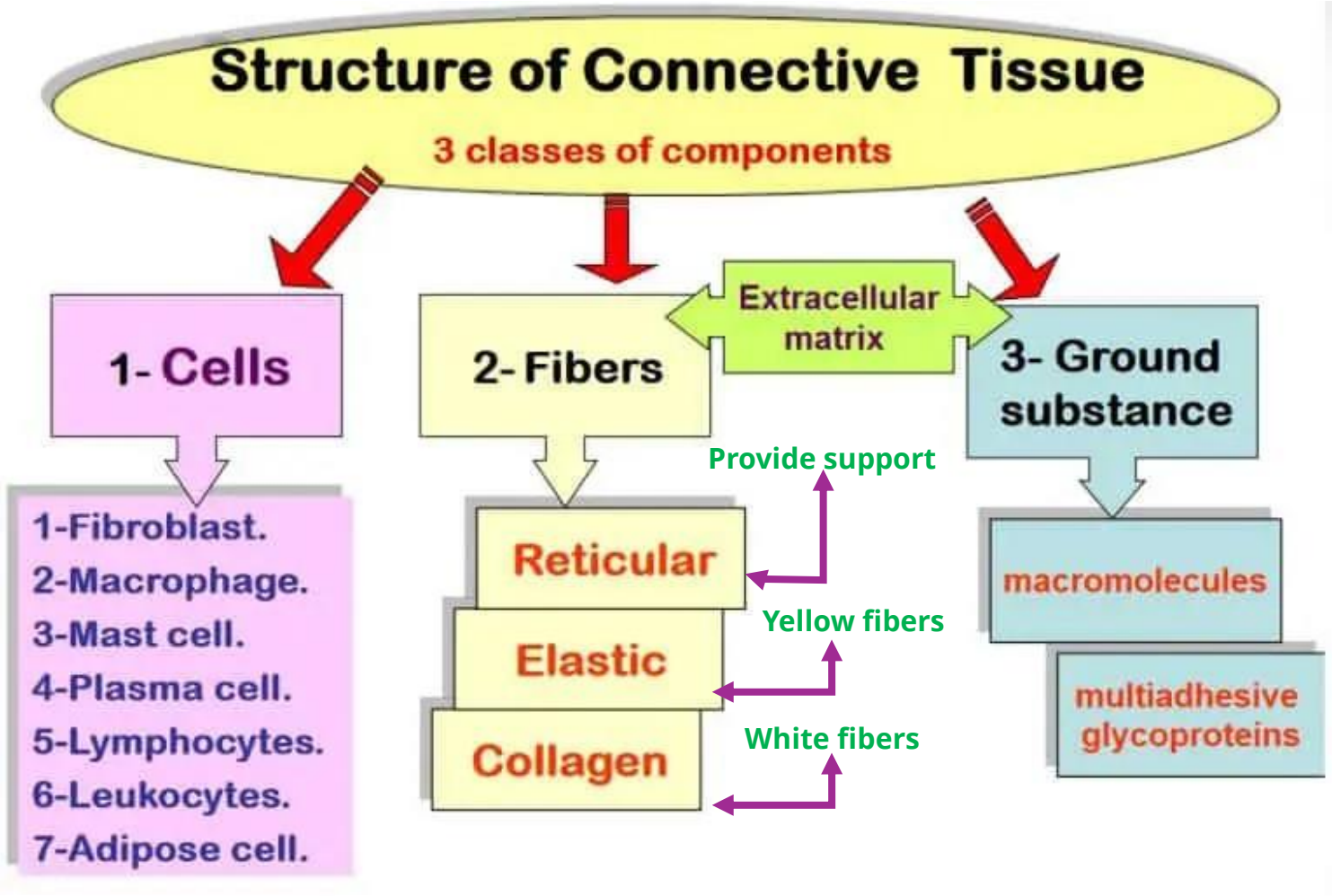
A portion of epithelial cells folds inward, which results in the formation of a multicellular gland.

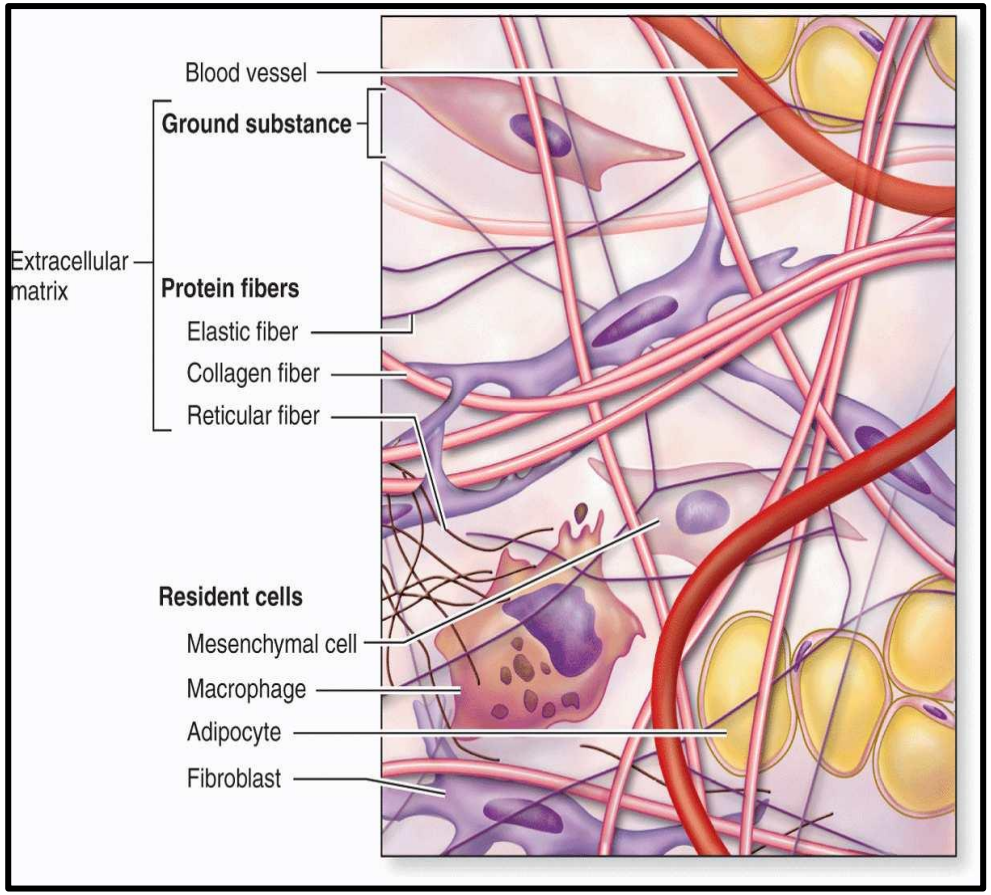
Location: It is found in the stomach, intestine and pancreas.

Function: It involves the synthesis and secretion of chemical substances at the epithelial surface.

Connective tissue

Origin: Connective tissue arises from the **mesoderm** of the embryo.
Location: These tissues are specialized to connect various body organs. It provides the **structural framework** and support different tissue to form organs.



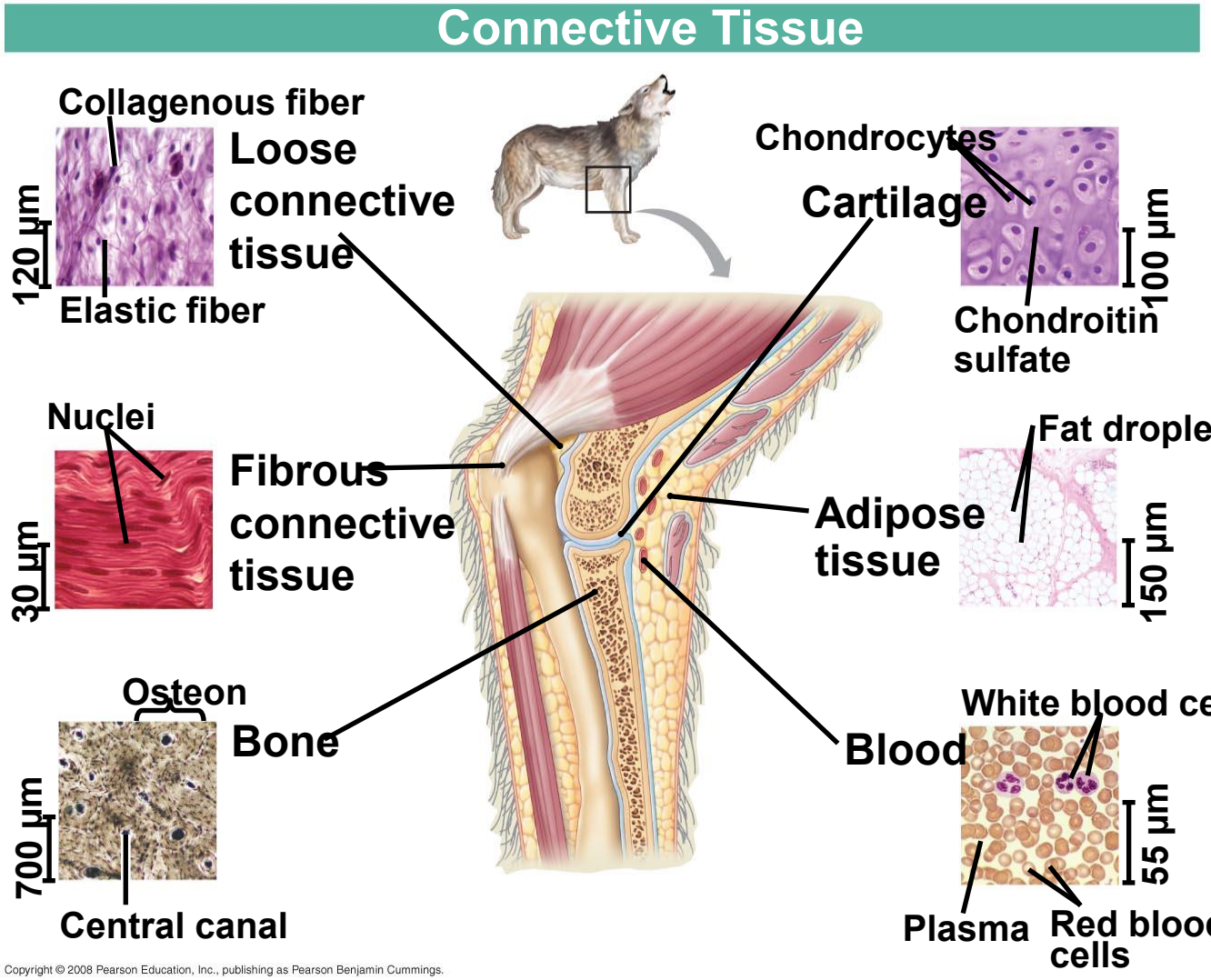


In vertebrates, the fibers and foundation combine to form *six major types of connective tissue*:

1- ***Loose connective tissue:*** binds epithelia to underlying tissues

2-(Dense)***Fibrous connective tissue*** is found in ***tendons***, which attach muscles to bones, and ***ligaments***, which connect bones at joints

3-(***Support connective tissue)*** ***Bone*** is mineralized and forms the skeleton.



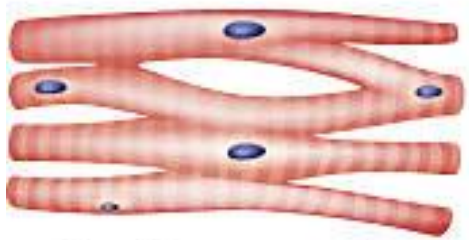
4- (***Support connective tissue) Cartilage*** is a strong and flexible support material.

5- ***Adipose tissue*** stores fat for insulation and fuel.

6- (Fluid connective tissue)***Blood*** is composed of blood cells and cell fragments in blood plasma.

Types of Muscle





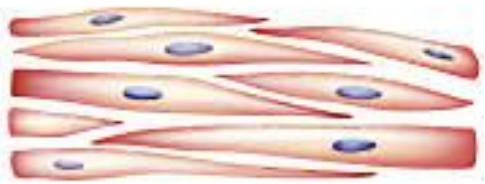
Cardiac muscle





Skeletal muscle

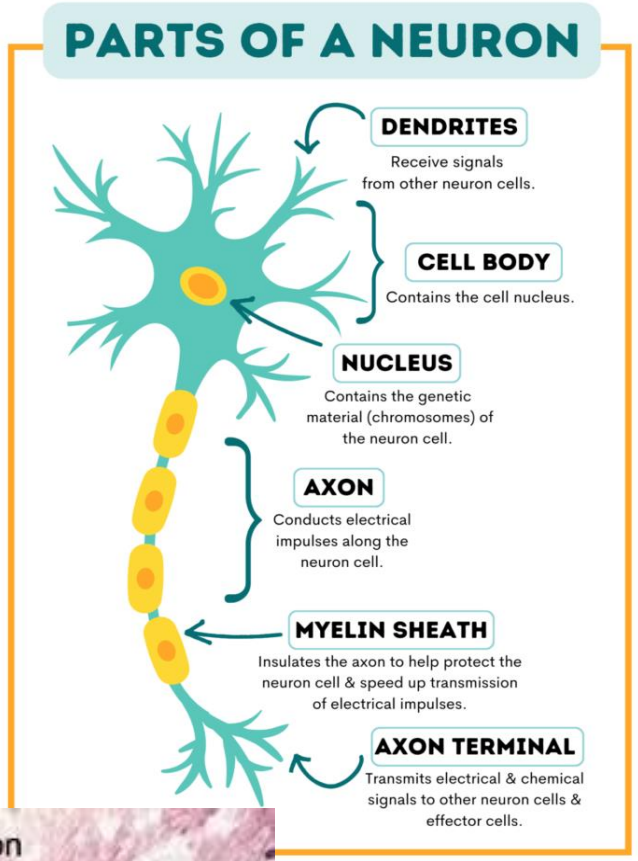




Smooth muscle

Nervous tissue

Nervous tissue senses stimuli and transmits signals throughout the animal. Also, it **abundantly occurs in the brain, spinal cord, and nerves.**



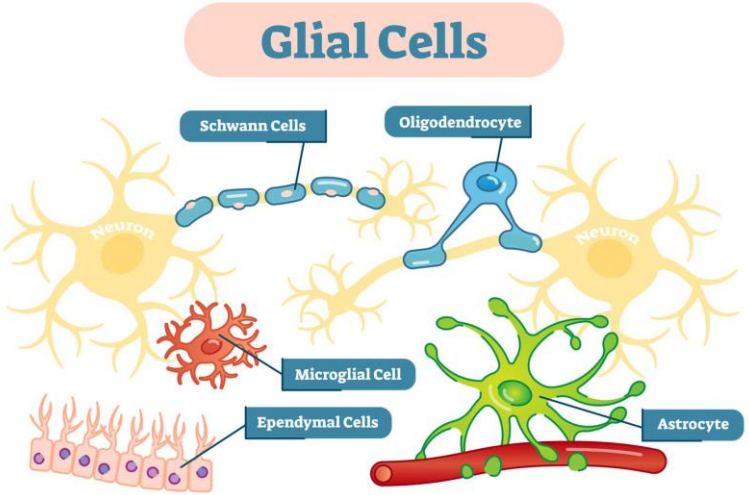
Nervous tissue contains:

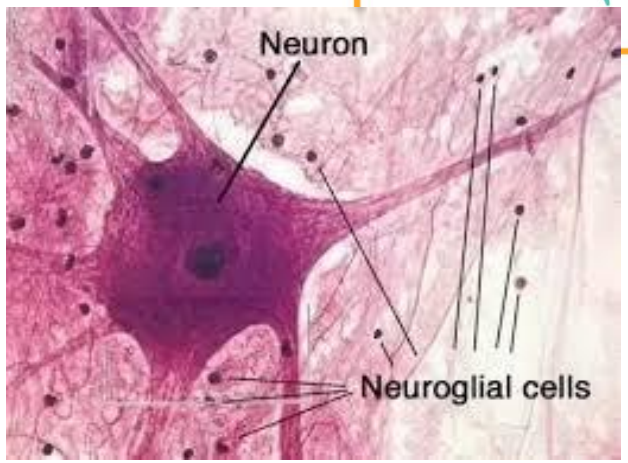
A-Neurons, or nerve cells, that transmit nerve impulses. A single neuron can be up to a meter long and is made up of three main components:

1.Cell body
2.Axon
3.Dendrites

B-Glial cells, or **glia**, are a group of supportive cells that help nourish, insulate, and replenish neurons.

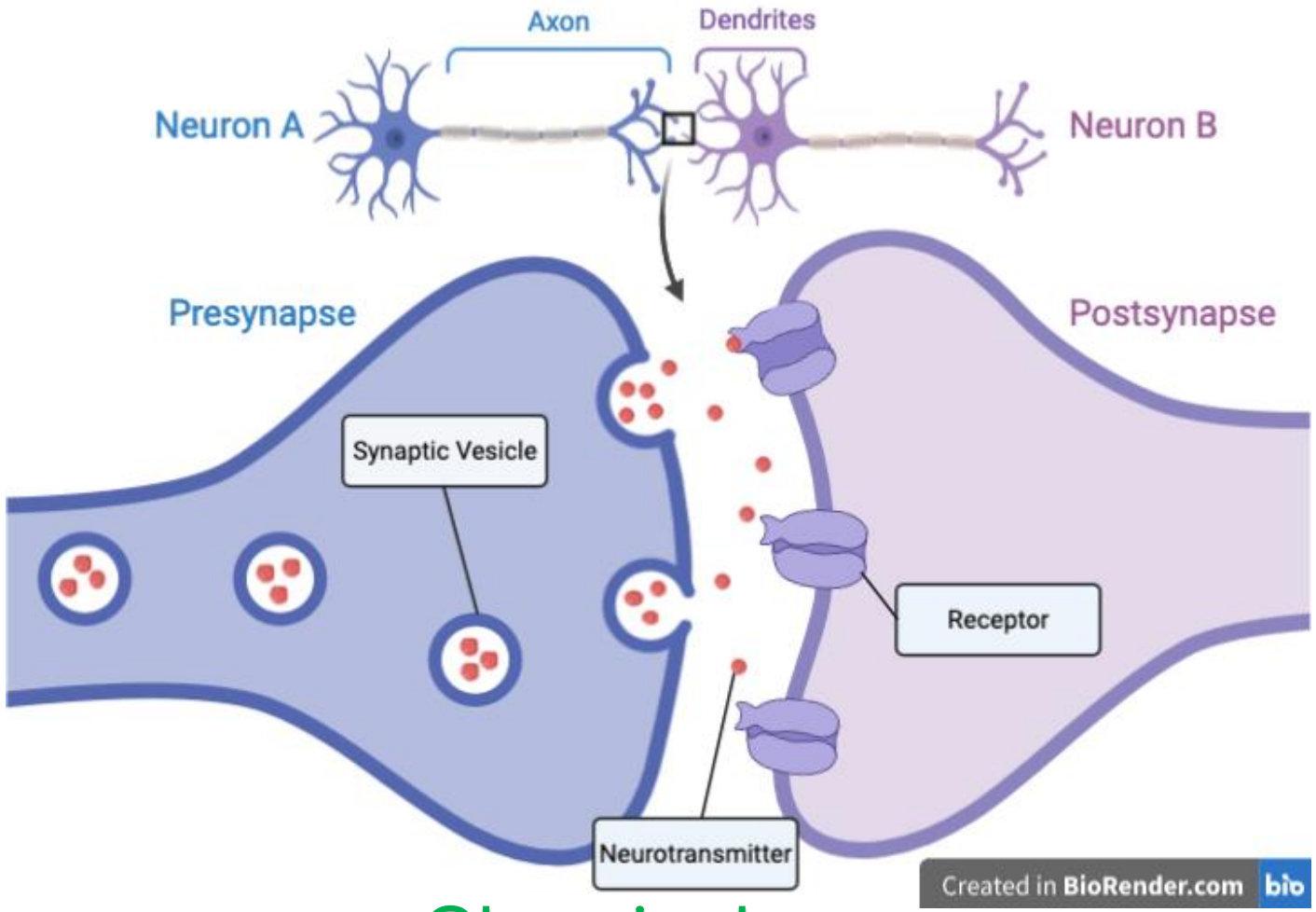
- They maintain the myelin sheath
- Provide nutrient support.
- They also retain homeostasis





Neurons communication (neuronal synapses): is a combination of electrical and chemical signals. A synapse is a small gap at the end of a neuron that allows a signal to pass from one neuron to the next.

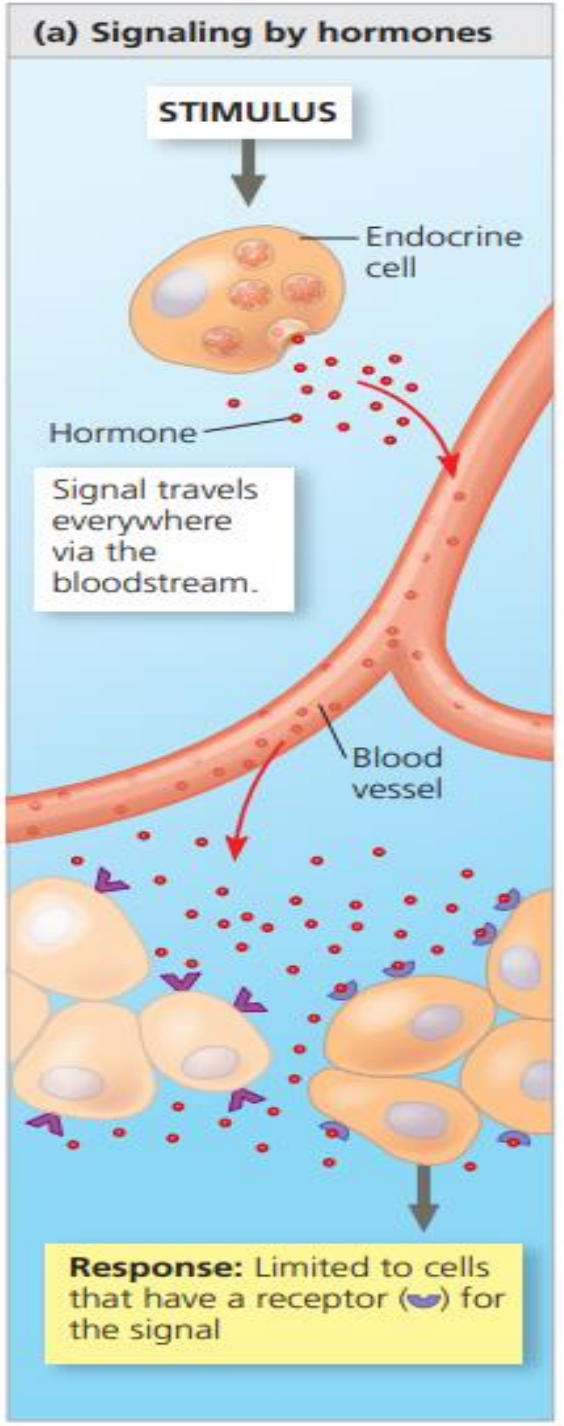
Neurons are cells that transmit information between your brain and other parts of the central nervous system.



Chemical synapse

Coordination and Control

- Control and coordination within a body depend on the *endocrine system* and the *nervous system*.
- The endocrine system transmits *chemical signals* called ***hormones*** to receptive cells throughout the body via blood.
- A hormone may affect one or more regions throughout the body.
- Hormones are relatively slow acting, but can have long-lasting effects. however, because hormones can remain in the bloodstream for minutes or even hours

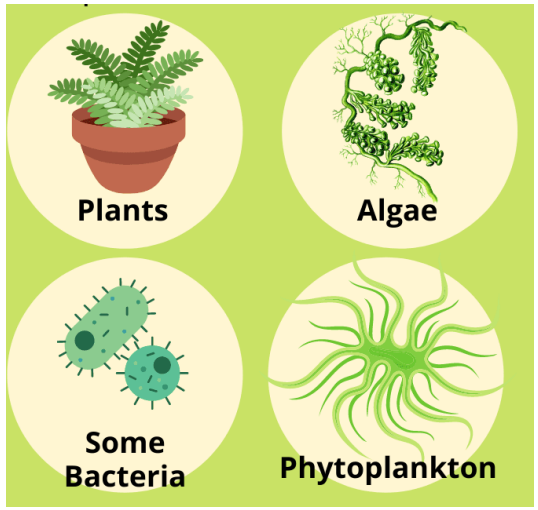


Animal Nutrition

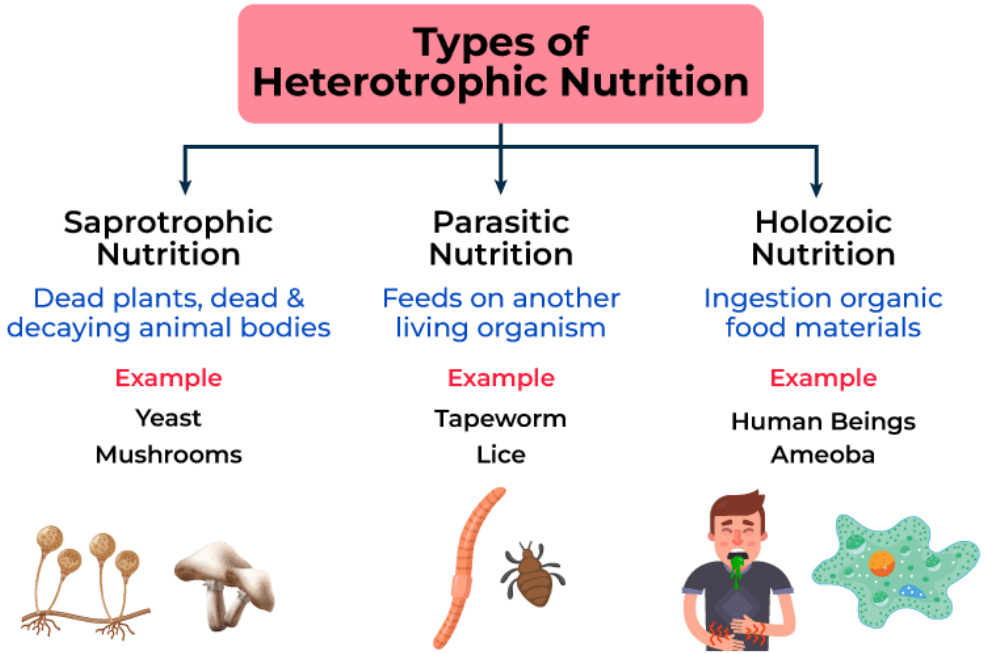
It is the process through which the animal feeds by ingesting complex organic food (either in the solid or liquid form), which is then digested and absorbed into their bodies.

Classifying Different Modes of Nutrition

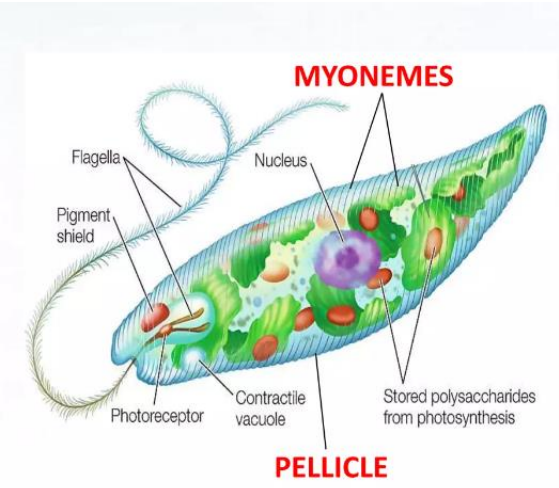
Autotrophs (producer):
It is an organism that produce its own food



Heterotrophs (consumers):
It is an organism that does not make its own food



Mixotrophic:
It is an organism that can be autotrophic and heterotrophic



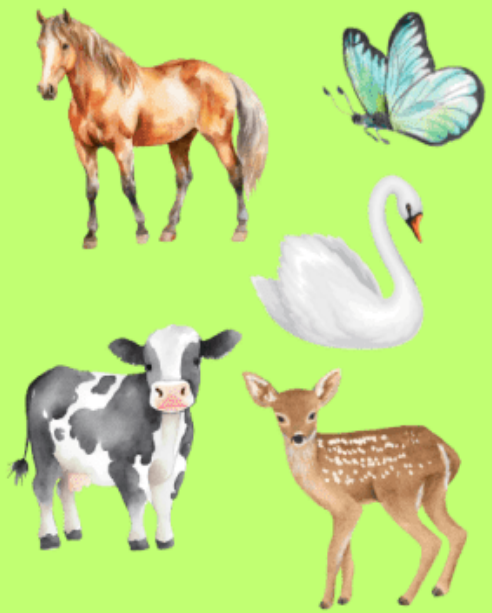
Euglena

Herbivores, Carnivores, and Omnivores

The three broad types of diets in the animal kingdom are herbivores, carnivores, and omnivores.

HERBIVORE

An herbivore eats plants.



CARNIVORE

A carnivore eats animals.



OMNIVORE

An omnivore eats both plants and animals.



sciencenotes.org

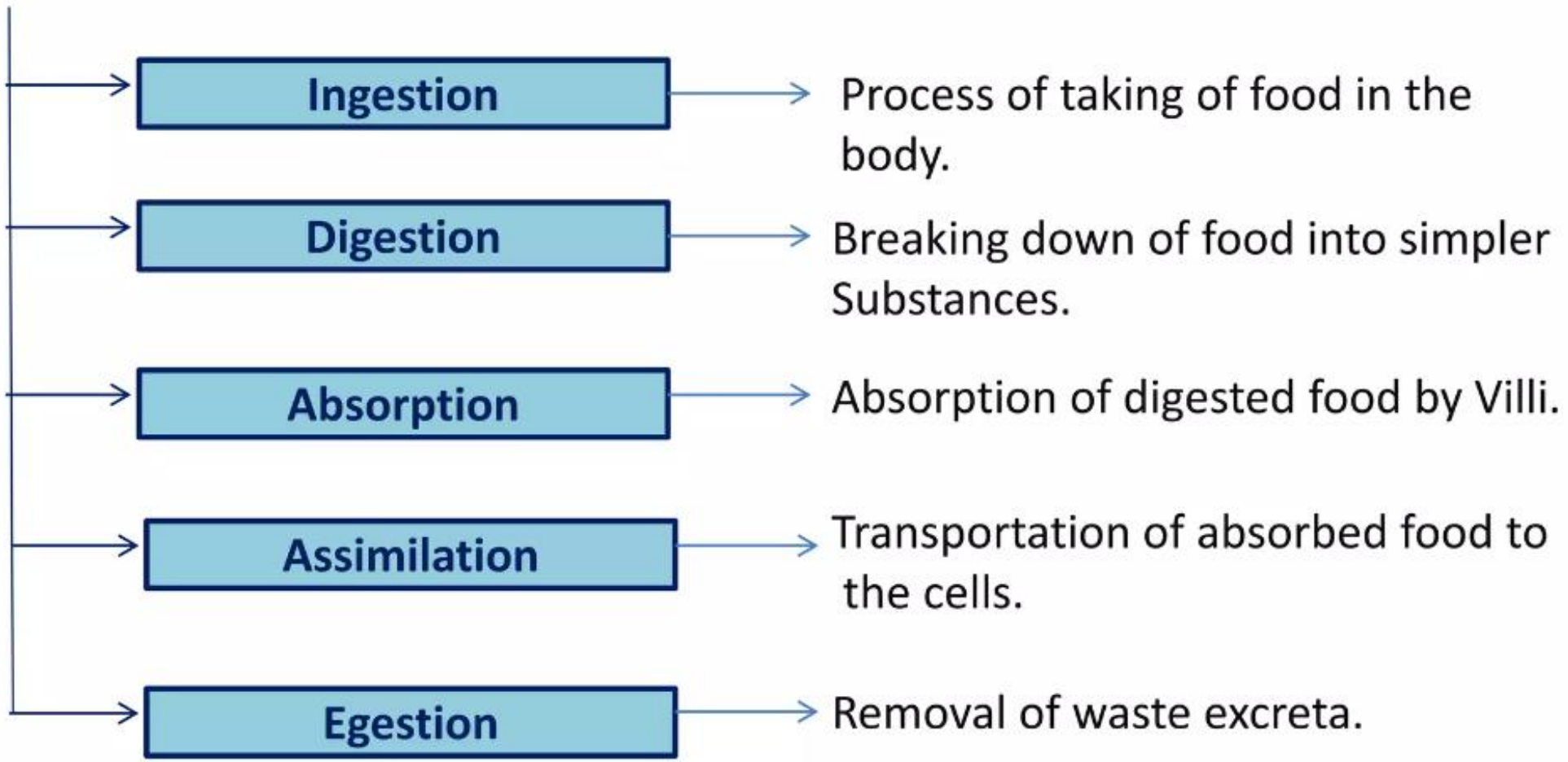
An animal's diet must supply chemical energy, organic molecules, and essential nutrients

- An animal's diet provides chemical energy, which is converted into **ATP** and powers processes in the body.
- Animals need a source of organic carbon and organic nitrogen in order to construct ***organic molecules***.
- **Essential nutrients** are required by cells and must be obtained from dietary sources.

There are six classes of essential nutrients:

1. **Water**: Dissolves and carries nutrients, regulate body function and body temperature.
2. **Carbohydrates**: Sugars-provides energy
3. **Protein:** Built and repairs tissues, enzymes and hormones.
4. **Fats and oils:** Store energy for long term in the body.
5. **Vitamins:** Promote normal growth. Provide proper metabolism and protect against diseases.
6. **Mineral:** support function of heart, metabolism, bones and teeth formation.

Five steps in the process of Nutrition in Animal:



Different ways of taking food(Ingestion)

Animal	Mode of ingestion
Amoeba	Engulfs food with the help of pseudopodia (false feet) and food vacuole digest it
Lice	Feeds by sucking blood from the skin
Honeybees and Hummingbirds	Collects nectar from flowers in plants
Dog	Chew and swallow their food using mouth
Frog	Long forked tongue to catch insects
Infants of mammalian	Feeds on mother's milk by using mouth
sponge	Filter tiny food particles



Sucking



Chewing



Long forked tongue

2.Digestion:-The process by which complex food substances are broken down into simpler substances is called digestion.



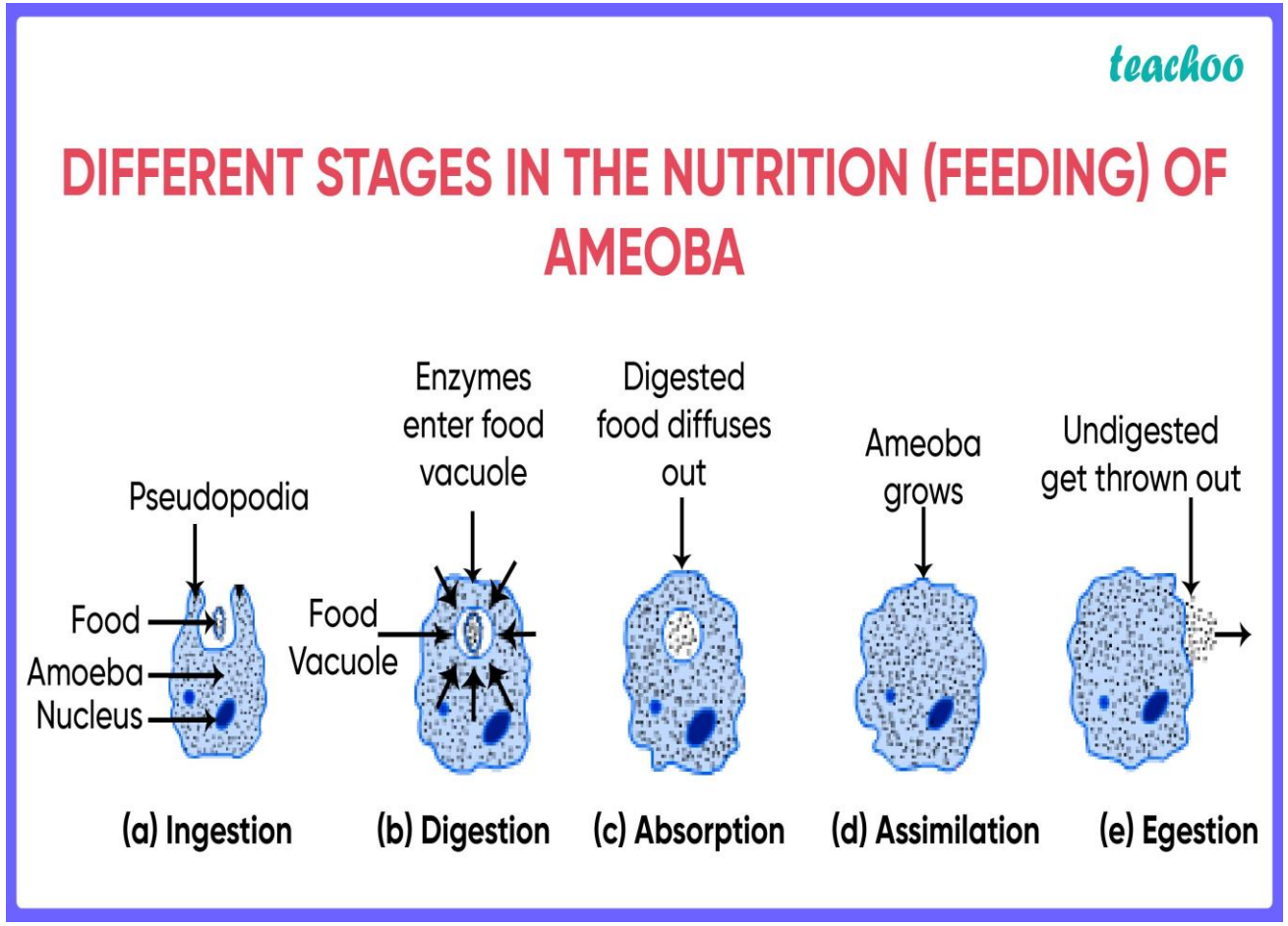
Complex Substances

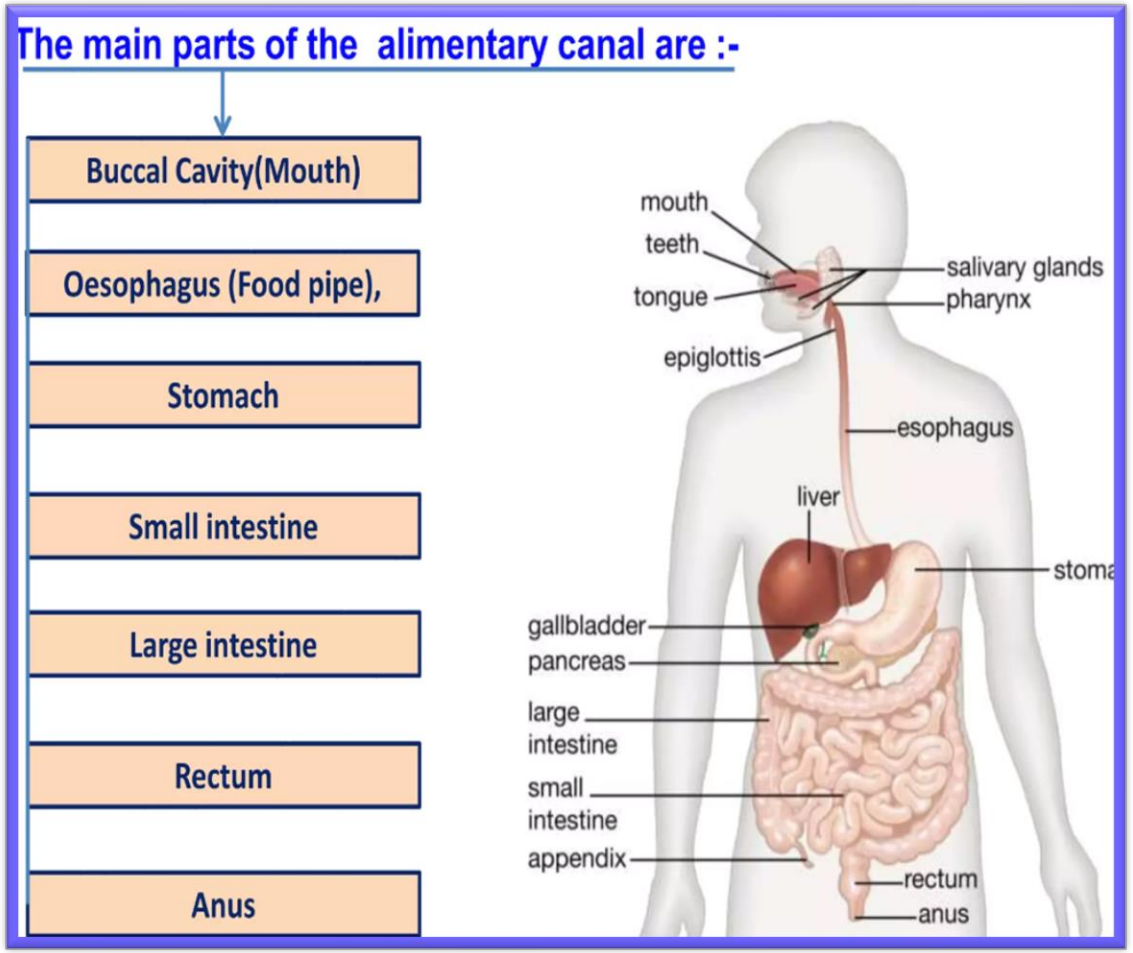
Simpler Substances

NUTRIENTS AND THEIR SIMPLER SUBSTANCES.

1.Carbohydrates	→	Glucose
2.Fats	→	Fatty Acids
3.Protiens	→	Amino Acids

Different stages in the Nutrition of Amoeba and Human

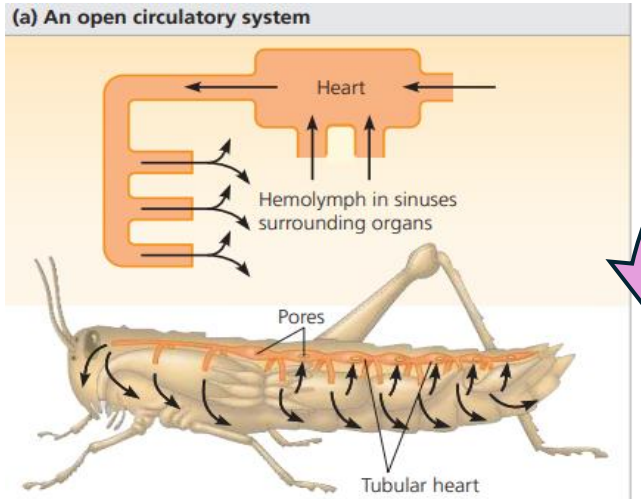


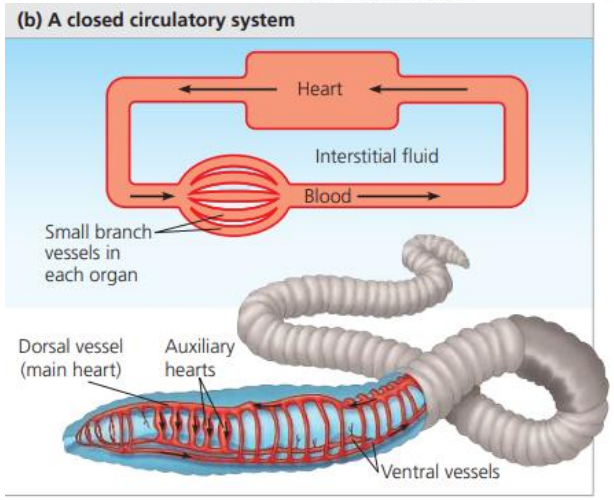


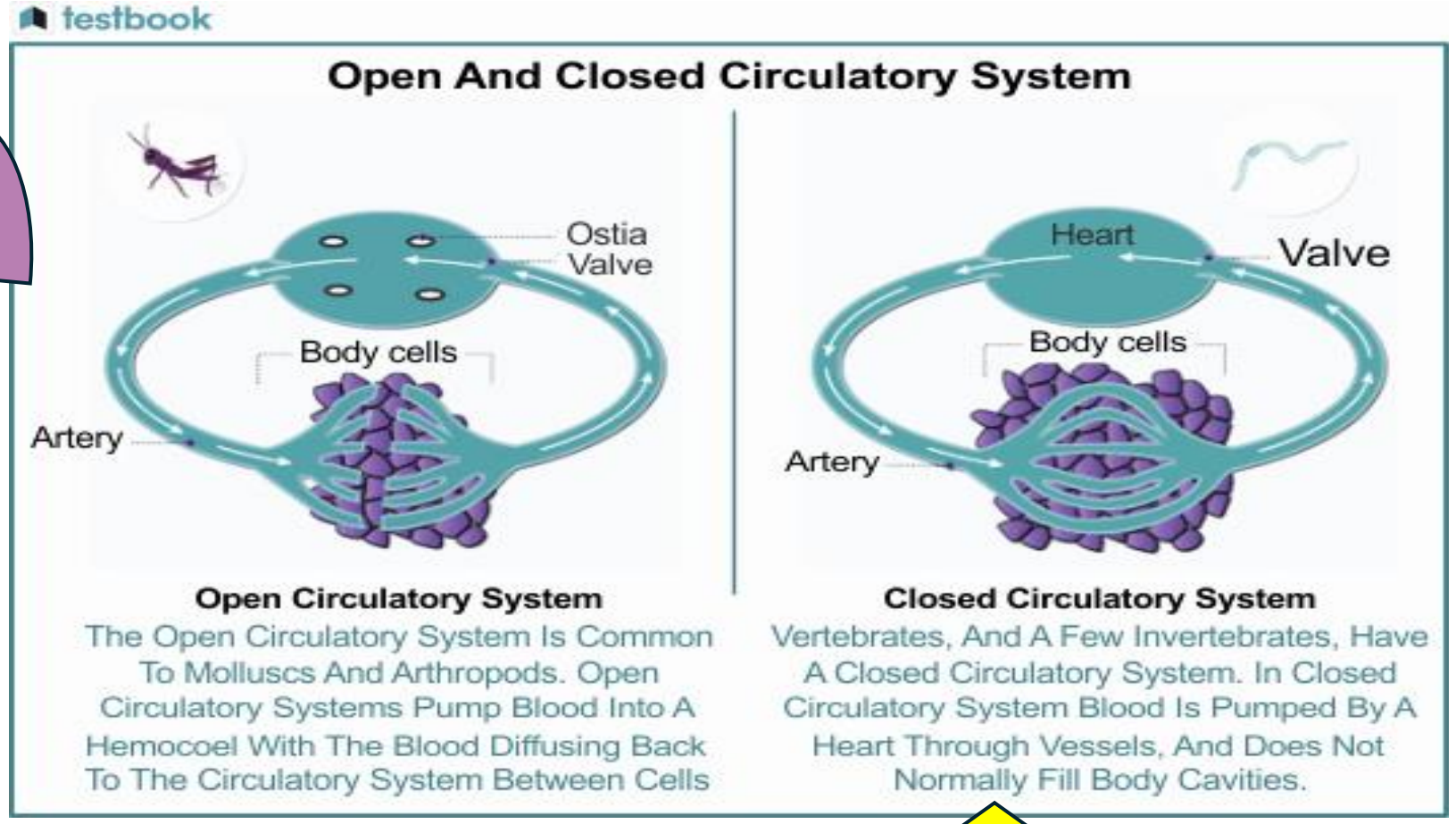
Circulation and Gas Exchange

The Circulatory System:

Large organisms require a transport system to distribute nutrients and oxygen and to remove wastes and CO_2 from cells distributed throughout the body.







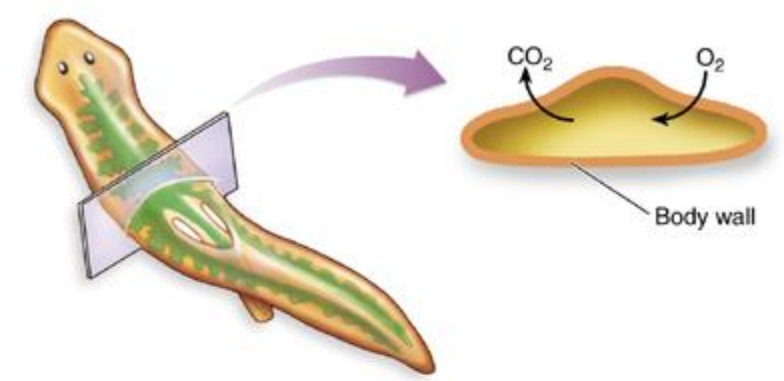
Gas exchange occurs across specialized respiratory surfaces

Gas exchange supplies oxygen for cellular respiration and disposes of carbon dioxide to stay a live.

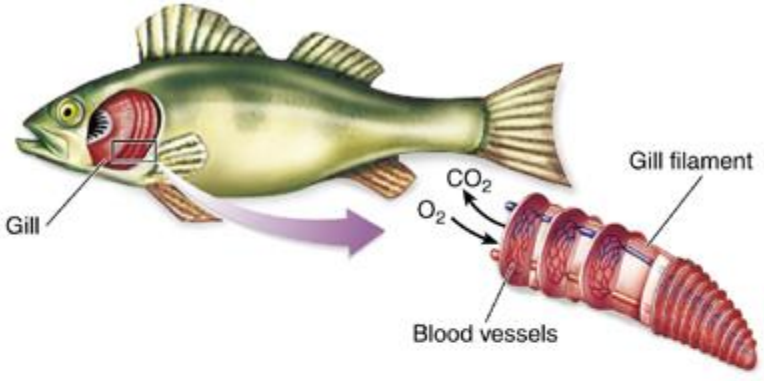
Major types of gas exchange system in animals:

1. Skin (body surface)
2. tracheae
3. gills
4. lungs

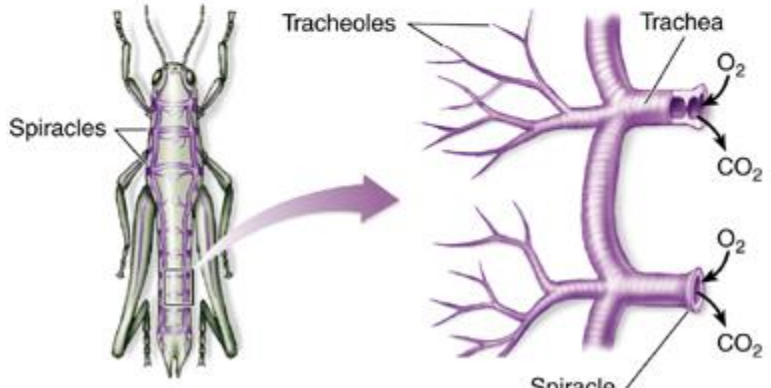
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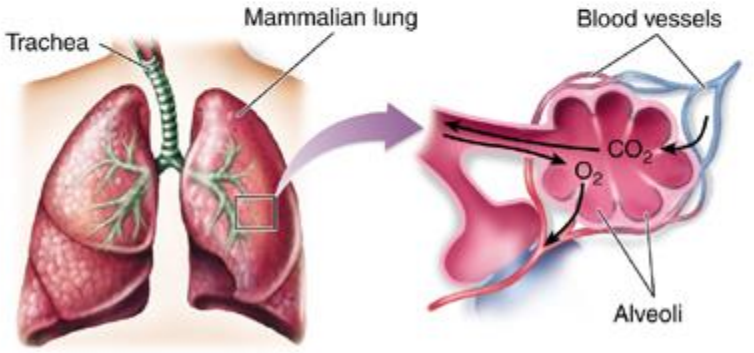
(a) Flatworm



(b) Fish



(c) Terrestrial arthropod



(d) Mammal

Animal reproduction

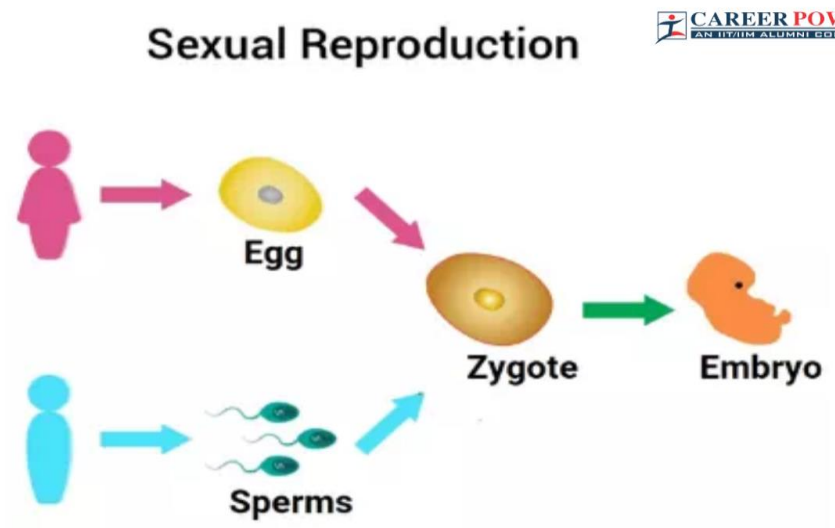
Reproduction is the biological process of producing the same kind of individuals. Most organisms reproduce by two types of animal reproduction include,

•Sexual Reproduction: is the creation of an offspring by fusion of a male gamete (*sperm*) and female gamete (*egg*) to form a *zygote*

•Asexual Reproduction: is creation of offspring without the fusion of egg and sperm . One parent *clones* offspring.

Type of Sexual reproduction in animals:

1- Internal fertilization occurs inside the female body when the male introduces the sperms into the female reproductive tract. The sperm fuses with the egg in the ampulla of the fallopian tube. This results in the formation of a zygote which undergoes mitosis to form an embryo.



2- External fertilization is a mode of reproduction in which a male organism's sperm fertilizes a female organism's egg outside of the female's body for example: fish and frog .



Type of Asexual reproduction in animals:

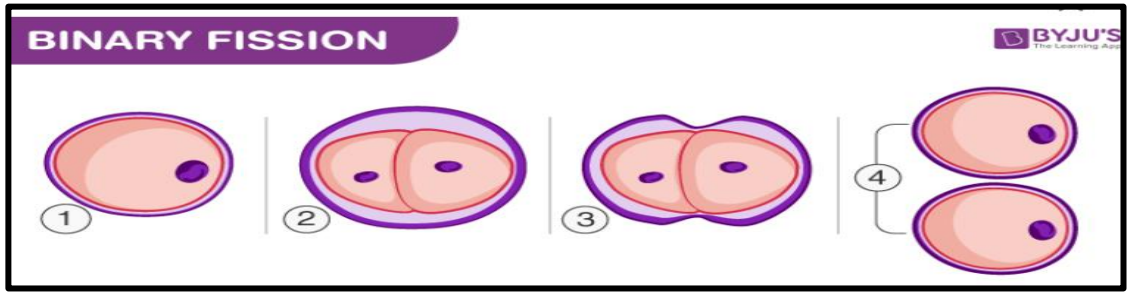
Binary Fission (separation of a parent into two or more individuals of about the same size ex: Amoeba

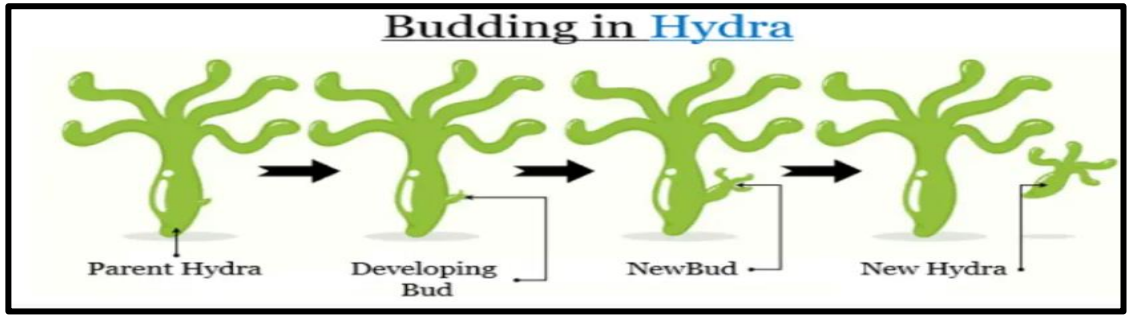
Budding : new individuals arise from outgrowths of existing ones. For example: Hydra.

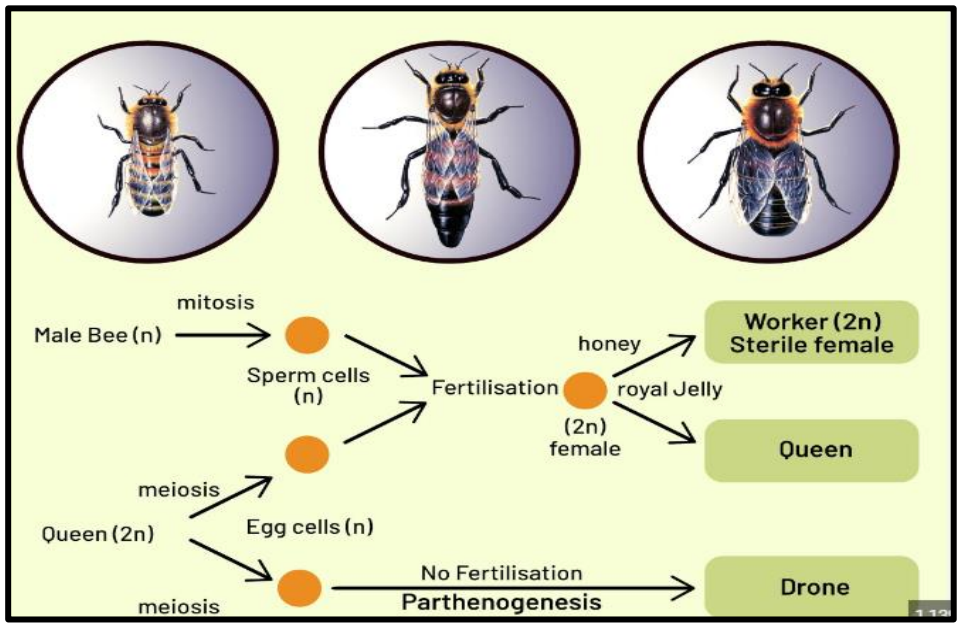
Fragmentation : breaking of the body into pieces, some or all of which develop into adults. *Fragmentation must be accompanied by regeneration* = regrowth of lost body parts. ex: starfish

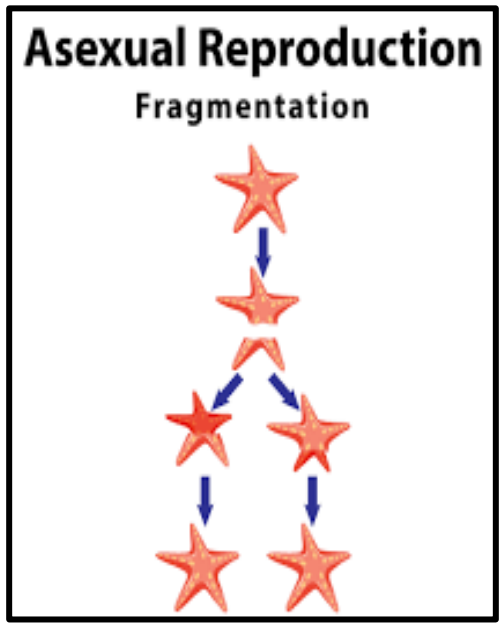
Parthenogenesis is the *development of a new individual from an unfertilized egg. Ex: Ant and honeybees*.

Gynogenesis, a form of parthenogenesis. The male donates his sperm, but this is only used as a stimulus for the development of the ovule. It does not actually provide its genetic material. *Ex.* rainbow trout and other species of fish.









Animal Development

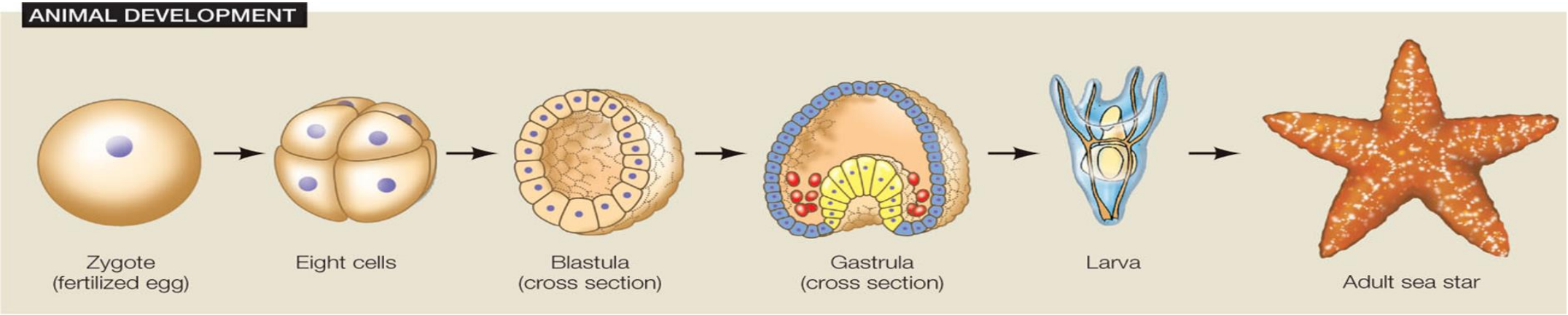
Animal development, the processes that lead eventually to the formation of a new animal starting from cells derived from one or more parent individuals

Development requires both **cell growth** and **cell differentiation** (different cells express different genes).

Some animals develop directly through transient stages into adults, but others have distinct larval stages.

- Larva is a sexually **immature stage** that is morphological distinct from the adult

- Larvae undergo **metamorphosis**, transforming the animal into an adult



Stages of Mammalian development

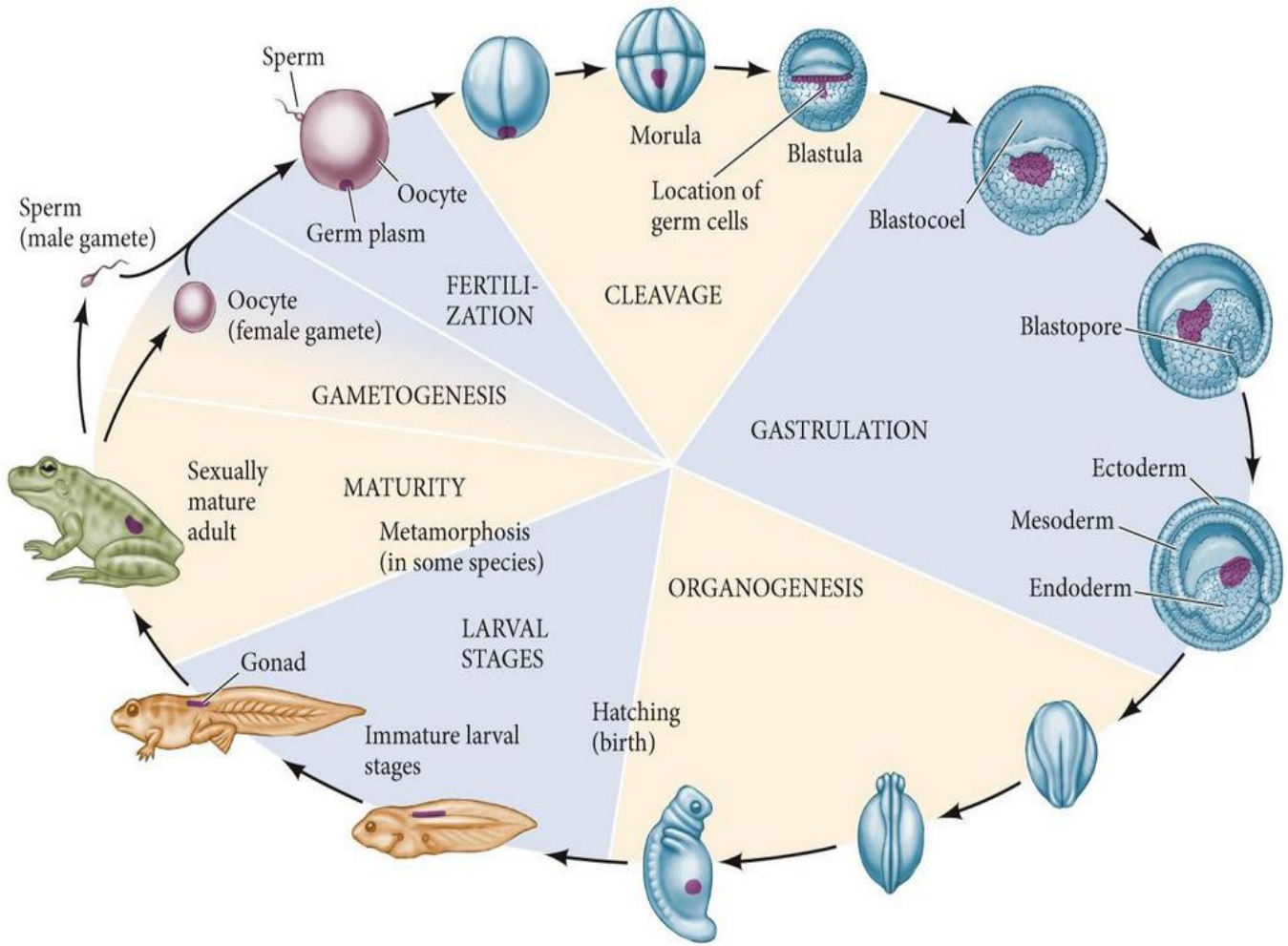
***1- Fertilization* and the zygote:** the process of union of two germ cells, **egg and sperm** to form zygot.

2-Cleavage: Mammals have a slow rate of division that is **between 12 and 24 hours**. These cellular divisions are asynchronous. Zygotic transcription starts at the two-, four-, or eight-cell stage.

3- Blastula to Morula: a hollow sphere of cells, or blastomeres, produced during the development of an embryo by **repeated cleavage** of a fertilized egg up 8–32 cells and it is called Morula.

3-Gastrulation: cells are **rearranged into a three-layered gastrula** that are ectoderm (Skin and Nerves system) , mesoderm (Muscles and spinal cord) and endoderm (elementary canal)

4- Organogenesis: the three germ layers interact and move to give rise to organs.



DEVELOPMENTAL BIOLOGY 11e, Figure 1.1
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The Immune System

A complex network of cells, tissues, organs, and the substances they make that helps the body fight infections and other diseases. The immune system includes white blood cells , organs, tissues of the lymph system, such as the thymus, spleen, and bone marrow.

Types of Immune system:

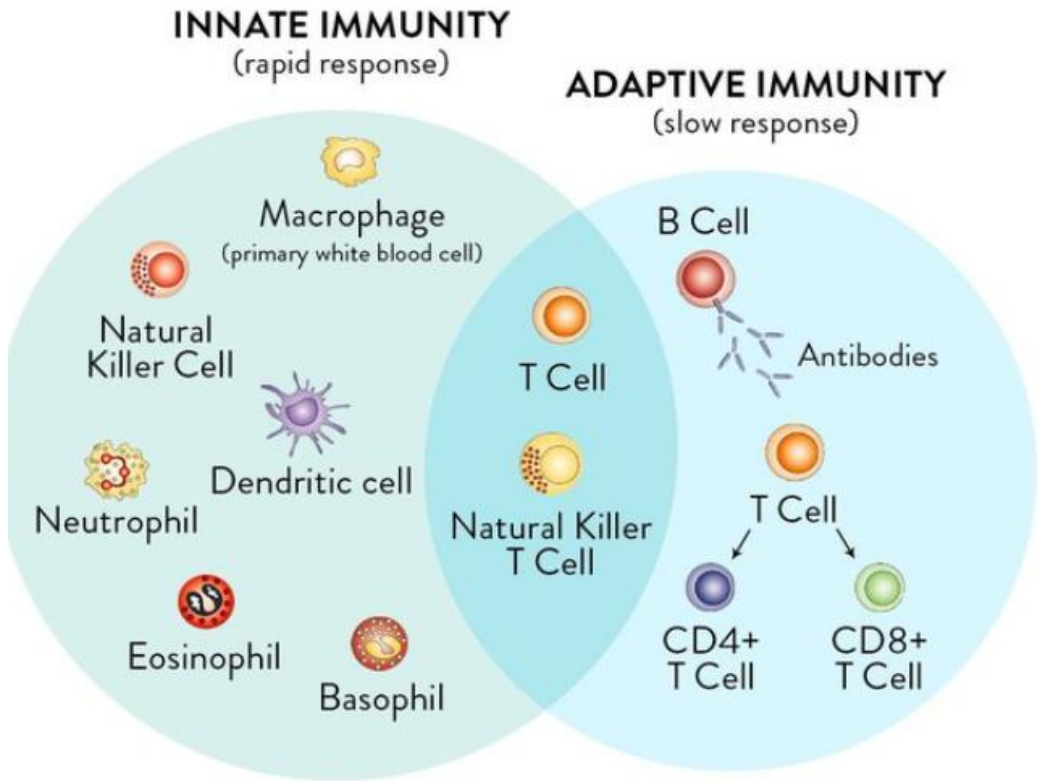
1-innate immunity **: is present before any exposure to pathogens and is effective from the time of birth (we are born with this). It has 3 components include:**

•Physical Barriers. such as skin, the gastrointestinal tract, the respiratory tract, the nasopharynx, cilia, eyelashes and other body hair.

•Defense Mechanisms. such as secretions, mucous, bile, gastric acid, saliva, tears, and sweat.

•General Immune Responses such as inflammation.

2-Adaptive immunity: **involves specialized immune cells and antibodies that attack and destroy foreign invaders and are able to prevent disease in the future by remembering what those substances look like and mounting a new immune response (You develop this when your body is exposed to microbes or chemicals released by microbes)**



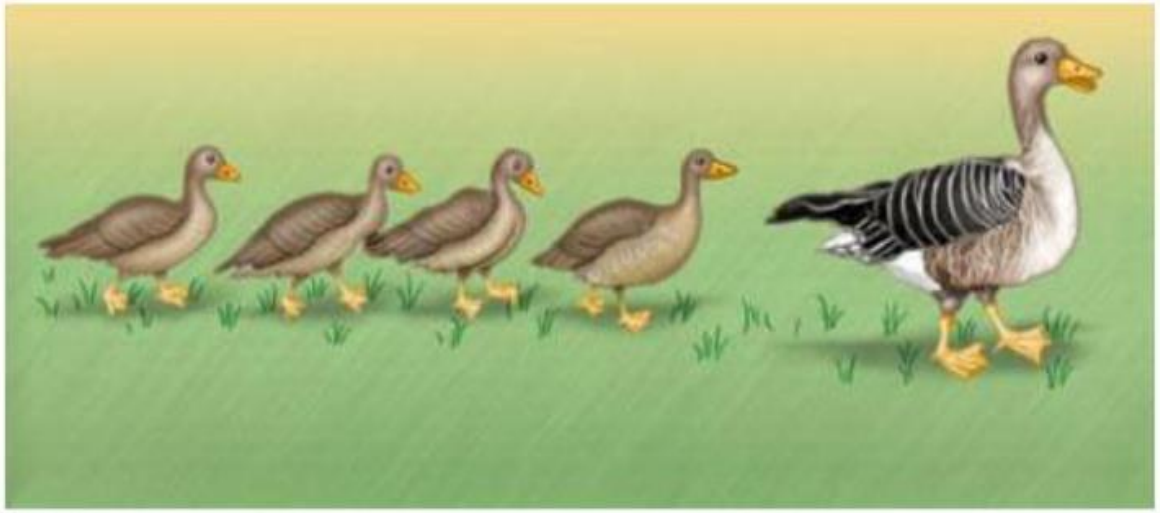
Animal behavior

- Animal behavior is based on physiological systems and processes.
- A **behavior** is the nervous system's response to a stimulus and is carried out by the muscular or the hormonal system.
- Behavior helps an animal:
  - Obtain food.
  - Find a partner for sexual reproduction.
  - Maintain homeostasis.
- An animal's behavior is its response to external and internal stimuli.

Animal Behavior is subject to Natural Selection.

- ***Ethology*** is the scientific *study of animal behavior*, particularly in **natural environments.**
- **Behavioral ecology** is the study of the ecological and evolutionary basis for animal behavior.
- It integrates proximate and ultimate explanations for animal behavior.
- **Proximate causation**, or "how" explanations, focus on
  - Environmental stimuli that trigger a behavior
  - Genetic, physiological, and anatomical mechanisms underlying a behavior.
- **Ultimate causation**, or "why" explanations, focus on
  - Evolutionary significance of a behavior.

BEHAVIOR: Young geese follow and imprint on their mother.



PROXIMATE CAUSE: During an early, critical developmental stage, the young geese observe their mother moving away from them and calling.

ULTIMATE CAUSE: On average, geese that follow and imprint on their mother receive more care and learn necessary skills, and thus have a greater chance of surviving than those that do not follow their mother.

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Ecology

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Biology

Eighth Edition

Neil Campbell and Jane Reece

Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

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What is Ecology?

- The branch of biology, study the relationships between organisms and their environments.

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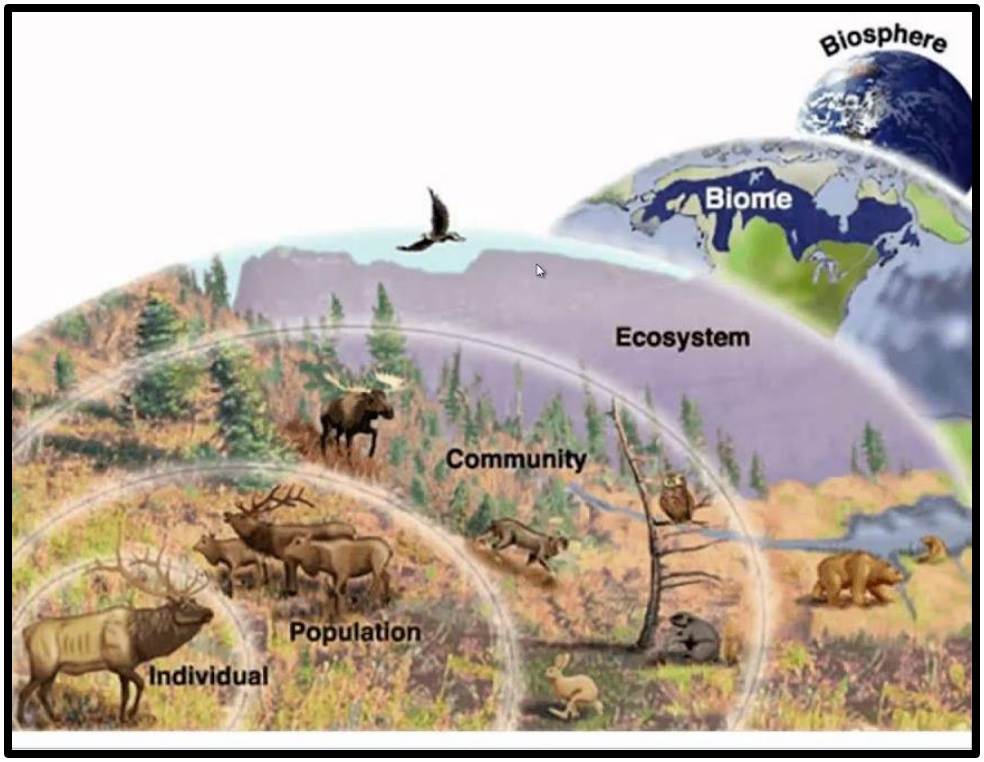
- The study of the relationships, distribution, and abundance of organisms, or groups of organisms, in an environment.

S.I. Dodson, 1998

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Levels of ecology:

Is the levels of organization are described from the smallest to the largest



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Levels of ecology:

Organism > individual organism in relation to other organism.

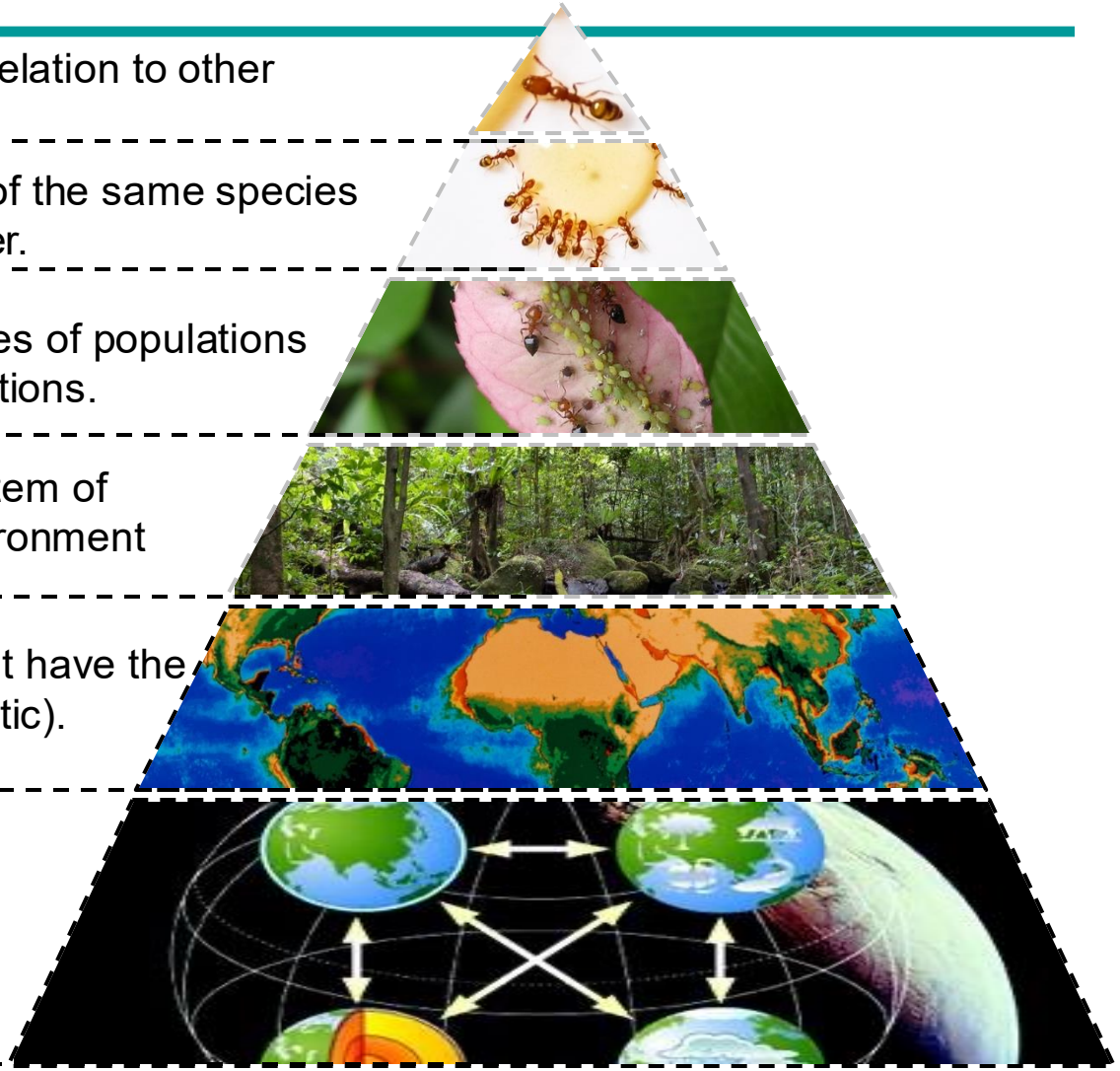
Populations > group of organisms of the same species and how they interact with each other.

Communities > natural assemblages of populations of different species and their interactions.

Ecosystem > the entire natural system of communities and their physical environment

Biomes > a group of ecosystem that have the same climate (i.e. terrestrial or aquatic).

Biosphere > all the biomes om earth.



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Population

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- **Populations :** group of organisms of the same species and how they interact with each other.
  - Studying the population involve how many organisms per unit area (density) and distribution (how clumped or spread).

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Measuring population

- Two important measures of a population are **population size** (the number of individuals in population) , and **population density** (It is the number of organisms per unit area or volume).

- To study the demographics of a population, it need to know **population size** and **population density**. Both important in describing the current status of the population, and making predictions about how it could change in the future.

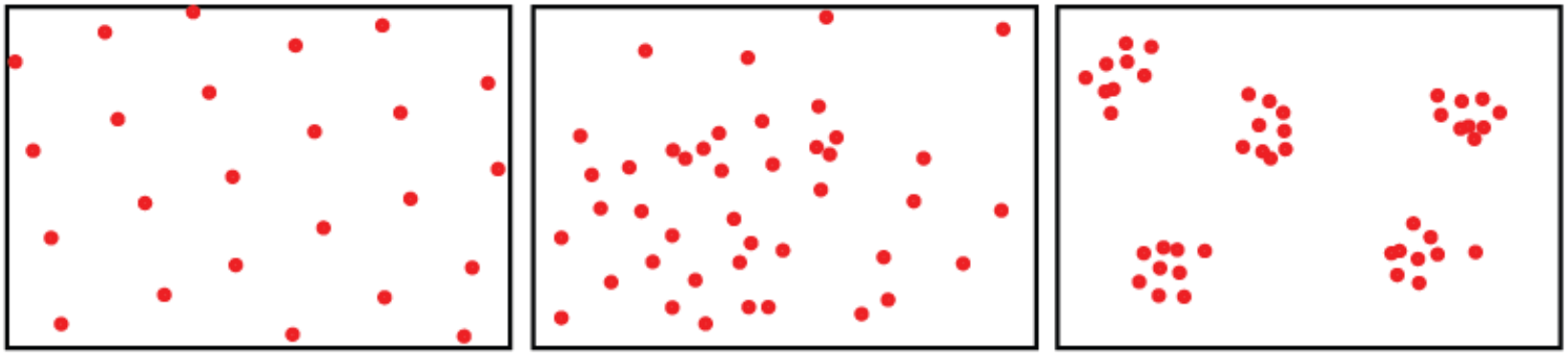
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Species distribution

Species distribution patterns (or **dispersion** patterns) refer to how the individuals in a population are distributed in space at a given time.

Species distribution patterns could be :

- uniform
- random
- clumped



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Uniform dispersion

- In uniform dispersion, individuals of a population are spaced more or less evenly.
- uniform dispersion pattern found in organisms that are solitary and/or territorial.
- An example of uniform dispersion in animal species where individuals stake out and defend territories (bear or wolves)

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Random dispersion

- In random dispersion, individuals are distributed randomly, without a predictable pattern.
- organisms that are not very territorial or do not live in big groups tend to have a more random dispersion due to the availability of good habitat. (snowshoe hare)

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Clumped dispersion

- In a clumped dispersion, individuals are clustered in groups.
- organisms that live in colonies, herds, flocks, or packs have a clumped dispersion pattern. (like a pack of wolves or dogs, schools of fish, or herds of elephants).

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Community Ecology

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The Community

- A biological **community** is an assemblage of populations of various species living close enough for potential interaction. All life / all populations in an area.
- Ecologists call relationships *between species* in a community ***interspecific interactions*****.**
- Interspecific interactions can affect the survival and reproduction of each species. *Effects can be positive (+), negative (–), or no effect (0).*
- Examples: competition, predation, herbivory, and symbiosis (parasitism, mutualism, commensalism).

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Competition

- **Interspecific competition** (–/– interaction) occurs when different species compete for a resource in short supply.
- Strong competition can lead to **competitive exclusion**, local elimination of a competing species.
- The ***competitive exclusion principle*** states that two species competing for the same limiting resources cannot coexist in the same place = 1 species per niche.

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Predation

- **Predation** (+/– interaction) refers to interaction where one species, the predator, kills and eats the other, the prey.
- Some feeding adaptations of predators are claws, teeth, fangs, stingers, and poison.
- Prey display various defensive adaptations: such as behavior and coloration.

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Herbivory: *Herbivores = Plant Predators*

- **Herbivory** (+/– interaction) refers to an interaction in which an herbivore eats parts of a plant or alga.
- It has led to evolution of ***plant defenses*** *against herbivores: secondary compounds* = are *chemical defenses*; and *mechanical defenses which are often osmoregulated.*

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Symbiosis: + + + 0 + -

- ***Symbiosis*** is a *dependency relationship* where two or more species live in direct and intimate contact with one another. The relationship is generally based one or some combination of the following ***benefits***:
- *Nutrition (food, water)*
- *Protection*
- *Reproduction*

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Parasitism + -

- In **parasitism** (+/– interaction), one organism, the **parasite**, derives nourishment from another organism, its **host**, which is harmed in the process.
- **Endoparasites** = parasites that live within the body of their host.
- **Ectoparasites** = parasites that live on the external surface of a host.
- Many parasites have a complex life cycle involving a number of hosts.
- Some parasites change the behavior of the host to increase their own fitness (reproduce more offspring).

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Mutualism + +

- Mutualistic symbiosis, or **mutualism** (+/+ interaction), is an interspecific interaction that benefits both species.
- A mutualism can be:
  - Obligate = *MUST* where one species cannot survive without the other.
  - Facultative = *OPTIONAL* where both species can survive alone.

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Commensalism + 0

- In **commensalism** (+/0 interaction), one species benefits and the other is apparently unaffected.
- Commensal interactions are hard to document in nature because any close association likely affects both species.

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A possible example of commensalism between cattle egrets (birds) and water buffalo: The Birds eat insects disturbed by the Buffalo as they move.



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Review

Interspecific Interaction	Description
Competition (−/−)	Two or more species compete for a resource that is in short supply. The competitive exclusion principle states that two species cannot coexist in the same community if their niches (ecological roles) are identical.
Predation (+/−)	One species, the predator, kills and eats the other, the prey. Predation has led to diverse adaptations, including mimicry.
Herbivory (+/−)	An herbivore eats part of a plant or alga. Plants have various chemical and mechanical defenses against herbivory, and herbivores have specialized adaptations for feeding.
Symbiosis	Individuals of two or more species live in close contact with one another. Symbiosis includes parasitism, mutualism, and commensalism.
Parasitism (+/−)	The parasite derives its nourishment from a second organism, its host, which is harmed.
Mutualism (+/+)	Both species benefit from the interaction.
Commensalism (+/0)	One species benefits from the interaction, while the other is unaffected by it.

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Ecosystems

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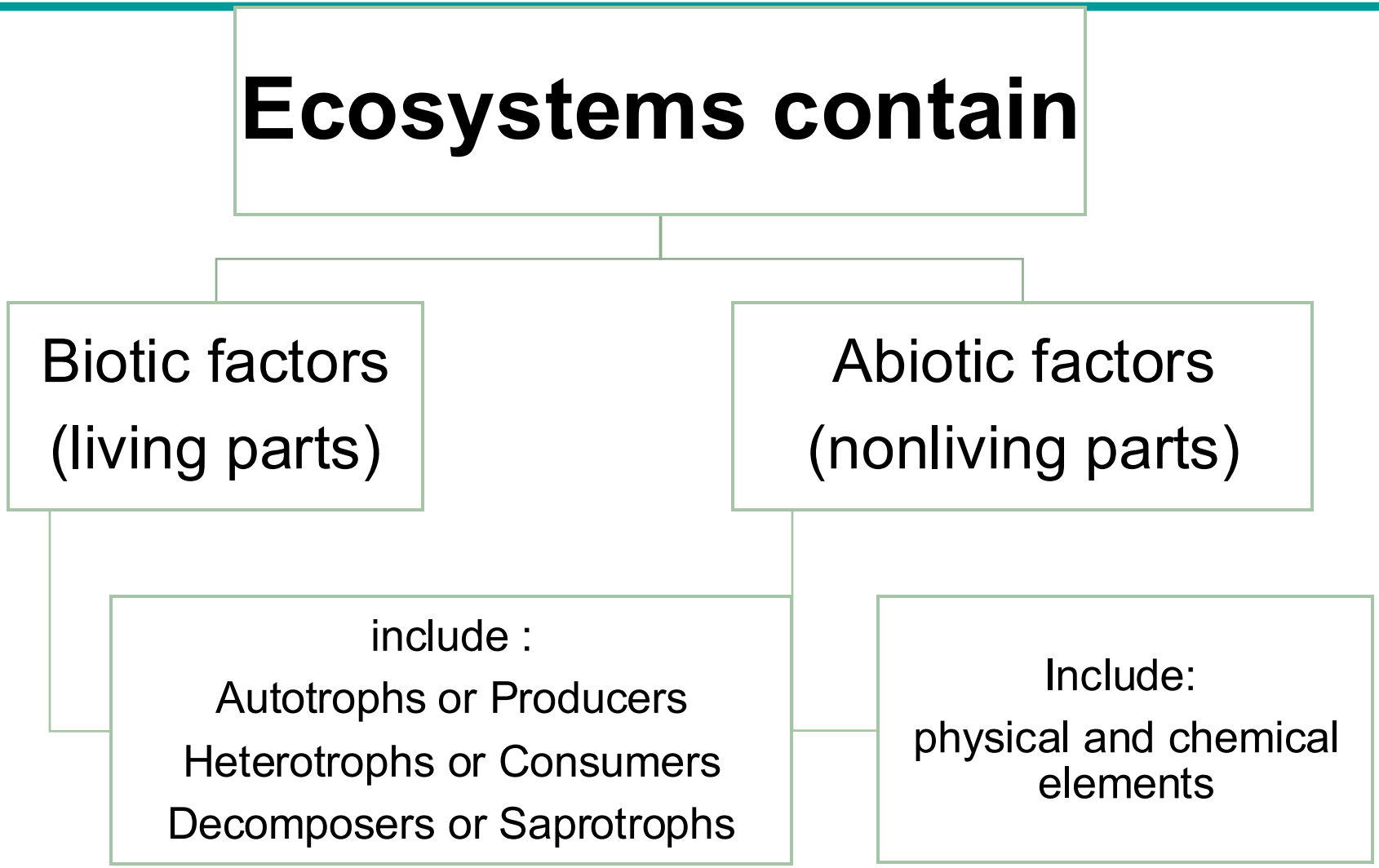
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Overview: Ecosystems

- An **ecosystem** consists of all the organisms living in a community, as well as the abiotic factors with which they interact.
- Ecosystems range from a microcosm, such as an aquarium, to a large area such as a lake or forest.

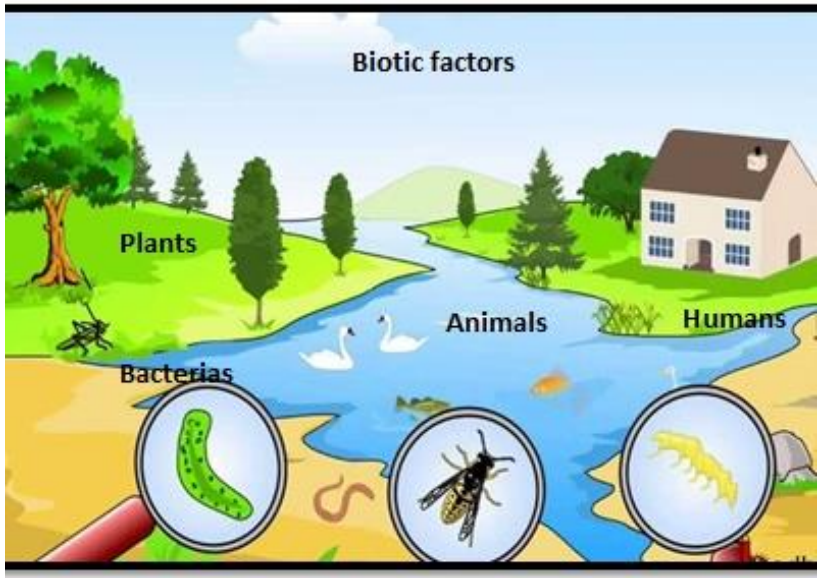
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Biotic factors

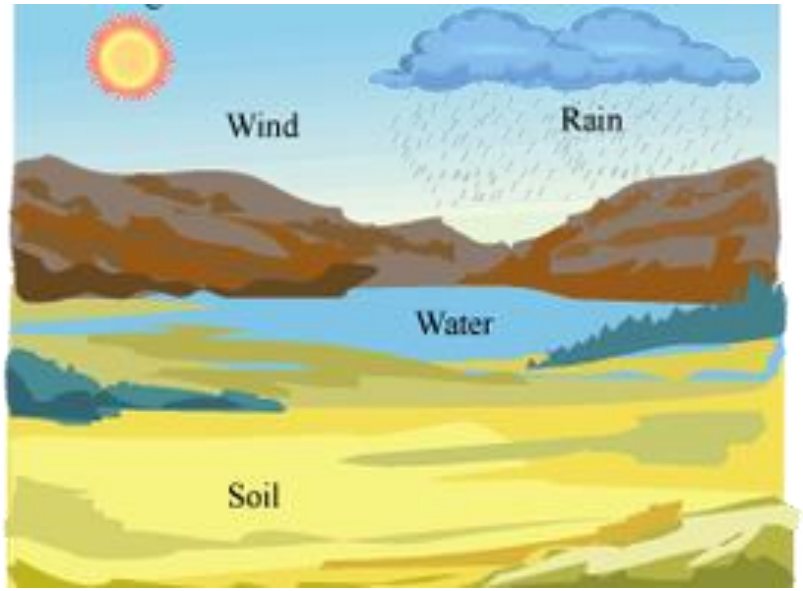
- **Biotic** factors are living or once-living organisms in the ecosystem.
- These are obtained from the biosphere
- They are capable of reproduction.
- Examples of biotic factors are animals, birds, plants, fungi, and other similar organisms.



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Abiotic factors

- **Abiotic** factors refer to non-living physical and chemical elements in the ecosystem.
- Abiotic resources are usually obtained from the lithosphere, atmosphere, and hydrosphere.
- Examples of abiotic factors are water, air, soil, sunlight, and minerals.



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Conservation Biology and Restoration Ecology

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Key points:

- Three Levels of Biodiversity
- Biodiversity and Human Welfare
- Ecosystem Services
- Three Threats to Biodiversity

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Human activities threaten Earth's biodiversity

- Rates of species extinction are difficult to determine under natural conditions.
- The high rate of species extinction is largely a result of ecosystem degradation by humans.
- Humans are threatening Earth's biodiversity.

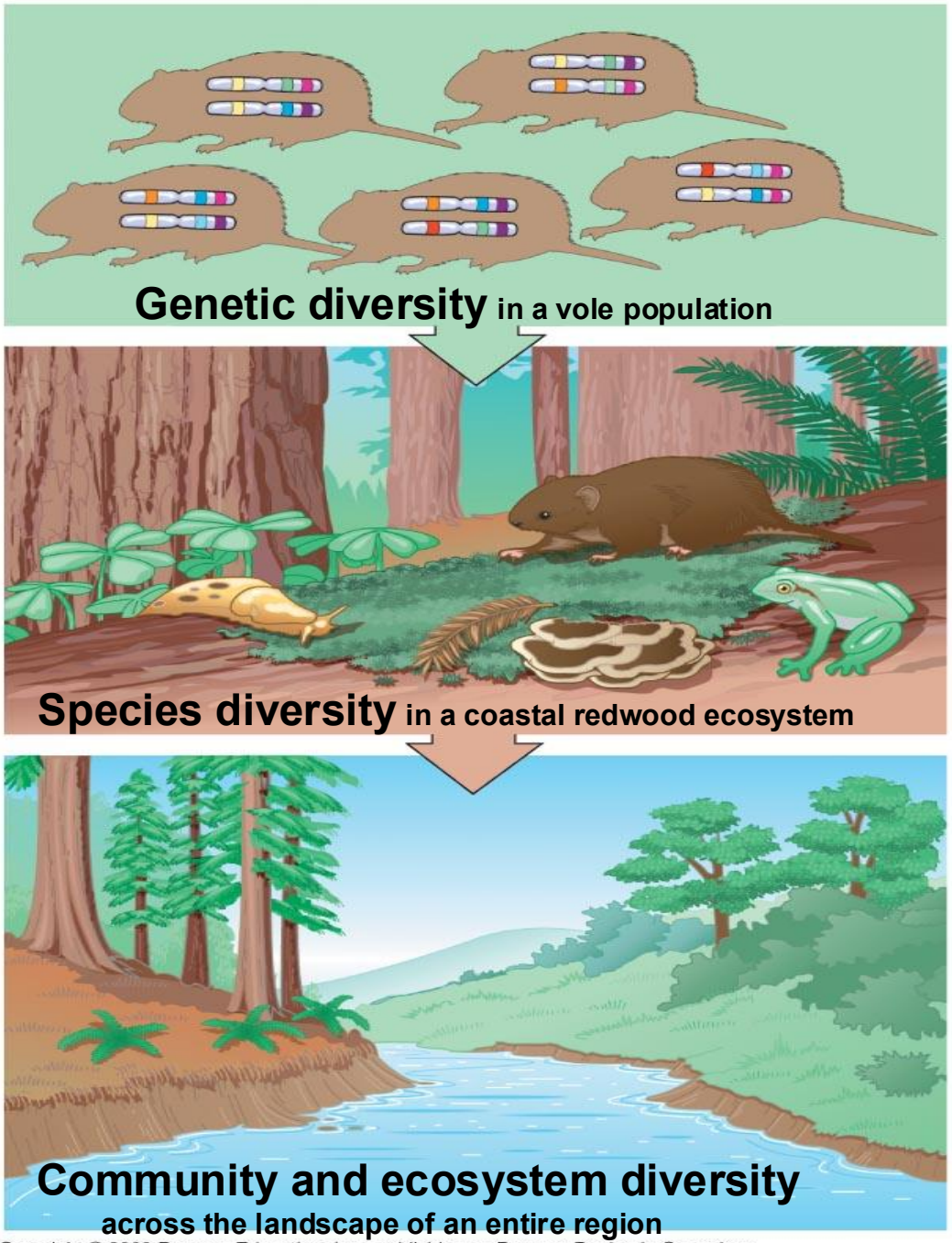
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Three Levels of *Biodiversity*

- Biodiversity has three main components:
  - ***Genetic diversity***
  - ***Species diversity***
  - ***Ecosystem diversity***

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Three Levels of Biodiversity



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Genetic Diversity & Species Diversity

- **Genetic diversity** comprises genetic variation within a population and between populations.
- **Species diversity** is the variety of species in an ecosystem or throughout the biosphere.
- According to the U.S. Endangered Species Act:
  - An **endangered species** is "in danger of becoming extinct throughout all or a significant portion of its range"
  - A **threatened species** is likely to become endangered in the foreseeable future.

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Ecosystem Diversity

- Human activity is reducing ecosystem diversity, the variety of ecosystems in the biosphere.
- More than 50% of wetlands in the contiguous United States have been drained and converted to other ecosystems.

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The endangered Marianas “flying fox” bat is an important pollinator



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Biodiversity and Human Welfare

- *Human **biophilia** allows us to recognize the value of biodiversity for its own sake*.
- Species diversity brings humans practical benefits. The enormous genetic diversity of organisms has potential for great human benefit.
- In the United States, 25% of prescriptions contain substances originally derived from plants.
- For example, the rosy periwinkle contains alkaloids that inhibit cancer growth.

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The rosy periwinkle, a plant that saves lives



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Ecosystem Services

- **Ecosystem services** encompass all the processes through which natural ecosystems and their species help sustain human life.
- Some examples of ecosystem services:
  - ***Purification of air and water***
  - ***Detoxification and decomposition of wastes***
  - ***Cycling of nutrients***
  - ***Moderation of weather extremes***.

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Three Threats to Biodiversity

- Most species loss can be traced to three major threats:
  - **Habitat destruction**
  - **Introduced species**
  - **Overexploitation**
- Human alteration of habitat is the greatest threat to biodiversity throughout the biosphere.
- In almost all cases, habitat fragmentation and destruction lead to loss of biodiversity.

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Introduced Species

- **Introduced species** are those that humans move from native locations to new geographic regions.
- Without their native predators, parasites, and pathogens, introduced species may spread rapidly.
- Introduced species that gain a foothold in a new habitat usually disrupt their adopted community.
- Sometimes humans introduce species by accident, as in case of the brown tree snake arriving in Guam as a cargo ship "stowaway."

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Overexploitation

- ***Overexploitation*** is *human harvesting* of wild plants or animals *at rates exceeding the ability of populations* of those species *to rebound*.
- Overexploitation by the fishing industry has greatly reduced populations of some game fish, such as bluefin tuna.
- DNA analysis can help conservation biologists to identify the source of illegally obtained animal products.

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Overexploitation



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General Biology 101

جامعة أم القرى
UMM AL-QURA UNIVERSITY

Environmental Sustainability, Biodiversity Conservation, and Food Security in Saudi Arabia

By

Dr. Afnan S. Quronfulah

1. Introduction

Saudi Arabia faces a complex set of environmental challenges:

rapid desertification, biodiversity loss, freshwater scarcity, and growing food demands.

In alignment with **Saudi Vision 2030**, the Kingdom has prioritized:

- Sustainable environmental management.
- Conservation of terrestrial and marine ecosystems.
- Strengthening national food security through modern agriculture.

1. Introduction

There are **three** interconnected topics:

1. **Environmental Sustainability & Biodiversity Conservation**
2. **Wildlife Conservation & Renewable Bio-based Industries**
3. **Agriculture and Food Security**

Together, they reflect a modern scientific approach to building a resilient future for Saudi Arabia in the context of climate change and ecological pressures.

2. Environmental Sustainability & Biodiversity Conservation



2.1 Desert Greening and Land Restoration

Saudi Arabia is one of the most arid nations globally, with desertification threatening habitats, infrastructure, and agricultural land.

*** Key Scientific Approaches:**

1. **Biotechnology in plant production**
   – Engineering drought- and salt-tolerant crop varieties.
   – Using microbial biofertilizers and mycorrhizal fungi to enhance soil productivity.

2. **Afforestation & Reforestation Programs**
   – Planting native desert species such as *Acacia(*Known for its drought tolerance and soil enrichment*)*, *Ziziphus(*Offers shade and fruit, supports biodiversity*)*, and *Haloxylon(*Excellent for stabilizing sandy soils).
   – Sand dune fixation using organic mulches and polymer-based soil stabilizers.

2. Environmental Sustainability & Biodiversity Conservation

2.1 Desert Greening and Land Restoration

3. **Water-efficiency Technologies**

- Drip irrigation, subsurface irrigation.
-Treated wastewater reuse for landscaping.
-Smart irrigation controlled by soil moisture sensors.



***Outcomes for Sustainability:**

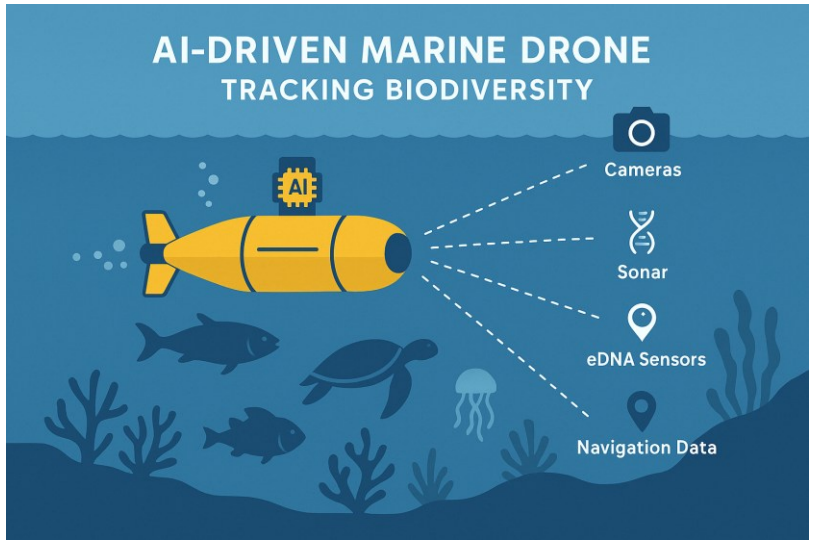
1- Reduced soil erosion.

2- Increased vegetation cover.

3- Microclimate improvement.

4- Greater carbon sequestration (supports Saudi Green Initiative).

2. Environmental Sustainability & Biodiversity Conservation



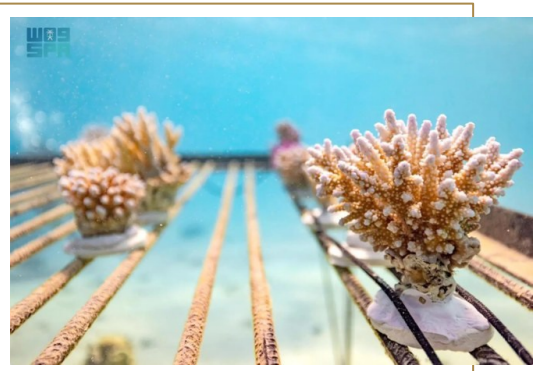
2.2 Coral Reef & Marine Biodiversity Conservation

Saudi Arabia's Red Sea hosts some of the world's most thermally tolerant coral reefs.

*** Threats**

- **Rising sea temperatures**
- **Habitat disturbance from coastal development**
- **Pollution & sedimentation**
- **Overexploitation of marine resources**

*** Conservation Programs**



Marine Protected Areas (MPAs)

– Restrict harmful activities

– Protect breeding grounds

Coral Reef Restoration

– Coral micro-fragmentation

– Coral gardening in underwater nurseries

Ecological Monitoring

– Satellite-based reef health assessment

– AI-driven marine drones (AUVs) to track biodiversity

2. Environmental Sustainability & Biodiversity Conservation

2.2 Coral Reef & Marine Biodiversity Conservation

*** Importance**

- Supports fisheries
- Promotes sustainable ecotourism
- Maintains marine ecosystem resilience
- Enhances national environmental heritage (NEOM, The Red Sea Project)





3. Wildlife Conservation & Renewable Bio-Based Industries

3.1 Wildlife Conservation Programs

Saudi Arabia hosts unique desert and mountain ecosystems with critically endangered fauna.

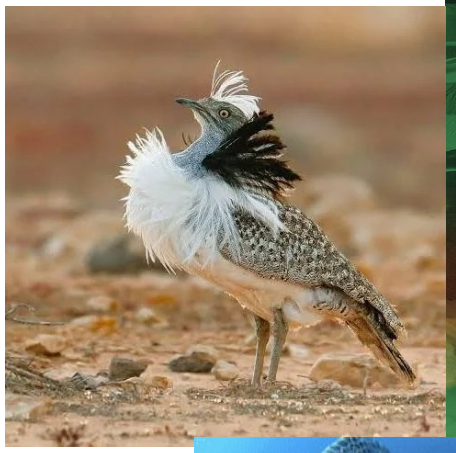
- **Case Study: Arabian Leopard Protection**
- The Arabian leopard (*Panthera pardus nimr*) is **critically endangered**.
- Conservation actions include:
  - Captive breeding centres
  - Anti-poaching laws & satellite monitoring
  - Habitat restoration in the Asir and Hijaz mountain ranges
  - Public awareness and community engagement



3. Wildlife Conservation & Renewable Bio-Based Industries

3.1 Wildlife Conservation Programs

- **Other Species Under Protection**
- Arabian oryx
- Sand gazelle
- Houbara bustard
- Hawksbill & green sea turtles
- **National Centers Involved**
- National Center for Wildlife
- King Abdullah University of Science and Technology (KAUST)
- Royal Commission for AlUla (Arabian Leopard Initiative)







3. Wildlife Conservation & Renewable Bio-Based Industries



3.2 Renewable Bio-Based Industries

Saudi Arabia's push toward renewable bio-based industries is a key part of its Vision 2030 strategy to diversify the economy beyond oil and create a sustainable, circular economy.

*** Industrial Sectors**

1- Biofuels

– Microalgae-derived biodiesel.

– Bioethanol from agricultural waste.

2- Biodegradable Materials

– Bioplastics from starch and cellulose.

– Microbial biopolymers (e.g., PHB, PLA).

3- Industrial Biotechnology (Green Chemistry)

– Enzymatic processes replacing petroleum-based synthesis.

– Biorefineries producing biochemicals, fertilizers, and bioenergy.



*** Environmental Significance**

- Reduces carbon emissions.
-Minimizes plastic waste.
-Creates sustainable economic opportunities.

4. Agriculture and Food Security in Saudi Arabia

4.1 Genetically Modified Crops (GMOs)

Saudi Arabia does not ban GMOs, but they are strictly regulated under the Saudi Food and Drug Authority (SFDA) and Gulf Cooperation Council (GCC) standards.



*** Benefits**

- Improved tolerance to drought, heat, and salinity.
- Higher productivity per unit of water.
- Resistance to pests & diseases.
- Reduced dependence on chemical pesticides.
- Enhanced nutritional content (e.g., vitamin-enriched crops).

*** Examples**

- Salt-tolerant wheat.
- Drought-resistant tomatoes.
- Pest-resistant corn.
- Engineered barley for desert agriculture.

4. Agriculture and Food Security in Saudi Arabia

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4.2 Sustainable Aquaculture

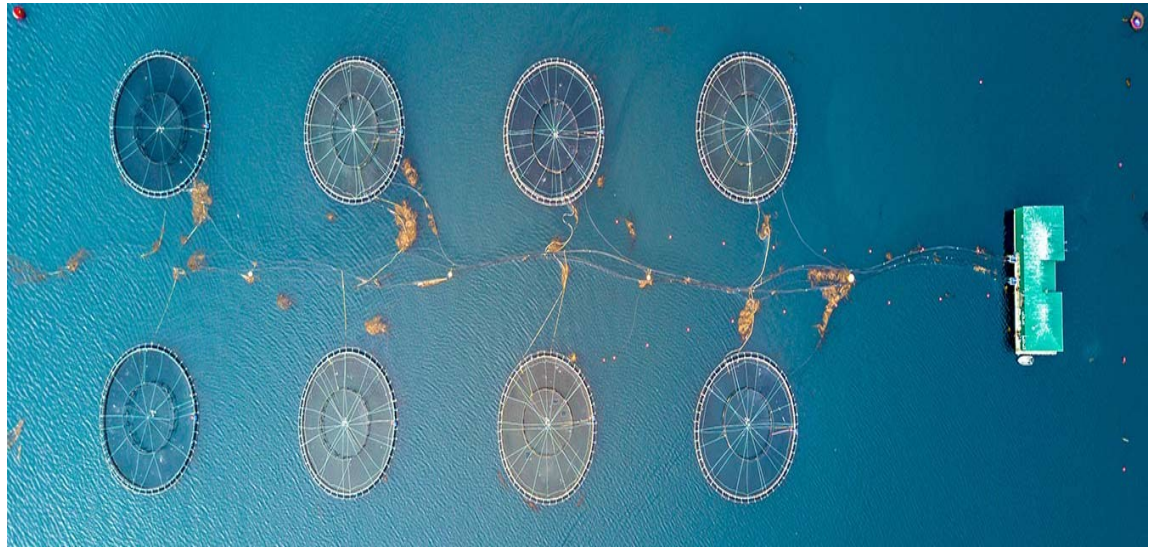
Saudi Arabia is expanding aquaculture to meet national protein demands.

*** Technological Approaches**

1. Recirculating Aquaculture Systems (RAS)
– Closed-loop systems minimizing water use.
2. Integrated Multi-Trophic Aquaculture (IMTA)
– Fish, seaweed, and shellfish raised together for nutrient recycling.
3. Sensor-driven Monitoring
– Real-time oxygen, pH, and salinity controls.
4. Selective breeding for fast-growing marine species

*** Outcomes**

- Reduced reliance on seafood imports.
- Stable high-quality production.
- Lower environmental footprint of fish farming.



4. Agriculture and Food Security in Saudi Arabia



4.3 Vertical Farming & Hydroponics:

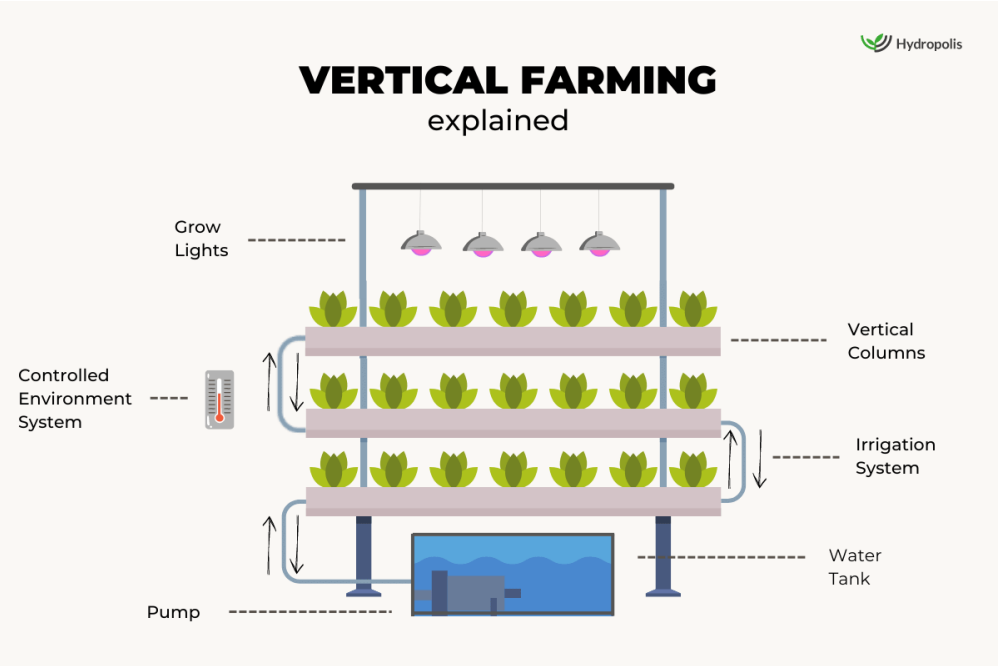
Ideal solutions for water-scarce, urbanizing environments.

1. What is Vertical Farming?

- Growing crops in **stacked layers** within controlled environments.
- Uses **LED lighting, climate control, and automation**.
- Ideal for urban areas and regions with limited farmland.

Benefits:

- Up to **90% less water** than traditional farming.
- Year-round production regardless of climate.
- Reduced transportation costs (local production).



4. Agriculture and Food Security in Saudi Arabia



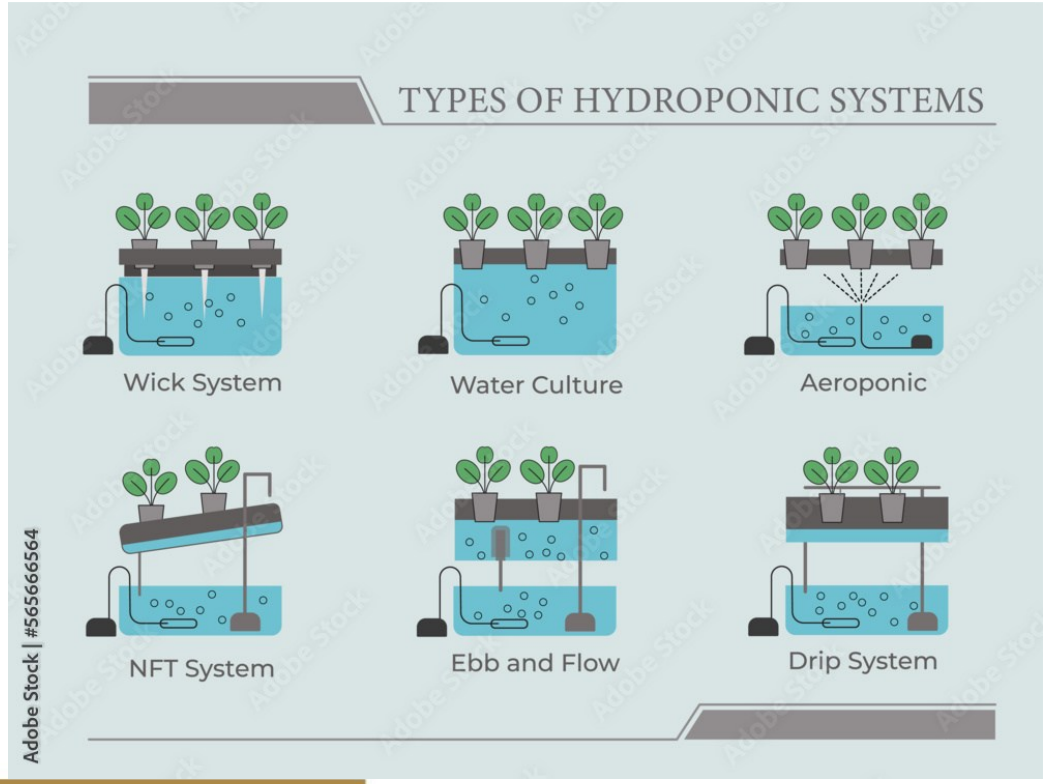
4.3 Vertical Farming & Hydroponics

2. What is Hydroponics?

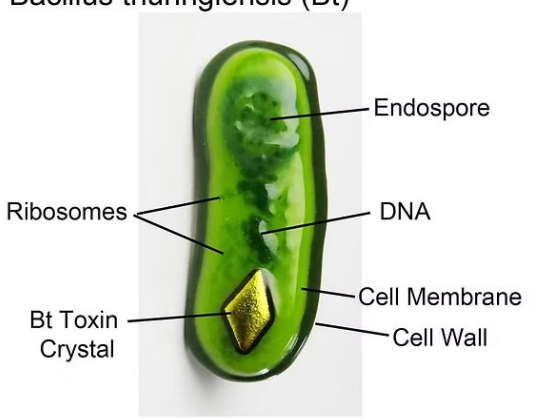
- Soil-less farming using **nutrient-rich water solutions**.
- Common systems: **NFT (Nutrient Film Technique)**, **Deep Water Culture**, **Drip Systems**.

Benefits:

- Faster crop growth.
- Efficient water use.
- Suitable for leafy greens, herbs, and high-value crops.



4. Agriculture and Food Security in Saudi Arabia



4.4 Biological Pest Control

A sustainable alternative to synthetic pesticides, supporting environmental health. Biological pest control uses natural enemies (predators, parasitoids, pathogens) or biopesticides to manage harmful pests instead of chemical pesticides, promoting sustainability and reducing chemical residues.

- **Methods**

- Beneficial insects (*ladybirds, lacewings, parasitoid wasps*).
- Microbial agents (e.g., *Bacillus thuringiensis*).
- Entomopathogenic fungi.
- Pheromone traps and mating disruption technologies.



4. Agriculture and Food Security in Saudi Arabia

4.4 Biological Pest Control

- **Benefits**

-Environmental protection.

-Reduced chemical residues in food.

-Long-term pest suppression.

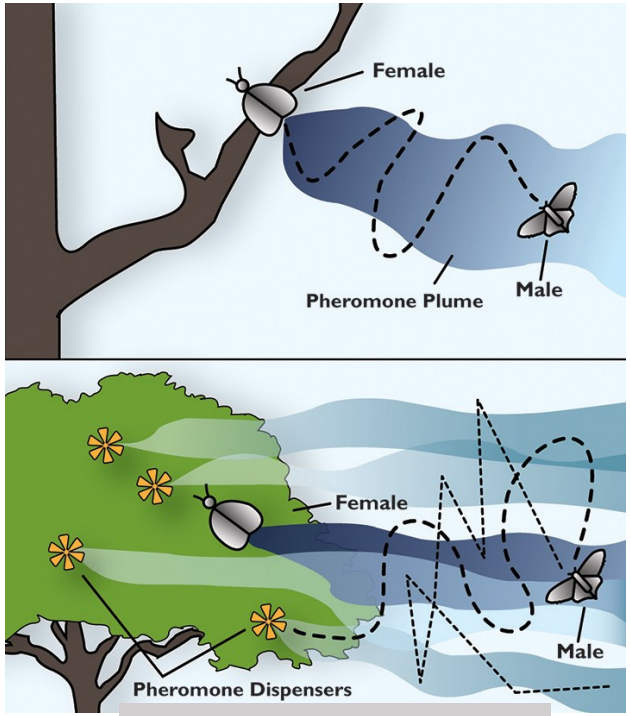
-Supports biodiversity in agricultural systems.

Pheromone traps



Entomopathogenic fungi





Mating disruption

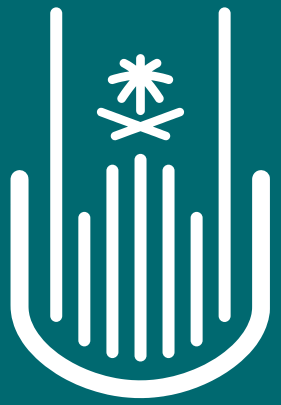
5. Conclusion

- Saudi Arabia is undergoing a transformative shift toward sustainability:
- **Desert greening and ecological restoration** enhance land productivity and combat desertification.
- **Marine and wildlife conservation** preserve the Kingdom's unique biological heritage.
- **Bio-based industries and modern farming technologies** ensure long-term food security.
- The synergy of biotechnology, ecological science, and innovative agriculture reflects Saudi Arabia's commitment to a **resilient, sustainable, and environmentally responsible future** under Vision 2030.

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