Eukaryotic Cells

Tishk International University,

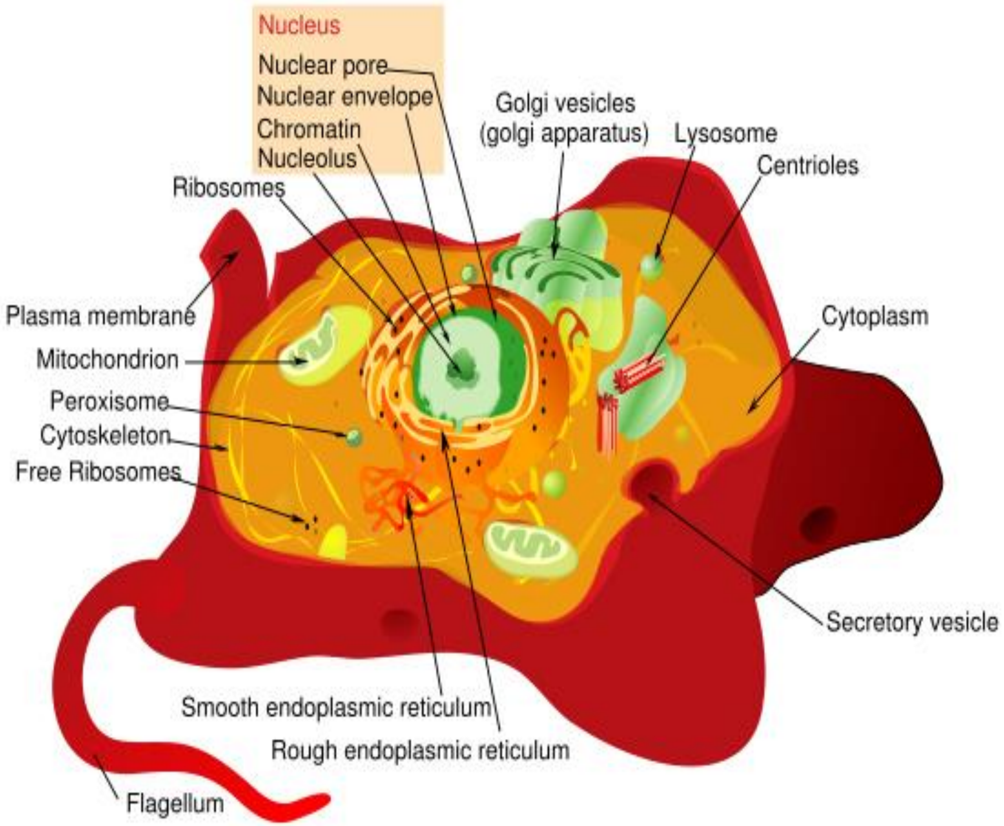
Education Faculty, Biology Dept,

Cell Biology, 1st Semester/W3

Outline

- Eukaryotic Cells
- Animal cells
- Plant cells
- Their structure and functions

Eukaryotic Cells

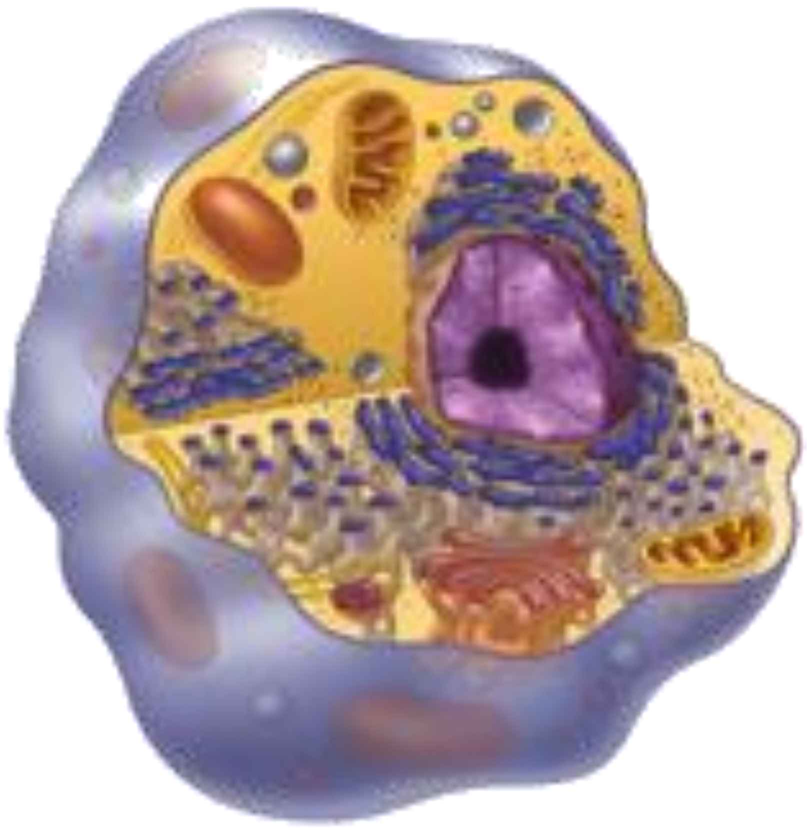


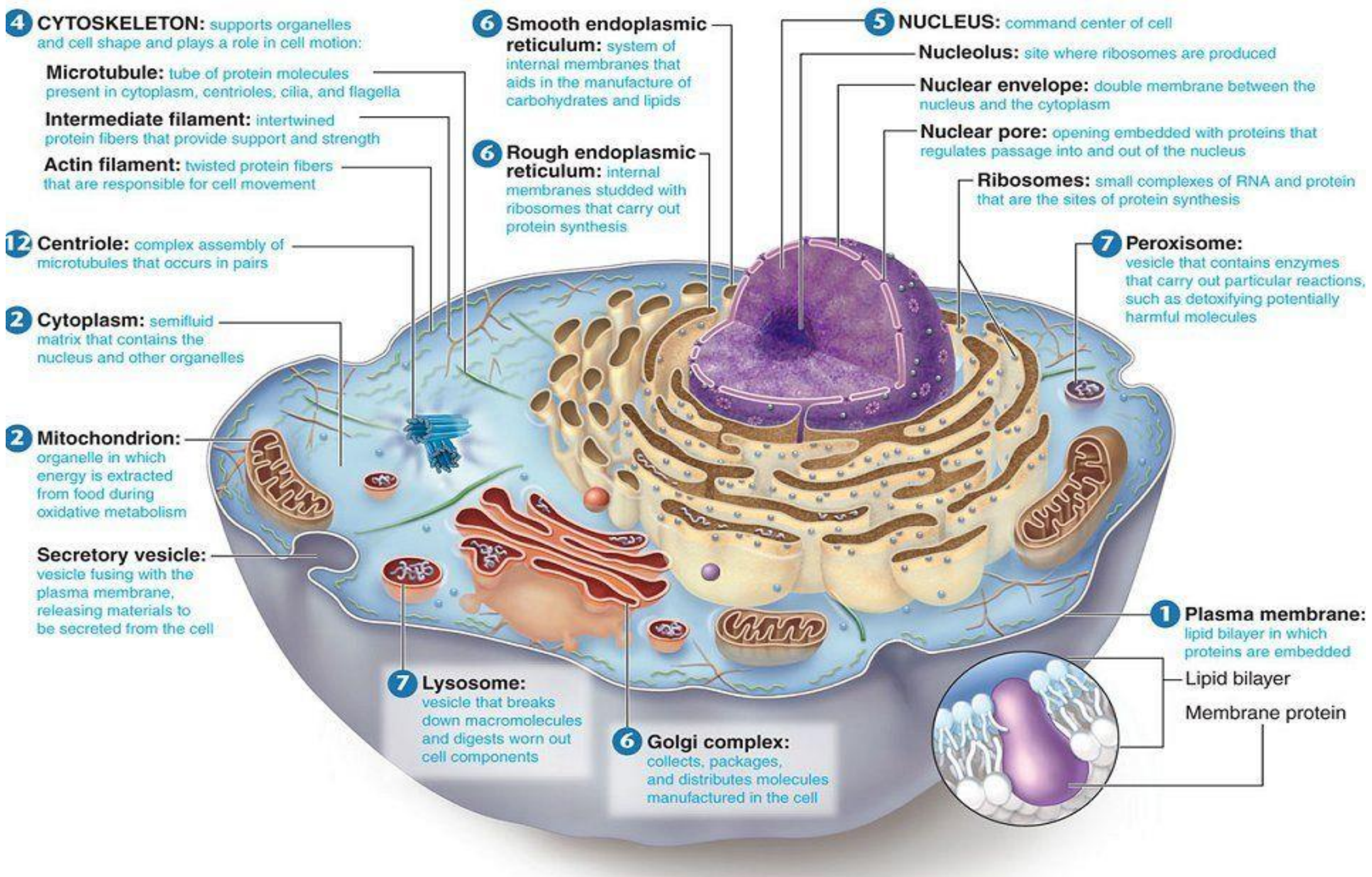
- Eu ="true", karyon="nucleus"
- Genetic material contained in a nuclear membrane.
- Membrane bound organelles.
- Include animal, plant, fungi, algae cells as well as other microscopic eukaryotes.
- Evolved from prokaryotic cells.

Eukaryotic Cell

Contain 3 basic cell structures:

- Nucleus
- Cell Membrane
- Cytoplasm with organelles





4 CYTOSKELETON: supports organelles and cell shape and plays a role in cell motion:
Microtubule: tube of protein molecules present in cytoplasm, centrioles, cilia, and flagella
Intermediate filament: intertwined protein fibers that provide support and strength
Actin filament: twisted protein fibers that are responsible for cell movement
12 Centriole: complex assembly of microtubules that occurs in pairs
2 Cytoplasm: semifluid matrix that contains the nucleus and other organelles
2 Mitochondrion: organelle in which energy is extracted from food during oxidative metabolism
Secretory vesicle: vesicle fusing with the plasma membrane, releasing materials to be secreted from the cell
6 Smooth endoplasmic reticulum: system of internal membranes that aids in the manufacture of carbohydrates and lipids
6 Rough endoplasmic reticulum: internal membranes studded with ribosomes that carry out protein synthesis
5 NUCLEUS: command center of cell
Nucleolus: site where ribosomes are produced
Nuclear envelope: double membrane between the nucleus and the cytoplasm
Nuclear pore: opening embedded with proteins that regulates passage into and out of the nucleus
Ribosomes: small complexes of RNA and protein that are the sites of protein synthesis
7 Peroxisome: vesicle that contains enzymes that carry out particular reactions, such as detoxifying potentially harmful molecules
1 Plasma membrane: lipid bilayer in which proteins are embedded
Lipid bilayer
Membrane protein
7 Lysosome: vesicle that breaks down macromolecules and digests worn out cell components
6 Golgi complex: collects, packages, and distributes molecules manufactured in the cell

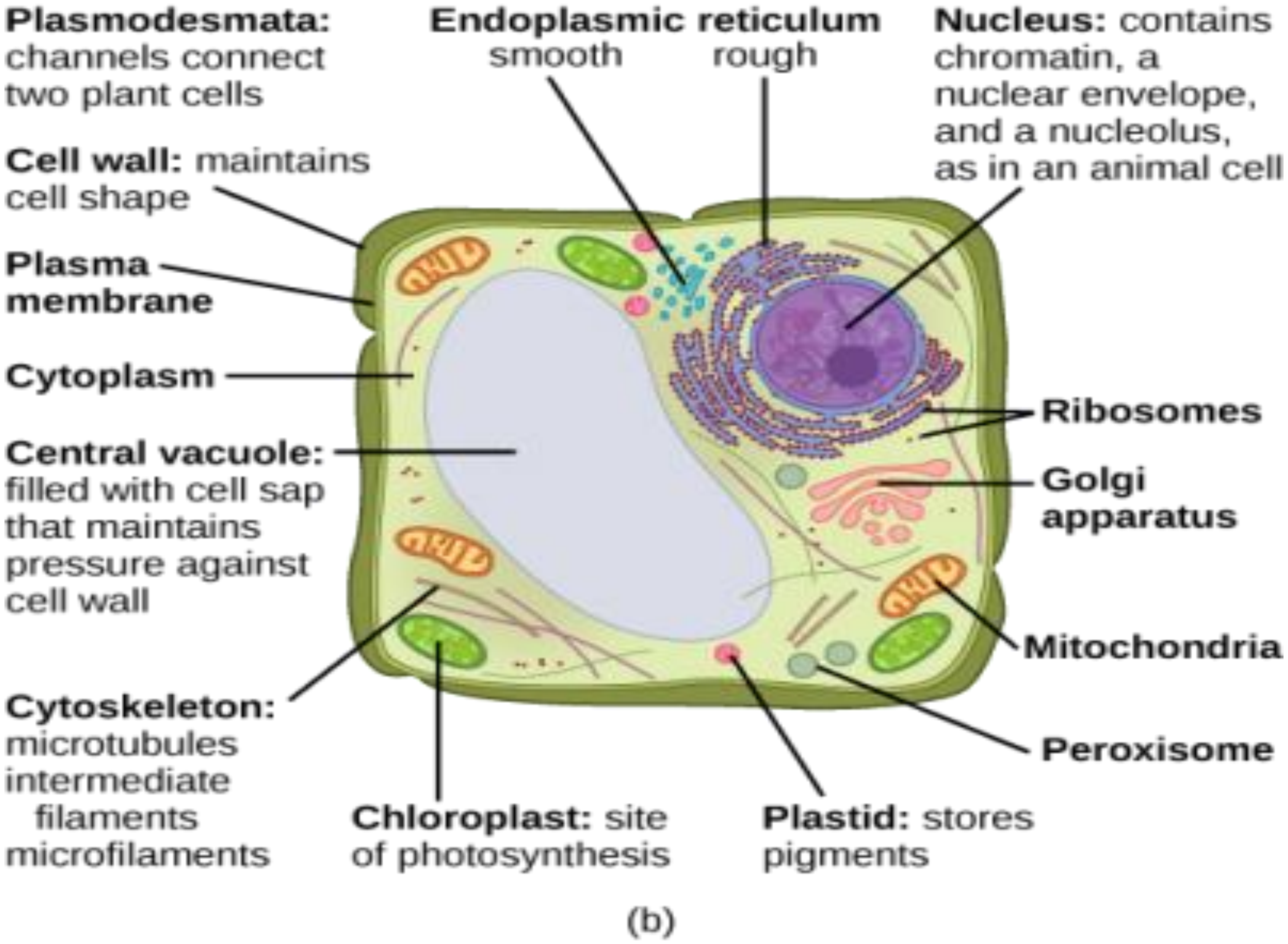
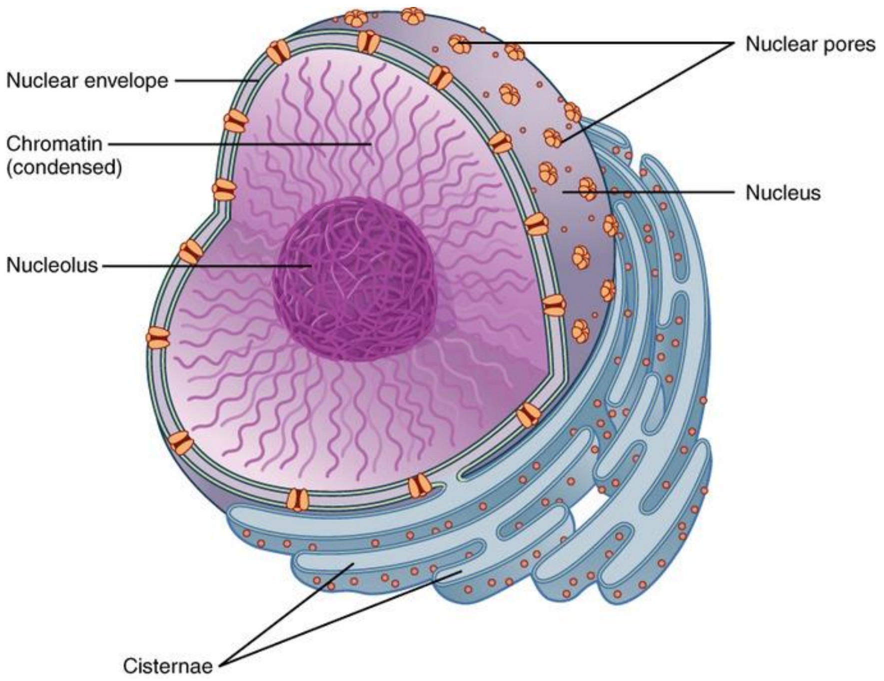


Figure 3.8 (b) This figures shows a typical plant cell.

1. Nucleus

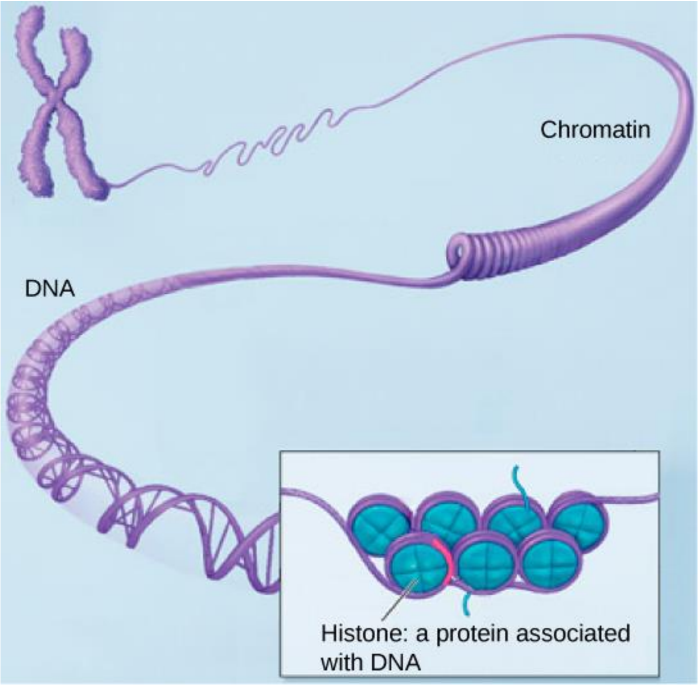
- Command center of cell, usually near center
- Separated from cytoplasm by nuclear envelope
  - Consists of double layer of membrane
  - Nuclear pores permit exchange between nucleoplasm & cytoplasm
- Contains chromatin in semifluid nucleoplasm
  - Chromatin contains DNA of genes
  - Condenses to form chromosomes
- Dark **nucleolus** composed of rRNA
  - Produces subunits of ribosomes

- One of the main differences between prokaryotic and eukaryotic cells is the nucleus.
- As previously discussed, prokaryotic cells lack an organized nucleus while eukaryotic cells contain membrane-bound nuclei (and organelles) that house the cell’s DNA and direct the synthesis of ribosomes and proteins.
- The nucleus stores chromatin (DNA plus proteins) in a gel-like substance called the nucleoplasm.
- To understand chromatin, it is helpful to first consider chromosomes.
- Chromatin describes the material that makes up chromosomes, which are structures within the nucleus that are made up of DNA, the hereditary material.



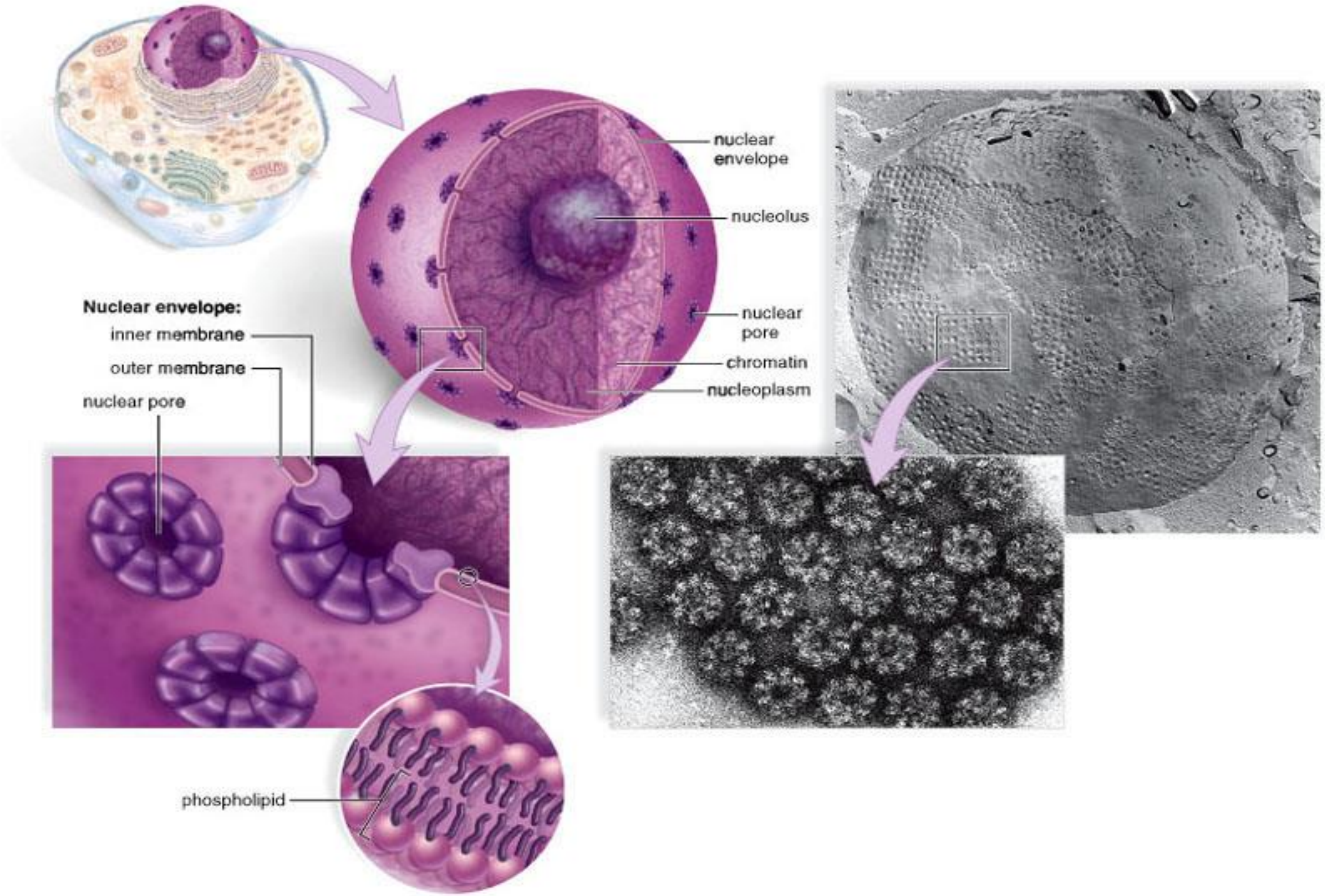
The nucleus stores the hereditary material of the cell: The nucleus is the control center of the cell. The nucleus of living cells contains the genetic material that determines the entire structure and function of that cell.

- You may remember that in prokaryotes, DNA is organized into a single circular chromosome. In eukaryotes, chromosomes are linear structures.
- Every eukaryotic species has a specific number of chromosomes in the nuclei of its body's cells.
- For example, in humans, the chromosome number is 46, while in fruit flies, it is 8.
- Chromosomes are only visible and distinguishable from one another when the cell is getting ready to divide.
- In order to organize the large amount of DNA within the nucleus, proteins called **histones** are attached to **chromosomes**; the DNA is wrapped around these histones to form a structure resembling beads on a string. These protein-chromosome complexes are called **chromatin**.



DNA is highly organized: This image shows various levels of the organization of chromatin (DNA and protein). Along the chromatin threads, unwound protein-chromosome complexes, we find DNA wrapped around a set of histone proteins.

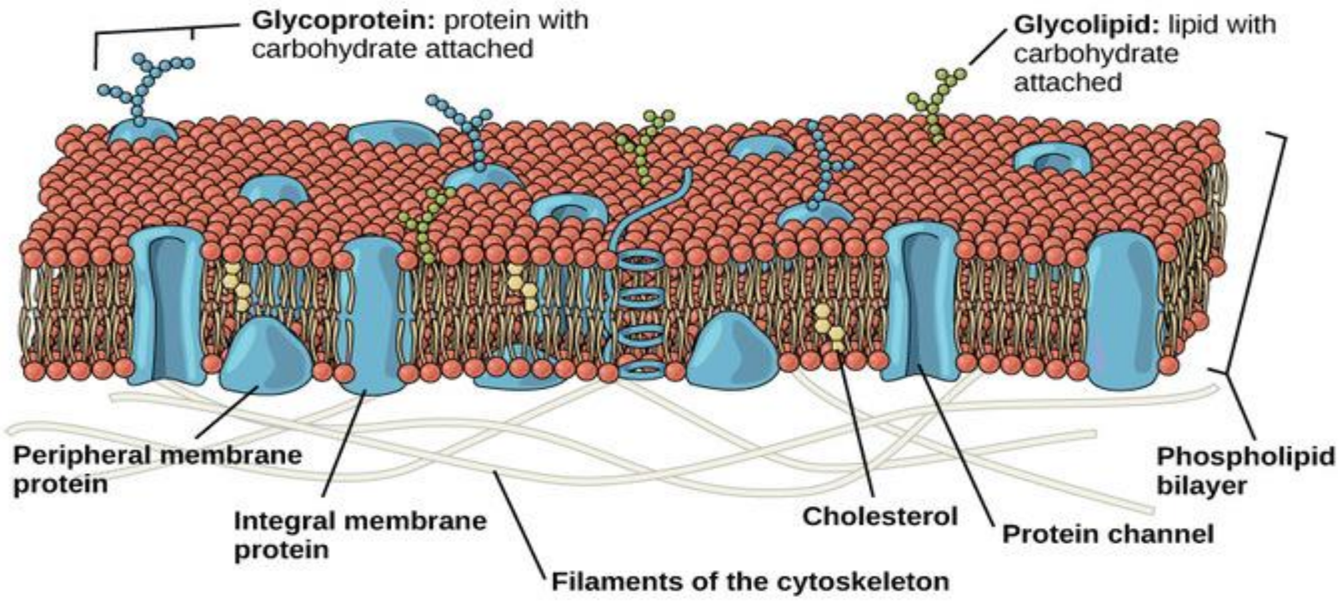
Anatomy of the Nucleus



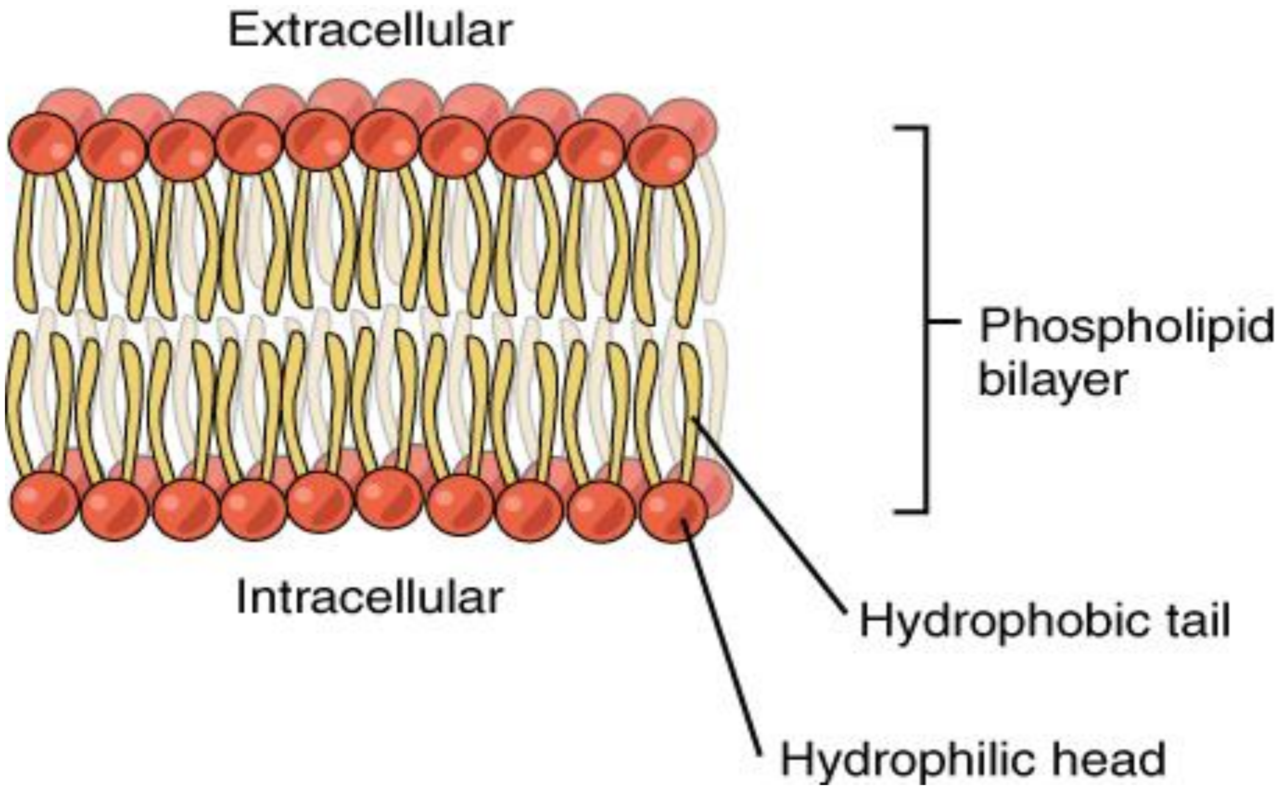
- the boundary of the nucleus is called the nuclear envelope. It consists of two phospholipid bilayers: an outer membrane and an inner membrane.
- The nuclear membrane is continuous with the endoplasmic reticulum, while nuclear pores allow substances to enter and exit the nucleus.
- **Nucleolus** composed of rRNA and produces subunits of ribosomes.

2. Cell or Plasma Membrane

- The plasma membrane separates the inner contents of a cell from its exterior environment.
- The plasma membrane can be described as a phospholipid bilayer with embedded proteins that controls the passage of organic molecules, ions, water, and oxygen into and out of the cell.
- Wastes (such as carbon dioxide and ammonia) also leave the cell by passing through the membrane.



- **Cholesterol,** also present, contributes to the fluidity of the membrane.
- A single phospholipid molecule consists of a polar phosphate “head,” which is hydrophilic, and a non-polar lipid “tail,” which is hydrophobic.
- The membrane’s lipid bilayer structure provides the cell with access control through permeability.

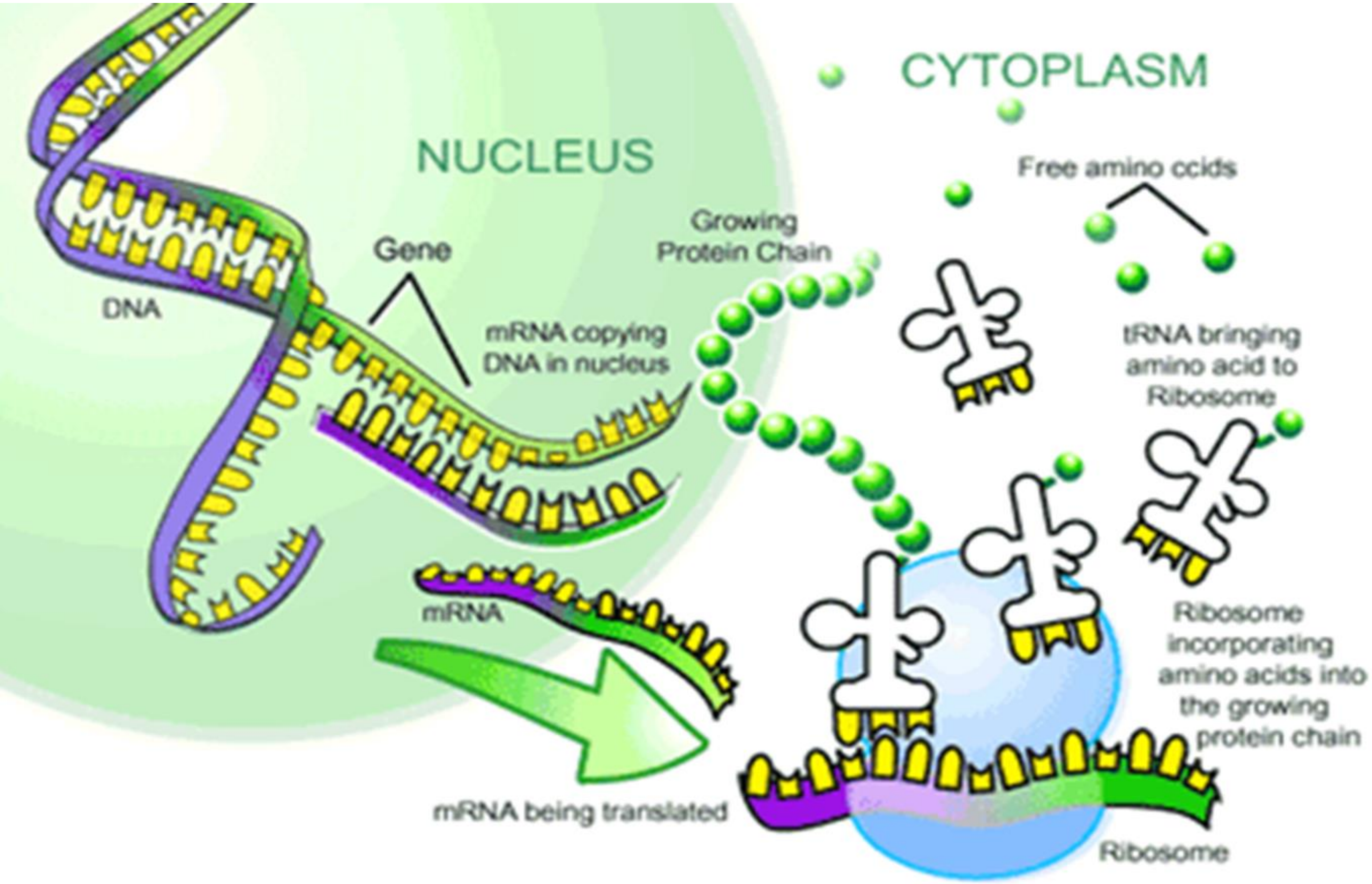


Phospholipid Bilayer: The phospholipid bilayer consists of two adjacent sheets of phospholipids, arranged tail to tail. The hydrophobic tails associate with one another, forming the interior of the membrane. The polar heads contact the fluid inside and outside of the cell.

3. Endomembrane System:
1. Ribosomes

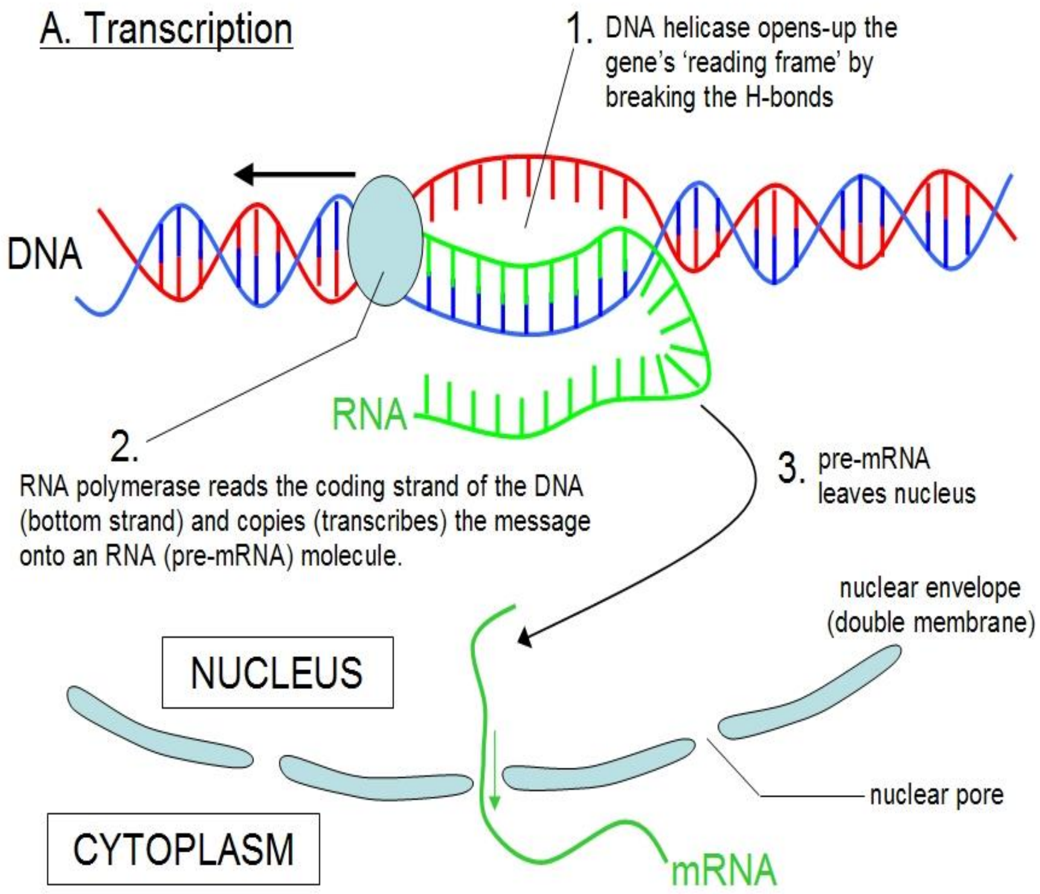
- Serve in protein synthesis
- Composed of rRNA
  - Consists of a large subunit and a small subunit
  - The eukaryotic ribosomes are 80S, comprised of sub units 60S and 40S.
  - Subunits made in nucleolus
- May be located:
  - On the endoplasmic reticulum (thereby making it “rough”), or
  - Free in the cytoplasm, either singly or in groups called polyribosomes

PROTEIN SYNTHESIS



Protein Synthesis

- The genes that encode proteins are key components of the genetic information because **proteins** play most of the functional roles in the cells.
- DNA is replicated and transcribed into **RNA**.
- The sequence of bases in a gene (that is, its sequence of A, T, C, G nucleotides) translates to an amino acid sequence.
- A **triplet** is a section of three DNA bases in a row that codes for a specific amino acid.
- Transcription starts when **RNA polymerase** unwinds the DNA segment.



- One strand, referred to as the coding strand, becomes the template with the genes to be coded.
- The polymerase then aligns the correct nucleic acid (A, C, G, or U) with its complementary base on the coding strand of DNA.
- **RNA polymerase** is an enzyme that adds new nucleotides to a growing strand of RNA. This process builds a strand of **mRNA**.
- When the polymerase has reached the end of the gene, one of three specific triplets **(UAA, UAG, or UGA)** codes a **"stop"** signal, which triggers the enzymes to terminate transcription and release the mRNA transcript.

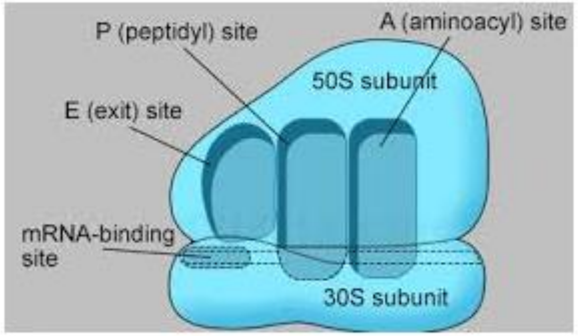
First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU, UUC – Phe UUA, UUG – Leu	UCU, UCC, UCA, UCG – Ser	UAU, UAC – Tyr UAA STOP UAG STOP	UGU, UGC – Cys UGA STOP UGG Trp	U C A G
C	CUU, CUC, CUA, CUG – Leu	CCU, CCC, CCA, CCG – Pro	CAU, CAC – His CAA, CAG – Gln	CGU, CGC, CGA, CGG – Arg	U C A G
A	AUU, AUC, AUA – Ile AUG Met	ACU, ACC, ACA, ACG – Thr	AAU, AAC – Asn AAA, AAG – Lys	AGU, AGC – Ser AGA, AGG – Arg	U C A G
G	GUU, GUC, GUA, GUG – Val	GCU, GCC, GCA, GCG – Ala	GAU, GAC – Asp GAA, GAG – Glu	GGT, GGC, GGA, GGG – Gly	U C A G

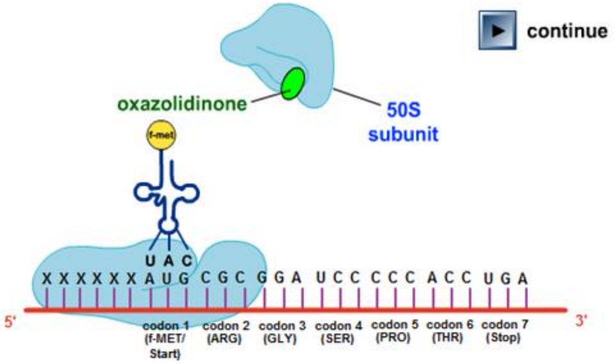
Key:

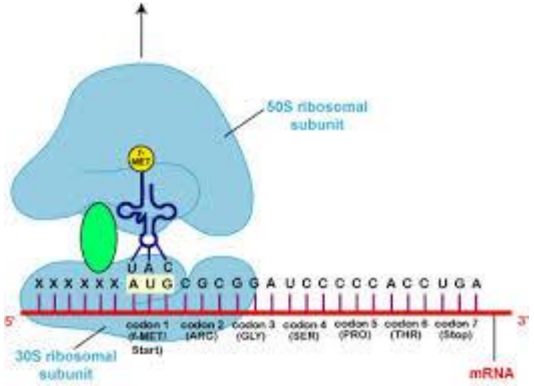
- **Ala** = Alanine (**A**)
- **Arg** = Arginine (**R**)
- **Asn** = Asparagine (**N**)
- **Asp** = Aspartate (**D**)
- **Cys** = Cysteine (**C**)
- **Gln** = Glutamine (**Q**)
- **Glu** = Glutamate (**E**)
- **Gly** = Glycine (**G**)
- **His** = Histidine (**H**)
- **Ile** = Isoleucine (**I**)
- **Leu** = Leucine (**L**)
- **Lys** = Lysine (**K**)
- **Met** = Methionine (**M**)
- **Phe** = Phenylalanine (**F**)
- **Pro** = Proline (**P**)
- **Ser** = Serine (**S**)
- **Thr** = Threonine (**T**)
- **Trp** = Tryptophan (**W**)
- **Tyr** = Tyrosine (**Y**)
- **Val** = Valine (**V**)

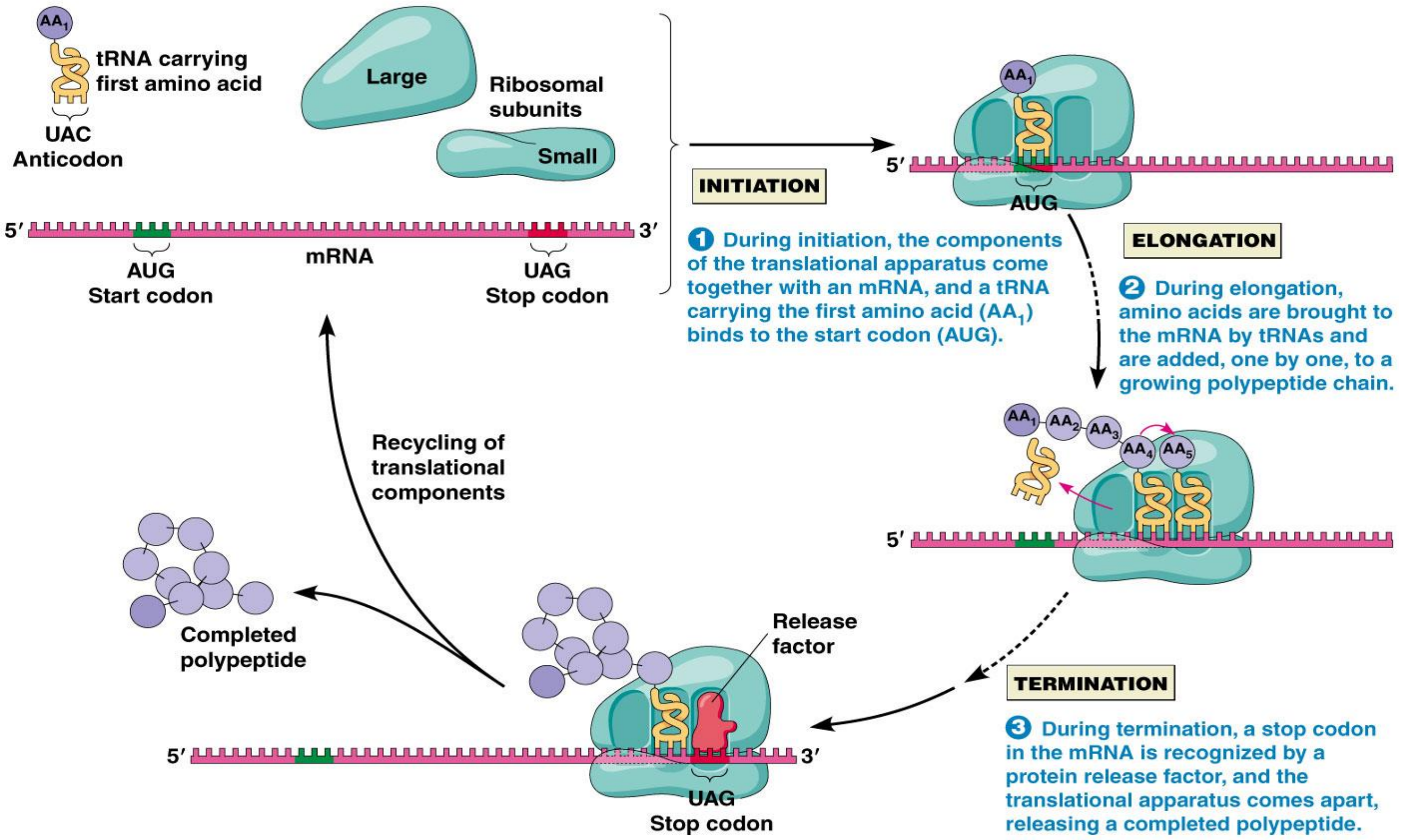
Translation

- Two ribosomal subunits join to translate mRNA into proteins.
- Following are steps of the translation:
- Intiation
- Elongation
- Termination





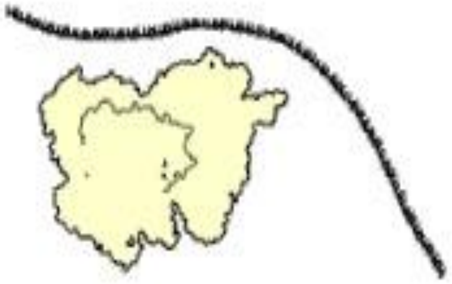




AA1
tRNA carrying first amino acid
UAC
Anticodon
Large
Ribosomal subunits
Small
5′
3′
AUG
Start codon
mRNA
UAG
Stop codon
INITIATION
1 During initiation, the components of the translational apparatus come together with an mRNA, and a tRNA carrying the first amino acid (AA1) binds to the start codon (AUG).
AUG
ELONGATION
2 During elongation, amino acids are brought to the mRNA by tRNAs and are added, one by one, to a growing polypeptide chain.
AA1
AA2
AA3
AA4
AA5
TERMINATION
3 During termination, a stop codon in the mRNA is recognized by a protein release factor, and the translational apparatus comes apart, releasing a completed polypeptide.
Release factor
UAG
Stop codon
Recycling of translational components
Completed polypeptide

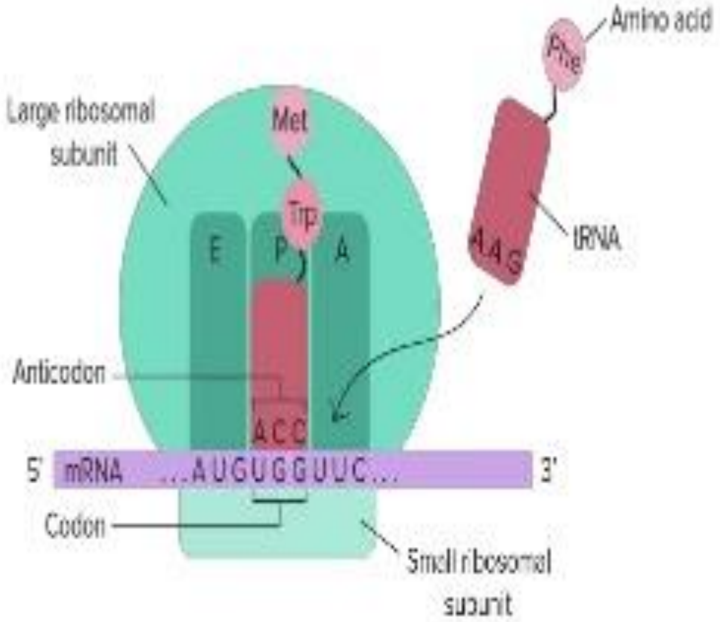
Function

- The one and only function is Protein Synthesis
- This process is called Translation
- Begins with transcription of mRNA in the nucleus
- mRNA travels to the cytoplasm with specific codes
- It binds with the small subunit of the ribosome
- The two subunits come together



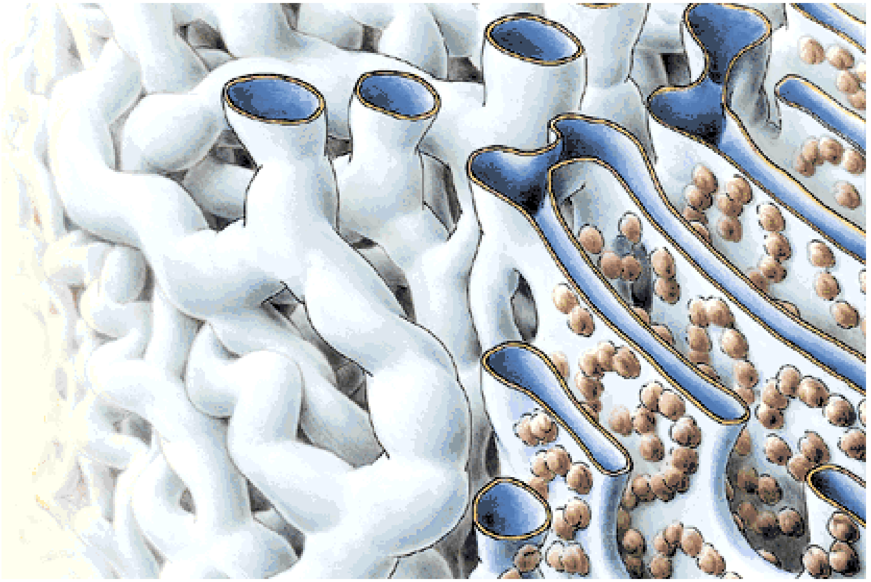
Continued

- tRNAs transfer amino acids to the ribosome
- Translation is started by AUG codon
- Starting amino acid is methionine
- Amino acids are attached in the active site to form peptide chains
- Synthesis is stopped when a stop codon comes (UAA, UGA UAG)
- The chain exits through the exit tunnel into cytoplasm or ER

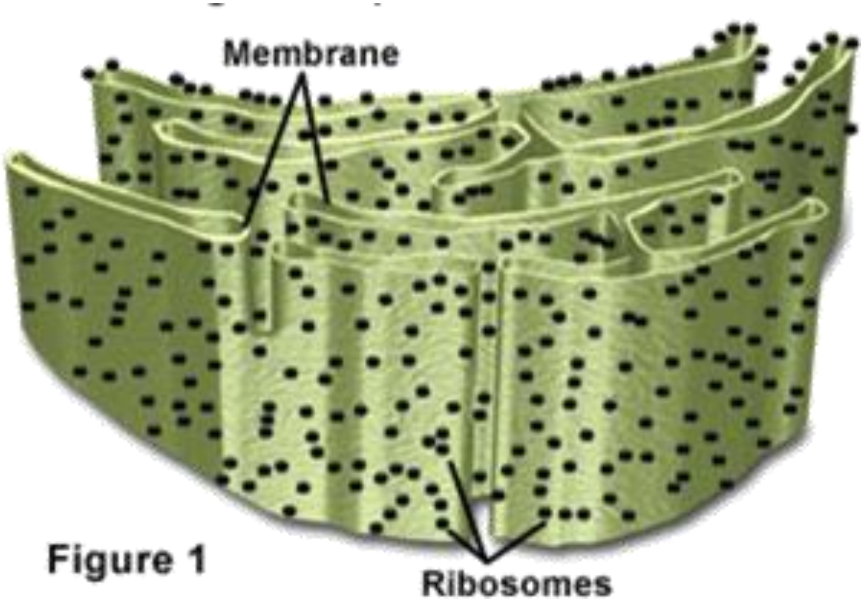


2. Endoplasmic Reticulum

- Network of hollow membrane tubules
- Connects to nuclear envelope & cell membrane
- Functions in Synthesis of cell products & Transport
- Two kinds of ER ---SMOOTH&ROUGH

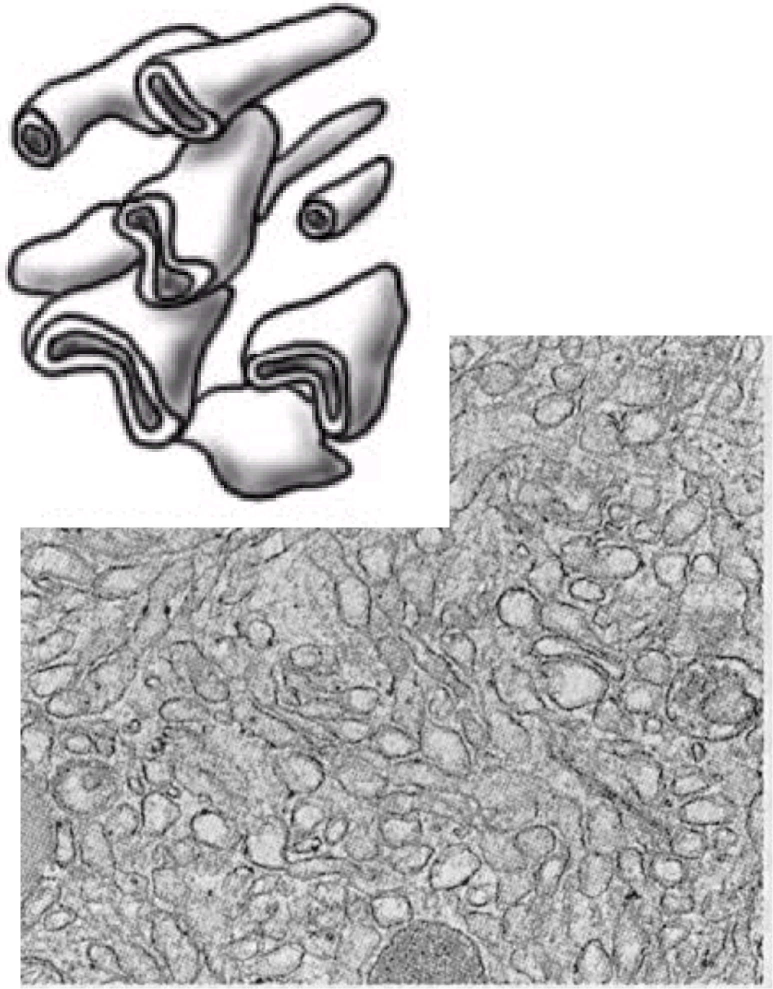


Rough Endoplasmic Reticulum (Rough ER)



- Has ribosomes on its surface
- Makes membrane proteins and proteins for export out of cell

Functions of the Smooth ER



- Makes membrane lipids (steroids)
- Regulates calcium (muscle cells)
- Destroys toxic substances (Liver)

3. Mitochondria

- "Powerhouse" of the cell
- Generate cellular energy (ATP).
- More active cells like muscle cells have MORE mitochondria.
- Both plants & animal cells have mitochondria.
- Site of CELLULAR RESPIRATION (burning glucose).
- **Surrounded by a DOUBLE membrane.**
- Has its own **DNA** and **ribosomes.**
- Folded inner membrane called CRISTAE (increases surface area for more chemical Reactions).
- **Note That!!**
- **Mitochondria Come from cytoplasm in the EGG cell during fertilization**

  Therefore …
- **You inherit your mitochondria from your mother!**

Mitochondria Inner Structure

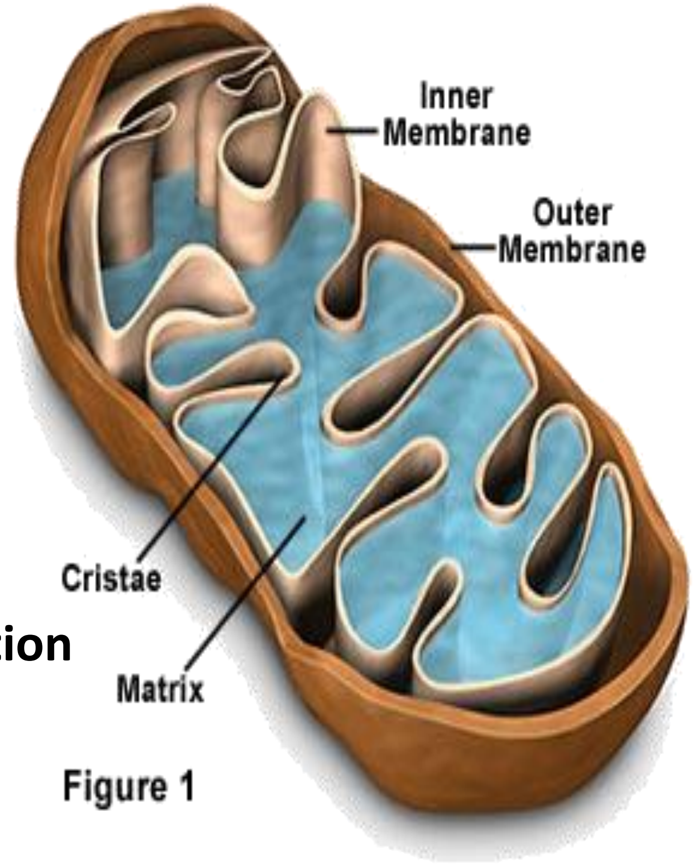


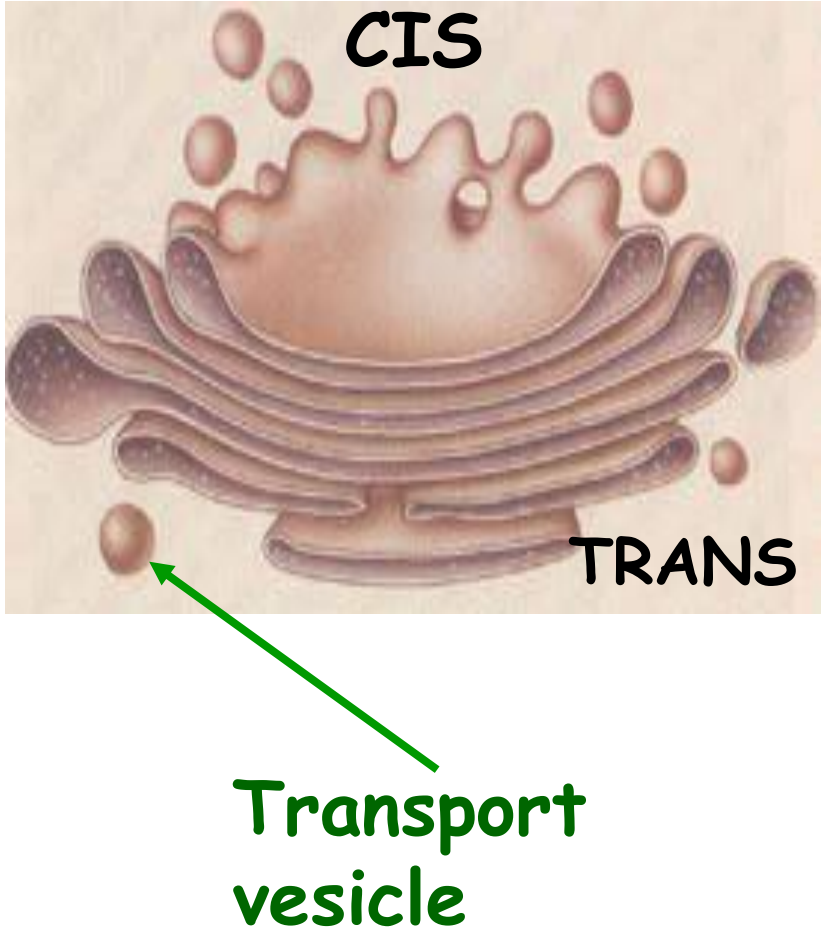
Figure 1

Cellular respiration is the process of making ATP using the chemical energy found in glucose and other nutrients.

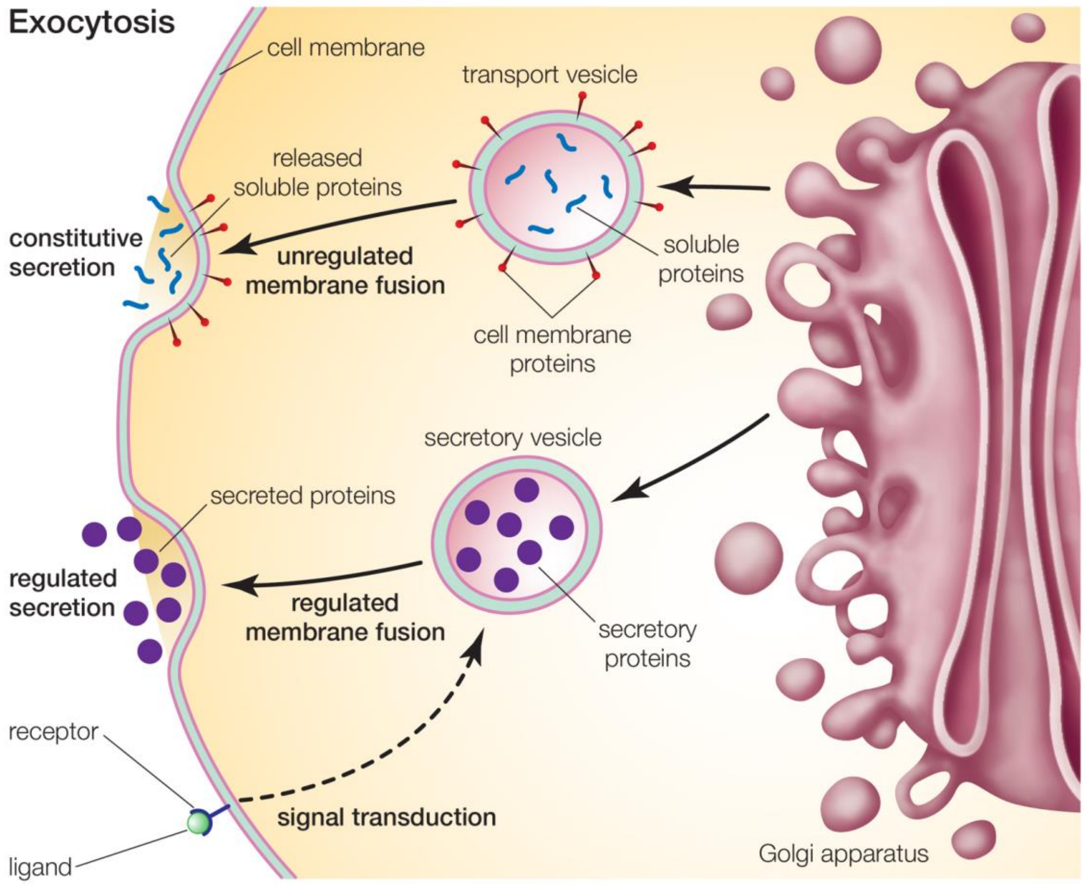
In mitochondria, this process uses oxygen and produces carbon dioxide as a waste product.

4. Golgi Bodies

- Stacks of flattened sacs
- Have a shipping side (trans face) & a receiving side (cis face)
- Receive proteins made by ER
- Transport vesicles with modified proteins pinch off the ends



- The ***cis face*** of the organelle is closest to the endoplasmic reticulum.
- The ***trans face*** is the side furthest from the E.R., which secretes vesicles to various parts of the cell.
- The Golgi apparatus is responsible for transporting, modifying, and packaging proteins and lipids into vesicles for delivery to targeted destinations.
- It is located in the cytoplasm next to the endoplasmic reticulum and near the cell nucleus.


Exocytosis
cell membrane
transport vesicle
released
soluble proteins
constitutive
secretion
unregulated
membrane fusion
soluble
proteins
cell membrane
proteins
secretory vesicle
secreted proteins
regulated
secretion
regulated
membrane fusion
secretory
proteins
receptor
ligand
signal transduction
Golgi apparatus

5. Lysosomes

- The lysosomes are the cell's "**garbage disposal**."
- In plant cells, the digestive processes take place in vacuoles.
- Enzymes within the lysosomes aid the breakdown of proteins, polysaccharides, lipids, nucleic acids, and even worn-out organelles.
- These enzymes are active at a much lower pH than that of the cytoplasm.
- Therefore, the pH within lysosomes is more acidic than the pH of the cytoplasm.
- Many reactions that take place in the cytoplasm could not occur at a low pH, so the advantage of compartmentalizing the eukaryotic cell into organelles is apparent.

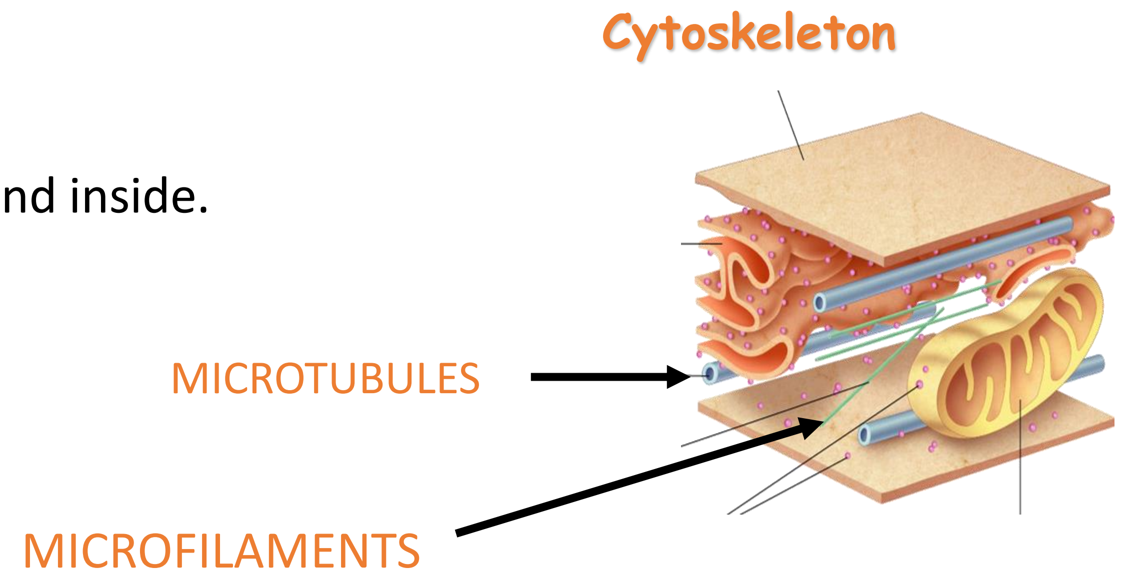
6. The Cytoskeleton

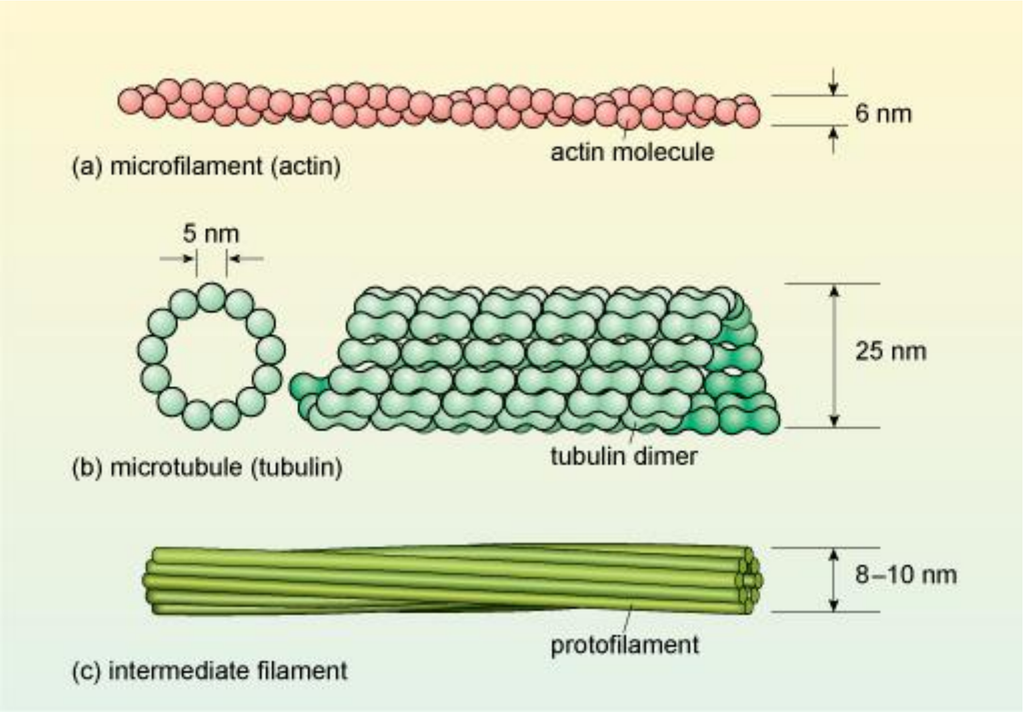
- Cytoskeleton (literally, “cell skeleton”),
- supports the plasma membrane and
- gives the cell an overall shape,
- but also aids in the correct positioning of organelles,
- provides tracks for the transport of vesicles, and (in many cell types) allows the cell to move.
- In eukaryotes, there are three types of protein fibers in the cytoskeleton;
  - microfilaments,
  - intermediate filaments, and
  - microtubules.

7. Cytosceleton

- made of microtubules
- found throughout cytoplasm
- gives shape to cell & moves organelles around inside.

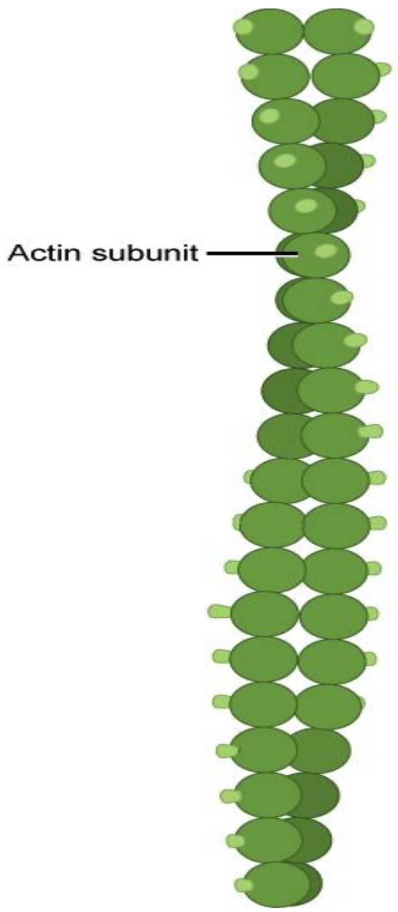
- Three types of macromolecular fibers;
    - Actin Filaments
    - Intermediate Filaments
    - Microtubules




6 nm
actin molecule
(a) microfilament (actin)
5 nm
25 nm
tubulin dimer
(b) microtubule (tubulin)
8–10 nm
protofilament
(c) intermediate filament

Microfilaments

- They have a diameter of about 7 nm and are made up of many linked monomers of a protein called **actin**, combined in a structure that resembles a double helix.
- Because they are made of actin monomers, microfilaments are also known as **actin filaments**.



- they serve as tracks for the movement of a motor protein called **myosin**, which can also form filaments.
- Because of its relationship to myosin, actin is involved in many cellular events requiring motion.
- For instance, in animal cell division, a ring made of actin and myosin pinches the cell apart to generate two new daughter cells.
- Actin and myosin are also plentiful in muscle cells, where they form organized structures of overlapping filaments called sarcomeres.
- When the actin and myosin filaments of a sarcomere slide past each other in concert, your muscles contract.

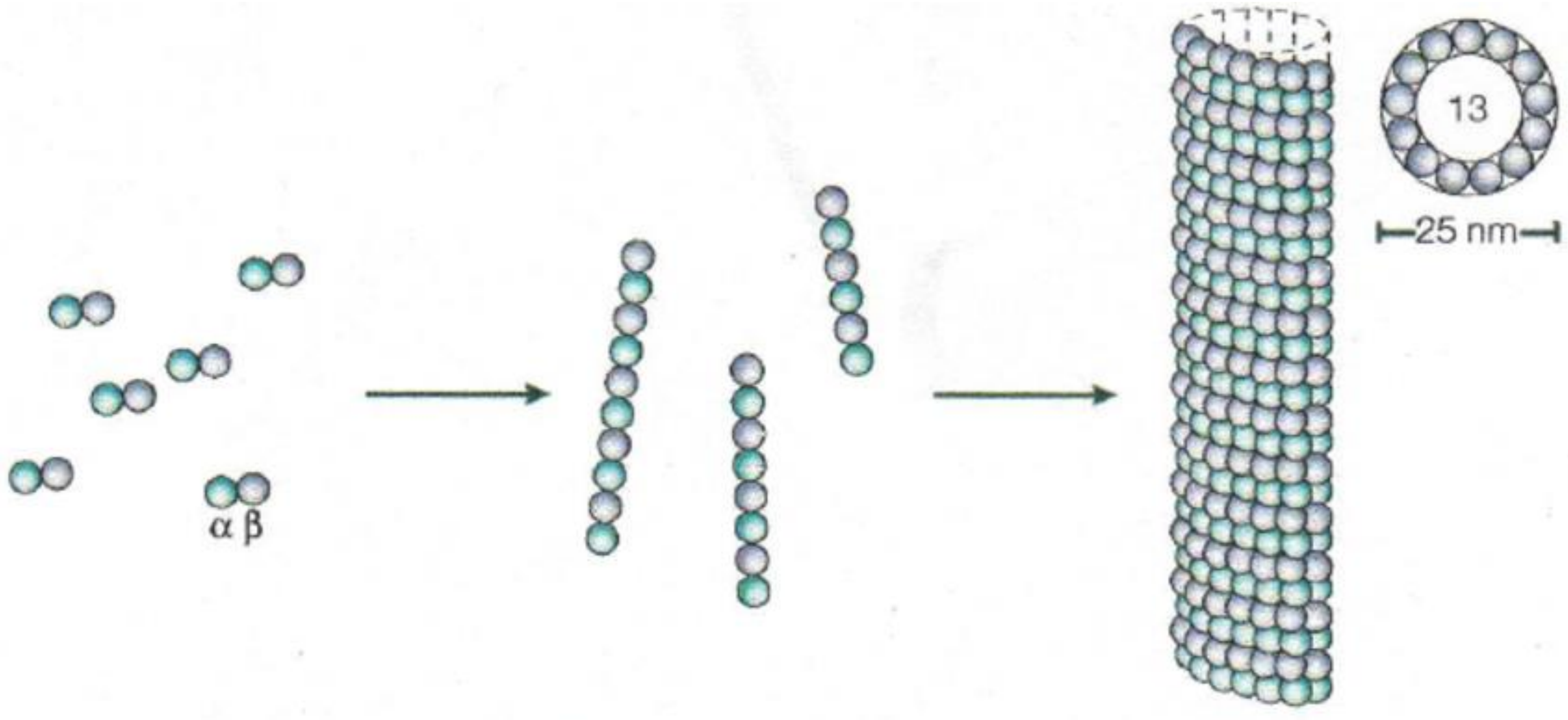
- Finally, actin filaments play key structural roles in the cell.
- In most animal cells, a network of actin filaments is found in the region of cytoplasm at the very edge of the cell.
- This network, which is linked to the plasma membrane by special connector proteins, gives the cell shape and structure.

Intermediate filaments

- Several strands of fibrous proteins that are wound together comprise intermediate filaments.
- Cytoskeleton elements get their name from the fact that their diameter, 8 to 10 nm, is between those of microfilaments and microtubules.
- Intermediate filaments consist of several intertwined strands of fibrous proteins like keratin, the fibrous protein that strengthens your hair, nails, and the skin's epidermis.
- Intermediate filaments have no role in cell movement. Their function is purely structural. They bear tension, thus maintaining the cell's shape, and anchor the nucleus and other organelles in place.

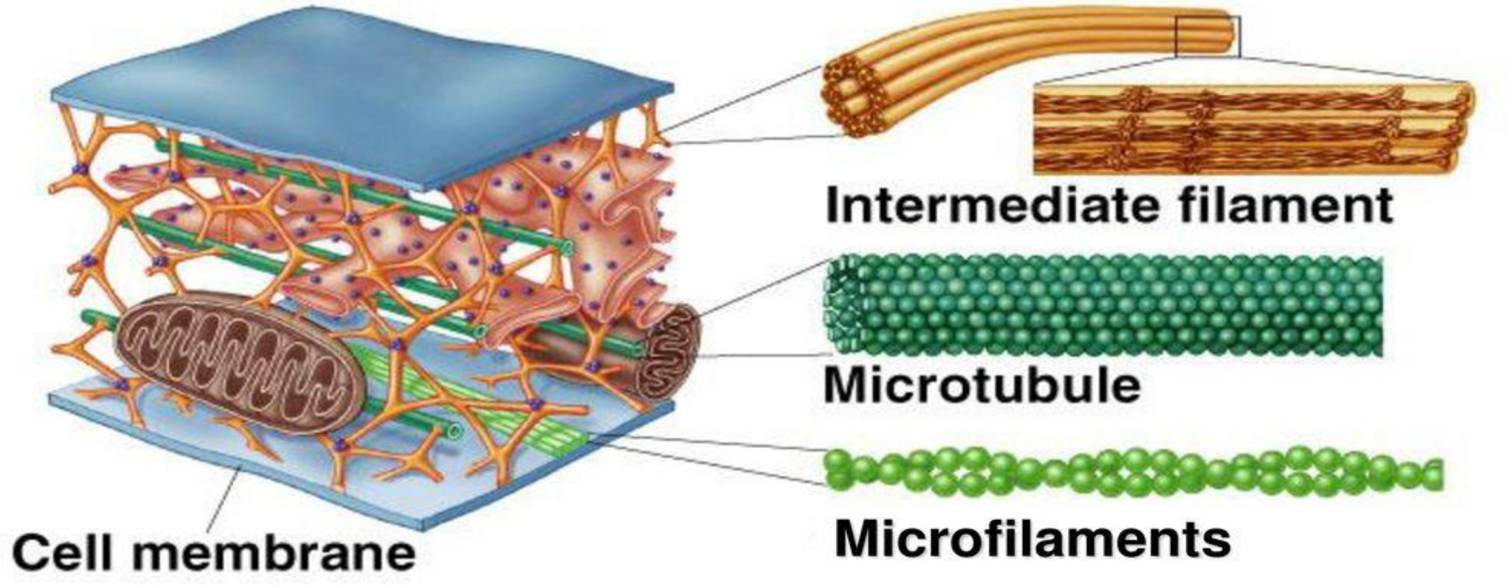
Microtubules

- microtubules are small hollow tubes.
- Polymerized dimers of α-tubulin and β-tubulin, two globular proteins, comprise the microtubule’s walls.
- With a diameter of about 25 nm, microtubules are cytoskeletons’ widest components.
- They help the cell resist compression, provide a track along which vesicles move through the cell, and pull replicated chromosomes to opposite ends of a dividing cell.
- Like microfilaments, microtubules can disassemble and reform quickly.
- Microtubules are hollow. Their walls consist of 13 polymerized dimers of α-tubulin and β-tubulin.



αβ heterodimers Short protofilaments Microtubule

Cytoskeleton



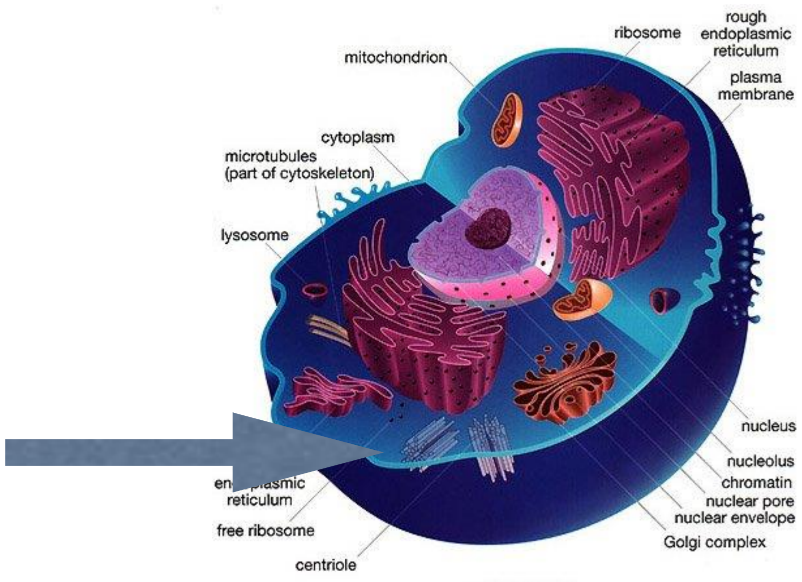
6. Centrioles

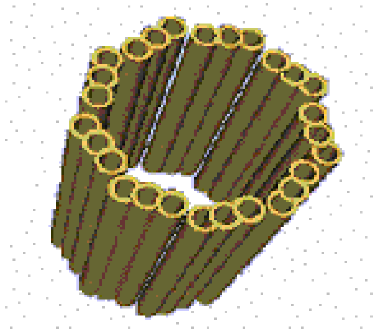
- Found only in animal cells
- Paired structures near nucleus
- Made of bundle of microtubules
- Appear during cell division

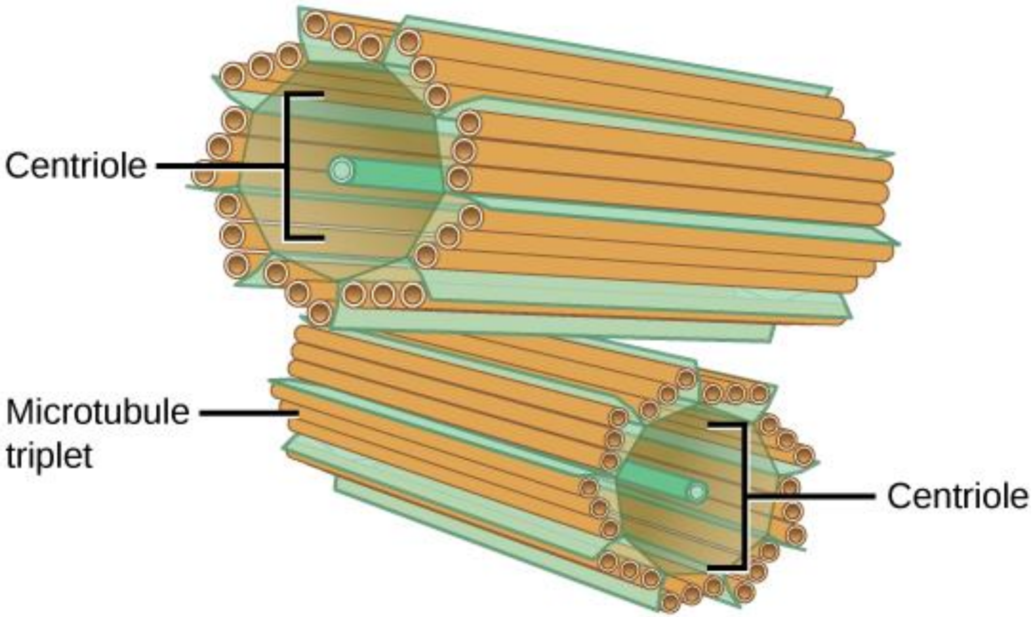
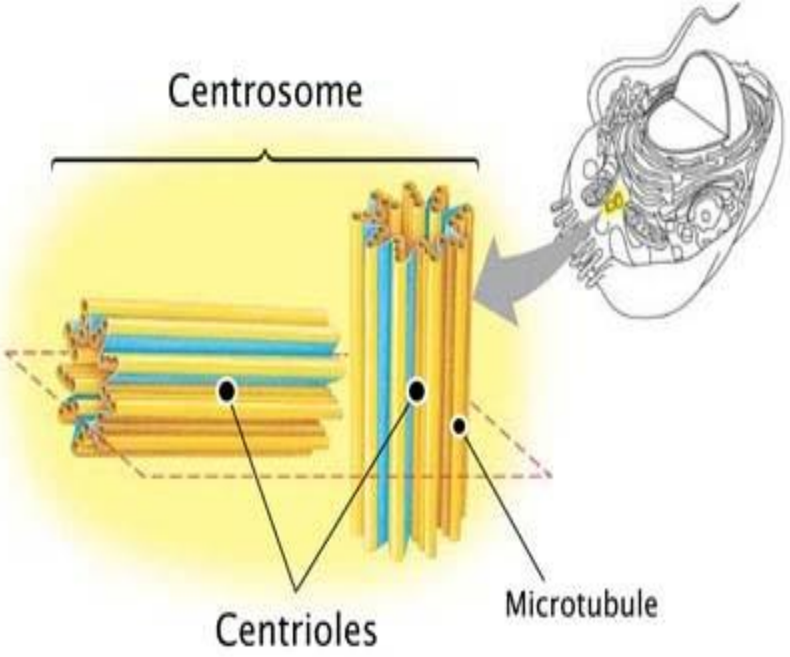
forming mitotic spindle

- Help to pull chromosome pairs apart

to opposite ends of the cell



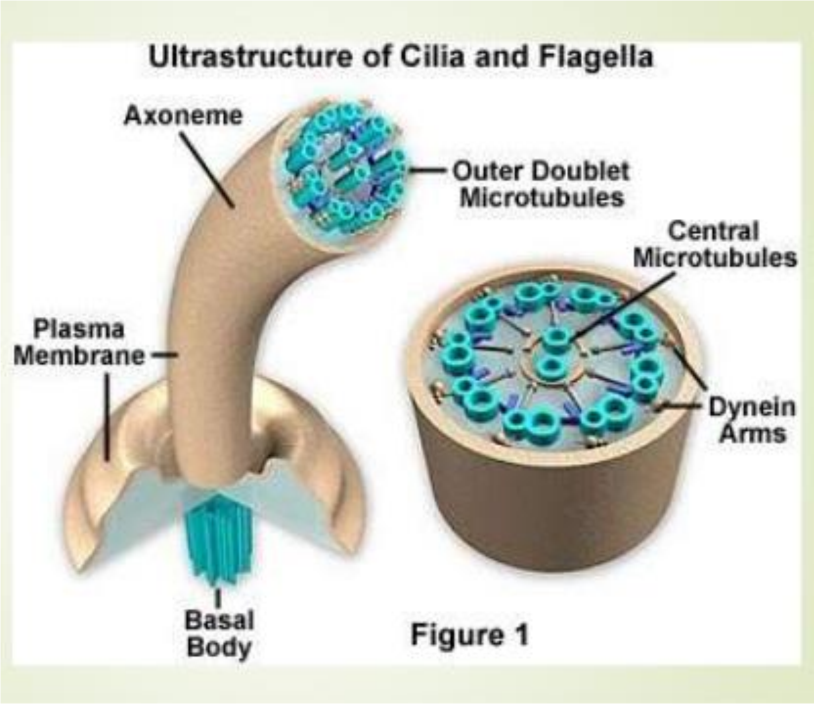


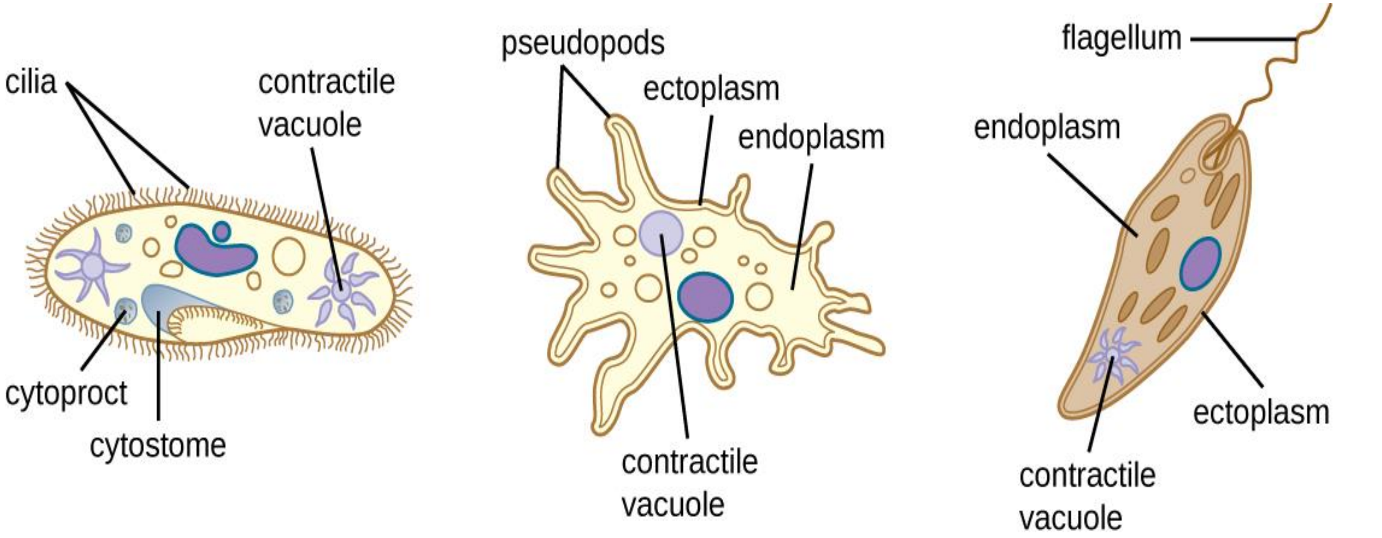

Centriole
Microtubule triplet
Centriole

Centrosome
Centrioles
Microtubule

- A centrosome is a cellular structure involved in the process of cell division.
- Before cell division, the centrosome duplicates and then, as division begins, the two centrosomes move to opposite ends of the cell.
- Proteins called microtubules assemble into a spindle between the two centrosomes and help separate the replicated chromosomes into the daughter cells.

Microtubular arrays:
Cilia and Flagella

- Hair-like projections from cell surface that aid in cell movement
- Very different from prokaryote flagella
  - Outer covering of plasma membrane
  - Inside this is a cylinder of 18 microtubules arranged in 9 pairs
  - In center are two single microtubules
  - This 9 + 2 pattern used by all cilia & flagella
- In eukaryotes, cilia are much shorter than flagella.

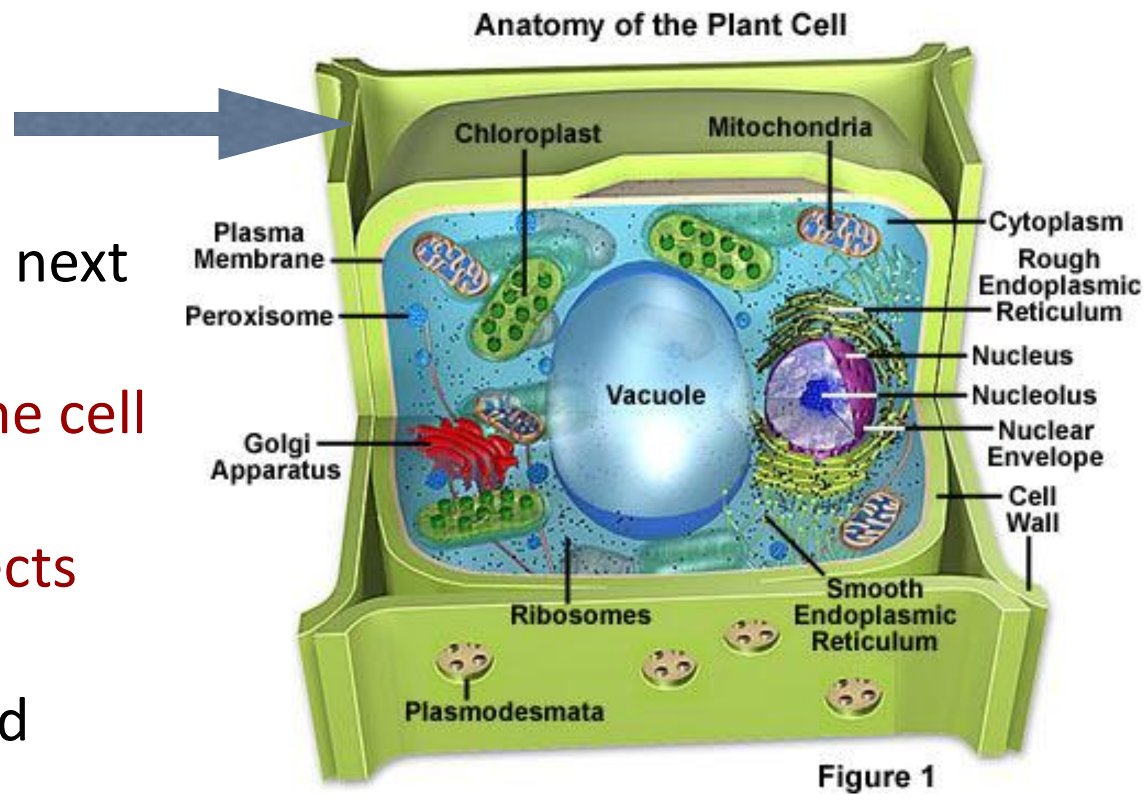




Paramecium (a) *Amoeba* (b) *Euglena* (c)

Structures found in plant cells

- Cell wall
  - very strong
  - made of cellulose
  - glued to other cells next door
  - Found outside of the cell membrane
  - Supports and protects cell
  - Found in plants, and fungi.



- **Vacuole**
- Fluid filled sacks for storage
- Small or absent in *animal* cells
- *Plant* cells have a large Central Vacuole
- Includes storage of sugars, proteins, minerals, lipids, wastes, salts, water, and enzymes.
- central vacuole is surrounded by a membrane called the **tonoplast**.
- Aside from storage, the main role of the vacuole is to maintain **turgor pressure** against the cell wall.
- The central vacuole also stores the pigments that color flowers.

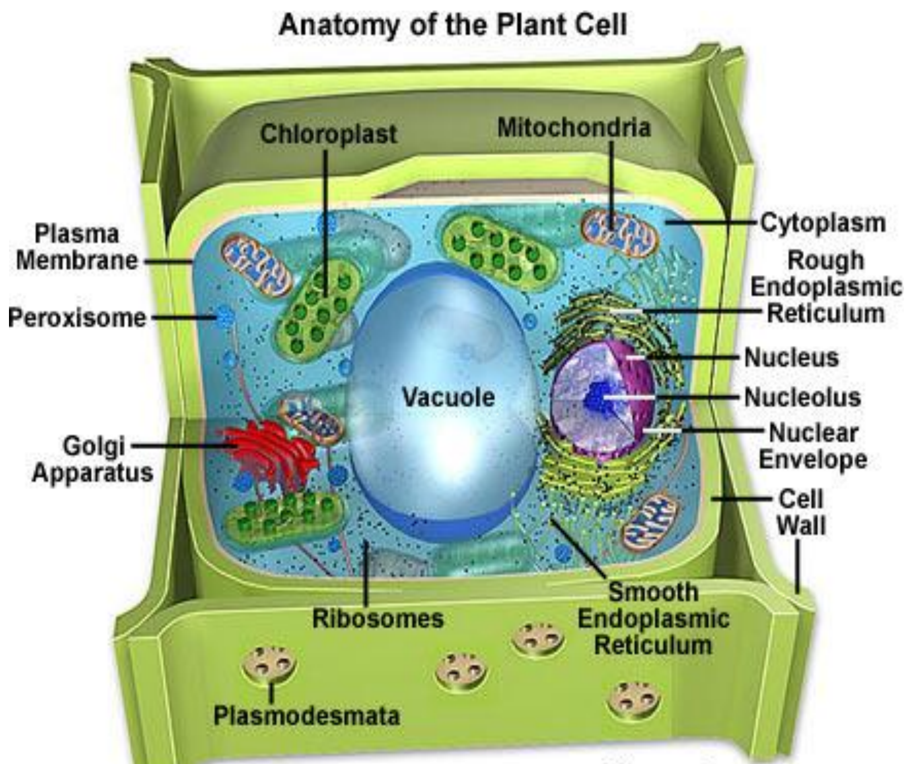


Figure 1

Peroxisomes;

- found in both animal and plant cells
- which oxidize toxic substances into hydrogen peroxide.
- They also contain the enzyme catalase, that functions to safely decompose hydrogen peroxide into substances that are not harmful to the cell.

Plastids

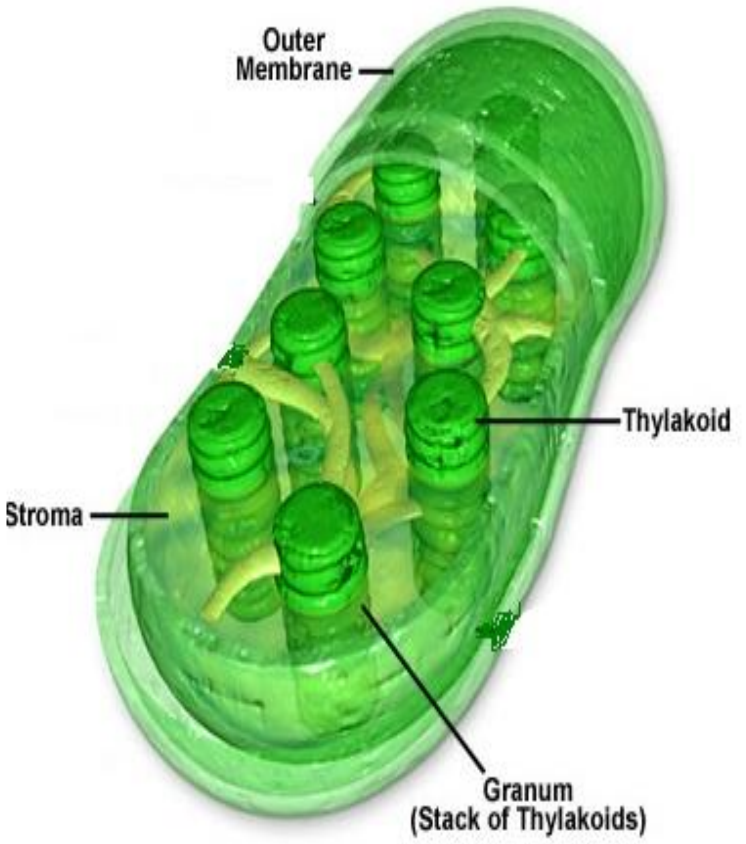
- Plant **plastids** are a group of closely related membrane-bound organelles that carry out many functions.
- They are responsible for photosynthesis, for storage of products such as starch, and for the synthesis of many types of molecules that are needed as cellular building blocks.
- Plastids have the ability to change their function between these and other forms.
- Plastids contain their own DNA and some ribosomes, and scientists think that plastids are descended from photosynthetic bacteria that allowed the first eukaryotes to make oxygen.

- The main types of plastids and their functions are:
- **Chloroplasts** are the organelle of photosynthesis. They capture light energy from the sun and use it with water and carbon dioxide to make food (sugar) for the plant.
- **Chromoplasts** make and store pigments that give petals and fruit their orange and yellow colors.
- **Leucoplasts** do not contain pigments and are located in roots and non-photosynthetic tissues of plants. They may become specialized for bulk storage of starch, lipid, or protein. However, in many cells, leucoplasts do not have a major storage function. Instead, they make molecules such as fatty acids and many amino acids.

Chloroplast

- Found only in producers (organisms containing chlorophyll)
- Use energy from sunlight to make own food (glucose)
- Energy from sun stored in the Chemical Bonds of Sugars
- Surrounded by DOUBLE membrane
- Outer membrane smooth
- Inner membrane modified into sacs called Thylakoids
- Thylakoids in stacks called Grana & interconnected
- Stroma – gel like material surrounding thylakoids

- **Photosynthesis;**
  - Synthesizes carbohydrates from CO_2 & H_2O
  - Makes own food using CO_2 as only carbon source
  - Energy-poor compounds converted to enery rich compounds



- Like mitochondria, chloroplasts have their own DNA and ribosomes, but chloroplasts have an entirely different function.
- Chloroplasts are plant cell organelles that carry out photosynthesis. Photosynthesis is the series of reactions that use carbon dioxide, water, and light energy to make glucose and oxygen.
- This is a major difference between plants and animals; plants (autotrophs) are able to make their own food, like sugars, while animals (heterotrophs) must ingest their food.

- Like mitochondria, chloroplasts have outer and inner membranes, but within the space enclosed by a chloroplast’s inner membrane is a set of interconnected and stacked fluid-filled membrane sacs called thylakoids.
- Each stack of thylakoids is called a granum (plural = grana). The fluid enclosed by the inner membrane that surrounds the grana is called the stroma.
- The chloroplasts contain a green pigment called chlorophyll, which captures the light energy that drives the reactions of photosynthesis. Like plant cells, photosynthetic protists (algae) also have chloroplasts.

Structure	Animal cells	Plant cells
cell membrane	Yes	yes
nucleus	Yes	yes
nucleolus	yes	yes
ribosomes	yes	yes
ER	yes	yes
Golgi	yes	yes
centrioles	yes	no
cell wall	no	yes
mitochondria	yes	yes
cholorplasts	no	yes
One big vacuole	no	yes
cytoskeleton	yes	Yes

Comparison of Prokaryotic and Eukaryotic Cells

	PROKARYOTES	EUKARYOTES
Organisms	Monera: Eubacteria and Archebacteria	Protists, Fungi, Plants and Animals
Level of organization	single celled	single celled (protists mostly) or multicellular usually with tissues and organs
Typical cell size	small (1 -10 microns)	large (10 - 100 microns)
Cell wall	almost all have cell walls (murein)	fungi and plants (cellulose and chitin); none in animals
Organelles	usually none	many different ones with specialized functions
Metabolism	anaerobic and aerobic; diverse	mostly aerobic
Genetic material	single circular double stranded DNA	complex chromosomes usually in pairs; each with a single double stranded DNA molecule and associated proteins contained in a nucleus
Mode of division	binary fission mostly; budding	mitosis and meiosis using a spindle; followed by cytokinesis

Poster project

- Create a 3 part poster comparing and contrasting the structures/organelles of each cell (prokaryotic, animal and plant)
    - Identify the shape of each cell
    - Identify the structure and function of each organelle in the eukaryotic cells
    - Point out differences between organelles in the plant and animal cell