

Chapter 7 : A Tour Of The Cell

Notes :

- Concept 6.1 : is an assignment ; you have to read it only . sometimes it has 2 or 3 questions in the first exam .. so study it after finishing other concepts .
- Concept 6.6 : you have to study it in brief , that's mean focusing on figures 😊 other information read them for more understanding ...

Overview: The Fundamental Units of Life

- All organisms are made of cells.
- The cell is the simplest collection of matter that can live .
- Cell structure is correlated to cellular function .
- Each action of an organisms begin at the cellular level .
- All cells are related by their descent(أصل) from earlier cells .
- Although cells can differ substantially from one another , cells share certain common characteristics .

CONCEPT 6.1 : To study cells, biologists use microscopes and the tools of biochemistry .

- Although Cells are usually too small to be seen by the unaided eye, cells can be complex.
- Scientists use microscopes to visualize cells .
- Microscopes are the most important tools of cytology (**cytology** : the study of cell structure).

Microscopy

1. **Light Microscope (LM)** :

- In a **light microscope**, visible light passes through a specimen and then through glass lenses, which magnify the image .
- Light microscope can magnify effectively to about 1000 times the actual size of specimen, but ; **at greater magnification; additional details can't be seen clearly** 😊
- specimen stained with colored molecules Before previewing it by **LM** .

☞ The quality of an image depends on :

- **Magnification** : the ratio of an object's image size to its real size
- **Resolution**: the measure of the clarity of the image, or the minimum distance of two distinguishable points .
- **Contrast**: visible differences in parts of the sample (Various techniques enhance contrast by enabling cell components to be stained or labeled to stand out visually).
- ☒ (LM) helps scientists to discover cells but most of (sub cellular) structures, including **organelles** (membrane-enclosed compartments), are too small to be resolved by an **LM** !

2. **Electronic Microscopes(EM)** :

- focuses a beam of electrons through a specimen or on it's surface .
- Electrons beam have much shorter wavelength than visible light .
note : resolution is inversely related to the wavelength of the radiation . so the resolution in EM is high 😊
- How EM focuses the beam of electrons ?
The stains for electron microscopy involve heavy metals that affect the beams to pass through the specimen .

Remember 😊

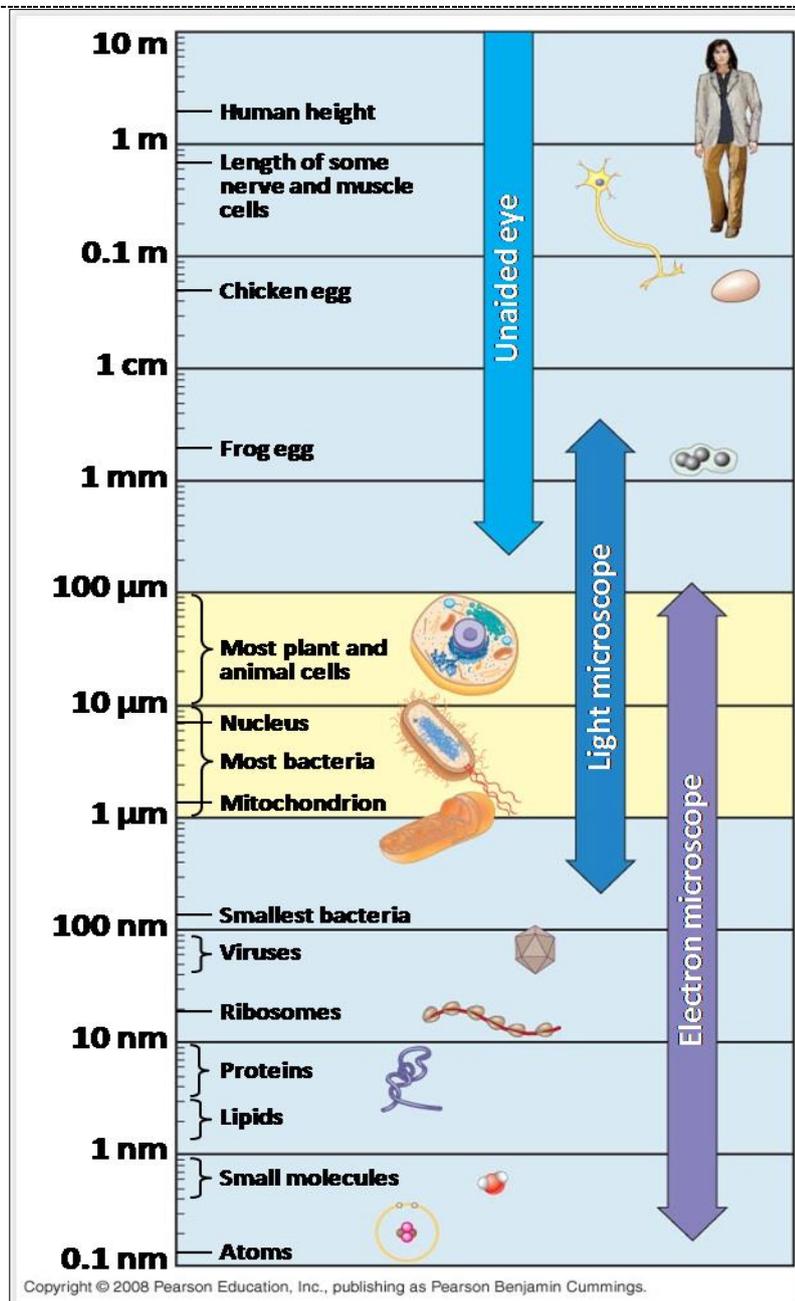
$$1 \text{ cm} = 10^{-2} \text{ m}$$

$$1 \text{ millimeter} = 10^{-3} \text{ m}$$

$$1 \text{ micrometer} = 10^{-6} \text{ m}$$

$$1 \text{ nanometer} = 10^{-9} \text{ m}$$

Most cells are between 1 micrometer and 100 micrometers in diameter, so you can't see them without a microscope.



❖ Let's Back to Electronic microscopes >>

Two basic types of **electron microscopes (EMs)** are used to study subcellular structures .

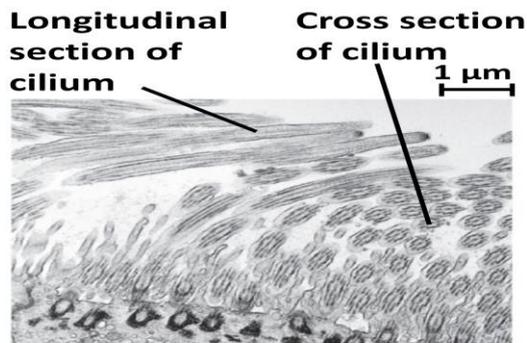
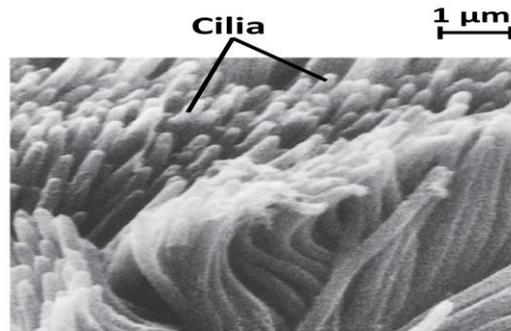
1. **Scanning electron microscopes (SEMs)** focus a beam of electrons onto the surface of a specimen, providing images that look 3-D.
2. **Transmission electron microscopes (TEMs)** focus a beam of electrons through a specimen , TEMs are used mainly to study the internal structure of cells.

TECHNIQUE

(a) Scanning electron microscopy (SEM)

(b) Transmission electron microscopy (TEM)

RESULTS



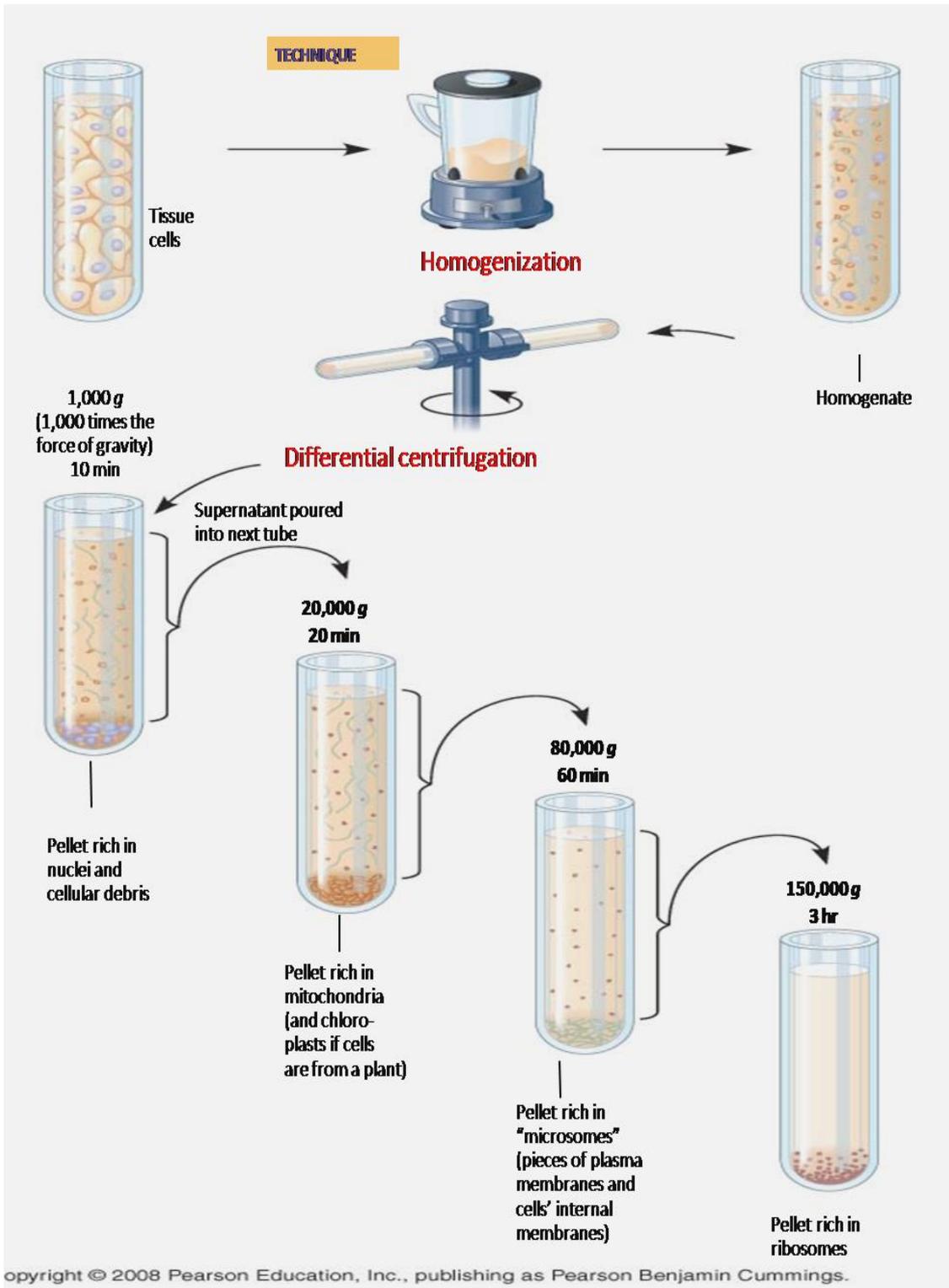
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- **Light microscope** offers advantages especially in studying living cells, when that disadvantage of **electron microscopy** is that the methods used to prepare the specimen Kill the cell .
 - In microscopy techniques , specimen preparation can introduce artifacts , artifacts means structural features seen in micrographs but that don't exist in the living cell.
- ➔ Micrograph : the image of specimen produced by microscopy.

Cell Fractionation

- **Cell fractionation** : takes cells apart and separates the major organelles from one another. We use cell fractionation to isolate (fractionate) cell components based on size and density ..
- The instrument used is the **centrifuge** which works at various speeds , the resulted forces cause a fraction of the cell components to settle to the bottom of the tube ..
 - Lower speed → pellet consists of larger components
 - Higher speed → pellet consists of smaller components

To know The application of cell fractionation Look to next figure ☺



First , cells are homogenized in a blender to break them up ..

Second , the resulting mixture (cell homogenate) is then centrifuged at various speeds , first speed in a certain period will result a type of pellet , then the supernatant (الباقى) could be poured into another tube in order to repeat the centrifugation and form another pellet 😊

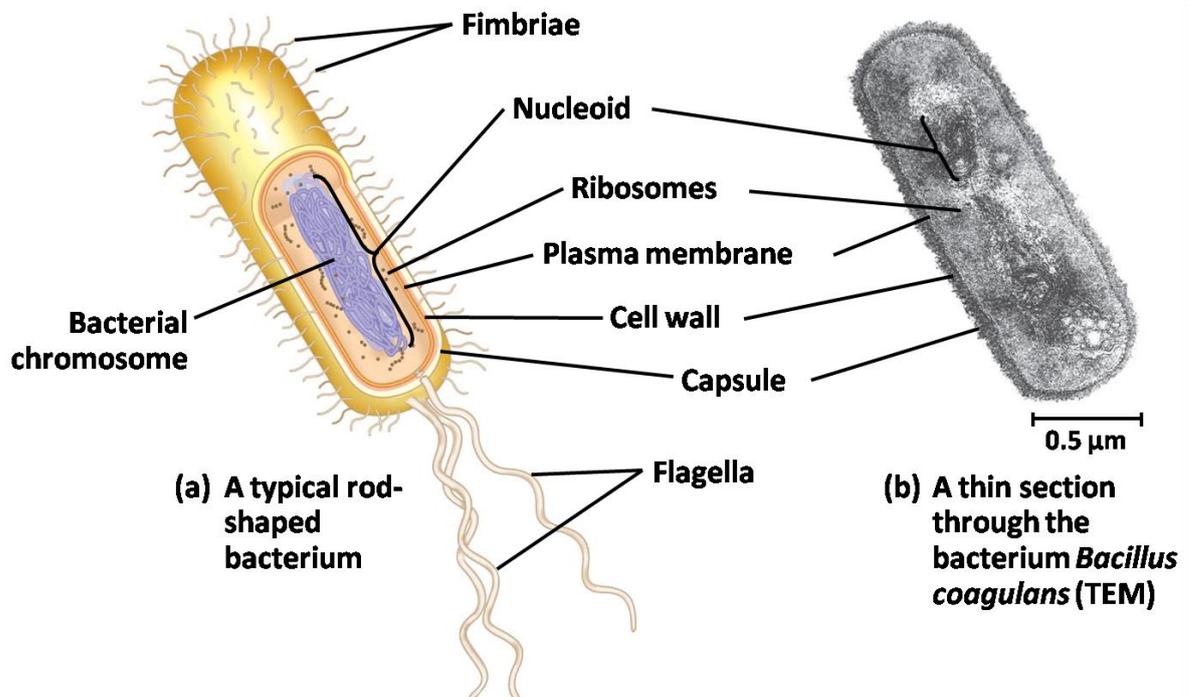
- **Ultracentrifuge** is the most powerful machine in fraction .
- Cell fractionation enable scientists to determine the function of organelles .

Concept 6.2 : *Eukaryotic cells have internal membranes that compartmentalize their functions*

- The basic structural and functional unit of every organism is cell
 - Cells are two types : **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.
-
- **Basic features of (prokaryotes and eukaryotes) cells:**
 1. **Plasma membrane** : selective barrier bound the cell
 2. **Cytosol** : semi-fluid substance enclosed by membrane ,where the organelles & other components of the cell are found .
 3. **Chromosomes** : carry genes in the form of DNA
 4. **Ribosomes** : tiny complexes that make proteins according to instruction from the genes

Prokaryotic cells

- **Prokaryotic cells** are characterized by having :
 - No nucleus >> Instead of nucleus there is **nucleoid** (*region that where DNA is concentrated without membrane enclose it*).
 - No membrane-bound organelles.
 - **Cytoplasm** bound by the plasma membrane.
- Its Smaller than eukaryotic cell .

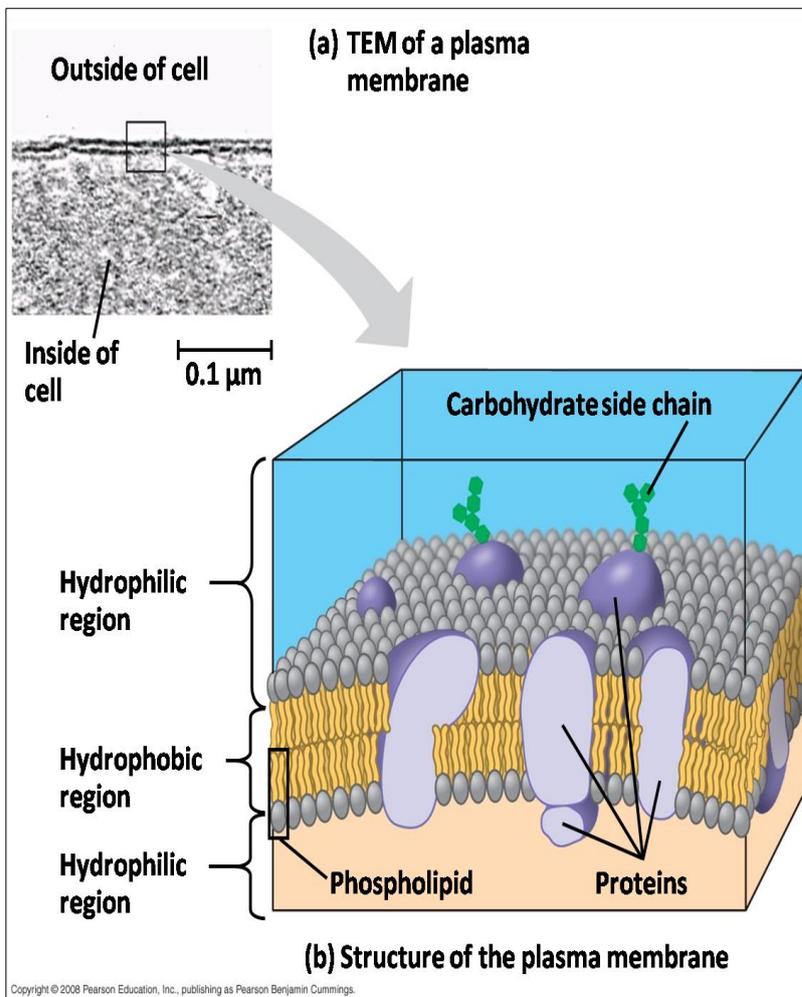


Eukaryotic cell

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

❖ Plasma Membrane

- The **plasma membrane** is a selective barrier that allows sufficient passage of oxygen, nutrients, and waste ; to service the entire of cell .
- The general structure of a biological membrane is a double layer of phospholipids , with embedded proteins . look to figure and notice the hydrophilic and hydrophobic regions >>



In the **interior** of a membrane , the **phospholipids tails** are hydrophobic , as are the interior portion of the membrane proteins in contact with them .

On the **outer surface** of the membrane

- **phospholipid heads** are hydrophilic , as are proteins (or parts of proteins) in contact with the aqueous solution outside of cell .

** channels through certain proteins are also hydrophilic ..

- carbohydrate side chains are found only attached to proteins or lipids on the outer surface of the plasma membrane .

- **(The Exchange of substances through plasma membrane) and (Surface area of the cell) :**

- For each square micrometer of membrane only a limited amount of a particular substance can cross per second .
- Increasing in size means that the cell has more work , so it needs more surface area in order to speed up the passage of substances from and to the cell ...
- The ratio of surface area to volume is critical , as a cell (or any other object) increases in size its volume grows proportionally more than its surface area . because >>

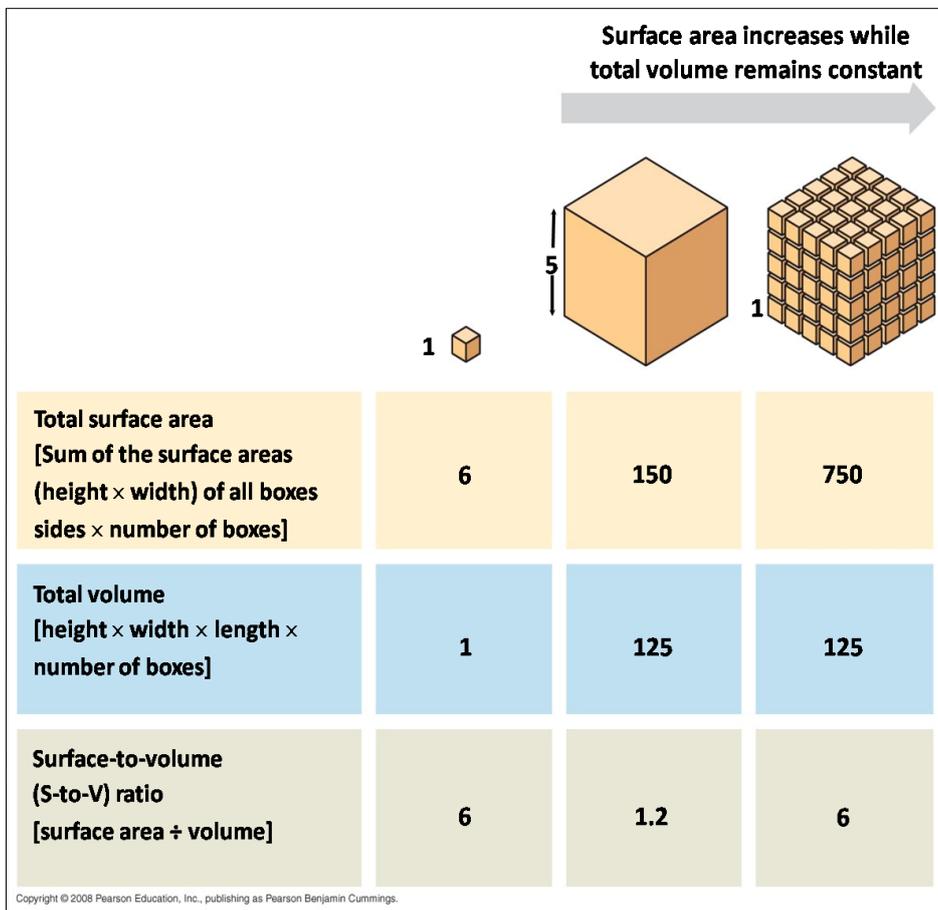
"surface area increases by a factor of n^2 , but the volume increases by a factor of n^3 ."

>> Small cells have a greater surface area relative to volume.

By **(surface area – volume ratio)** we can predict if the surface area is enough for a cell :)

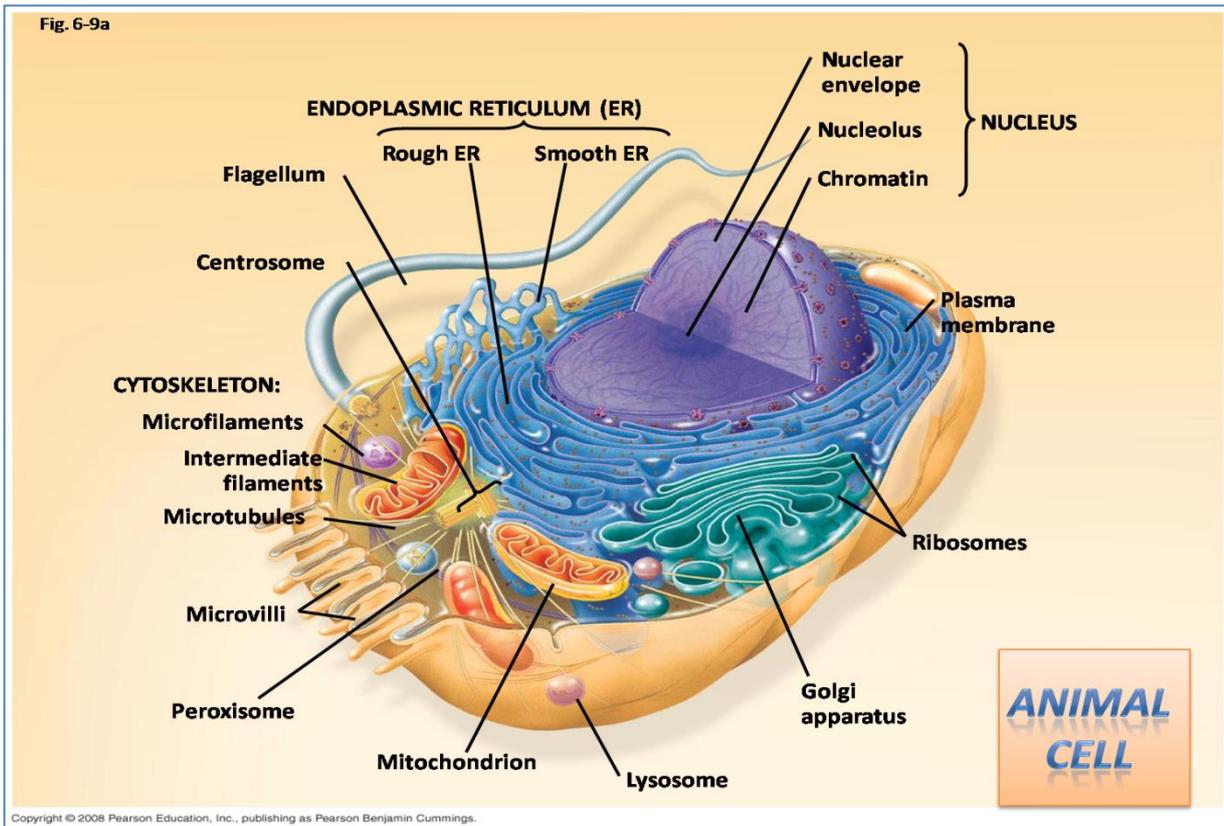
surface area – volume ratio = area / volume
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- Because of all above ,, the larger organisms don't generally have larger cells than other smaller organisms ! they only have more cells .. because increasing in size will make the cell less efficient in its work . look to figure >>

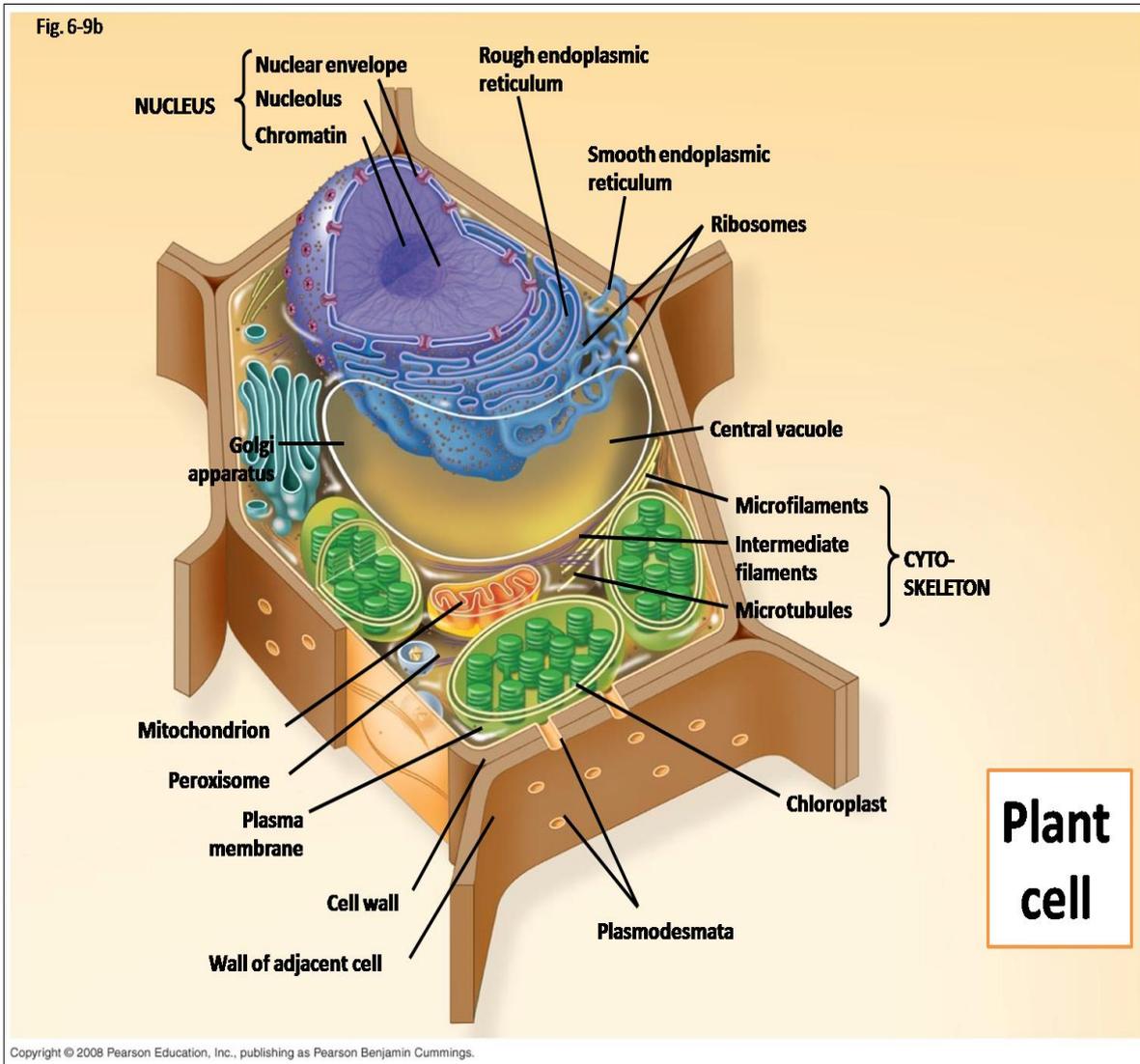


A Panoramic View of the Eukaryotic Cell

- Plant and animal cells have most of the same organelles .
- A eukaryotic cell has internal membranes that partition (divide) the cell into organelles.
- Plasma membrane & organelles membrane have the same structure , and they participate directly in the cells metabolism .



- The most prominent organelle in an animal cell is nucleus .
- Most of cell's activities occur in cytoplasm (which consist of organelles & other cell components suspended in a semi-fluid medium) .
- Structures found In animal cells but not in plant cells :
 - 1-lysosomes
 - 2-centrosomes with centrioles .
 - 3- flagella (but it present in some plant sperm) .



From the picture >>

Found In plant cells but not in animal cells :

1. Chloroplast
2. Central vacuole
3. Cell wall
4. Plasmodesmata

- Plant cell has a large central **vacuole** , and some plant cells have one or more smaller vacuoles .
- Plant cell has organelle called plastids the most important type of plastid is chloroplast (**carry out photosynthesis**) .

Concept 6.3 : The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosome

- In the eukaryotic cells The **nucleus contains most of the DNA**.
- Some genes are located in mitochondria & chloroplast.
- Ribosome uses the information from the DNA to make proteins.

Nucleus

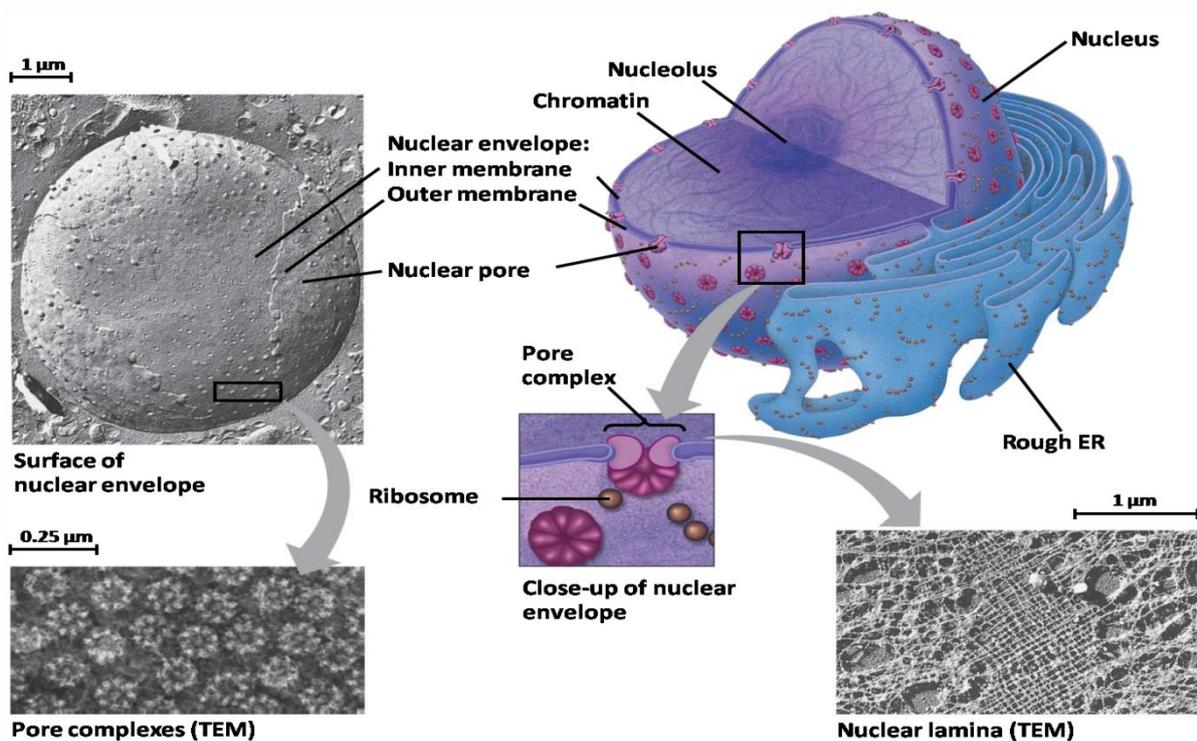
- Diameter of it in average is **5 Mm** (micro meter) .

Structure

1. Nuclear Envelope :

- It encloses the nucleus, separating it from the cytoplasm.
- The nuclear envelope is a double membrane (inner and outer membranes) ; each membrane consists of a lipid-bilayer with associated protein .
- Inner & outer membranes of nuclear envelope are continuous and perforated by pores .
- Pores regulate the entry and exit of molecules from the nucleus .
- Pore's Structure : it's about 100 nm in diameter , and ringed by protein particles called **pore complexes** (have an important role in regulating the entry and exit of nucleus) .

Note : The shape of the nucleus is maintained by the **nuclear lamina** (a net like array of protein filaments that maintain the shape of the nucleus mechanically supporting the nuclear envelope (attached to inner surface of it)).



2. DNA :

- DNA and proteins form genetic material called **chromatin**
- Chromatin condenses to form discrete **chromosomes**.

DNA + protein = chromatin

Chromatin + chromatin + = chromosomes

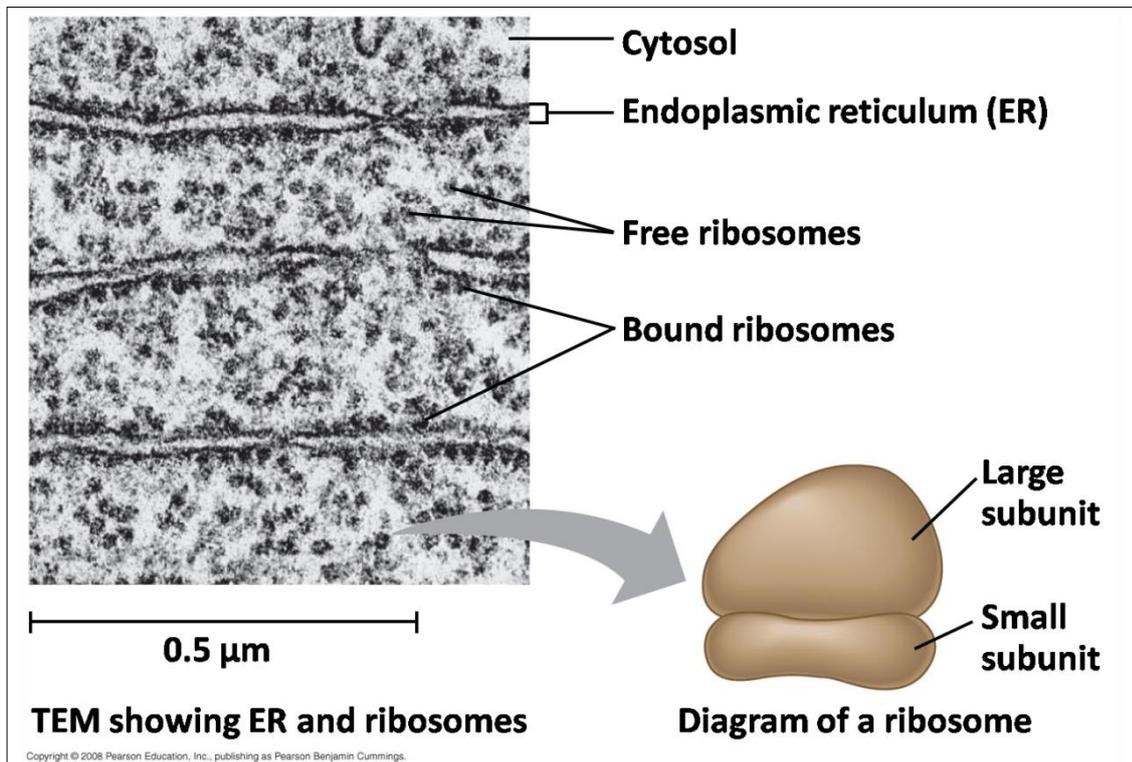
- So Chromosomes will carry the genetic information .
- Each eukaryotic cell species has a specific number of chromosome:
- **example : Human cell** has 46 chromosome,
Fruit fly cell has 8 chromosomes .

3- Nucleolus (plural =nucleoli) :

- It is located within the nucleus and its prominent structure .
 - It is the site of **ribosomal RNA** (rRNA) synthesis.
 - Sometimes there are 2 or more nucleoli , the number depends on the species and the stage in the cell's reproductive cycle .
- >> look to the previous picture to see nucleolus 😊

4- Ribosomes :

- **Ribosomes** are particles made of ribosomal RNA (rRNA) 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).



- **Cells have a large numbers of ribosome** have **High rate of protein synthesis ..**
Example : Pancreas cells
- **Protein's function depends on the type of ribosome which produced it .**
- Free ribosome :produce enzymes (catalyze breaking down of molecules)
- Bound ribosomes: produce protein that is destined for insertion into membrane or export from the cell (secretion) .
 - pancreas cells which secretes digestive enzymes frequently have a high proportion of bound ribosomes .
- Note : Nucleus directs protein synthesis (which happens in ribosomes) by synthesizing messenger RNA (mRNA) according to instructions provided by the DNA .

Concept 6.4: *The Endomembrane system regulates protein traffic and performs metabolic functions in the cell*

- Components of the **endomembrane system** :
 - Nuclear envelope (discussed in the previous concept)
 - Endoplasmic reticulum
 - Golgi apparatus
 - Lysosomes
 - Vacuoles
 - Plasma membrane
- ***These components are either continuous or connected via transfer by vesicles***
- The endomembrane system is a complex and dynamic player in the cell's compartmental organization .

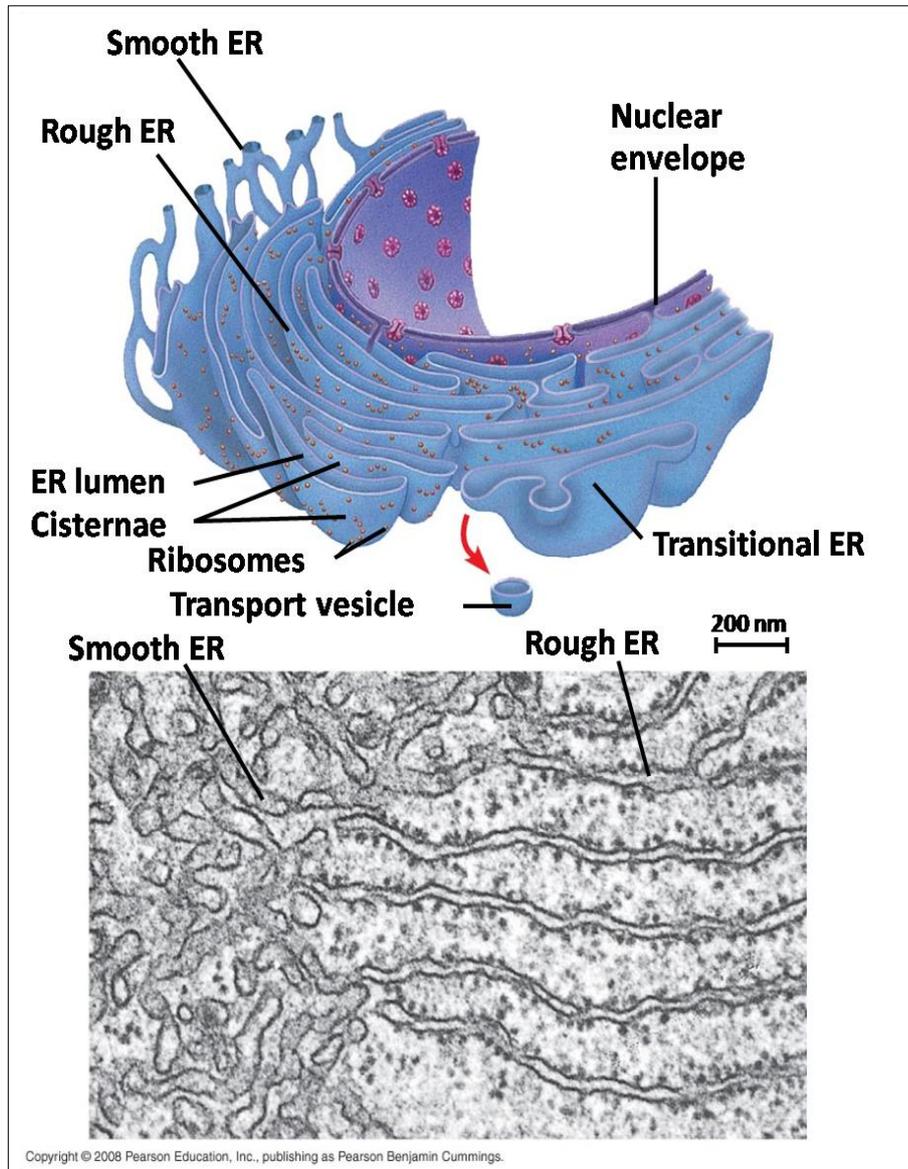
1. Endoplasmic Reticulum (ER) - Biosynthetic Factory -

- **Endoplasmic Reticulum** : a network of membranous tubules and sacs called "cisternae" .
- The **endoplasmic reticulum (ER)** accounts for more than half of the total membrane in many eukaryotic cells.

- There are two distinct regions of ER:

Smooth ER , which lacks ribosomes (**SER**)

Rough ER, with ribosomes studding its surface (**RFR**)



The ER membrane separate the internal compartment called [ER lumen(cavity) or cisternal space] from the cytosol .

The ER membrane is continuous with the nuclear envelope, so the space between them is continuous with the lumen of ER .

❖ Functions of Smooth ER :

1- Synthesizes lipids;

- synthesize all types of lipids .
- Steroids that are produced by smooth ER in animal cells are sex hormones ,the cells synthesize and secrete these hormones are in the testes & ovaries , and they are rich in smooth ER .

2- Metabolism of carbohydrates .

3- Detoxifies poison :

- The smooth ER helps to detoxify drugs and poisons , especially in liver cells .
- Barbiturates and alcohol and many other drugs **induce the proliferation of smooth ER and its associated detoxification enzymes , this in turn ,increase tolerance to the drugs (meaning that higher doses are required to achieve a particular effect)** .

• تعاطي المخدرات وتناول الادوية المفرط يؤدي الى توالد الشبكة الاندوبلازمية الملساء بشكل كبير وبالتالي زيادة عدد انزيمات المسؤولة عن ازالة السموم التي تتواجد على الشبكة عادةً , وهذا بدوره يؤدي الى ان يصبح الجسم بحاجة الى جرعة كبيرة ليتأثر !

4- store calcium :

- **Smooth ER** stored calcium ions in ER lumen
- As example in muscle cell
 - a specialized smooth ER membrane pumps calcium ions from the cytosol into the ER lumen ,
 - when muscle cell is stimulated by a nerve , calcium ions rush back across the ER membrane into cytosol and trigger contraction of the muscle cell .

> In other cell types calcium release from smooth ER and trigger different responses ..

❖ Functions of Rough ER :

1. Making secretory proteins

- Rough ER has bound ribosomes, which secrete **glycoproteins** (proteins covalently bonded to carbohydrates) .
- **Rough ER** membrane keeps the secretory protein separate from proteins that are produced by free ribosomes and will remain in cytosol how ?
By depart secretory protein from the ER wrapped in the membranous vesicles which bud from specialized region called **transitional ER** .

2. Distributes transport vesicles (proteins surrounded by membranes)

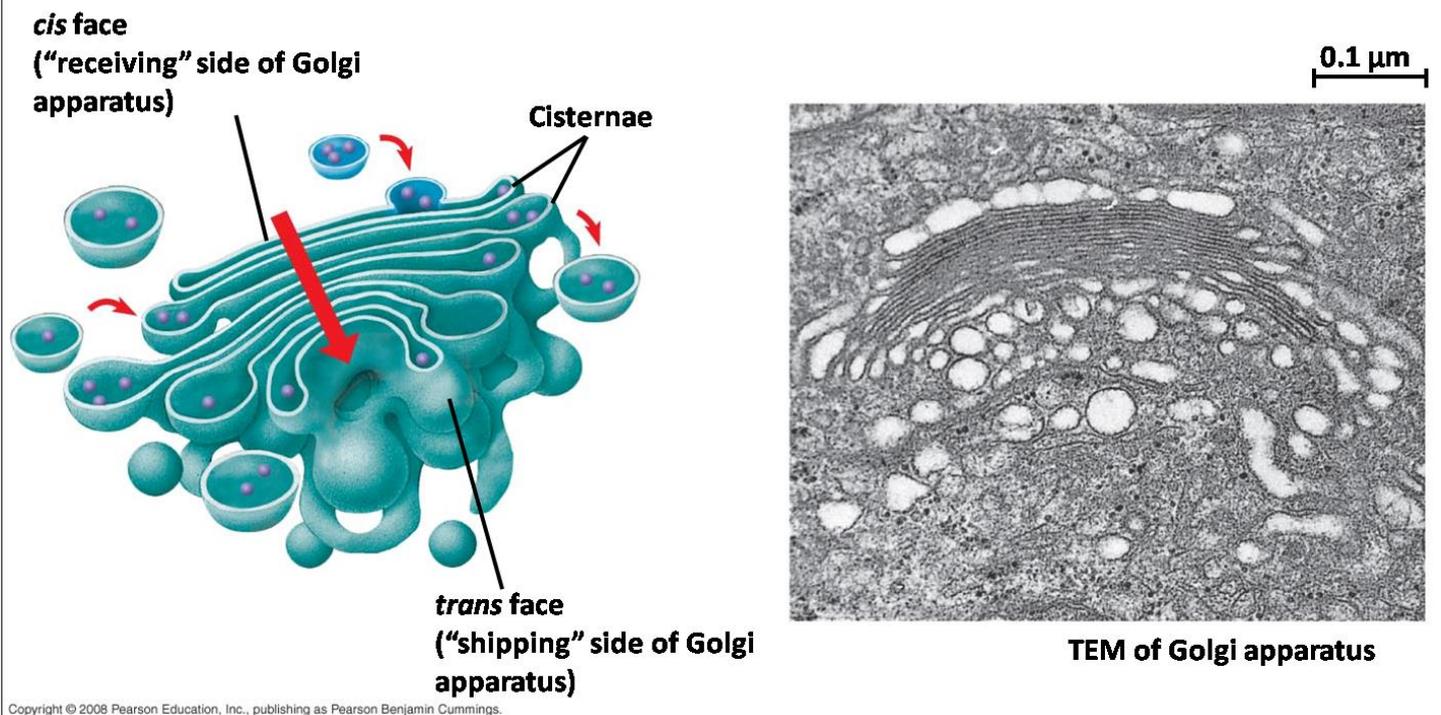
- **Transport vesicle** : vesicle in transit from one part of the cell to another (trans between endomembrane system organelles)

3. It is a membrane factory for the cell .

- It Grows in place by adding membrane proteins and phospholipids to its own membrane .
- As polypeptides are ready to be membrane protein , they are inserted into the ER membrane itself , and they are anchored there by their Hydrophobic portions.
- rough ER also make its own membrane phospholipids ; enzymes in it assemble phospholipids from precursors in the cytosol .

2. The Golgi Apparatus (Shipping and Receiving Center)

- The **Golgi apparatus** consists of flattened membranous sacs called cisternae (unlike ER cisternae , they are not physically connected) .
- Functions of the Golgi apparatus:
 - Modifies products of the ER.
 - Manufactures certain macromolecules .
 - Sorts and packages materials into transport vesicles .



- Golgi has a structural polarity . Opposite 2 sides (called 2 faces) of the stack differing in thickness and molecular composition :
1. **Cis face** : (located near the ER)it’s the receiving side of Golgi apparatus .. Vesicle that buds from the ER can add its membrane and the content of its lumen to the **Cis face** by fusing with a Golgi membrane.
 2. **Trans face** : gives rise to vesicles which pinch off and travel to other sites .

❖ The Golgi Apparatus functions

1. modifying products of the ER :

ER products are modified During transit between cis face and trans face .

- Various Golgi enzymes modify the carbohydrate portion of glycoprotein .
- Golgi removes some sugar monomers and substitutes others , that producing a large variety of carbohydrates . And membrane phospholipids may also be altered in the Golgi ...

2. Manufactures certain molecules :

- Many polysaccharides secreted by cells are Golgi product , including **pectin and certain other polysaccharides** .
- **Golgi** products can fused with plasma membrane .
- **Golgi** is **dynamic structure** not static . That’s mean it has movable parts ...

3- Sorts and packages materials into transport vesicles .

- Before a Golgi stack dispatches its products by budding vesicles from transface , it **sorts** these products and **targets** them to various parts of the cell .

- They targeted by :

1. molecular identification tags (ex: phosphate group)
2. External molecules on the membrane of budded vesicles .

3. Lysosomes: Digestive Compartments

- A **lysosome** is a membranous sac of hydrolytic enzymes that can digest macromolecules (proteins, fats, polysaccharides, and nucleic acids) .
- Lysosomal membrane and hydrolytic enzymes are made by **RoughER** , then transit to Golgi . At least Some lysosome arise by budding from the **transface** of Golgi .
- Lysosomal enzymes do best work in lysosomes (which is an acidic environment) , if these enzymes release out lysosomes , they will not work efficiently because cytosol has a neutral pH .
 - Excessive leakage of hydraulic enzymes from a large number of lysosome can destroy the cell by(auto - digestion) .

❖ Lysosome's Role :-

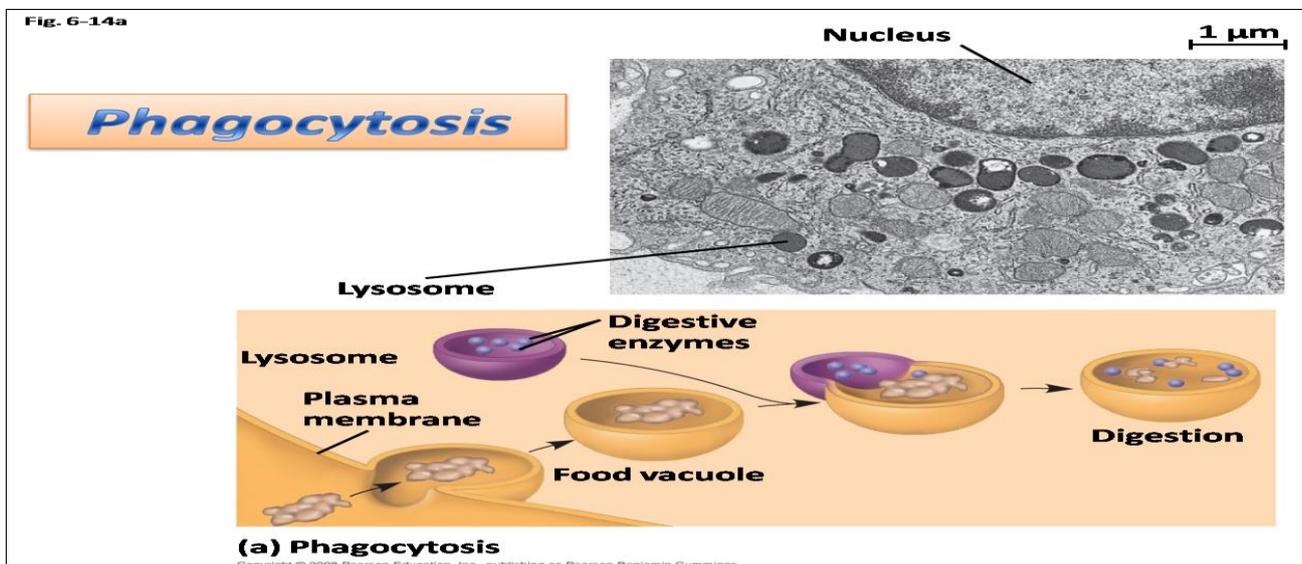
1. **Phagocytosis** :- engulf another cell , that forms a food vacuole.

>> a lysosome fuses with the food vacuole and its Hydrolytic enzymes digest the molecules .

>> **digestion** products including simple sugar , amino acid , other monomers pass into the cytoplasm and become nutrients for the cell ..

Example >

macrophages : a type of white cells that carry out the phagecytosis in preventing the bacteria and other invaders from destroying the body ..



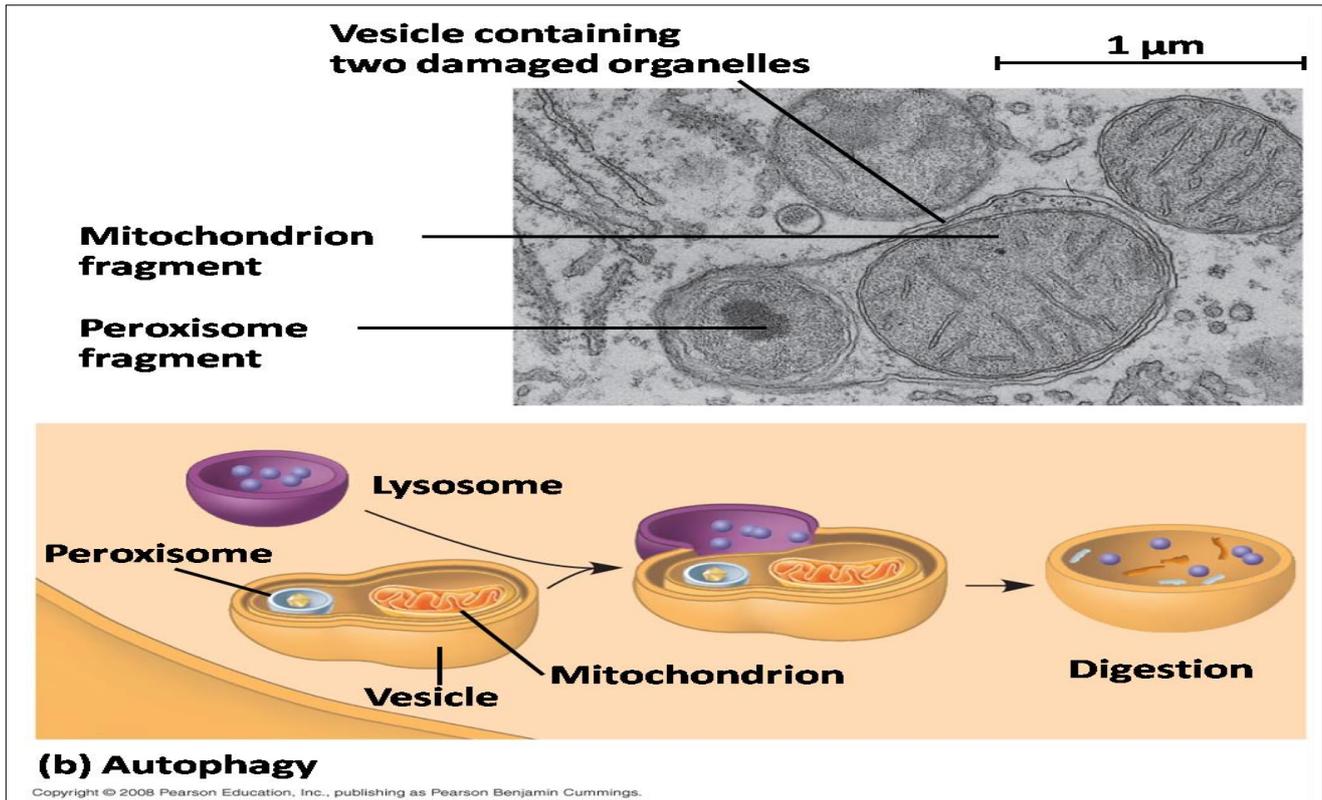
2. Autophagy :

- Lysosomes also use enzymes to recycle the cell's own organelles and macromolecules .

✓ by autophagy cells break down own damaged organelles continually and renews it self ..

- Autophagy process:

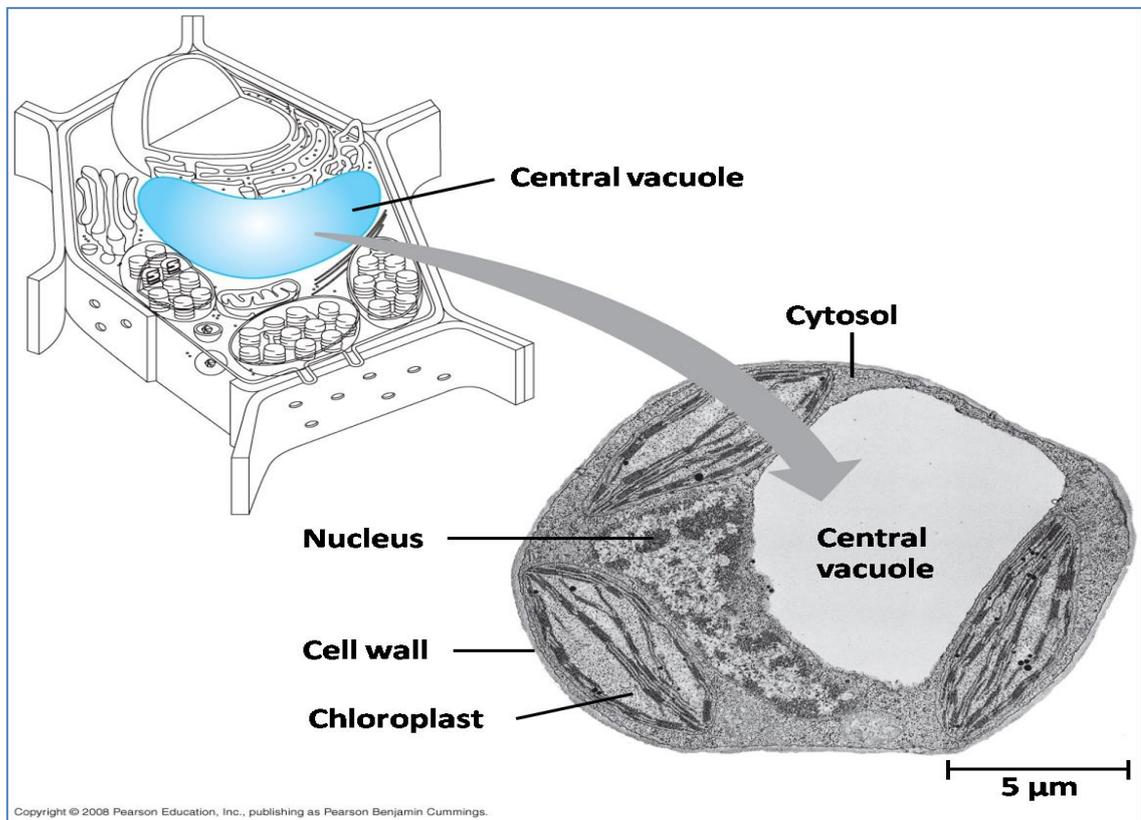
1. a type of vesicle will surround the organelle with double membrane(from unknown origin).
2. The outer membrane fuses with lysosome
3. The inner membrane degraded along with the damaged organelle.
4. Organic monomers are returned to cytosol for reuse .



- The cells of people with **inherited lysosomal storage diseases** lack a functioning hydrolytic enzyme which present in lysosomes ..
 - the lysosomes become engorged (filled) with indigestible substrate ,which begin to interfere with other cellular activities .
 - In Tay – sachs disease > lipid –digesting enzyme is missing or inactive , and the brain becomes impaired by an accumulation of lipids in the cells ...
- Fortunately these diseases are rare in general population ..

4. Vacuoles (Diverse Maintenance Compartments)

- A plant cell or fungal cell may have one or several **vacuoles (vacuole is a membrane bounded vesicles)**..
- Vacuole's membrane is selective in transporting solutes .
- There are 3 types of vacuoles :
 1. **Food Vacuole** : formed by phagocytosis
 2. **Contractile vacuoles**, found in many freshwater protists, its function is to pump excess water out of cells .
 3. **Central vacuoles**, found in many mature plant cells, hold organic compounds and water.
 - Developed by coalescence of smaller vacuoles from ER & Golgi .
 - The solution inside the central vacuole ,called cell sap differs in composition from the cytosol.
 - because of the large volume of central vacuole Cytosol is a thin layer between vacuole and plasma membrane ..

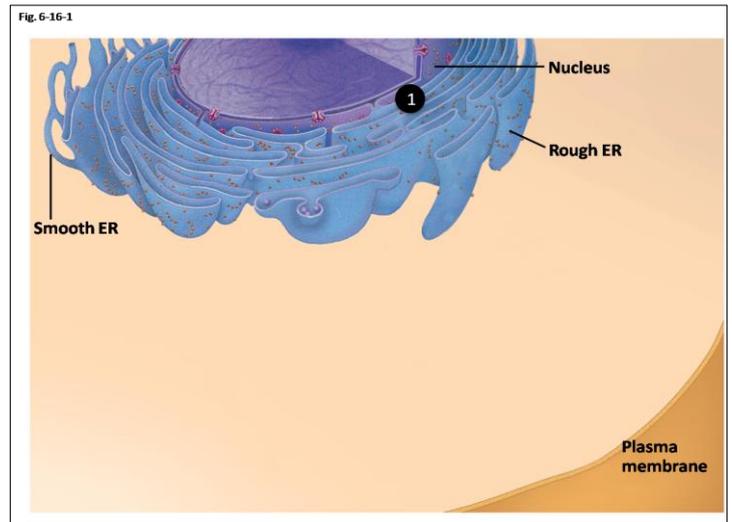


- **Central vacuoles functions :**
 1. Hold reserves of important organic compounds .
 2. Repository of inorganic ions (K^+ , Cl^-).
 3. Disposed sites for metabolic by products that would endanger cell if they accumulated in the cytosol .
 4. Containing pigments that color the cells .
 5. Protect plants against predators by containing compounds that are (poisonous or unpalatable to animals).
 6. Its major role is in growth of plant cell ..

The Endomembrane System: A Review

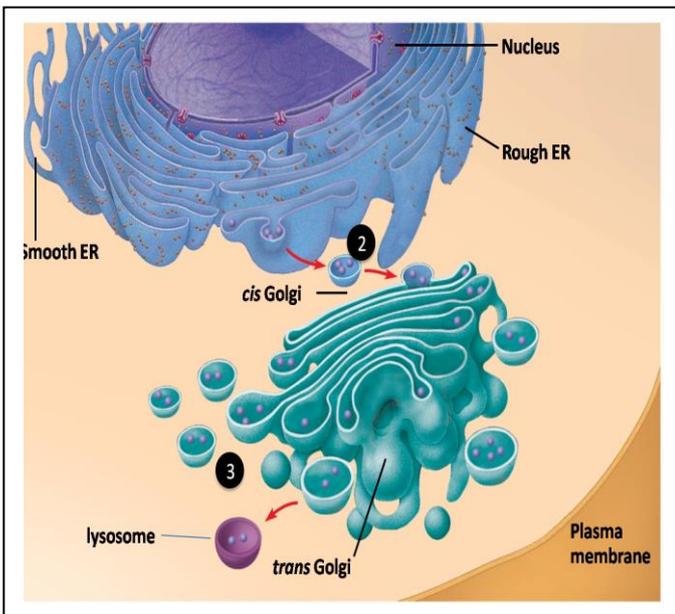
Relationship among organelles of the endomembrane .

1. nuclear envelope is connected to rough ER which is also continuous with smooth ER .



2. Membranes & proteins produced by the ER flow in the form of transport vesicles to the Golgi .

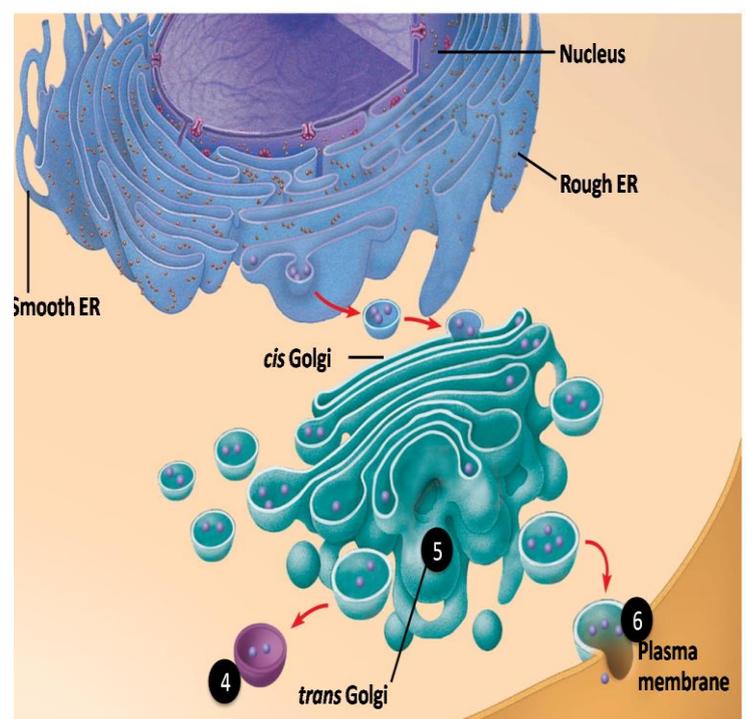
3. Golgi pinches off transport vesicles and other vesicles(that give rise to lysosomes and other types of specialized vesicles and vacuoles)



4. Lysosome is available for fusion with another vesicle for digestion .

5. Transport vesicle carries proteins to plasma membrane for secretion .

6. plasma membrane expands by fusion of vesicles and proteins are secreted from cell.



Concept 6.5: Mitochondria and chloroplasts change energy from one form to another

This concept talks about :

- **Mitochondria** are the sites of cellular respiration (a metabolic process that generates ATP)
- **Chloroplasts**, found in plants and algae ,they are the sites of photosynthesis.
- **Peroxisomes** are oxidative organelles .
- **Mitochondria and chloroplasts**
 - Are not parts of the endomembrane system
 - Have a double membrane , but chloroplasts typically have 3 membranes .
 - Have proteins made by free ribosomes
 - Contain their own DNA .
 - Their function > Convert energy to forms that cells can use for work ..
 - Semiautonomous organelles (شبه مستقلة)

Mitochondria (chemical energy conversion)

- Mitochondria are nearly in all eukaryotic cells.
- Some cells have a single large mitochondrion , but more often a cell has hundreds or even thousands of mitochondria , the number correlates with the cell's level of metabolic activity (ex. Motile & contractile cells have more mitochondria because, they are an active cells) .
- Mitochondria generate ATP by extracting energy from sugars , fats , and other foods with the help of oxygen ..
- **Structure :**
 1. (1-10)nm long
 2. Enclosed by 2 membranes (each one is a phospholipid bilayer with a collection of embedded proteins).
 3. They have a smooth outer membrane and an inner membrane folded into **cristae**.
 4. The inner membrane divides mitochondria into two compartments :

***intermembrane space :**

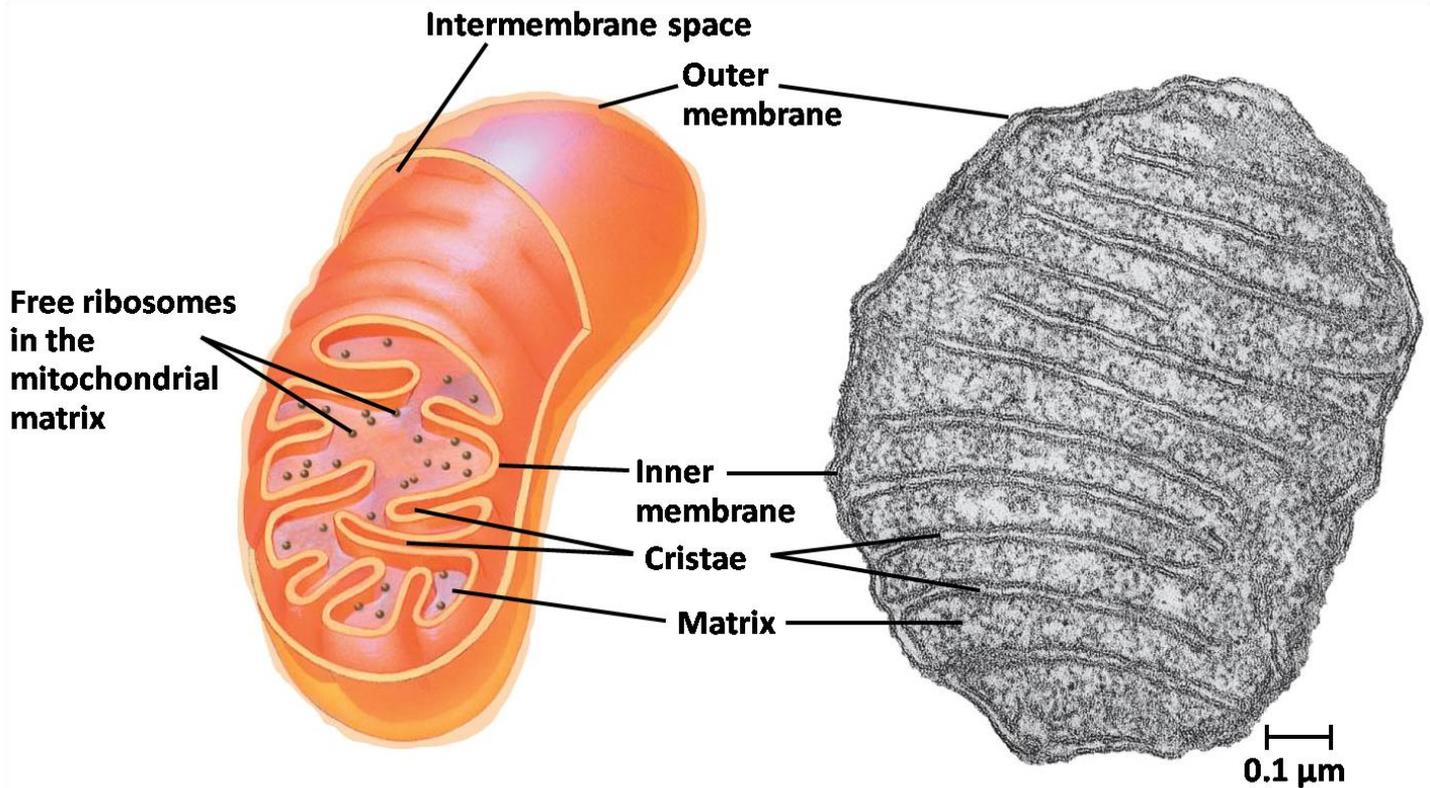
narrow region between the inner & outer membranes

***mitochondrial matrix :**

enclosed by inner membrane ,contains:

- a) many different enzymes (catalyze some steps of cellular respiration),and other proteins function in respiration
 - these proteins & enzymes are built into the inner membrane
- b) Mitochondrial DNA and ribosomes .

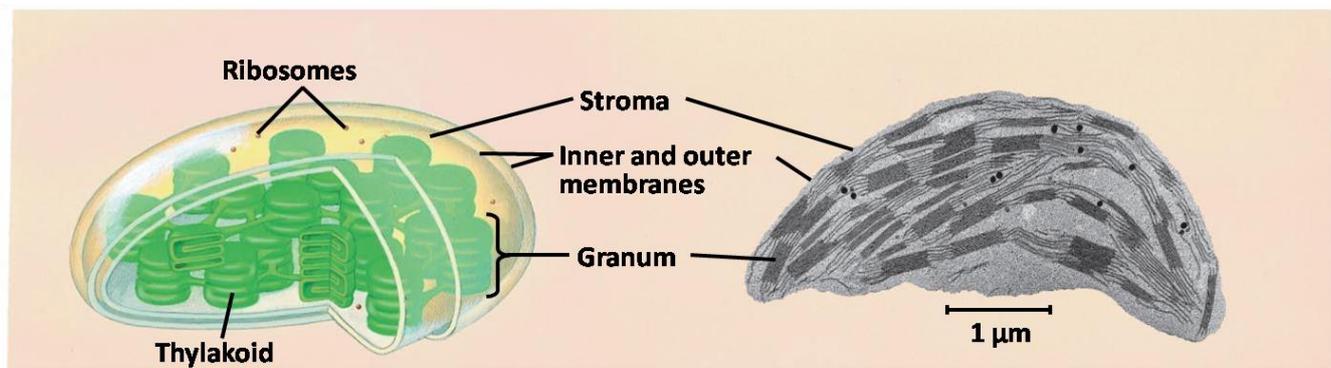
Note : highly folded surface of inner membrane enhancing the productivity of cellular respiration ,because that gives a large surface area for enzyme that synthesis ATP (and remember * these enzymes are built into the inner membrane).



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Chloroplasts: Capture of Light Energy

- The chloroplast is a member of a family of organelles called **plastids** .
- Chloroplasts contain the green pigment (chlorophyll) and enzymes and other molecules those function in photosynthesis.
- Found in leaves & other green organs of plants & algae .
- Shape: lens – shaped
- Has 2 membranes separated by narrow intermembrane space ..
- Chloroplast structure includes:
 - **Thylakoids** , flatted interconnected membranous sacs. (its membrane is folding and contain synthesis enzymes)
 - Thylakoids stacked to form a **granum** (plural = Grana) .
 - **Stroma** , the internal fluid (inside the chloroplast and out of Grana) contain (ribosomes , DNA, enzymes)



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- Grana are further connected by thin tubules between individual thylacoids .

- So , The 2 membranes of chloroplast divide its space into 3 parts :

1. Intermembrane space (enclosed by outer membrane)
2. Stroma
3. Thylakoid space .

**** chloroplasts are mobile and their shapes are changeable and they grow and occasionally pinch in two to reproducing itself .**

• The Role of chloroplasts : **photosynthesis**

➤ **Convert Solar Energy to chemical Energy ,**

HOW?

By absorbing sun light , and using it to drive the synthesis of organic compounds such as (synthesis sugar from water H_2O and carbon dioxide CO_2)

Note : There are another types of plasts :

1. Amyloplasts : colorless plastids store starch (amylose)
2. Chrome plasts : have pigments that give fruit and flowers their orange and yellow hues .

But we are interested in chloroplasts only ..

Peroxisomes : Oxidation

• Peroxisomes are specialized metabolic compartments bounded by a single membrane , produce hydrogen peroxide and convert it to water..

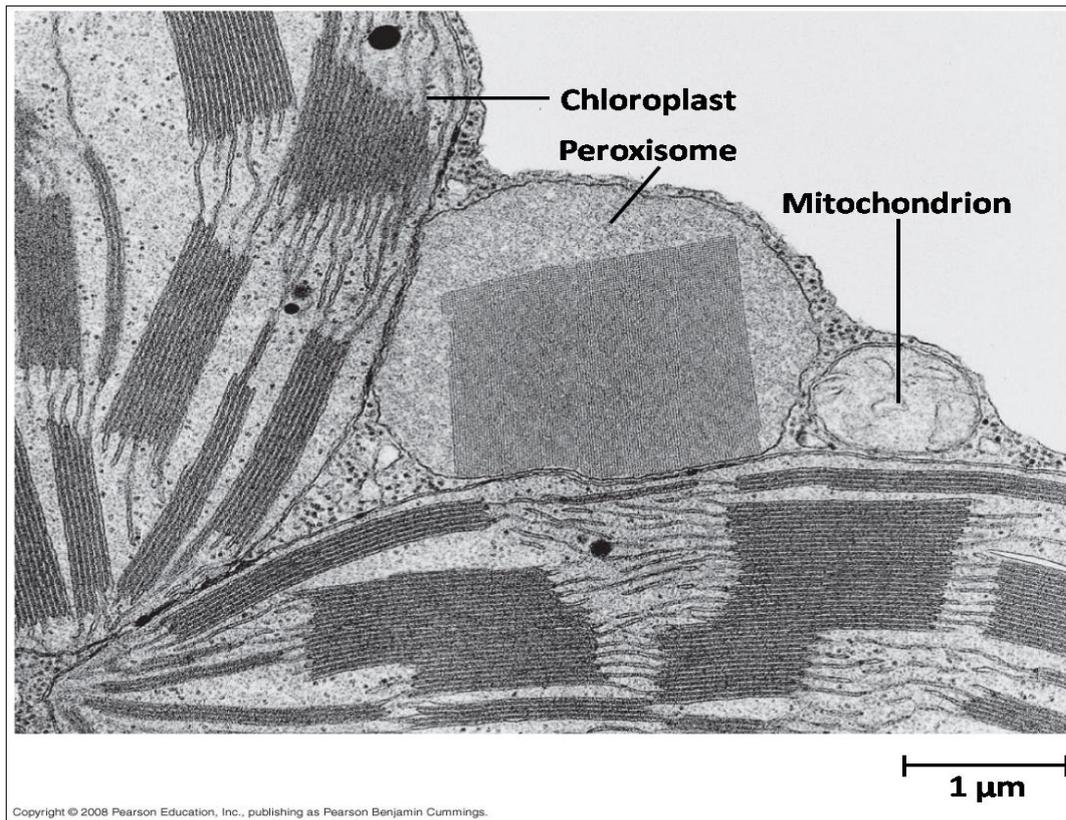
➡ How ?

- By enzymes that transfer hydrogen from various substrates to oxygen (they producing **Hydrogen peroxide** { H_2O_2 } as a by-product in their reaction , and this is the cause of organelle's name)..

- O_2 that produced by their reactions is used to break down different types of molecules..

1. Breaking fatty acid to small molecules (which are used as a fuel in cellular respiration in mitochondria).
2. Detoxify harmful compounds and alcohol by transferring hydrogen from the poisons to oxygen, (such as peroxisomes in liver).

- **Glyoxysomes** (it's a Specialized peroxisomes) found in **fat storing tissues of plant seeds** .
 - enzymes (which glyoxysomes contain) **Convert** fatty acids to sugars ,as a fuel for until the plant produced its own sugar by photosynthesis ..
- Peroxisomes don't bud from endomembrane system .
 - **they grow by incorporating protein and lipids**
 - They increase their numbers by dividing in 2 when they reach a certain size .
 - They imports its protein primarily from the cytosol(like mitochondria and chloroplasts) .



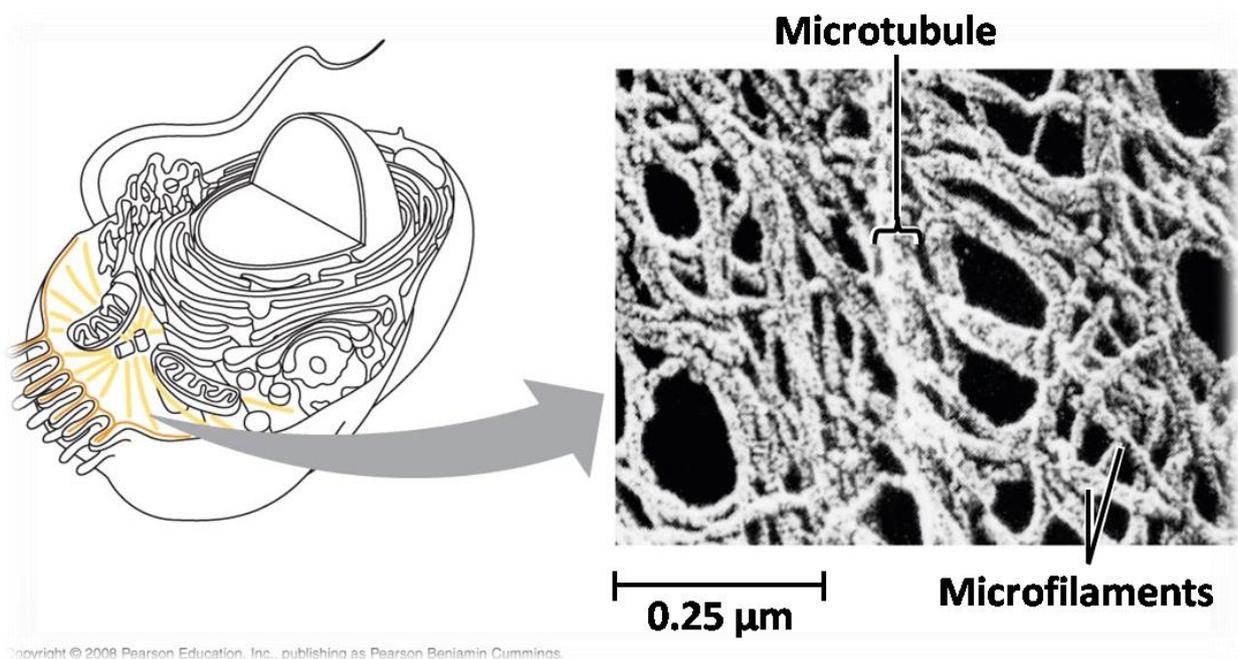
Q : Describe two common characteristics of chloroplasts and mitochondria (function and membrane structure) :

answer :

- both organelles are involved in energy transformation , mitochondria in cellular respiration and chloroplast in photosynthesis .
- They both have multiple membranes that separate their interiors into compartment .
- in both organelles the innermost membranes- cristae (infoldings in the inner membrane)in mitochondria and the thylakoid membranes in chloroplast have large surface areas with embedded enzymes that carry their main functions ..

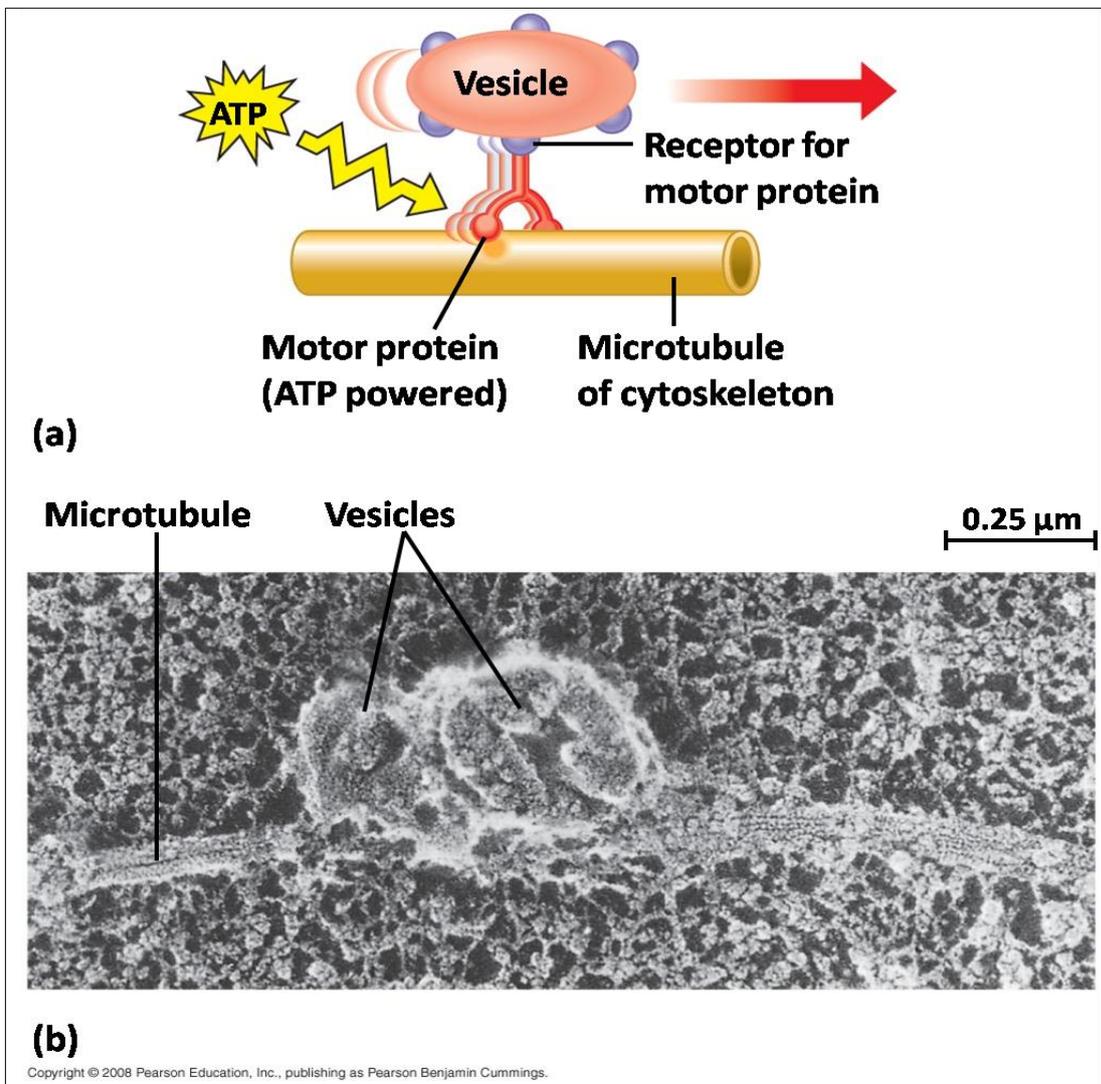
Concept 6.6: The cytoskeleton is a network of fibers that organizes structures and activities in the cell

- The **cytoskeleton** is a network of fibers extending throughout the cytoplasm
- It organizes the cell's structures and activities, and anchoring many organelles .
- It is composed of three types of molecular structures:
 - Microtubules
 - Microfilaments
 - Intermediate filaments



❖ Roles of the Cytoskeleton: **Support, Motility, and Regulation**

- cytoskeleton helps to **support the cell** and maintain its shape (the most obvious function)
 - this is especially important for animal cells , which lack to cell walls ..
- **Cell Motility** : encompasses both changes in cell location (whole cell movement) and limited movements of parts of the cell .
 - It interacts with **motor proteins** to produce motility.
 - Inside the cell, vesicles can travel along “monorails” provided by the cytoskeleton .
look to next figure >>
- Recent evidence suggests that the cytoskeleton may help **regulate biochemical activities**.



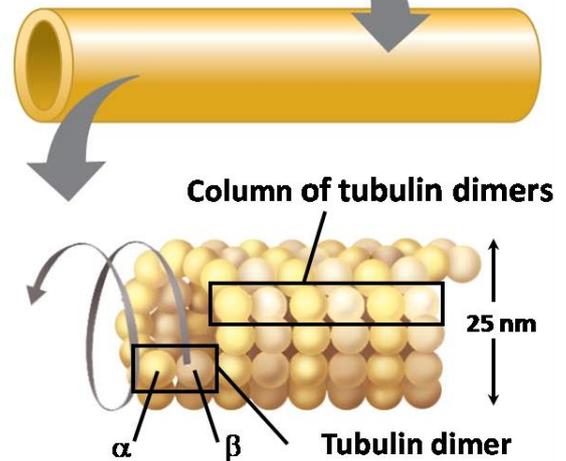
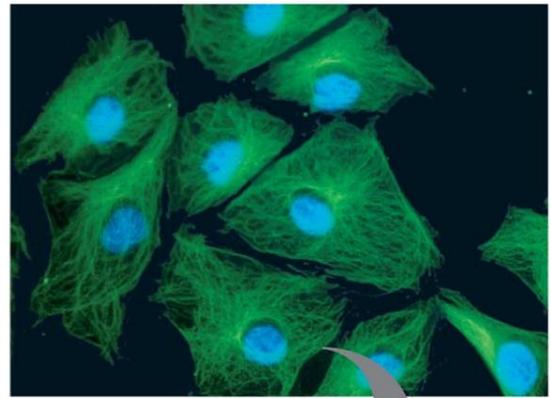
❖ Components of the Cytoskeleton

- Three main types of fibers make up the cytoskeleton:
 - **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

Microtubules

- **Microtubules** are hollow rods about 25 nm in diameter and about 200 nm to 25 microns long.
- The wall of the hollow tube is constructed from Tubulin molecules
 - Tubulin: is a globular and dimer protein
 - Dimer : molecule consist of 2 subunits
 - Tubulin dimer consists of (α - tubulin) & (β - tubulin) .

Property	Microtubules (Tubulin Polymers)
Structure	Hollow tubes; wall consists of 13 columns of tubulin molecules
Diameter	25 nm with 15-nm lumen
Protein subunits	Tubulin
Main functions	Maintenance of cell shape Cell motility Chromosome movements in cell division Organelle movements



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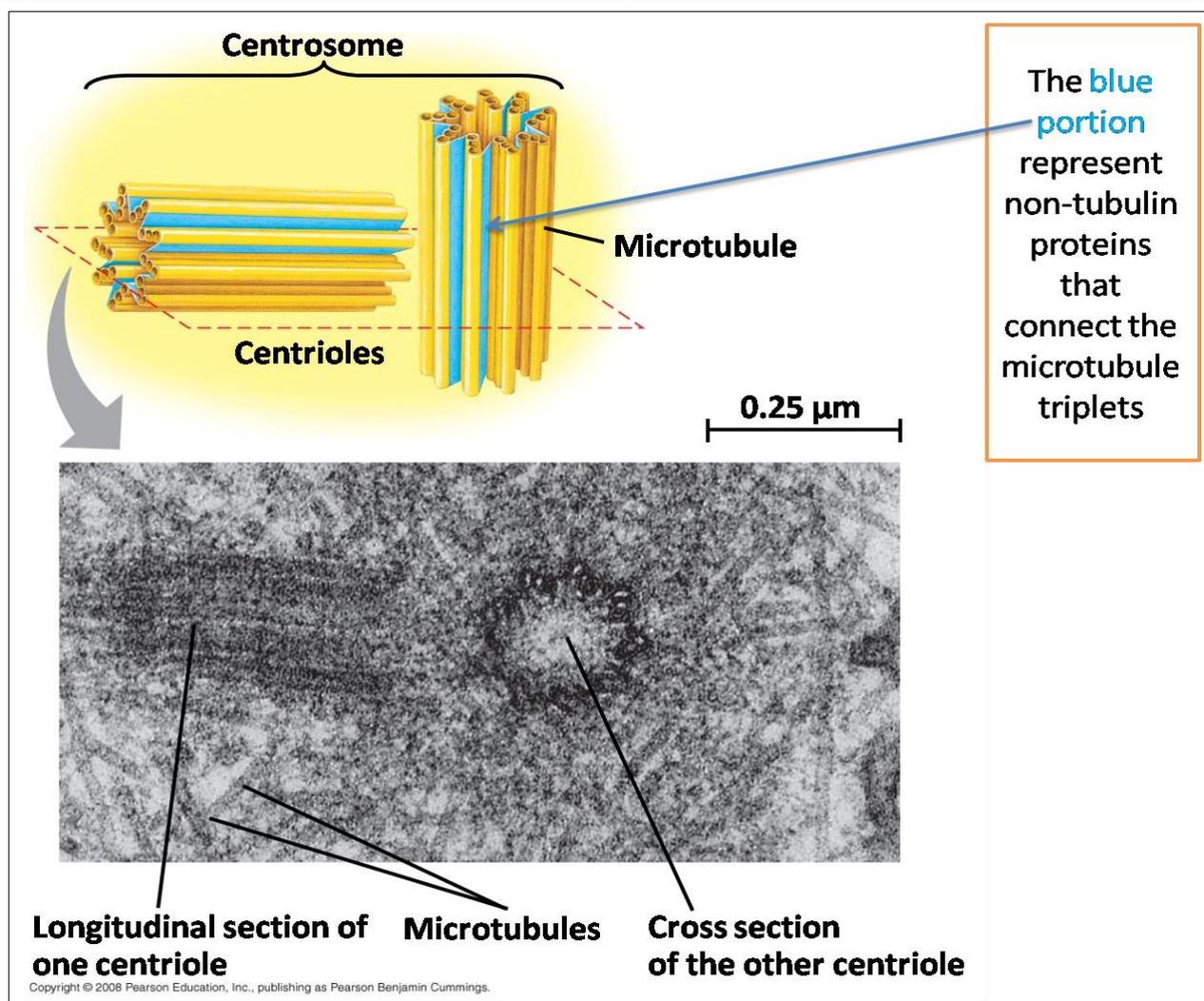
- example of microtubule function “Guiding movement of organelles” :
Microtubules guide secretory vesicles from the Golgi apparatus to the plasma membrane .

□ Centrosomes and Centrioles , what are those ?!

- In animal cells, microtubules grow out from a **centrosome** near the nucleus..
- The centrosome is a “microtubule-organizing center” . These microtubules function as compression – resisting girders of the cytoskeleton .. (داعمات مقاومة للضغط)
- In animal cells, the centrosome has a pair of **centrioles** (near 250 nm in diameter) each with nine triplets of microtubules arranged in a ring .

Importance of centrosomes :

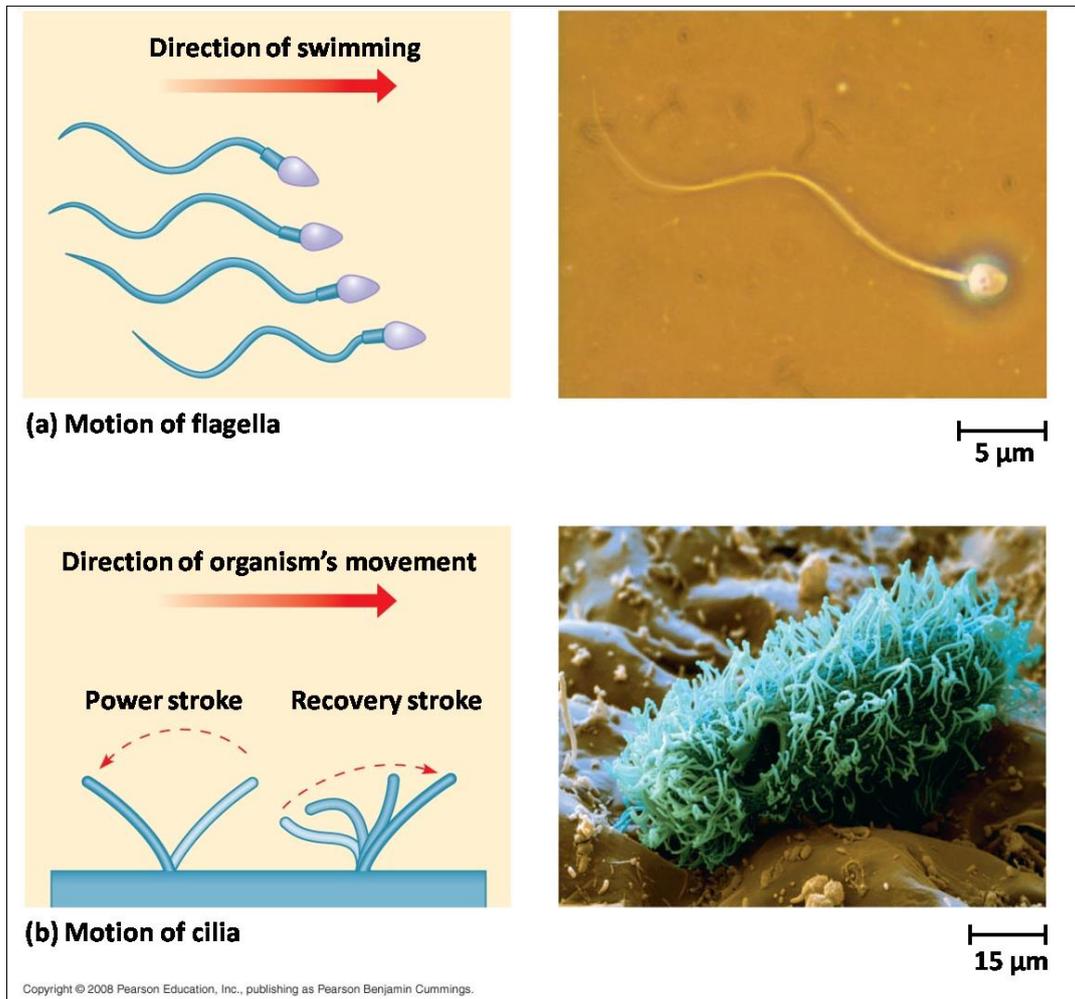
- Centrosomes with centrioles help in separating chromosomes in animal cell division , before that centrioles must be duplicated .
- centrosomes help in organizing microtubules assembly in animal cells .. but they are not essential for this function in all eukaryotes .
As example yeast and plant cells lack centrosomes with centrioles but have well organized microtubules ..



Cilia and flagella

- **cilia & flagella** : are locomotor appendages of some cells .
- Microtubules control the beating of **cilia** and **flagella** .
 - many unicellular eukaryotic are propelled through the water by **cilia** or **flagella** .
 - Sperm of animals & algae & some plants have **flagella** .
- **Cilia : (singular cilium)**
 1. Occur in a large number on cell surface
 2. Its about 250nm in diameter and (2-20) micro meter in long
 3. Work like oars (مجداف) , separate force in a direction perpendicular (عمودي) to the cilium's axis.
- **Flagella** (singular : Flagellum)
 1. Are usually limited to just 1 or a few per cell .
 2. Diameter: 250 nm
long: 10-200 micrometer
 3. Have undulating motion (generate force in the same direction of the flagellums action)

So Cilia and flagella differ in their beating patterns



- Although they are different in length , number per cell , and beating pattern , Cilia and flagella share a common ultra-structures :

- A core of microtubules sheathed in an extension of the plasma membrane.
- Nine doublets of microtubules arranged in the ring . The arrangement is (9+2) pattern in motile cilia & flagella , and (9+0) in non-motile primary cilia .
- ** (2) comes from central pair of microtubules

Look to the figure in the next page and notice to >>

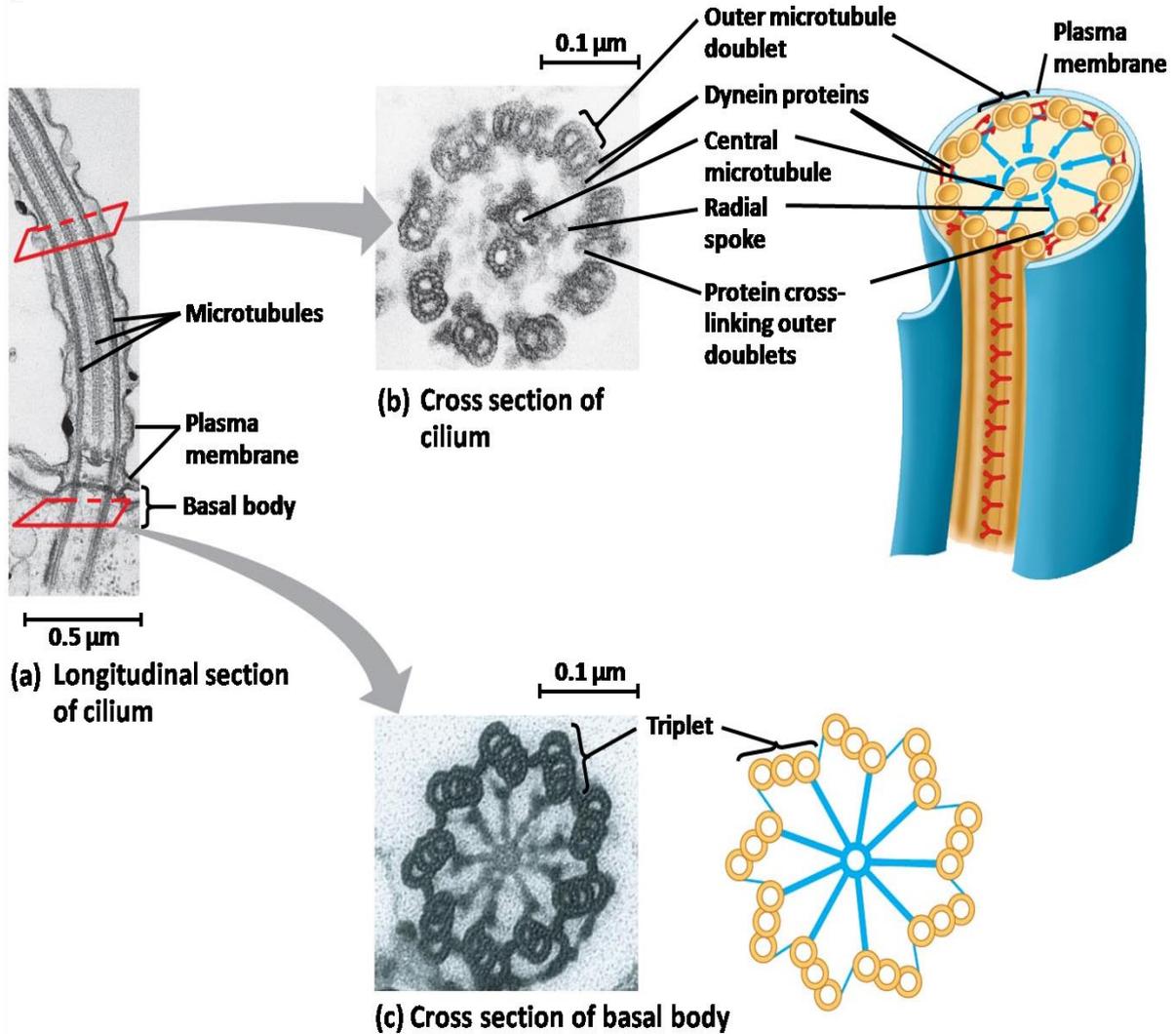
- A **basal body** that anchors the cilium or flagellum
this basal body is very similar to centriole

** (many animals sperm's flagella their basal bodies enter the egg and become centrioles after fertilization)

- A motor protein called **dynein**, which drives the bending movements of a cilium or flagellum

This protein spaced along the length of the cilium or flagellum , connect the outer doublets to each other and to the two central microtubules ..

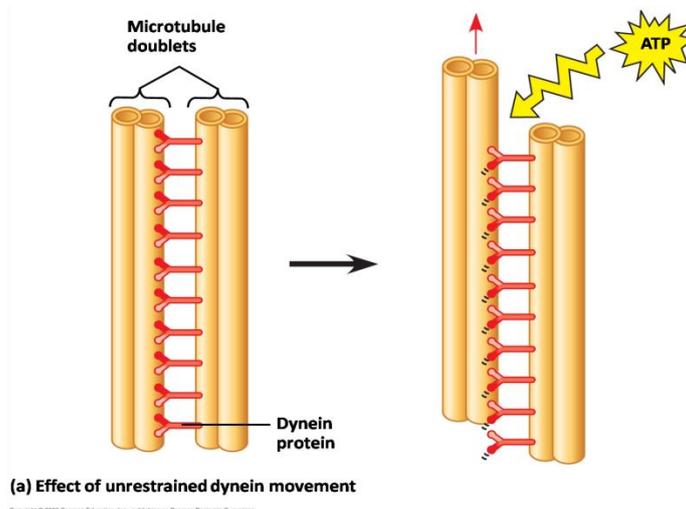
Fig. 6-24



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• **How dynein “walking” moves flagella and cilia:**

- Dynein has 2 feet that walk along the microtubule of the adjacent doublet , one foot maintaining contact while the other releases and reattaches one step further .
- Dynein feet alternately grab, move, and release the outer microtubules

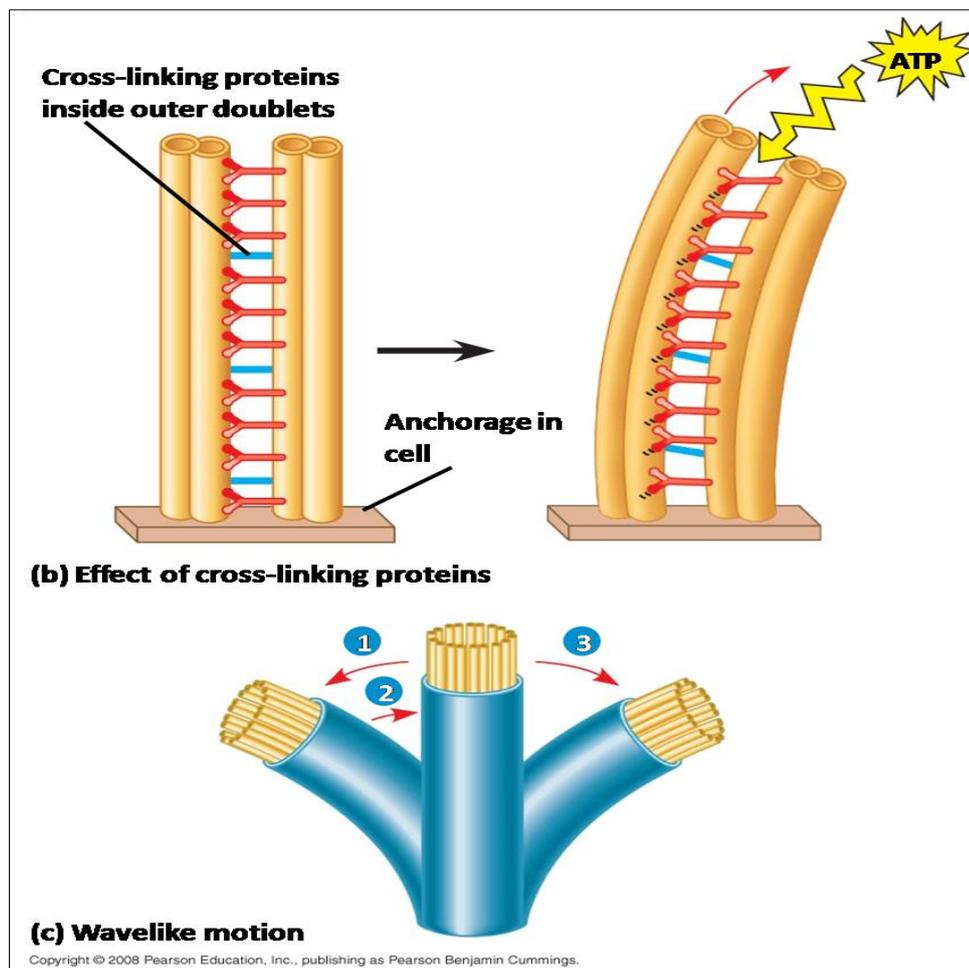


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But (Protein cross-links) limit sliding ?

- * The microtubules doublets seem to be held in place by the cross-linking proteins.
- * that makes Neighboring doublets cannot slide past each other very far .
- * so the forces exerted by (dynein walking) cause doublets to curve, bending the cilium or flagellum (that causes wavelike motion)

look to next figure



Q : How the cilia & flagella bend ??

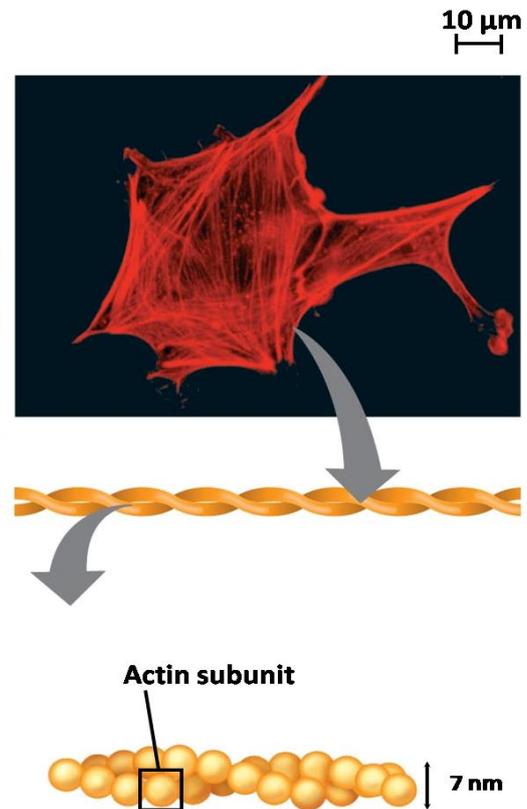
- Dynein feet , powered by ATP , move neighboring doublets of microtubules relative to one another , because they are anchored within the organelle and with respect to each other the doublets bend instead of sliding past one another .
- Cause : Protein cross-links

Microfilaments (Actin Filaments)

- **Microfilaments** are solid rods about 7 nm in diameter, built as a twisted double chain of **actin** subunits (actin =globular protein)
- Microfilaments seem to be present in all eukaryotic cells ..
- the structural role of microfilaments is **to bear tension**, resisting pulling forces within the cell (In contrast to compression –resisting role of microtubules) .

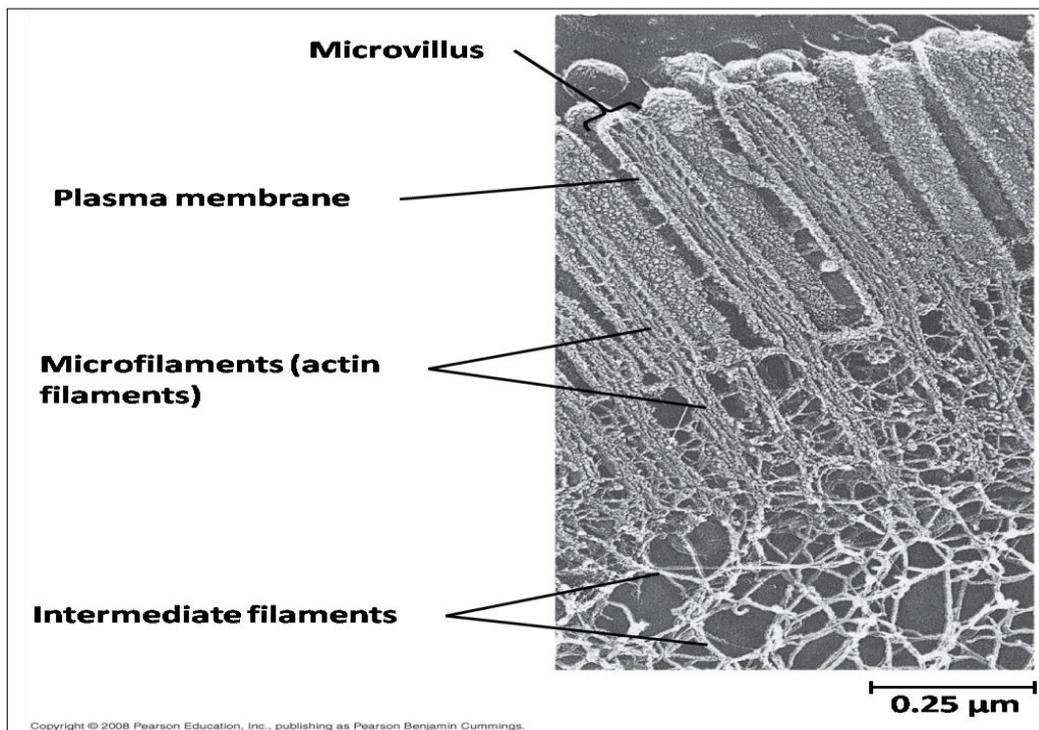
Table 6-1b

Property	Microfilaments (Actin Filaments)
Structure	Two intertwined strands of actin
Diameter	7 nm
Protein subunits	Actin
Main functions	Maintenance of cell shape Changes in cell shape Muscle contraction Cytoplasmic streaming Cell motility Cell division



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- They form a 3-D network called the **cortex** just inside the plasma membrane to help support the cell's shape.
- This network is semisolid consistency of a gel, surrounded cytoplasm which is in a fluid state.
- Bundles of microfilaments make up the core of microvilli of intestinal cells ..
- Microvilli : projections that increase the cell surface area there . (next figure)

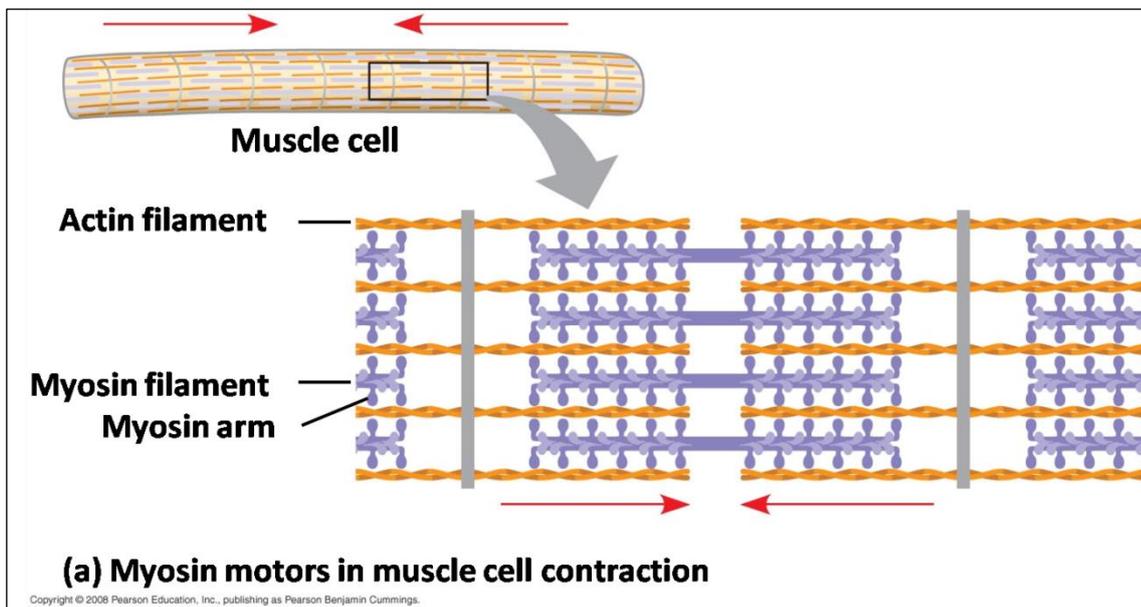


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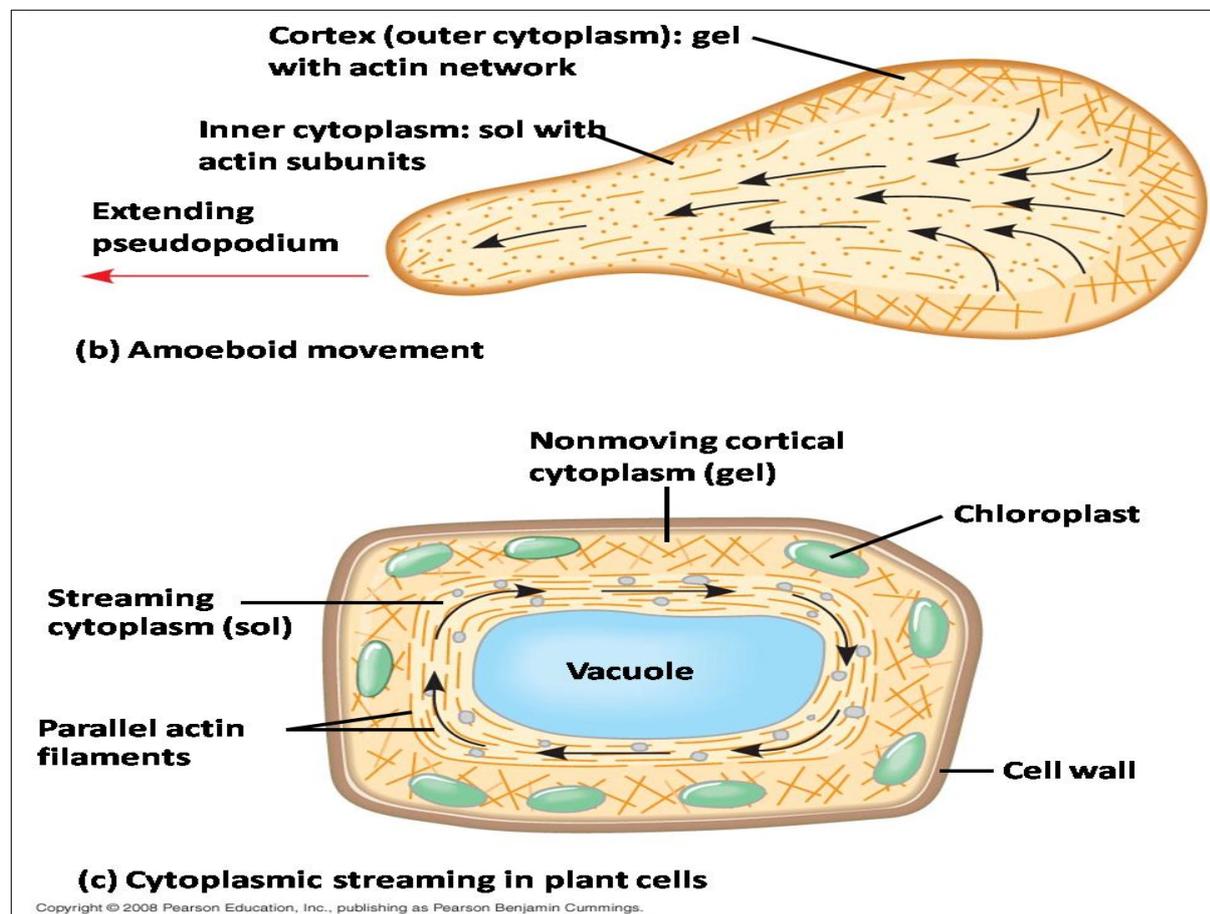
❖ Microfilaments functions

▪ Motility :

- Microfilaments is part of the contractile apparatus of muscle cells ..
- Microfilaments that function in cellular motility contain the protein myosin in addition to actin .
- In muscle cells, thousands of actin filaments are arranged parallel to one another..
- Thicker filaments(composed of myosin) interdigitate with the thinner (actin fibers) .
- Contraction of muscle cell results from the actin & myosin filaments sliding past one to another ,in this way shortening the cell ...



- Localized contraction brought about by actin and myosin also drives **amoeboid** movement .
 - This movement called **Pseudopodia**
 - **Pseudopodia** (cellular extensions) : extend and contract through the reversible assembly and contraction of actin subunits into microfilaments .
- That happen by interaction between actin & myosin near the cell's trailing end . look to next figure (6.27 b)
- In plant cells, actin-myosin interactions and sol-gel transformations drive cytoplasmic streaming
 - **Cytoplasmic streaming** is a circular flow of cytoplasm within cells , This streaming speeds distribution of materials within the cell . (Figure 6.27 c)
 -



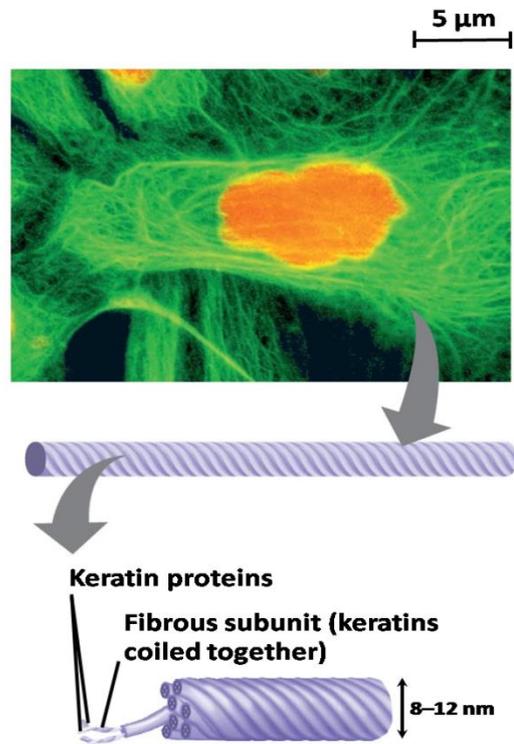
Q : Describe shared features of microtubule-based motion of flagella and microfilaments – based muscle contraction ?

- Both systems of movement involve long filaments that are moved in relation to each other by motor proteins that grip, release, and grip again adjacent polymers

Intermediate Filaments

- Intermediate filaments range in diameter from 8–12 nanometers, larger than microfilaments but smaller than microtubules .
- They support cell shape and fix organelles in place , specialized for bearing tension like (microfilaments)
- Subunits : diverse types of proteins from keratin family .

Property	Intermediate Filaments
Structure	Fibrous proteins supercoiled into thicker cables
Diameter	8–12 nm
Protein subunits	One of several different proteins of the keratin family
Main functions	Maintenance of cell shape Anchorage of nucleus and certain other organelles Formation of nuclear lamina



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- **Intermediate filaments are more permanent cytoskeleton fixtures than microfilaments & microtubules .**
- **After cells die , intermediate filament networks often persist .**

Concept 6.7 : Extracellular components and connections between cells help coordinate cellular activities

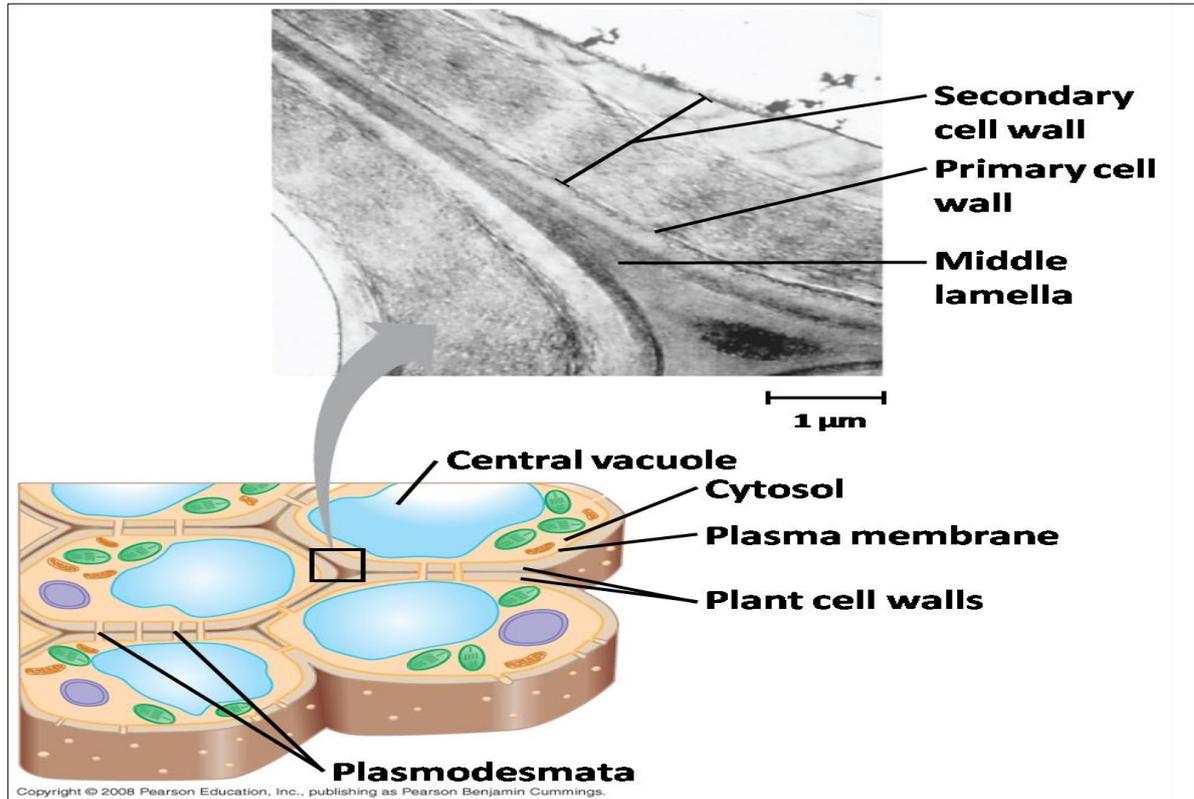
- **Most cells synthesize and secrete materials that are external to the plasma membrane**
- **These extracellular structures include:**
 - **Cell walls of plants**
 - **The extracellular matrix (ECM) of animal cells**
 - **Intercellular junctions**

Cell walls of plants

- **cell wall : Extracellular structure that distinguish plant cell from animal cell.**
- **prokaryotes & fungi & some protists also have cell walls .**
- **Functions :**
 - *protects the plant cell
 - *maintains its shape
 - *prevents excessive uptake of water
 - *on the level of whole plant the strong walls of specialized cells hold the plant up against the force of gravity .
- ❖ **Structure**
- **Plant cell wall is more thicker than plasma membrane (thickness :0.1 micrometer to several micrometer)**
- **Plant cell walls are made of cellulose fibers embedded in a matrix of other polysaccharides and proteins .**
- **Chemical composition vary from type to another but the basic design is consistent.**
- **Cell walls always perforated by channels between adjacent cells called plasmodesmata .**

- **Plant cell walls may have multiple layers:**

- **Primary cell wall:** relatively thin and flexible (secreted first and microtubules oriented these fibrils)
- **Middle lamella:** thin layer between primary walls of adjacent cells (rich in sticky polysaccharides called pectin)
- **Secondary cell wall (in some cells):** added between the plasma membrane and the primary cell wall when the cell become mature
- **Often deposited in several laminated layers ,** has a strong and durable matrix ,that gives support & protection for cells .



2. Extracellular Matrix (ECM) of animal cells

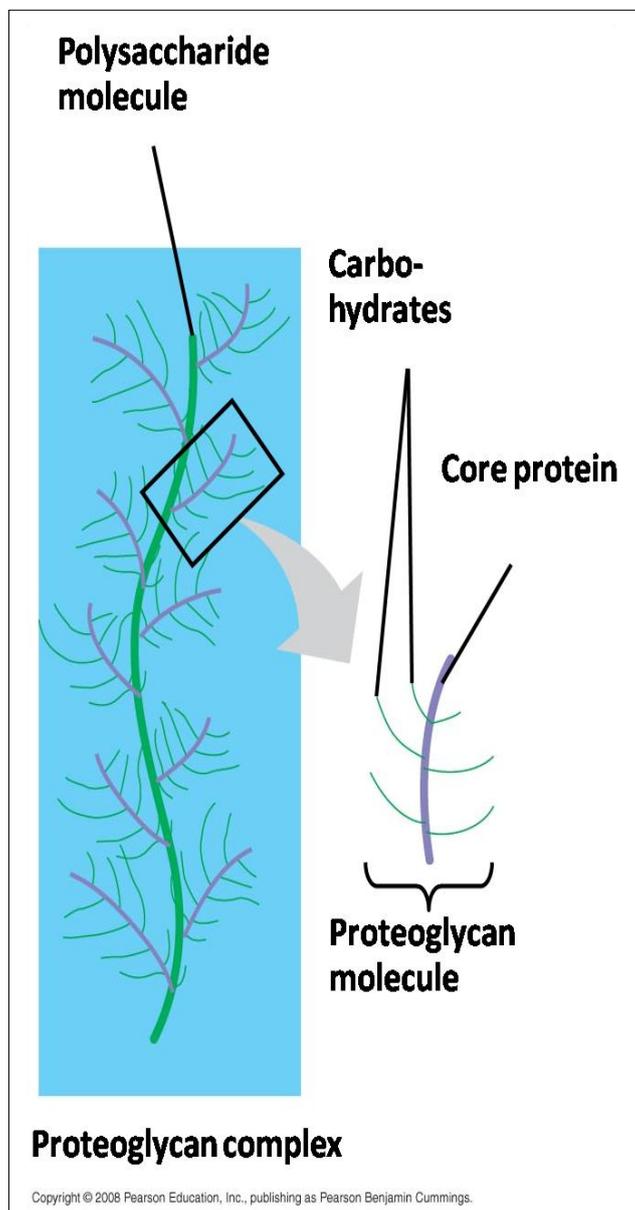
- Animal cells lack cell walls but are covered by an elaborate **extracellular matrix (ECM)**
- The ECM is made up of glycoproteins such as **collagen**, **proteoglycans**, and **fibronectin**
- ECM proteins bind to receptor proteins in the plasma membrane called **integrins**

1- Collagen :

- forms strong fibers outside the cells
- account for about half of the total proteins in the body .

- its fibers are embedded in a network woven from **protyglycans** (which consist of a small core protein with many carbohydrate chains covalently attached , it may be up 95% carbohydrate) .

- **Protyglycan complexes** can form when hundreds of proteglycans become noncovalently attached to a single long polysaccharide molecule.



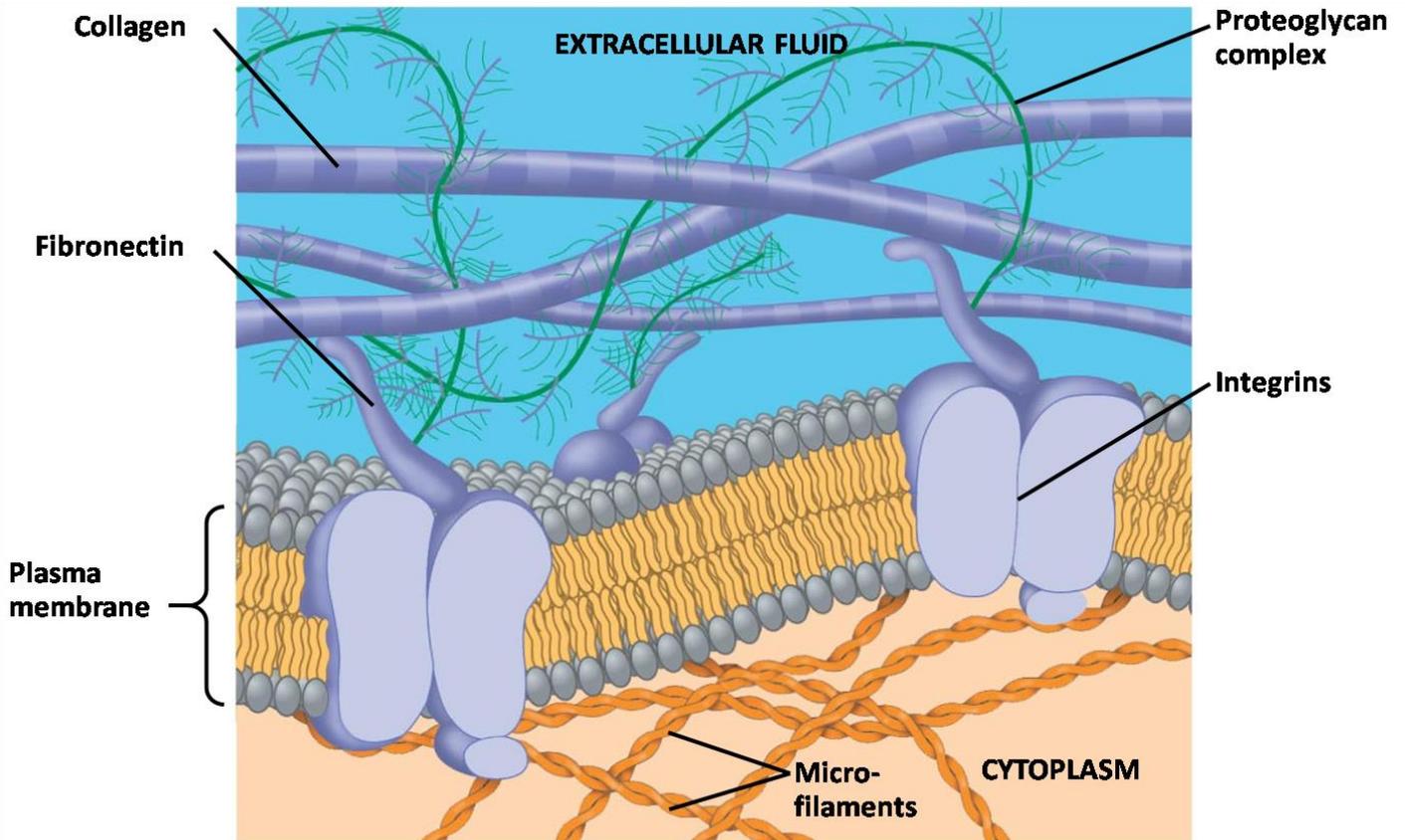
2- Fibronectin

Cells are attached to ECM by it .

It binds with integrins (receptor protein built into plasma membrane) on the surface of cell.

➤ integrins :

span the membrane , and connect the 2 sides (on cytoplasmic side ,bind with associated proteins attached to microfilaments of the cytoskeleton) , so they transmit signals between ECM and cytoskeleton and thus to integrate the changes occurring outside and inside the cell .



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Functions of the ECM:

- Support
- Adhesion
- Movement
- Regulating cell behavior

Examples :

- Some cells in development embryo migrate along specific pathways by matching the orientation of microfilaments to the grain of fibers in the extracellular matrix .
- ECM around cell can influence the activity of genes in the nucleus .

3- intercellular junctions

Body > system > organ > tissue > cells

- Neighboring cells in tissues, organs, or organ systems often adhere, interact, and communicate through direct physical contact.
- Intercellular junctions facilitate this contact 😊

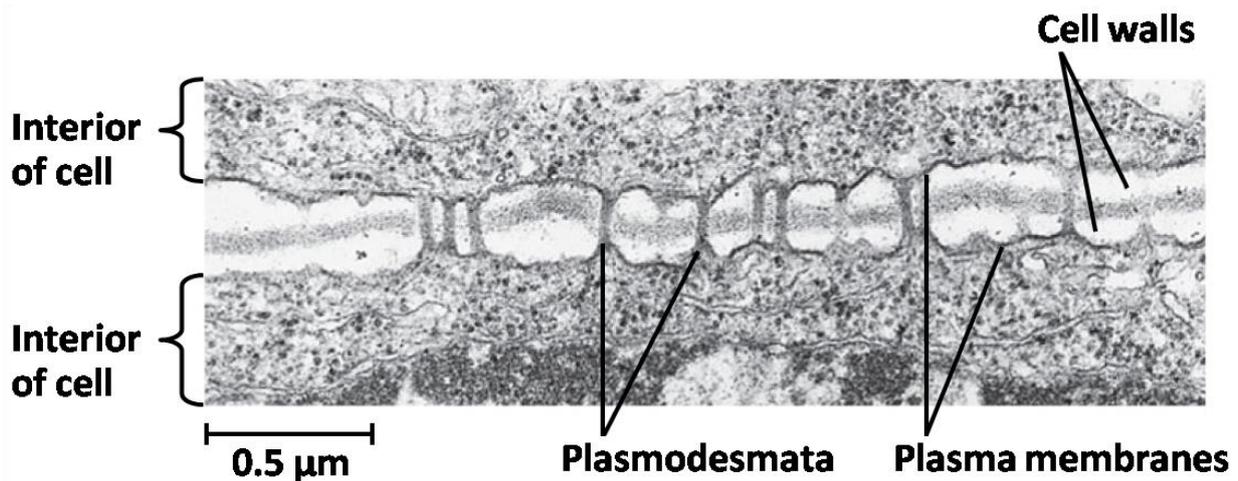
- There are several types of intercellular junctions

- Plasmodesmata → plant cell

- Tight junction
 - Desmosomes
 - Gap junctions
- } animal cell

❖ Plasmodesmata between Plant Cells

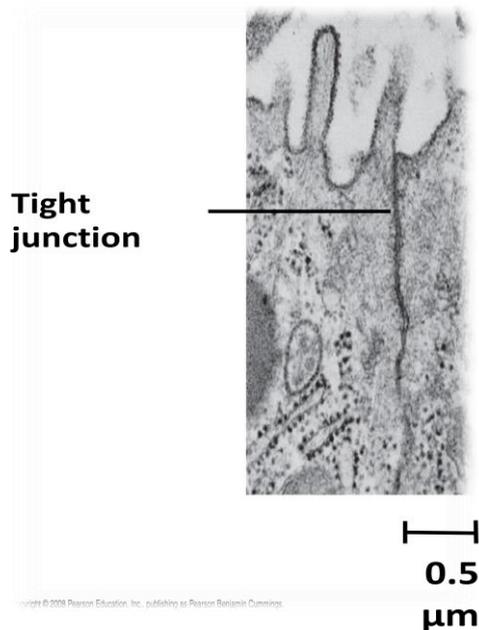
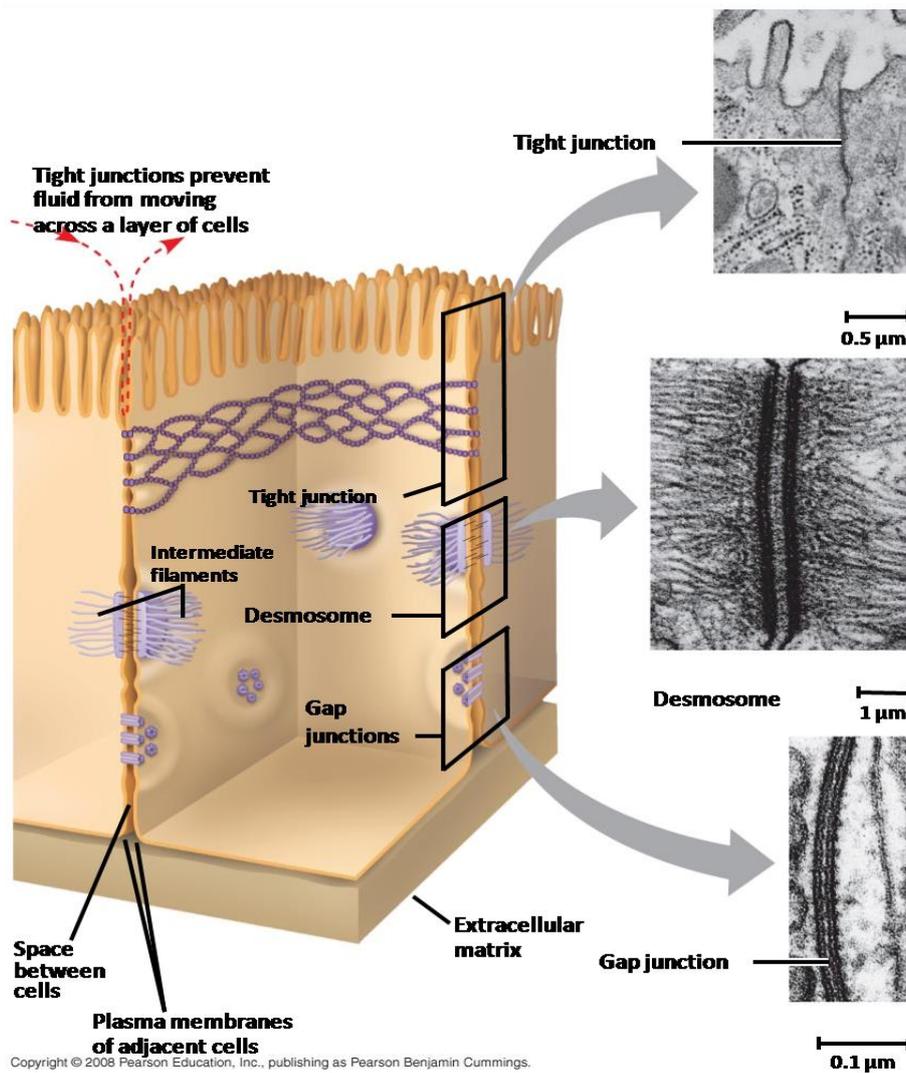
- Cell walls (non living structure) of plants would isolate cells from one another .
- **Plasmodesmata** are channels that perforate plant cell walls .
- Through plasmodesmata , water and small solutes (and sometimes proteins and RNA) can pass from cell to cell
- Plasmodesmata connect the chemical environment of adjacent cells > this connection unify most of the plant into one living continuum
- Macromolecules transported to neighboring cell seem to reach the plasmodesmata by moving along fibers of the cytoskeleton .



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❖ **Tight Junctions, Desmosomes, and Gap Junctions in Animal Cells**

- All These three types of intercellular junctions are especially common in epithelial tissues .

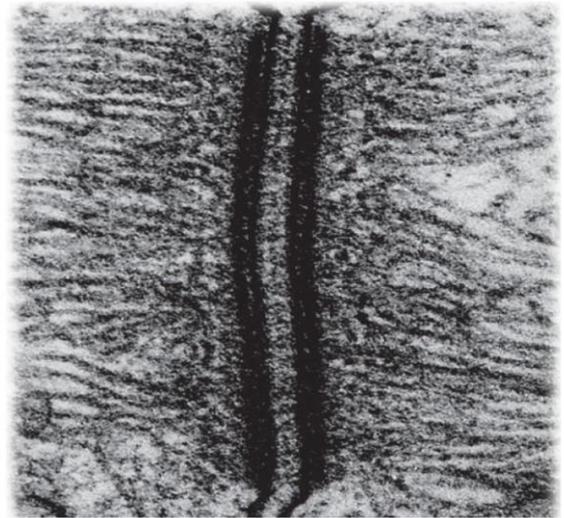


1. Tight Junctions :

- At tight junctions membranes of neighboring cells are pressed
- a against each other , forming continuous seals around the cells.
- preventing leakage of extracellular Fluid.
- Example : tight junctions between skin cells make us watertight by preventing leakage between cells in our sweat glands .

2. Desmosomes (anchoring junctions)

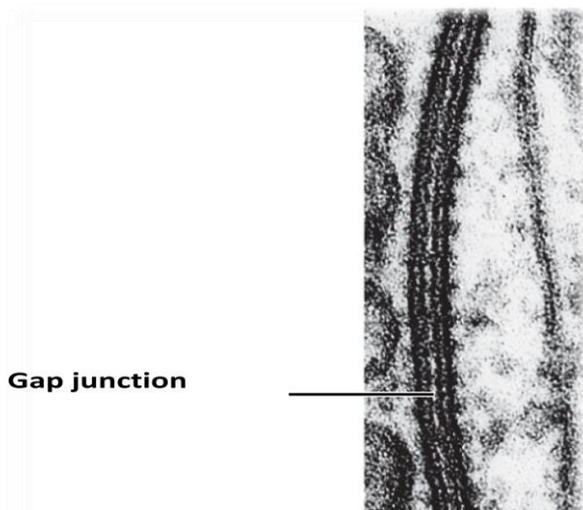
- fasten cells together into strong Sheets
- Intermediate filaments of sturdy keratin proteins anchor desmosomes in the cytoplasm .
- Desmosomes attach muscle cells to each other in a muscle .



Desmosome

1 μm

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Gap junction

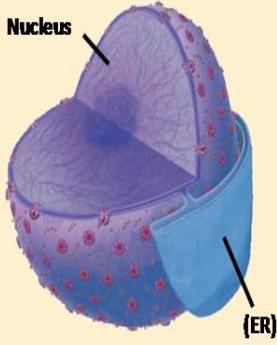
0.1 μm

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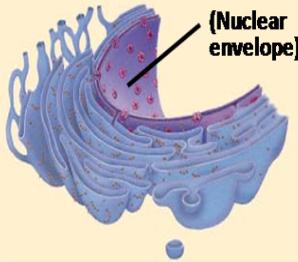
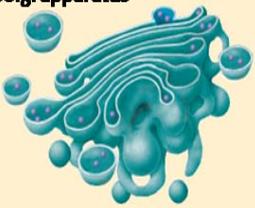
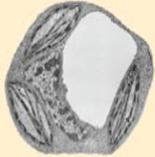
3- Gap junctions (communicating junctions)

- provide cytoplasmic channels between adjacent cells.
- In this way their are similar in their function to the plasmodesmata in plants .
- They consist of proteins surround a pore through which molecules may pass.
- They are necessary for communication of the cells

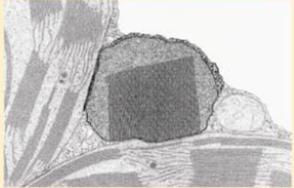
Abstract

	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 	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 of materials.
	Ribosome 	Two subunits made of ribosomal RNA and proteins; can be free in cytosol or bound to ER	Protein synthesis

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	Cell Component	Structure	Function
Concept 6.4 The endomembrane system regulates protein traffic and performs metabolic functions in the cell	Endoplasmic reticulum 	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 synthesis of secretory and other proteins from bound ribosomes; adds carbohydrates to glycoproteins; produces new membrane
	Golgi apparatus 	Stacks of flattened membranous sacs; has polarity (<i>cis</i> and <i>trans</i> faces)	Modification of proteins, carbohydrates on proteins, and phospholipids; synthesis of many polysaccharides; sorting of Golgi products, which are then released in vesicles.
	Lysosome 	Membranous sac of hydrolytic enzymes (in animal cells)	Breakdown of ingested substances cell macromolecules, and damaged organelles for recycling
	Vacuole 	Large membrane-bounded vesicle in plants	Digestion, storage, waste disposal, water balance, cell growth, and protection

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	Cell Component	Structure	Function
Concept 6.5 Mitochondria and chloroplasts 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 (H₂O₂) as a by-product, which is converted to water by other enzymes in the peroxisome

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The End of chapter 7

Good Luck in Your Exam 😊