SUMMARY

BIOLOGY

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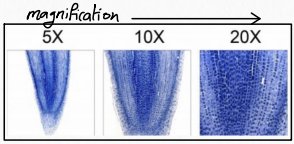
chapter 7 ,cell structure and function

Concept7.1 : To study cells, biologists use microscopes and the tools of biochemistry .

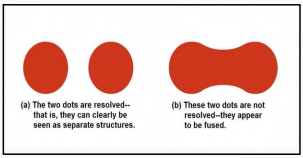
💥Microscopy

- Scientists use microscopes to visualize cells too small to see with the naked eye
- The quality of an image taken by a microscope depends on:

-Magnification(التكبير), the ratio of an object's image size to its real size



-Resolution(الدقة), the measure of the clarity of the image, or the minimum distance of two distinguishable points.



- contrast (التباين)

: is the difference in brightness between the light and dark areas of an image.

🔬light microscope (LM)

- In a light microscope (LM), visible light passes through a specimen and then through glass lenses, which magnify the image.
- LMs can magnify effectively to about 1,000 times the size of the actual specimen.
- Various techniques enhance contrast and enable cell components to be stained or labeled.
- Most subcellular structures, including organelles (membrane-enclosed compartments), are too small to be resolved by an LM.
- the light microscope cannot resolve detail finer than about 0.2 micrometer (μm), or 200 nanometers (nm), regardless of the magnification .

electron microscope:

- focuses a beam of electrones through the specimen or into it's surface.
- electron beams have much shorter wavelengths than visible light used in light microscope so electron microscope has much higher resolution (resolution is inversely related to the wavelength)
- practically, electron microscope can resolve structures around 2 nm.
- Two basic types of electron microscopes (EMs) are used to study subcellular structures:

Scanning electron microscopes (SEMs)

-focus a beam of electrons onto the surface of a specimen, providing images that look 3D.

-used for detailed study of the surface of the specimen.

Transmission electron microscopes (TEMs)

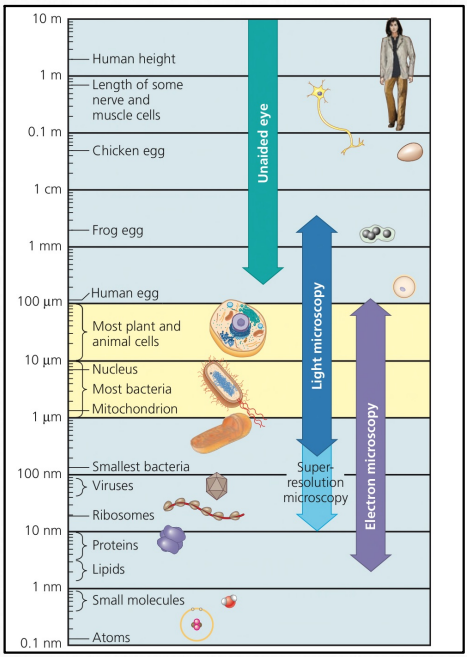
focus a beam of electrons through a specimen

-TEMs are used mainly to study the internal structure of cells.

-Advantage of light microscope: help us studying living cells .

-disadvantage of electron microscope:the methods used to prepare the specimen kill the cells

»the size range of cells



Cell fractionation: Cell fractionation is used to separate (fractionate) cell components based on size and density.

-في هذه التقنية يتم استخدام جهاز الطرد المركزي (centrifuge) الذي يحمل عدة أنابيب اختبار تحوي بداخلها مزيج من الخلايا المحطمة (disrupted cells) ويدور الجهاز على سرعات مختلفة بهدف ترسيب الكونات الخلوية على شكل راسب (pellet)

- عند السرعات المنخفضة تترسب مكونات الخلية الكبيرة.
- عند السرعات العالية تترسب مكونات الخلية الصغيرة.

Concept 7.2: Eukaryotic cells have internal membranes that compartmentalize their functions.

- cells: The basic structural and functional unit of every organism.
- types of cells:

-prokaryotic cells : bacteria and archaea.

-eukaryotic cells : protists,fungi,animals and plants.

- Basic features of all cells:

-Plasma membrane

-Semifluid substance called cytosol

-Chromosomes (carry genes)

-Ribosomes (make proteins)

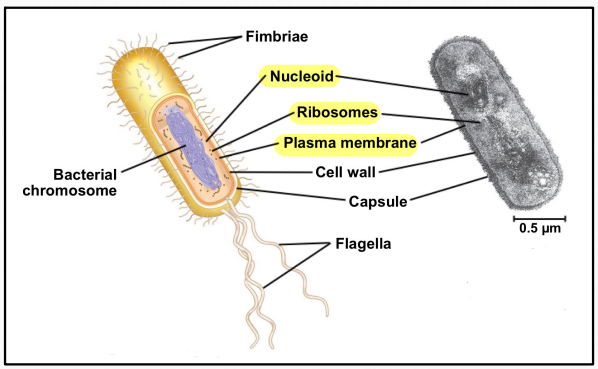
- **Prokaryotic cells** are characterized by having:

-**No nucleus**

-DNA in an unbound region called the **nucleoid**.

-No membrane-bound organelles (for example mitochondria)

-Cytoplasm bound by the plasma membrane



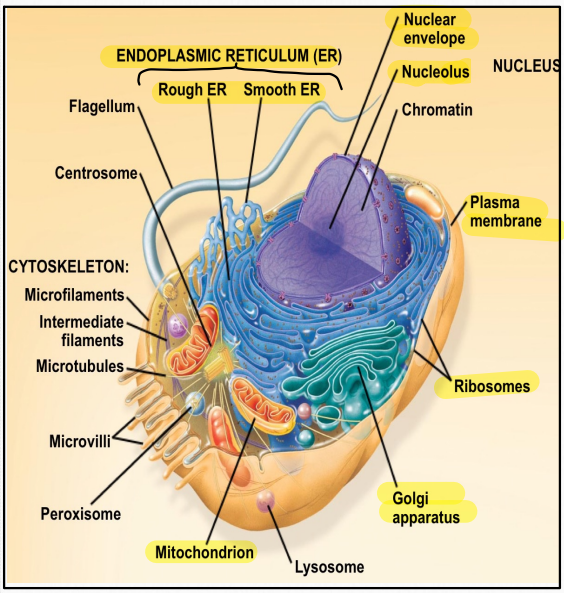
Nucleoid: the region where the cell's DNA is located (not enclosed by a membrane)

Ribosomes: complexes that synthesize proteins

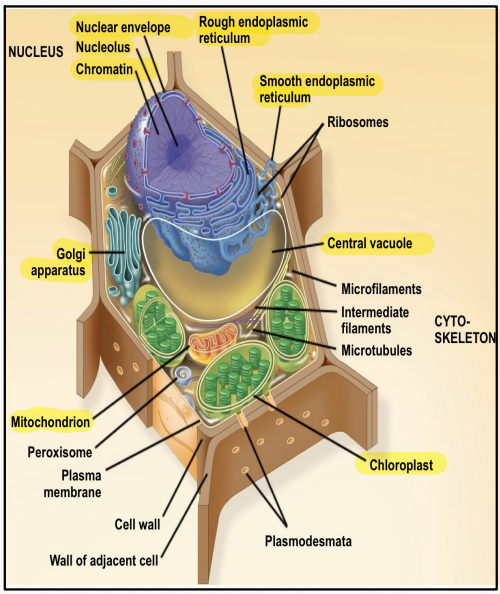
- Eukaryotic cells are characterized by having:
  -DNA in a **nucleus** that is bounded by a **membranous nuclear envelope.**
  -Membrane-bound organelles.
  -Cytoplasm in the region between the plasma membrane and nucleus.
- Eukaryotic cells are generally much larger than prokaryotic cells.

Surface area to volume ratio of cells .
-The plasma membrane is a selective barrier that allows sufficient passage of oxygen, nutrients, and waste to service the volume of every cell.
-The general structure of a biological membrane is a double layer of phospholipids.
-The general structure of a biological membrane is a double layer of phospholipids.
-The surface area to volume ratio of a cell is critical.
-As the surface area increases by a factor of n^(2), the volume increases by a factor of n^(3).
-Small cells have a greater surface area relative to volume
#for better understanding ,watch this video : https://youtu.be/uu9eHX6Tu8Q

A Panoramic View of the Eukaryotic Cell



Animal cell



Plant cell

Concept 7.3: The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes

- The nucleus contains most of the DNA in a eukaryotic cell.
- Ribosomes use the information from the DNA to make proteins.

The Nucleus: Information Central.

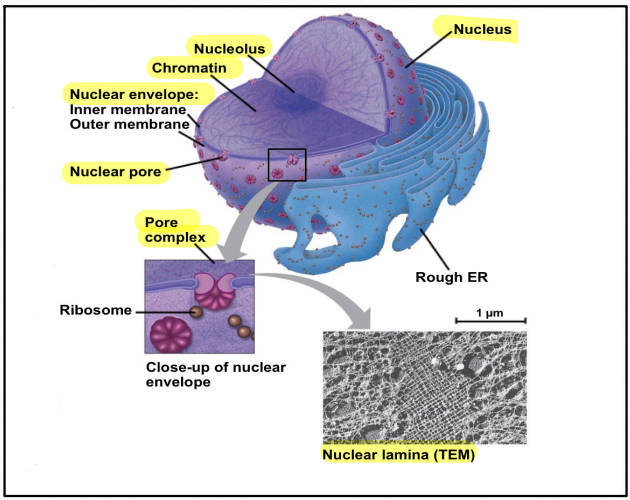
- The nucleus contains most of the cell's genes and is usually the most conspicuous organelle.
- Some genes are located in mitochondria and chloroplasts .
- The **nuclear envelope** is a double membrane encloses the nucleus, separating it from the cytoplasm.

-each membrane is a lipid bilayer.

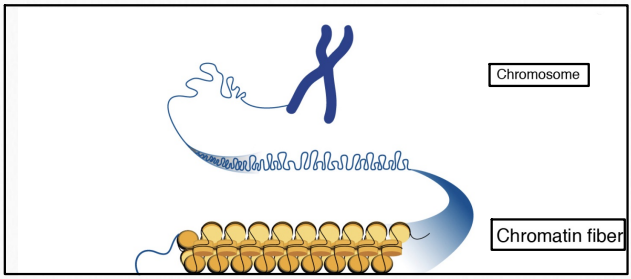
-the two membranes are separated by a space.

-The envelope is perforated by **pore structures** that regulate the entry and exit of molecules from the nucleus.

- Except at the pores, the nuclear side of the envelope is lined by the **nuclear lamina**, a netlike group of protein filaments that maintains the shape of the nucleus by mechanically supporting the nuclear envelope.



- Within the nucleus, the DNA is organized into separated units called **chromosomes**.
- Each chromosome contains one long DNA molecule associated with many proteins.
- These proteins help coil the DNA molecule reducing its length and allowing it to fit into the nucleus.
- The complex of DNA and proteins making up chromosomes is called **chromatin.**
- When a cell is not dividing, chromatin appears as a diffuse mass , and the chromosomes cannot be distinguished from one another, even though separated chromosomes are present.
- As a cell prepares to divide, the chromosomes coil (condense) further, becoming thick enough to be distinguished as separate structures



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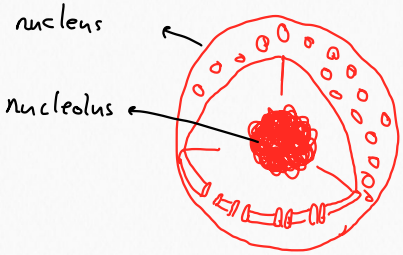
* Nucleolus :

- It is a prominent structure within the nondividing nucleus .
- **fuction:synthesis of ribosomal subunits** (ribosomal subunits are composed of ribosomal RNA and protein ,the ribosomal RNA is synthesyzed within the nucleus and the proteins are imported from the cytoplasm and assembled with rRNA within the nuleolus to form small and large ribosomal subunits)

for better understanding watch this video : https://youtu.be/0JFGg_C4fTM



Ribosomes (protein factories)

- Ribosomes are particles made of ribosomal RNA and protein.
- Ribosomes carry out protein synthesis in two locations:

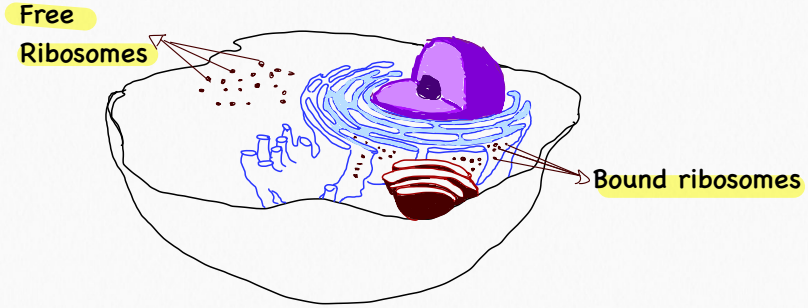
1-In the cytosol (free ribosomes)

-they are located in the cytosol

-Responsible for producing the proteins that will remain in the cytosol and function there

2-On the outside of the endoplasmic reticulum or the nuclear envelope (bound ribosomes)

-These ribosomes are connected to the endoplasmic reticulum or the nuclear envelope and are responsible for producing proteins that will be part of the cell membrane or the membranes of cellular organelles as well as producing proteins that will be excreted outside the cell, such as the insulin protein in the pancreas.



Concept 7.4: The endomembrane system regulates protein traffic and performs metabolic functions in the cell.

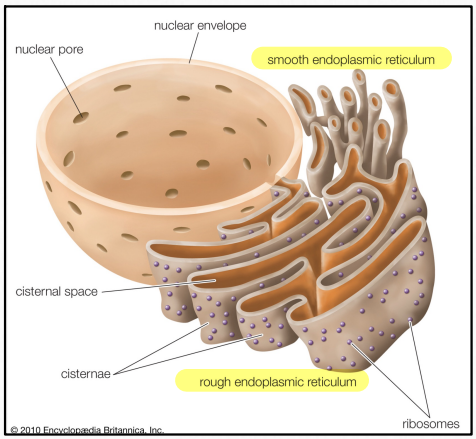
- Components of the endomembrane system:

-Nuclear envelope
-Endoplasmic reticulum
-Golgi apparatus
-Lysosomes
-Vacuoles
-Plasma membrane

- These components are either continuous or connected via transfer by vesicles.
- the thickness,molecular composition,and types of chemical reactions carried out in a given membrane are not fixed ,but may be modified several times during the membrane's life.

The Endoplasmic Reticulum: Biosynthetic Factory

- The endoplasmic reticulum (ER) , is a continuous membranous system that forms a Series of flattened sacs within the cytoplasm and usually constitutes more than half of the membranous content of the cell.
- All eukaryotic cells contain an endoplasmic reticulum.
- There are two distinct regions of ER:
  -**Smooth ER,** which lacks ribosomes.
  -**Rough ER,** with ribosomes on its surface.



Functions of Smooth ER:

- Synthesizes lipids(oils, steroids and new membrane phospholipids)
- Metabolizes carbohydrates(breaking carbohydrates to form simpler sugars ,or using simple sugers to produce carbohydrates and store them)
- Detoxifies poison(get rid of toxic substances in drugs for example)
- Stores calcium.

Functions of rough ER:

- Synthesize proteins that would be secreted out of the cell (secretory proteins)

»these proteins may be bounded to carbohydrates then we call them **glycoproteins.**

»Secretory proteins leave the ER enveloped in the membranes of **transport vesicles** that bud from specialized region called transitional ER.

- makes its own proteins and phospholipids.

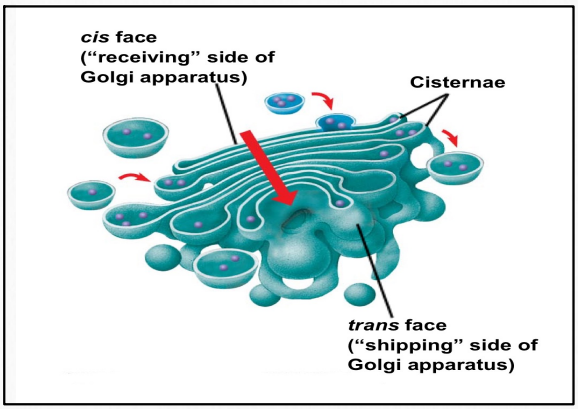
The Golgi Apparatus: Shipping and Receiving Center.

- The Golgi apparatus consists of flattened membranous sacs called **cisternae**.
- Unlike the ER cisternae, these sacs are not physically connected.
- A Golgi stack has a structural and functional **directionality**, with a **cis face** that **receives vesicles containing ER products** and a **trans face** that sends vesicles to several distinctions.
- Functions of the Golgi apparatus:

-modifies and stores products of the ER, such as proteins, and then sends them to other destinations(also lipids can be modified)

-Manufactures certain macromolecules such as polysaccharides.

-Sorts and packages materials into transport vesicles.



Lysosomes: Digestive Compartments

- A **lysosome** is a membranous sac of hydrolytic enzymes (digestive enzymes) that can digest macromolecules
- Lysosomal enzymes can hydrolyze proteins, fats, polysaccharides, and nucleic acids.

-we have two intracellular digestion process:

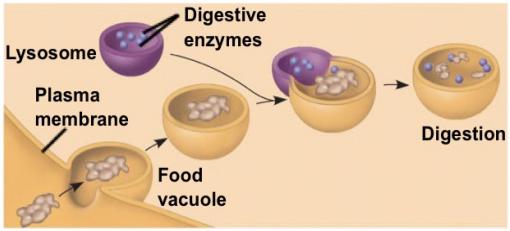
A.phagocytosis : engulfing smaller organisms,food particles and sometimes other cells forming **food vacuoles** .

-A lysosome fuses with the food vacuole and digests the molecules.

B.Autophagy : recycling the cell's own organelles and macromolecules.

-lysosomes digest cell's own organells to produce smaller nutrients and building blocks.

» digestion products,including simple sugers ,amino acids,and other monomers, pass into the cytosol and become nutrients for the cell.



(a) Phagocytosis (b) Autophagy

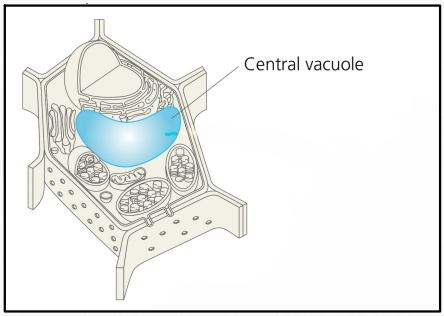
Vacuoles: Diverse Maintenance Compartments

- A plant cell or fungal cell may have one or several vacuols .

-**Food vacuoles** are formed by phagocytosis.

-**Contractile vacuoles**, found in many freshwater protists, pump excess water out of cells.

-**Central vacuoles**, found in many mature plant cells, hold organic compounds and water



Concept 7.5: 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.
- Mitochondria and chloroplasts

-Are not part of the endomembrane system

-Have a double membrane

-Have proteins made by free ribosomes

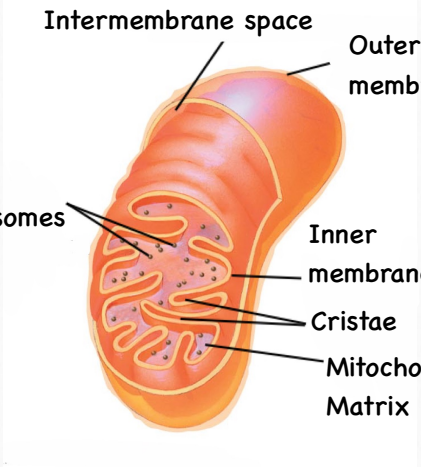
-Contain their own DNA

Mitochondria: Chemical Energy Conversion

- Mitochondria found almost in all eukaryotic cells
- They have a smooth outer membrane and an inner membrane folded into **cristae (foldings made by the inner mitochondrial membrane providing a large surface area to make cellular respiration more efficient)**
- The inner membrane divides the mitochondrion into two internal compartments:

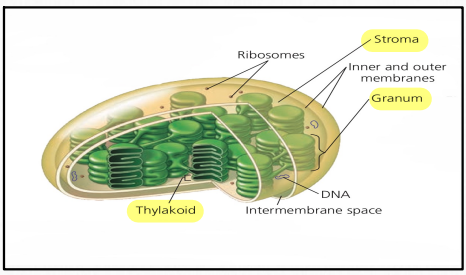
-intermembrane space: narrow region between the inner and outer membranes

-mitochondrial matrix: enclosed by the inner membrane contains respiratory enzymes



Chloroplasts: Capture of Light Energy

- 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 contents of a chloroplast are surrounded by an envelope consisting of two membranes separated by a very narrow intermembrane space.
- Inside the chloroplast is another membranous system in the form of flattened, interconnected sacs called **thylakoids**.
- In some regions, thylakoids are stacked ,each stack is called **granum**.
- The fluid outside the thylakoids is the **stroma**, which contains the chloroplast DNA and ribosomes as well as many enzymes.

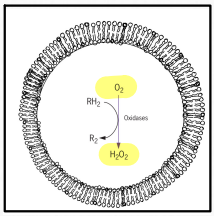


Peroxisomes: Oxidation

- Peroxisomes are specialized metabolic compartments bounded by a single membrane.
- Function: contain enzymes that remove hydrogen atoms from various substrates and transfer them to oxygen (O_2), producing hydrogen peroxide (H_2O_2) as a by-product.
- importance of this reaction :

-breaking fatty acids down into smaller molecules .

-detoxification of alcohol and other harmful molecules in the liver.



The main reaction in the peroxisome

Concept 7.6 : 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, anchoring many organelles.
- It is composed of three types of molecular structures:

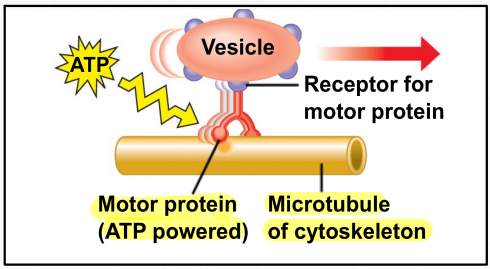
-Microtubules

-Microfilaments

-Intermediate filaments

Roles of the Cytoskeleton: Support, Motility, and Regulation

- The cytoskeleton helps to support the cell and maintain its shape
- It interacts with motor proteins to produce **motility** (motility here means either the movement of the cell itself or movement of some cellular parts (for example:vesicles) from one place to another inside the cell)
- Inside the cell, vesicles can travel along tracks provided by the microtubules of the cytoskeleton.



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

1-Microtubules:

- Microtubules are hollow rods about 25 nm in diameter and about 200 nm to 25 microns long.
- Functions of microtubules:

-Maintenance of cell shape

-Guiding movement of organelles

-Separating chromosomes during cell division

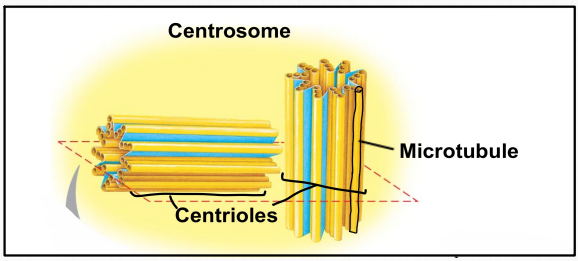
- **Centrosomes and Centrioles**

-In many cells, microtubules grow out from a centrosome near the nucleus

-The **centrosome** is a "microtubule-organizing center"

-In animal cells, the centrosome has a pair of centrioles, each with nine triplets of microtubules arranged in a ring.

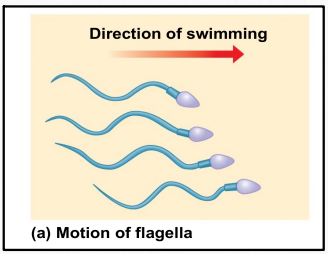
Note:plant cells don't have centrosomes or centrioles

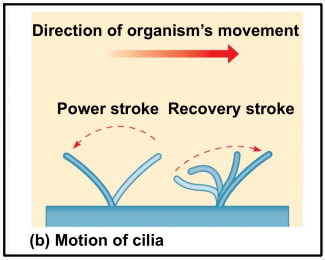


- **Cilia and Flagella**

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

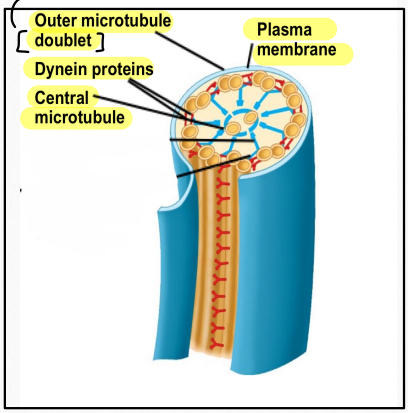
-Cilia and flagella differ in their beating patterns.



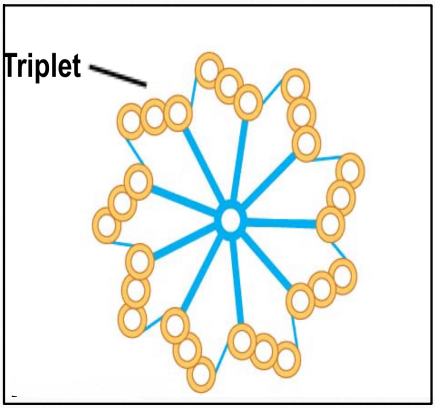


• Cilia and flagella share a common ultrastructure:

- a core of microtubules sheathed by the plasma membrane
- a basal body that anchors the cilium or flagellum
- a motor protein called dynein (powered by ATP) which drives the bending movements of a cilium or flagellum



cilium



Cross section of basal body

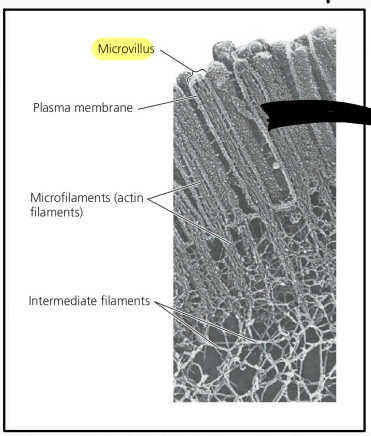
2-Microfilaments (Actin Filaments)

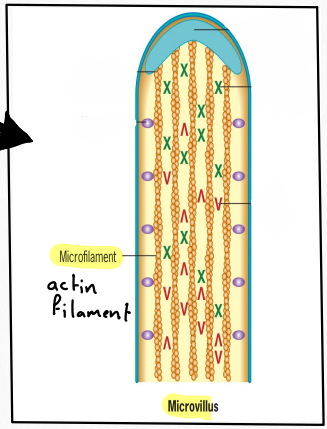
• Microfilaments are solid rods about 7 nm in diameter, built as a twisted double chain of actin subunits.

• The structural role of microfilaments is to bear tension, resisting pulling forces within the cell.

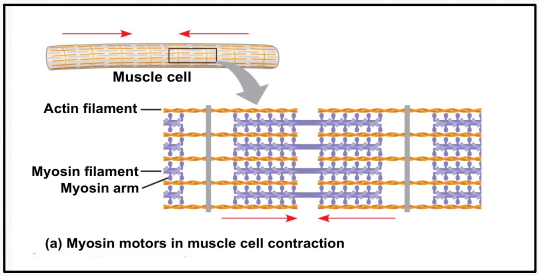
• They form a 3-D network called the cortex just inside the plasma membrane to help support the cell's shape.

• Bundles of microfilaments make up the core of microvilli of intestinal 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.



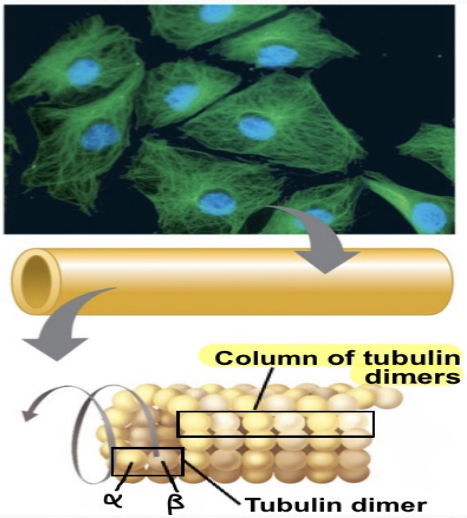
3-Intermediate Filaments.

- 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.

Important summary

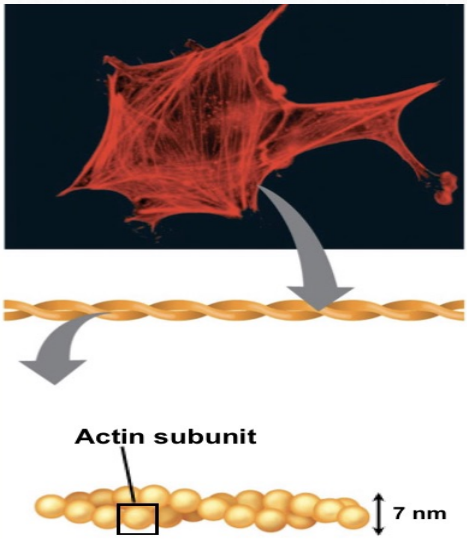
Microtubules

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



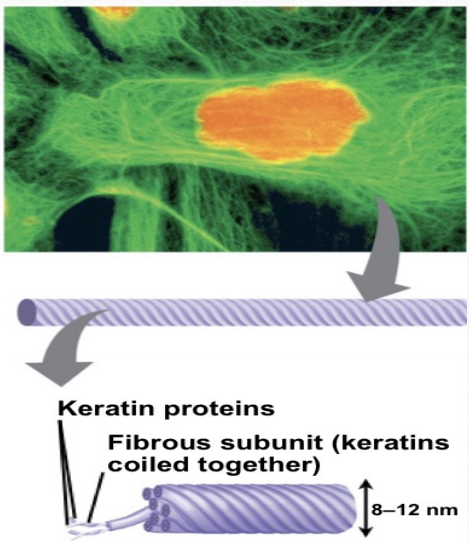
Microfilaments

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



Intermediate filaments

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



Concept 7.7: 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

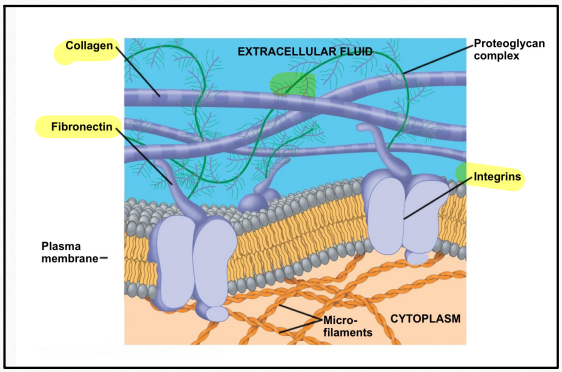
Cell Walls of Plants:

- The cell wall is an extracellular structure that distinguishes plant cells from animal cells.
- Prokaryotes, fungi, and some protists also have cell walls.
- The cell wall protects the plant cell, maintains its shape, and prevents excessive uptake of water.
- Plant cell walls are made of cellulose fibers embedded in other polysaccharides and protein

The 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.**
- Functions of the ECM:

-Support
-Adhesion
-Movement
-Regulation



Intercellular Junctions

- 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
-Tight junctions
-Desmosomes
-Gap junctions

- 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.
- At tight junctions, membranes of neighboring cells are pressed together, preventing leakage of extracellular fluid.
- Desmosomes (anchoring junctions) fasten cells together into strong sheets
- Gap junctions (communicating junctions) provide cytoplasmic channels between adjacent cells.