Cell biology

Cell biology is a branch of biology that studies the structure and function of the cell, which is the basic unit of life. Cell biology is concerned with the physiological properties, metabolic processes, signaling pathways, life cycle, chemical composition and interactions of the cell with their environment. This is done both on a microscopic and molecular level as it encompasses prokaryotic cells and eukaryotic cells. Knowing the components of cells and how cells work is fundamental to all biological sciences; it is also essential for research in biomedical fields such as cancer, and other diseases. Research in cell biology is closely related to genetics, biochemistry, molecular biology, immunology, and developmental biology.

The cell

A cell is a mass of cytoplasm that is bound externally by a cell membrane. Usually microscopic in size, cells are the smallest structural units of living matter and compose all living things. Most cells have one or more nuclei and other organelles that carry out a variety of tasks. Some single cells are complete organisms, such as a bacterium or yeast. Others are specialized building blocks of multicellular organisms, such as plants and animals.

History

a. The cell was not known when the scientist Antoine Van Leeuwenhoek invented the microscope; he could be the first to see the cell.

b. The English scientist Robert Hooke is the first to use the word (cell) when he examined the structure of oak tree cortex. He described corky units and defined the cell as aerobic chamber similar to bee hive.

c. The Scottish scientist Robert Brown discovered the nucleus of the cell and described it.

d. The German scientist Matthias Schleiden concluded that all plants consist of cells.

e. The German Scientist Theodor Schwann concluded that all animals consist of cells.

Cell theory and its states

Cell theory states that the cell is the fundamental structural and functional unit of living matter. In 1839 German physiologist Theodor Schwann and German botanist Matthias Schleiden promulgated that cells are the "elementary particles of organisms" in both plants and animals and recognized that some organisms are unicellular and others multicellular. This theory marked a great conceptual advance in biology and resulted in renewed attention to the living processes that go on in cells.

The cell theory is mainly based on the work of both M. Schleiden and T. Schwann, which can be briefed as follows:

a- All organisms are made of cell or cells.

b- Cells are the basic structural and functional units of all organisms.

c- One cell come from another cell by means of cell division.

Cell size

Cells vary in size, the diameter of frog"s egg is 1mm it can be seen by the naked eye. Human egg is 100 micrometer or less. Cells can be seen by light microscope, but inner components of the cell like organelles, viruses and organic particles can only be seen by the electron microscope.

Prokaryotic cell

It is undeveloped cell, it is more primitive in structure, and it is characterized by having a genetic material without a membrane and it"s called nucleoid, the cytoplasm of prokaryotic cell has no membranous organelles like Golgi bodies and mitochondria, it is represented by blue green algae, bacteria and Mycoplasma.

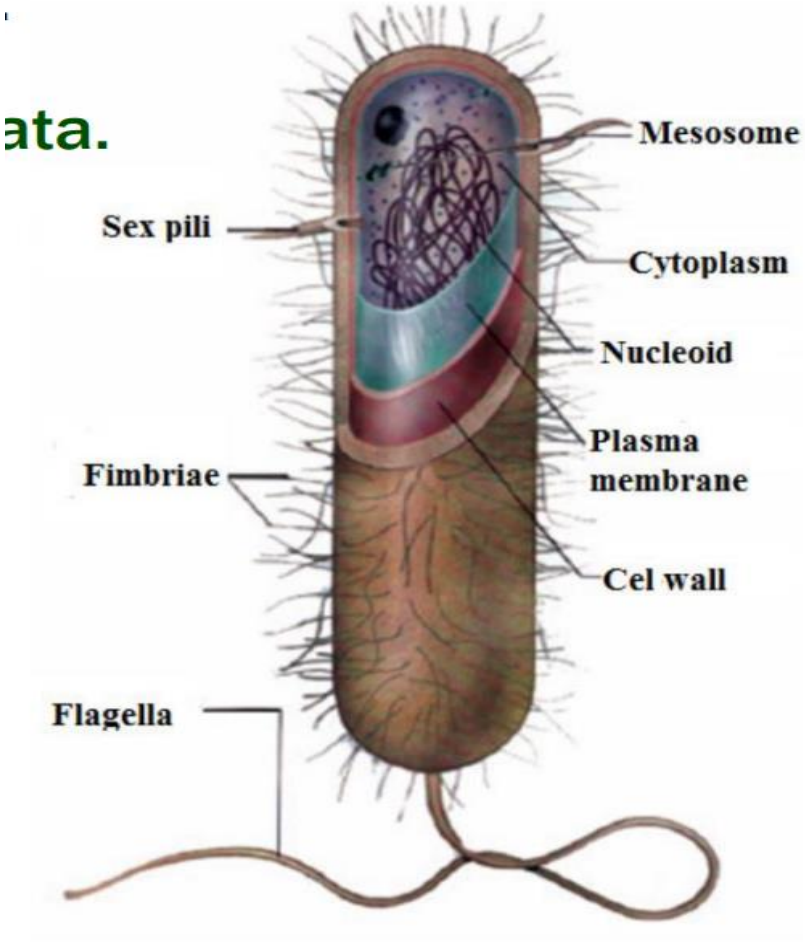
Characteristics of the prokaryotic cells

a. Prokaryotic cell has genetic material without a membrane and it is called as nucleus zone or Nucleoid.

b. Prokaryotic cell cytoplasm has no membranous organelles like Golgi bodies and mitochondria, yet. It has ribosome in the form of numerous small grains, which build proteins.

c. Prokaryotic cell is represented by blue green algae, bacteria and Mycoplasma which all belong to Monera.

The difference between bacteria and blue green algae, Bacteria have no chlorophyll pigment and cell wall of bacteria is surrounded by capsule while blue green algae cell wall is surrounded by gelatin membrane.



Eukaryotic cell

It is the cell that has a true nucleus and it is found in Protists, Fungi, Plants and Animals, eukaryotic cells differ in shape and some of these cells have varying shape, they change from time to time like amoeba and this change in shape is due to function of these cells because cells often have shapes that adapt the functions.

Some of eukaryotic cells have varying shape, they change from time to time, this change in shape is due to function of these cells because cells often have shapes that adapt the functions. Eukaryotic cells need surface area (plasma membrane), to exchange materials with surrounding environment appropriately.

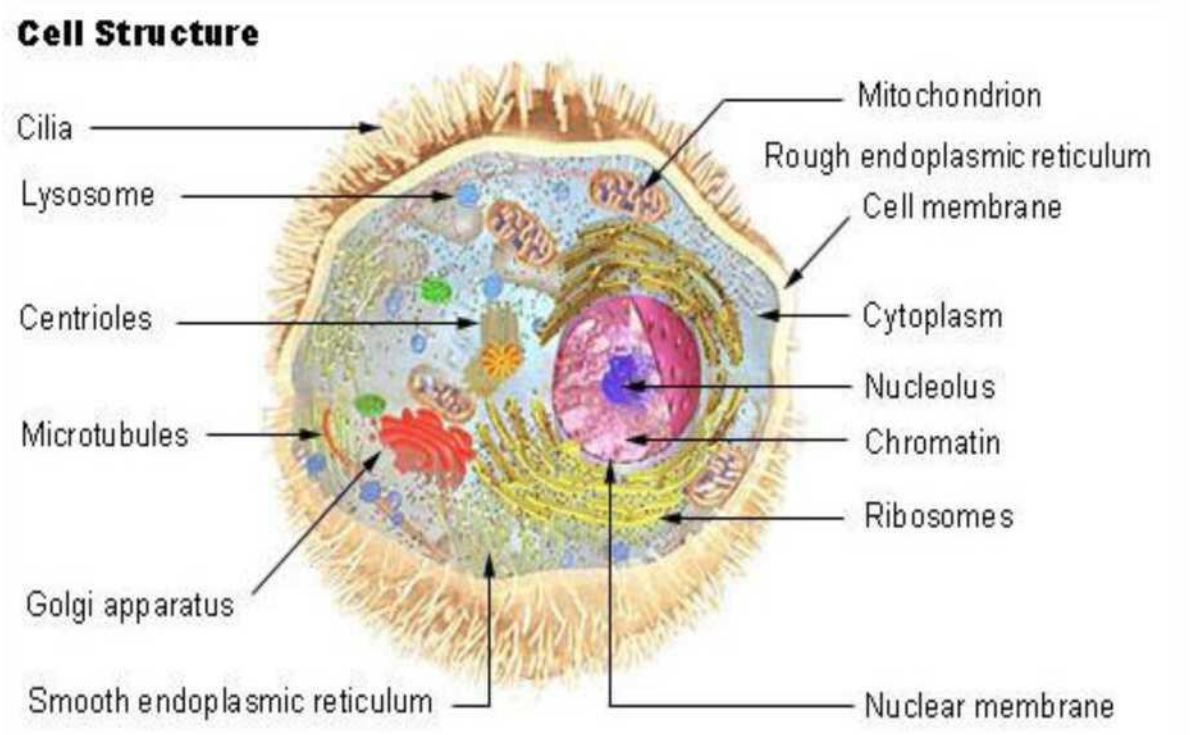


Figure 1 : The generalized structure and molecular components of a cell

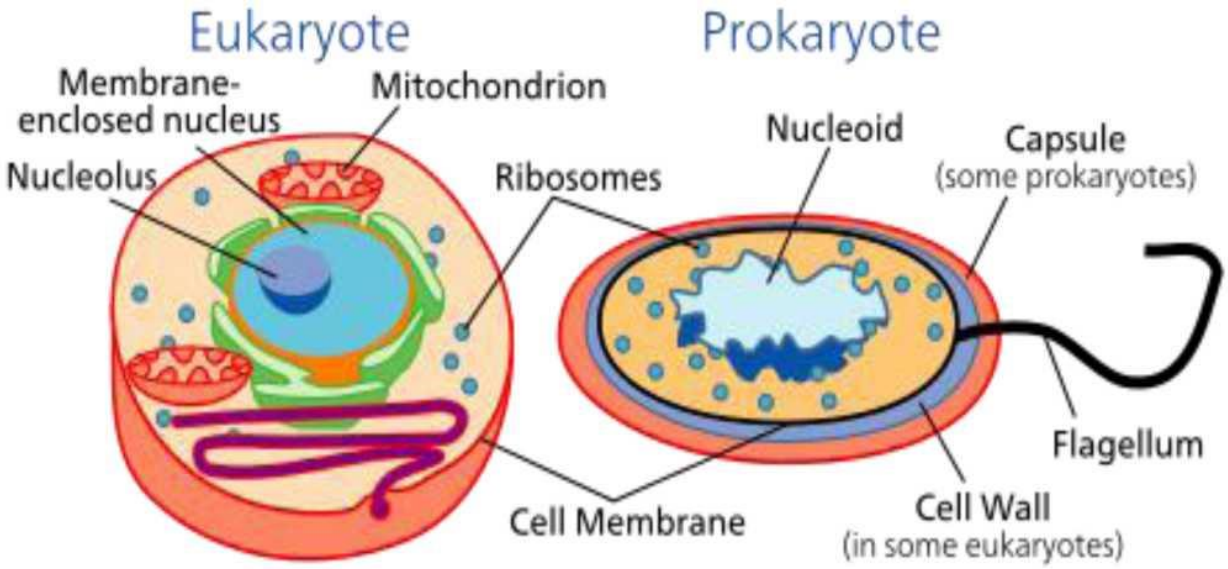


Figure 2: Eukaryotic and Prokaryotic Cell

There are two fundamental classifications of cells: prokaryotes and eukaryotes.

The major difference between the two is the presence and/or absence of organelles. Other factors such as size, the way in which they reproduce, and the number of cells distinguish them from one another. Eukaryotic cells include animal, plant, fungi, and protozoa cells which all have a nucleus enclosed by a membrane, with various shapes and sizes. Prokaryotic cells, lacking an enclosed nucleus, include bacteria and archaea. Prokaryotic cells are much smaller than eukaryotic cells, making prokaryotic cells the smallest form of life. Cytologists typically focus on eukaryotic cells whereas prokaryotic cells are the focus of microbiologists, but this is not always the case.

Characteristic	Prokaryotes	Eukaryotes
Size of cell	Typically 0.2-2.0 m m in diameter	Typically 10-100 m m in diameter
Nucleus	No nuclear membrane or nucleoli (nucleoid)	True nucleus, consisting of nuclear membrane & nucleoli
Membrane-enclosed organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria & chloroplasts
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Glycocalyx	Present as a capsule or slime layer	Present in some cells that lack a cell wall
Cell wall	Usually present; chemically complex(typical bacterial cell wall includes peptidoglycan)	When present, chemically simple
Plasma membrane	No carbohydrates and generally lacks sterols	Sterols and carbohydrates that serve as receptors present

Cytoplasm	No cytosketeton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); smaller size(70S) in organelles
Chromosome (DNA)	Single circular chromosome;	Multiple linear chromosomes
arrangement	lacks histones	with histones
Cell division	Binary fission	Mitosis
Sexual reproduction	No meiosis; transfer of DNA fragments only (conjugation)	Involves Meiosis

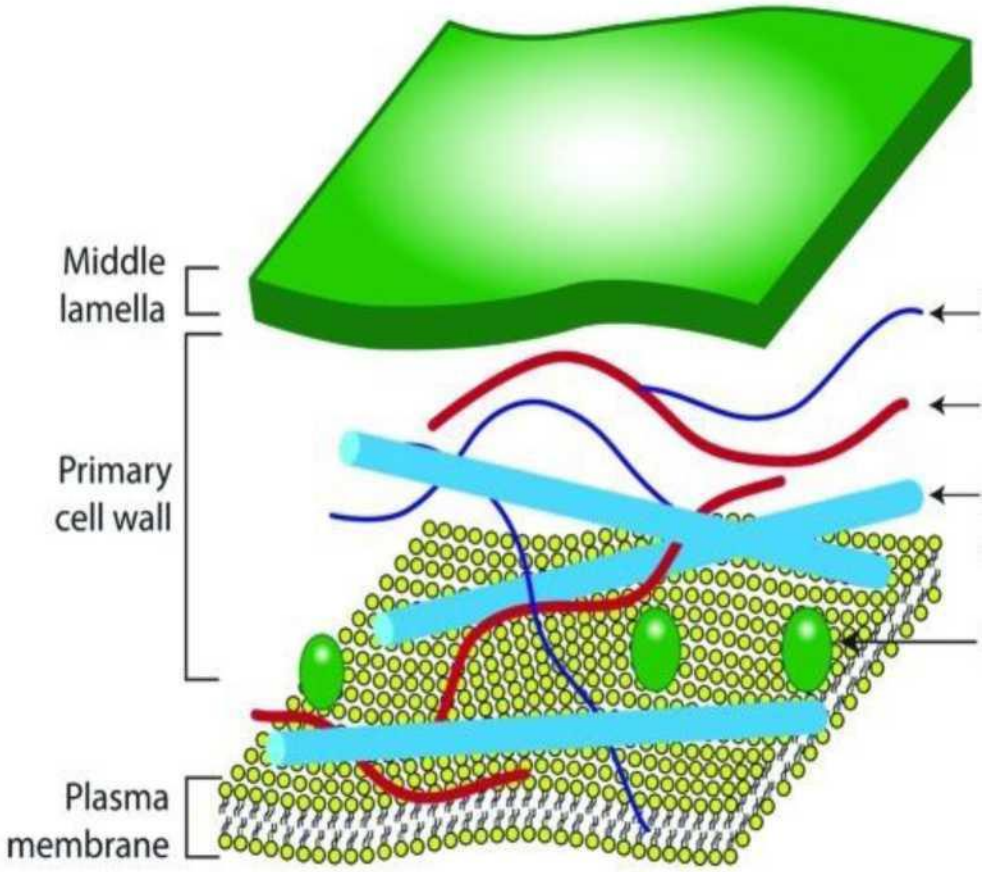
Cell structure

Cell wall

Cell wall exists only in plant cells, it is an outer thick wall surrounding the cell, and it covers the plasma membrane which is inside. Cell wall provides protection and support to plasma membrane and cytoplasm.

The Structure and Function of a Cell Wall

A cell wall is a rigid, semi-permeable protective layer in some cell types. This outer covering is positioned next to the cell membrane (plasma membrane) in most plant cells, fungi, bacteria, algae, and some archaea. Animal cells however, do not have a cell wall. The cell wall has many important functions in a cell including protection, structure, and support. Cell wall composition varies depending on the organism. In plants, the cell wall is composed mainly of strong fibers of the carbohydrate polymer cellulose. Cellulose is the major component of cotton fiber and wood, and it is used in paper production. Bacterial cell walls are composed of a sugar and amino acid polymer called peptidoglycan. The main components of fungal cell walls are chitin, glucans, and proteins.



Plant Cell Wall Structure

The plant cell wall is multi-layered and consists of up to three sections. From the outermost layer of the cell wall, these layers are identified as the middle lamella, primary cell wall, and secondary cell wall. While all plant cells have a middle lamella and primary cell wall, not all have a secondary cell wall.

Plant Cell Wall Function

A major role of the cell wall is to form a framework for the cell to prevent over expansion. Cellulose fibers, structural proteins, and other polysaccharides help to maintain the shape and form of the cell. Additional functions of the cell wall include:

• **Support:** The cell wall provides mechanical strength and support. It also controls the direction of cell growth.

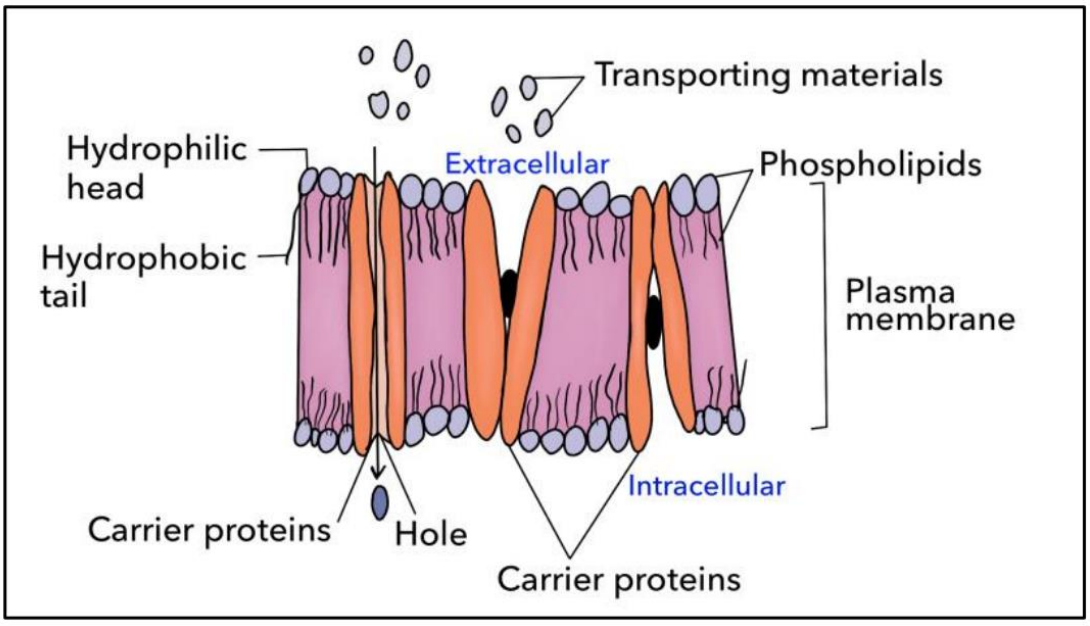
- **Withstand turgor pressure:** Turgor pressure is the force exerted against the cell wall as the contents of the cell push the plasma membrane against the cell wall. This pressure helps a plant to remain rigid and erect, but can also cause a cell to rupture.
- **Regulate growth:** The cell wall sends signals for the cell to enter the cell cyclein order to divide and grow.
- **Regulate diffusion:** The cell wall is porous allowing some substances, including proteins, to pass into the cell while keeping other substances out.
- **Communication:** Cells communicate with one another via plasmodesmata (pores or channels between plant cell walls that allow molecules and communication signals to pass between individual plant cells).
- **Protection:** The cell wall provides a barrier to protect against plant viruses and other pathogens. It also helps to prevent water loss.
- **Storage:** The cell wall stores carbohydrates for use in plant growth, especially in seeds.

Plasma membrane

Introduction

Every cell, prokaryotic or eukaryotic, is surrounded by a thin layer of outermost boundary called the plasma membrane or cell membrane or plasma - lemma. The plasma membrane is a discrete structure and is remarkably complex in its molecular organization. It maintains the difference of the internal environment of the cell from its external environment by controlling the entrance and exit of the molecules and ions. It checks the loss of metabolically useful substances and encourages the release of toxic metabolic byproducts of the cell. Thus, it functions as semi-permeable or selectively permeable membrane. It is about 70-100Å in thickness. In plant cells plasma lemma is further covered by cellulosic cell wall.

It is an important cell organelle composed of lipids and proteins. It possesses devices for attachment to other cells for cell-to-cell communications, ion pumps for controlling internal milieu of the cell, receptors for hormones and mechanisms for the production of secondary messengers that activates the cell's physiological response.



History

It had been shown by Karl W. Nageli (1817-1891) that the cell membrane is semipermeable and is responsible for the osmotic and other related phenomena

exhibited by living cells. Before 1855, he used the term zellen membrane in his early papers. The term plasma membrane was used in 1855 by him to describe the membrane as a firm protective film that is formed by out flowing cytoplasm of an injured cell when protein rich cell sap came in contact with water.

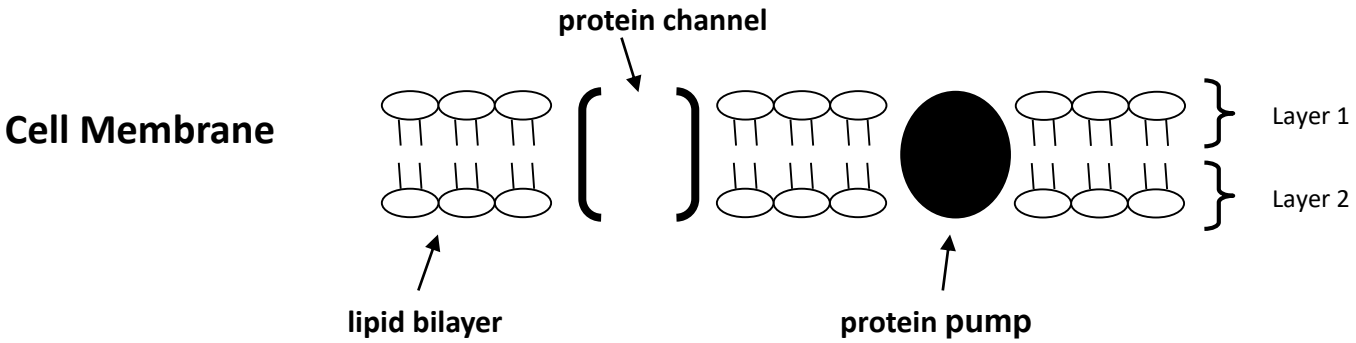
Chemical composition and membrane structure

Plasma membrane is primarily composed of protein and lipid, although carbohydrate is often present in association with protein (as However, the relative proportions of protein and lipid vary considerably in membranes from different sources.

Most current knowledge about the biochemical constituents of cell membranes originates in studies of red blood cells. The chief advantage of these cells for experimental purposes is that they may be obtained easily in large amounts and that they have no internal membranous organelles to interfere with study of their cell membranes. Membranes actively involved in metabolism contain a higher proportion of protein; thus, the membrane of the mitochondrion, the most rapidly metabolizing organelle of the cell, contains as much as 75 percent protein, while the membrane of the Schwann cell, which forms an insulating sheath around many nerve cells, has as little as 20 percent protein.

Cell Membrane aka "The Phospholipid Bilayer"

- **ALL** cells have a **cell membrane** made of **Phosphate, proteins,** and **lipids**
- **That's why it's called the Phospholipid Bilayer**



All Cells have a cell (plasma membrane):

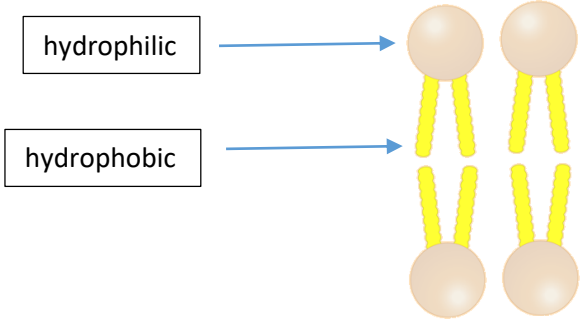
- **Prokaryotes (have a cell wall + cell membrane)**
- **Eukaryotes:**
  - **a) Animal Cells (cell membrane only)**
  - **b) Plant cells (cell membrane + cell wall)**

Cell Membrane Lipids

The plasma membrane contains about 20 to 79% lipids mainly of three types like phospholipids, cholesterol and glycolipids. The phospholipids which make up between 55% and 75% of the total lipid content, consists chiefly of lecithin and cephalin.

The outer layer of phospholipids consists mainly of lecithin and sphingomyeline, while the inner layer is composed mainly of phosphatidyl ethanolamine and phosphatidyl serine (both are phosphoglycerides). The glycolipids (sugar containing lipids) are mainly in the outer half of the bilayer.

Phospholipids are a major component of cell membranes. Phospholipids form a lipid bilayer in which their hydrophilic (attracted to water) head areas spontaneously arrange to face the aqueous cytosol and the extracellular fluid, while their hydrophobic (repelled by water) tail areas face away from the cytosol and extracellular fluid. The lipid bilayer is semi-permeable, allowing only certain molecules to diffuse across the membrane.



Cholesterol is another lipid component of animal cell membranes. Cholesterol molecules are selectively dispersed between membrane phospholipids. This helps to keep cell membranes from becoming stiff by preventing phospholipids from being too closely packed together. Cholesterol is not found in the membranes of plant cells.

Glycolipids are located on cell membrane surfaces and have a carbohydrate sugar chain attached to them. They help the cell to recognize other cells of the body.

Membrane lipids are amphipathic molecules. They contain both a hydrophobic and hydrophilic moiety. Hydrophilic unit is also called the polar head groups, is represented by a circle and their hydrocarbon tails are depicted by straight or wavy lines. Polar head groups.

- A single **phospholipid** has ***hydrophilic*** (water loving) *phosphate heads* AND ***hydrophobic*** (water hating) *fatty acid tails*
- The cell membrane both repels and attracts water through the membrane at the same time

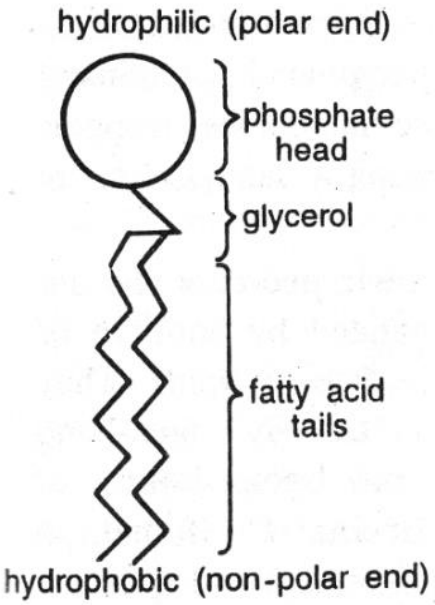


Fig.2. 4: A phospholipids molecule

Cell Membrane Proteins

Proteins are the main component of plasma membrane. It is composed of about 80% lipids and 20% protein and. The cell membrane contains two types of associated proteins.

Peripheral membrane proteins are exterior to and connected to the membrane by interactions with other proteins.

Integral membrane proteins are inserted into the membrane and most pass through the membrane. Portions of these transmembrane proteins are exposed on both sides of the membrane. Cell membrane proteins have a number of different functions.

Types of membrane proteins that serve various functions:

1- Channel proteins: Proteins that provide passageways through the membranes for certain hydrophilic or water-soluble substances such as polar and charged molecules. No energy is used during transport, hence this type of movement by Channel proteins is called facilitated diffusion.
2- Transport proteins: Proteins that spend energy (ATP) to transfer materials across the membrane by the process is called active transport.
3- Recognition proteins: Proteins that distinguish the identity of neighboring cells. These proteins have oligosaccharide or short polysaccharide chains extending out from their cell surface.
4- Adhesion proteins: Proteins that attach cells to neighboring cells or provide anchors for the internal filaments and tubules that give stability to the cell.
5- Receptor proteins: Proteins that initiate specific cell responses for hormones or other trigger molecules bind to them.
6- Electron transfer proteins: Proteins that are involved in moving electrons from one molecule to another during chemical reactions.

Carbohydrates

The membranes of eukaryotic cells usually contain 2% to 10% carbohydrates in the form of glycolipids and glycoproteins. Hexose, hexosamine, fucose and sialic acid are the commonest carbohydrates found in the membrane. Plasma membranes of neuronal surface contain gangliosides and are probably involved in the ion transfers. The distribution of oligosaccharides is also highly asymmetrical.

Salts and water

They are also present in cell membranes. Water in cell membranes forms parts of membrane structure as it does in all cell constituents.

Functions of Cell membrane:

(a) Transportation of different materials inside and outside the cell,

(b) Absorption of different substances (mainly nutrients) from outside the cell,

(c) Protection of the cell body and giving the cell a definite shape.

(d) It separates the contents of the cell from its outside environment and it regulates what enters and exits the cell.

(e) It plays a vital role in protecting the integrity of the interior of the cell by allowing only selected substances into the cell and keeping other substances out.

The Cell Membrane & Homeostasis

- The cell membrane is responsible for maintaining homeostasis (home-E-O-Stay-sis) within the cell
- Homeostasis is a stable, internal environment
- The cell membrane maintains homeostasis through balancing the pH, temperature, glucose (sugar intake), water balance
- It does this through active and passive transport

PH and homeostasis

- The pH of a solution tells how acidic or basic it is. pH ranges from a scale to 0-14
- Solutions with a pH from 0-6 are acidic
- Solutions with a pH of 8-14 are basic
- Solutions with a pH of 7 are Neutral.

If a solution’s pH is unbalanced, it is corrected with a BUFFER.

Cell membrane transport and function (lecture 3)

Cell membrane or plasma membrane is selectively permeable membrane also regarded as differentially permeable membrane or semi permeable membrane, because is allow some molecules pass through it while prevent other molecule from passing.

غشاء الخلية أو غشاء البلازمي هو غشاء منفذ بشكل انتقائي ويعتبر أيضًا غشاءًا منفذًا تفاضليًا أو غشاء شبه منفذ، لأنه يسمح لبعض الجزيئات بالمرور عبره بينما يمنع جزيء آخر من المرور.

Permeable molecules to the cell membrane include: small hydrophobic molecule like O2, CO2, N2 and benzene. And small uncharged polar molecules like water, glycerol and ethanol.

تشمل الجزيئات المنفذة لغشاء الخلية ما يلي: جزيء صغير كاره للماء مثل O2 و CO2 و N2 والبنزين. والجزيئات القطبية الصغيرة غير المشحونة مثل الماء والجلسرين والإيثانول.

Non permeable molecules to the cell membrane include: large uncharged polar molecules like sugar, amino acids. And Ions like H+, Na+, K+, Cl^-, Ca++, Mg++, $HCO3^-$.

تشمل الجزيئات غير المنفذة لغشاء الخلية: الجزيئات القطبية الكبيرة غير المشحونة مثل السكر والأحماض الأمينية. والأيونات مثل+H ، +Na، +K، Cl^-، Ca++، Mg++، $HCO3^-$.

Molecules cross the plasma membrane in 2 ways:

1. **Passive ways**: no energy used. Include: simple diffusion, channel diffusion and facilitated diffusion.
2. **Active ways**: use energy. Include: active transport, endocytosis & exocytosis.

Passive ways

1. **Diffusion** is the movement of molecules from higher concentration to lower concentration until they are distributed equally for examples:

   - Gases diffuse through the lipid bilayer, this is the mechanism by which oxygen enters cells and carbon dioxide exits cells
   - Glycerol and ethanol diffuse simply through the plasma membrane.
   - Water also can diffuse through the plasma membrane by using protein channels called aquaporins. This phenomenon called osmosis.

1. **الانتشار** : هو حركة الجزيئات من التركيز الأعلى إلى التركيز الأقل حتى يتم توزيعها بالتساوي على سبيل المثال:

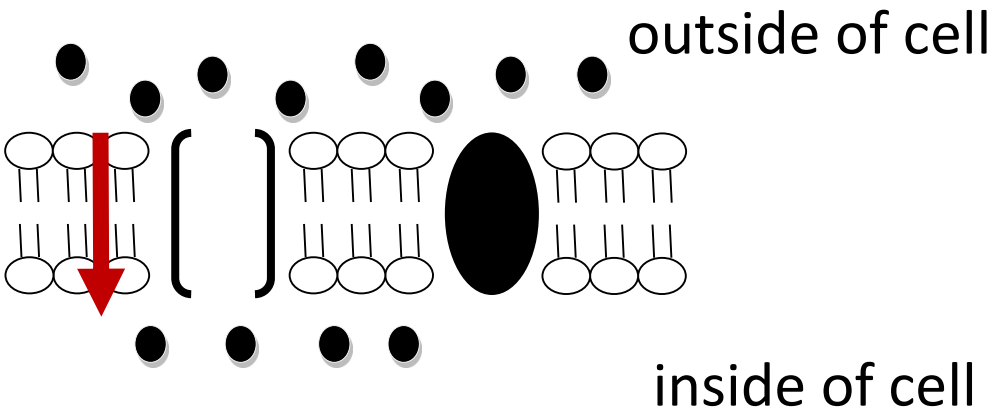
- تنتشر الغازات عبر الطبقة الدهنية الثنائية، وهذه هي الآلية التي يدخل بها الأكسجين إلى الخلايا ويخرج ثاني أكسيد الكربون من الخلايا
- ينتشر الجلسرين والإيثانول ببساطة عبر غشاء البلازمي.
- يمكن أن ينتشر الماء أيضًا عبر غشاء البلازمي باستخدام قنوات بروتينية تسمى أكوابورينات. هذه الظاهرة تسمى التناضح.

*** Simple diffusion:** this type of passive transport system doesn't use energy, used for movement of Ions (H- or Cl-) required only channel protein.

***. الانتشار البسيط :** هذا النوع من نظام النقل السلبي لا يستخدم الطاقة، ويستخدم لحركة الأيونات (H-أو Cl-)ويتطلب بروتين القناة فقط.

*** Facilitated diffusion**: is another type of passive transport system doesn't use energy but required a carrier protein assist the movement of glucose or amino acids. Each protein carrier, sometimes called a transporter, binds only to a particular molecule, such as glucose. Facilitated diffusion requires the help of carrier and channel proteins. These particles move from an area of high concentration to an area of low concentration.

***.الانتشار الميسر:** هو نوع آخر من أنظمة النقل السلبي لا يستخدم الطاقة ولكنه يحتاج إلى البروتين الحامل يساعد على حركة الجلوكوز أو الأحماض الأمينية. كل بروتين حامل، يسمى أحيانًا الناقل، يرتبط فقط بجزيء معين، مثل الجلوكوز. يتطلب الانتشار الميسر مساعدة البروتينات الناقلة والقناة. تنتقل هذه الجزيئات من منطقة ذات تركيز عالٍ إلى منطقة ذات تركيز منخفض.



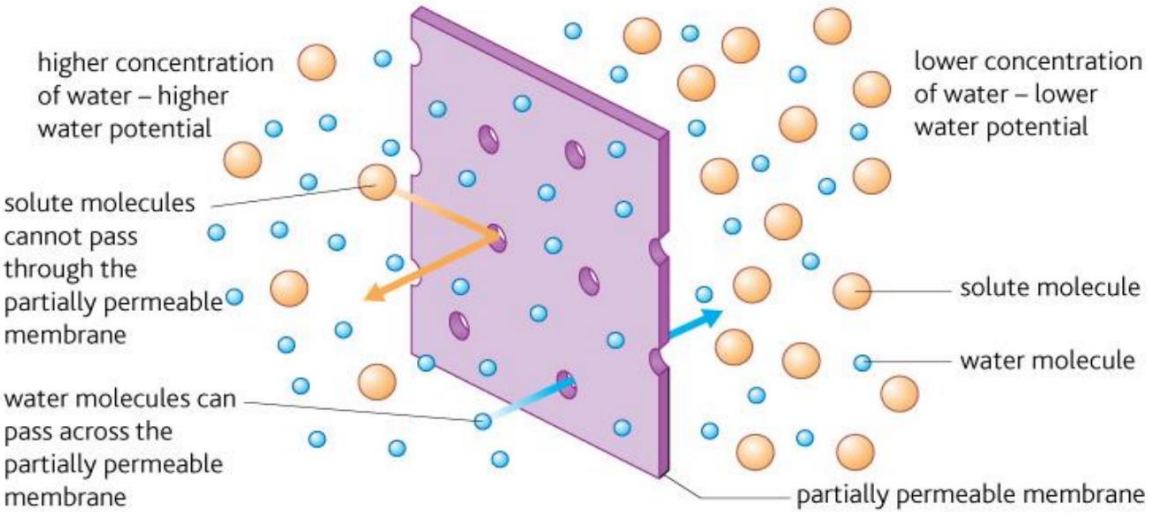
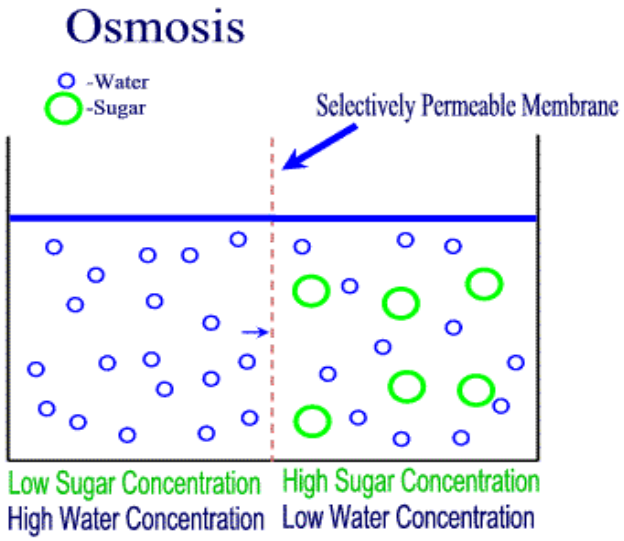


Figure5A: cell membrane permeability, simple diffusion (osmosis)

2. **Osmosis** is the movement of water molecules through semi-permeable membrane from a solution with a low solute concentration to a solution with a higher solute concentration until there is an equal solute concentration on both sides of the membrane.

2. **التناضح** هو حركة جزيئات الماء عبر غشاء شبه منفذ من محلول ذو تركيز منخفض من المذاب إلى محلول ذو تركيز أعلى من المذاب حتى يكون هناك تركيز مذاب متساوي على جانبي الغشاء.



¬ **Osmotic pressure** refers to the amount of pressure that necessary to stop the flow of water across the semi permeable membrane and is developed on the side of the membrane that has the higher solute concentration.

الضغط الأسموزي يشير إلى مقدار الضغط اللازم لوقف تدفق الماء عبر الغشاء شبه النفاذ ويتم تطويره على جانب الغشاء الذي يحتوي على تركيز أعلى من المذاب

¬ **Solution** is a homogeneous mixture of one or more substances (Solutes) dispersed molecules in a sufficient quantity of dissolving medium (solvent). e.g. on solvent distilled water and solutes sugar or salts.

المحلول هو خليط متجانس من مادة أو أكثر (المذابات) جزيئات متناثرة في كمية كافية من وسط الذوبان (المذيب). على سبيل المثال على مذيب الماء المقطر ويذوب السكر أو الأملاح.

Isotonic solution المحلول متعادل التركيز

- **Isotonic solution** refers to two solutions having the same osmotic pressure across a semi permeable membrane.

- يشير المحلول متساوي التوتر إلى محلولين لهما نفس الضغط الأسموزي عبر غشاء شبه منفذ.

- **Solution** that causes cells neither to gain nor to lose water that is the solute concentration is the same on both sides of the membrane.

- المحلول الذي يمنع الخلايا من اكتساب الماء أو فقدانه، ويكون تركيز المذاب هو نفسه على جانبي الغشاء.

- **Normal saline** solution is the most common example on isotonic solution, is containing 0.9% of sodium chloride (NaCl) is known to be isotonic to red blood cells because the cells neither swell nor shrink when placed in other solution.

- المحلول الملحي العادي هو المثال الأكثر شيوعاً على المحلول متساوي التوتر، فهو يحتوي على 0.9% من كلوريد الصوديوم (NaCl) المعروف بأنه متساوي التوتر بالنسبة لخلايا الدم الحمراء لأن الخلايا لا تنتفخ ولا تنكمش عند وضعها في محلول آخر.

Therefore, physician must put this point in his mind when giving fluid to the patients that suffering from dehydration. Use isotonic solution as intravenous fluid in medical settings.

لذلك يجب على الطبيب أن يضع هذه النقطة في ذهنه عند إعطاء السوائل للمرضى الذين يعانون من الجفاف. استخدم المحلول متساوي التوتر كسوائل في الوريد في الأماكن الطبية.

Hypertonic solution: محلول عالي التركيز

- Solutions that cause cells to shrink due to loss of water.

- المحاليل التي تسبب تقلص الخلايا بسبب فقدان الماء.

- Any concentration with a concentration higher than 0.9% sodium chloride is hypertonic to red blood cells.

•أي تركيز أعلى من 0.9% كلوريد الصوديوم يعتبر عالي التركيز لخلايا الدم الحمراء.

- E.g. concentrated salt solution

• على سبيل المثال. محلول الملح المركز

Hypotonic solution:

- Solutions that cause cells to swell or even to burst, due to an intake of water.

• المحاليل التي تسبب انتفاخ الخلايا أو حتى انفجارها نتيجة تناول الماء.

- Any concentration of salt solution lower than 0.9% is hypotonic to red blood cell E.g. distilled water.

• أي تركيز للمحلول الملحي أقل من 0.9% يعتبر واطئ التركيز لخلايا الدم الحمراء. ماء مقطرة.

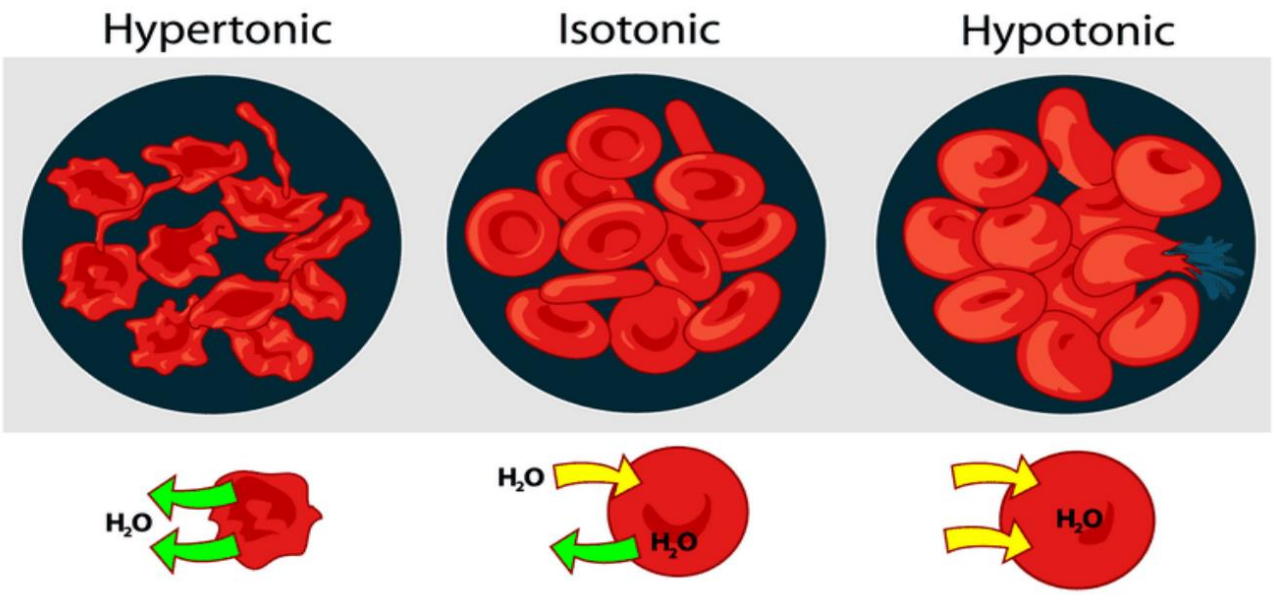


Figure5B: Osmosis in human red blood cell (RBC)

Active ways

1. **Active transport**: molecules and ions can be transported across cell membrane against their concentration gradient if the appropriate transport proteins and a source of energy (ATP) are available.

1. النقل النشط: يمكن نقل الجزيئات والأيونات عبر غشاء الخلية ضد تدرج تركيزها إذا توفرت بروتينات النقل المناسبة ومصدر الطاقة (ATP).

ATP Adenosine Triphosphate -Nucleotide with three phosphate groups.

The breakdown of ATP into ADP one phosphate molecules makes energy available for energy-requiring processes in cells.

إن تحطيم ATP إلى جزيئات فوسفات واحد مع ADP يجعل الطاقة متاحة للعمليات التي تتطلب الطاقة في الخلايا.

Proteins involved in active transport often are called pumps,

just as a water pump uses energy to move water against the force of gravity; energy is used to move substances against their concentration gradients.

مثلما تستخدم مضخة الماء الطاقة لتحريك الماء ضد قوة الجاذبية؛ تستخدم الطاقة لتحريك المواد ضد تدرجات تركيزها.

Sodium-Potassium Pump – is transport protein (pump) in the plasma membrane that moves sodium ions (Na+) out of and potassium ions (K+) into animal cells; important in nerve and muscle cells. The sodium potassium pump cause an electrical concentration gradient (difference of charge) across the membrane and this is known as a membrane potential. Nerve cells use this membrane potential to send electrical signals along nerves. The passage of salt (NaCl) across a plasma membrane is of primary importance in cells. First, sodium ions are pumped across a membrane. Then, chloride ions diffuse through channels that allow their passage.

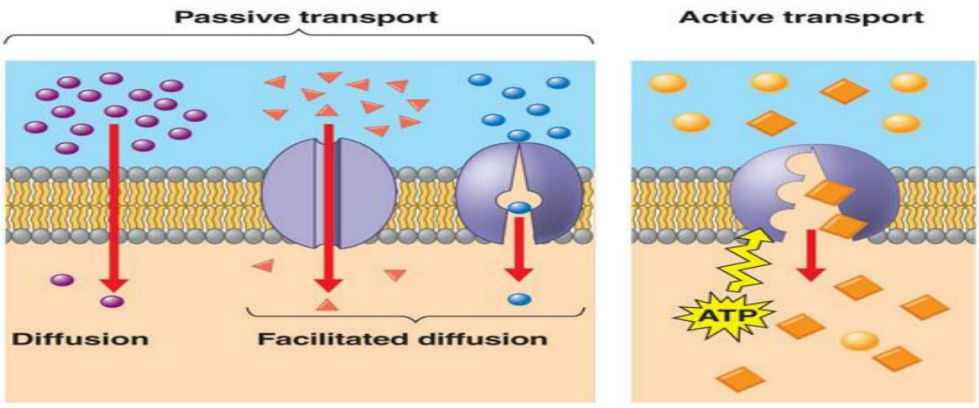


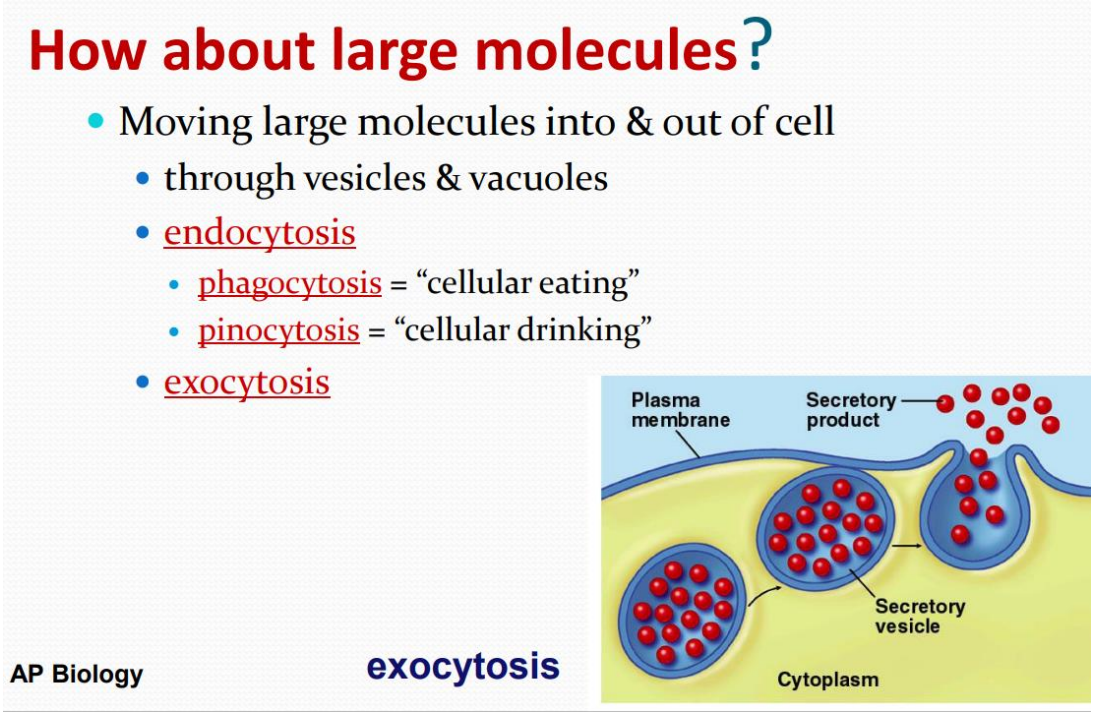
Figure6: Types of C.M. transport

One of important clinical application on active transport is a cystic fibrosis.

Cystic fibrosis is a genetic disorder occurs when there is a defects in a gene on chromosome 7. This gene, called CFTR (cystic fibrosis Transmembrane conductance regulator), codes for the CFTR protein is a channel protein that controls the flow of H2O and Cl- ions in and out of cells inside the lungs. When the CFTR protein is working correctly, ions freely flow in and out of the cells. However, when the CFTR protein is malfunctioning, these ions cannot flow out of the cell due to a blocked channel. This causes cystic fibrosis, characterized by the buildup of thick mucus in the lungs.

أحد التطبيقات السريرية المهمة على النقل النشط هو التليف الكيسي.

التليف الكيسي هو اضطراب وراثي يحدث عندما يكون هناك خلل في الجين الموجود على الكروموسوم 7. هذا الجين، المسمى CFTR(منظم توصيل الغشاء للتليف الكيسي)، يرمز لبروتين CFTR وهو بروتين قناة يتحكم في تدفق H2O و -Clالأيونات داخل وخارج الخلايا داخل الرئتين. عندما يعمل بروتين CFTR بشكل صحيح، تتدفق الأيونات بحرية داخل وخارج الخلايا. ومع ذلك، عندما يكون هناك خلل في بروتين CFTR، لا يمكن لهذه الأيونات أن تتدفق خارج الخلية بسبب قناة مسدودة وهذا يسبب التليف الكيسي، الذي يتميز بتراكم المخاط السميك في الرئتين.



2. Endocytosis: is uptake process of molecules and transport it across cell membrane into the cell interior by vesicle formation, a portion of the plasma membrane invaginates to envelop the substance, and then the membrane pinches off to form an intracellular vesicle.

2.الالتقام الخلوي: هو عملية امتصاص الجزيئات ونقلها عبر غشاء الخلية إلى داخل الخلية عن طريق تكوين الحويصلة، حيث يغزو جزء من الغشاء البلازمي ليغلف المادة، ثم ينضغط الغشاء ليشكل حويصلة داخل الخلايا.

ϖ There are three methods of endocytosis:

A. **Phagocytosis**: means "cell eating", occurs when large solid materials taken inside the cell, such as food particles, dead cell, cell debris or another cell such as bacteria . Best example on phagocytic cell is white blood cells (WBC) can engulf bacteria and worn- out red blood cells by phagocytosis. Digestion occurs when the resulting vacuole (phagocytic vacuole) fuses with a lysosome.(figure7A.a)

أ- البلعمة: تعني "أكل الخلية"، وتحدث عند تناول مواد صلبة كبيرة الحجم داخل الخلية، مثل جزيئات الطعام أو الخلية الميتة أو بقايا الخلية أو خلية أخرى مثل البكتيريا. أفضل مثال على الخلايا البلعمية هي خلايا الدم البيضاء (WBC) التي يمكنها ابتلاع البكتيريا وخلايا الدم الحمراء البالية عن طريق البلعمة. يحدث الهضم عندما تندمج الفجوة الناتجة (الفجوة البلعمية) مع الليزوزوم. (الشكل 7 أ. أ)

B. **Pinocytosis**: means "cell drinking", occurs when vesicles form around fluid droplets. e.g. cells that line the kidney tubules or intestinal wall use this method of ingesting water substances. (figure7A.b)

ب- ابتلاع السائل: ويعني "شرب الخلايا"، ويحدث عندما تتشكل حويصلات حول قطيرات السوائل. على سبيل المثال تستخدم الخلايا التي تبطن أنابيب الكلى أو جدار الأمعاء هذه الطريقة في تناول المواد المائية. يحدث أيضًا شكل موروث

من أمراض القلب والأوعية الدموية عندما تفشل الخلايا في تناول جزيء البروتين الدهني والكوليسترول من الدم عن طريق كثرة الخلايا. (الشكل 7 أ. ب)

C. **Receptor- mediated endocytosis**: A special form of endocytosis uses a receptor, a special form of membrane protein, on the surface of the cell to concentrate specific molecules of interest for endocytosis. (figure7A.c)

ج. الالتقام الخلوي بوساطة المستقبل: هناك شكل خاص من الالتقام الخلوي يستخدم مستقبلًا، وهو شكل خاص من البروتين الغشائي، على سطح الخلية لتركيز جزيئات محددة ذات أهمية في الالتقام الخلوي. (الشكلA.7ج)

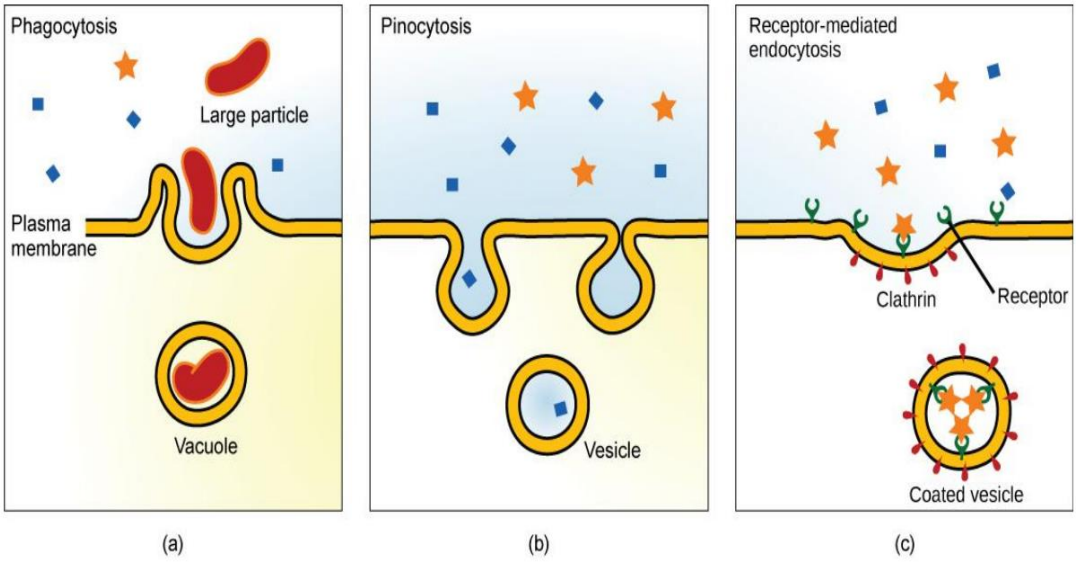
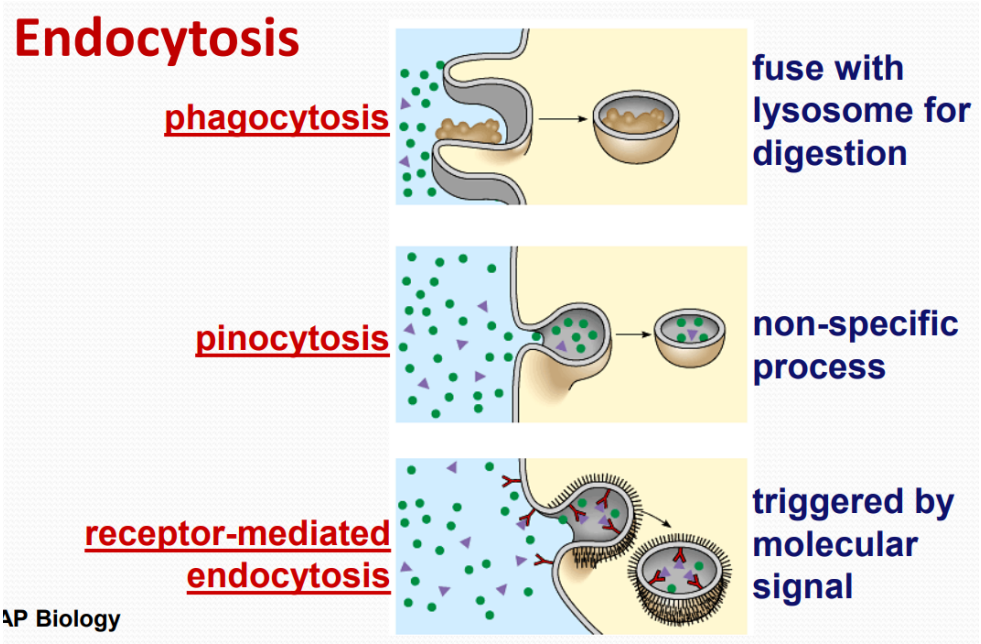


Figure7A: The methods of endocytosis



Lec 4

Note : An inherited form of cardiovascular disease occurs when cells fail to take up a combined lipoprotein and cholesterol molecule from the blood by receptor mediated endocytosis.

Also one type of dwarfism is caused by nonfunctioning growth hormone receptors, In this condition the gland produce the hormone, but the target cells cannot respond because they lack normal receptors.

الشكل الوراثي من أمراض القلب والأوعية الدموية يحدث عندما تفشل الخلايا في تناول جزيء البروتين الدهني والكوليسترول من الدم عن طريق الالتقام الخلوي بوساطة المستقبلات.

كما يحدث أحد أنواع التقزم بسبب خلل في مستقبلات هرمون النمو، وفي هذه الحالة تنتج الغدة الهرمون، لكن الخلايا المستهدفة لا تستطيع الاستجابة لأنها تفتقر إلى المستقبلات الطبيعية.

3. Exocytosis: is release process of material from the cell. During exocytosis vesicles often formed by Golgi apparatus and carrying a specific molecule fused with plasma membrane and secretion occurs. e.g. release of insulin molecules from beta cells or releasing of neurotransmitter molecules into the synaptic cleft by the process of exocytosis. figure7B.

3. الإخراج الخلوي: هو عملية إطلاق المواد من الخلية. أثناء خروج الخلايا، تتكون الحويصلات غالبًا بواسطة جهاز جولجي وتحمل جزيءًا محددًا مندمجًا مع غشاء البلازما ويحدث الإفراز. على سبيل المثال إطلاق جزيئات الأنسولين من خلايا بيتا أو إطلاق جزيئات الناقل العصبي في الشق التشابكي عن طريق عملية الإخراج الخلوي. الشكل 7 ب.

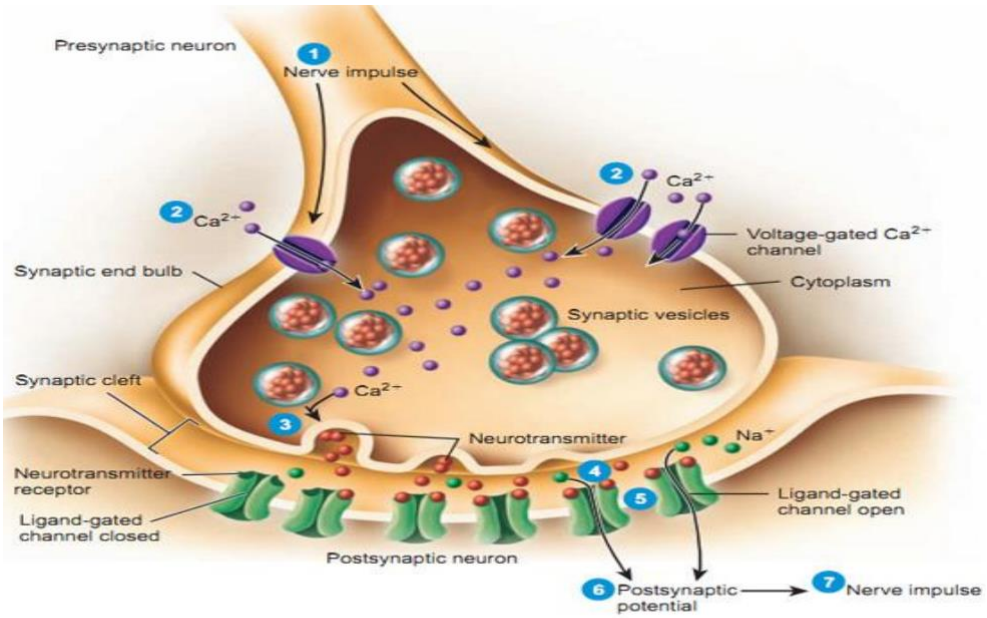


Figure7B: The exocytosis of vesicles containing neurotransmitter molecules

Cell membrane , Cell junctions lec 4

Gap, Tight and Adhesion Junctions

Introduction

If you were building a building, what kinds of connections might you want to put between the rooms? In some cases, you'd want people to be able to walk from one room to another, in which case you'd put in a door. In other cases, you'd want to hold two adjacent walls firmly together, in which case you might put in some strong bolts. And in still other cases, you might need to ensure that the walls were sealed very tightly together – for instance, to prevent water from dripping between them.

إذا كنت تقوم ببناء مبنى، ما هي أنواع الاتصالات التي قد ترغب في وضعها بين الغرف؟ في بعض الحالات، قد ترغب في أن يتمكن الأشخاص من المشي من غرفة إلى أخرى، وفي هذه الحالة عليك أن تضع بابًا. في حالات أخرى، قد ترغب في تثبيت جدارين متجاورين معًا بقوة، وفي هذه الحالة قد تضع بعض البراغي القوية. وفي حالات أخرى، قد تحتاج إلى التأكد من أن الجدران مغلقة بإحكام شديد معًا - على سبيل المثال، لمنع تقطر الماء بينها.

As it turns out, cells face the same questions when they're arranged in a tissue next to other cells. Should they put in doors that connect them directly to their neighbors? Do they need to spot-weld themselves to their neighbors to make a strong layer, or perhaps even form tight seals to prevent water from passing through the tissue? Junctions serving all of these functions can be found in cells of different types, and here, we'll look at each of them in turn.

وكما تبين، تواجه الخلايا نفس الأسئلة عندما يتم ترتيبها في الأنسجة بجوار الخلايا الأخرى. هل يجب عليهم وضع أبواب تربطهم مباشرة بجيرانهم؟ هل يحتاجون إلى اللحام الموضعي لجيرانهم لتكوين طبقة قوية، أو ربما حتى تشكيل أختام محكمة لمنع مرور الماء عبر الأنسجة؟ يمكن العثور على الوصلات التي تخدم كل هذه الوظائف في خلايا ذات أنواع مختلفة، وهنا، سننظر إلى كل منها على حدة

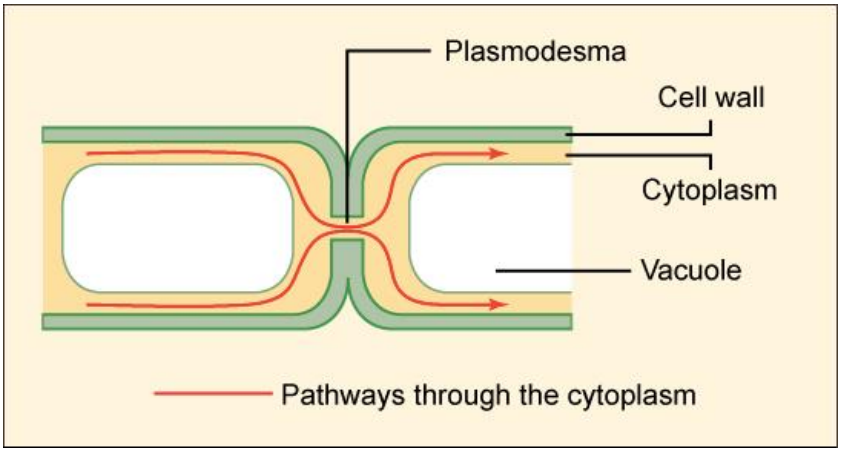
Cells within tissues and organs must be anchored to one another and attached to components of the extracellular matrix. Cells have developed several types of junctional complexes to serve these functions, and in each case, anchoring proteins extend through the plasma membrane to link cytoskeletal proteins in one cell to cytoskeletal proteins in neighboring cells as well as to proteins in the extracellular matrix.

يجب أن تكون الخلايا الموجودة داخل الأنسجة والأعضاء مرتبطة ببعضها البعض وأن ترتبط بمكونات القالب خارج الخلية. طورت الخلايا عدة أنواع من معقدات التواصل لخدمة هذه الوظائف (الترابط)، وفي كل حالة، تمتد بروتينات التثبيت عبر الغشاء البلازمي لربط بروتينات الهيكل الخلوي في خلية واحدة ببروتينات الهيكل الخلوي في الخلايا المجاورة وكذلك بالبروتينات الموجودة في القالب خارج الخلية

Plasmodesmata

Plant cells, surrounded as they are by cell walls, don't contact one another through wide stretches of plasma membrane the way animal cells can. However, they do have specialized junctions called **plasmodesmata** (singular, **plasmodesma**), places where a hole is punched in the cell wall to allow direct cytoplasmic exchange between two cells.

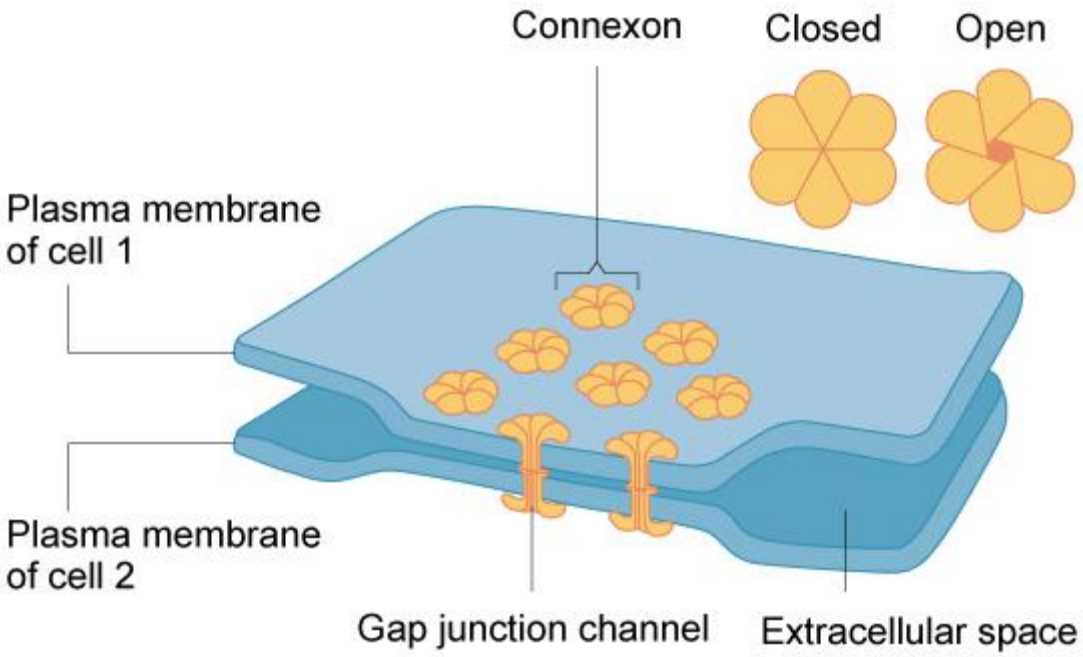
الخلايا النباتية، المحاطة بجدران خلوية، لا تتصل ببعضها البعض من خلال مساحات واسعة من غشاء البلازما كما تفعل الخلايا الحيوانية. ومع ذلك، لديهم وصلات متخصصة تسمى plasmodesmata (مفردها plasmodesma)، وهي الأماكن التي يتم فيها ثقب جدار الخلية للسماح بالتبادل السيتوبلازمي المباشر بين خليتين.



Gap junctions

Functionally, **gap junctions** in animal cells are a lot like plasmodesmata in plant cells: they are channels between neighboring cells that allow for the transport of ions, water, and other substances . Structurally, however, gap junctions and plasmodesmata are quite different.

من الناحية الوظيفية، تشبه الوصلات الفجوية في الخلايا الحيوانية إلى حد كبير البلازموديسماتا في الخلايا النباتية: فهي عبارة عن قنوات بين الخلايا المجاورة تسمح بنقل الأيونات والماء والمواد الأخرى. ومع ذلك، من الناحية الهيكلية، تختلف تقاطعات الفجوة والبلازموديماتا تمامًا.



Gap junctions are particularly important in cardiac muscle: the electrical signal to contract spreads rapidly between heart muscle cells as ions pass through gap junctions, allowing the cells to contract in tandem.

تعتبر الوصلات الفجوية مهمة بشكل خاص في عضلة القلب: تنتشر الإشارة الكهربائية للانقباض بسرعة بين خلايا عضلة القلب حيث تمر الأيونات عبر الوصلات الفجوية، مما يسمح للخلايا بالتعاقد جنبًا إلى جنب.

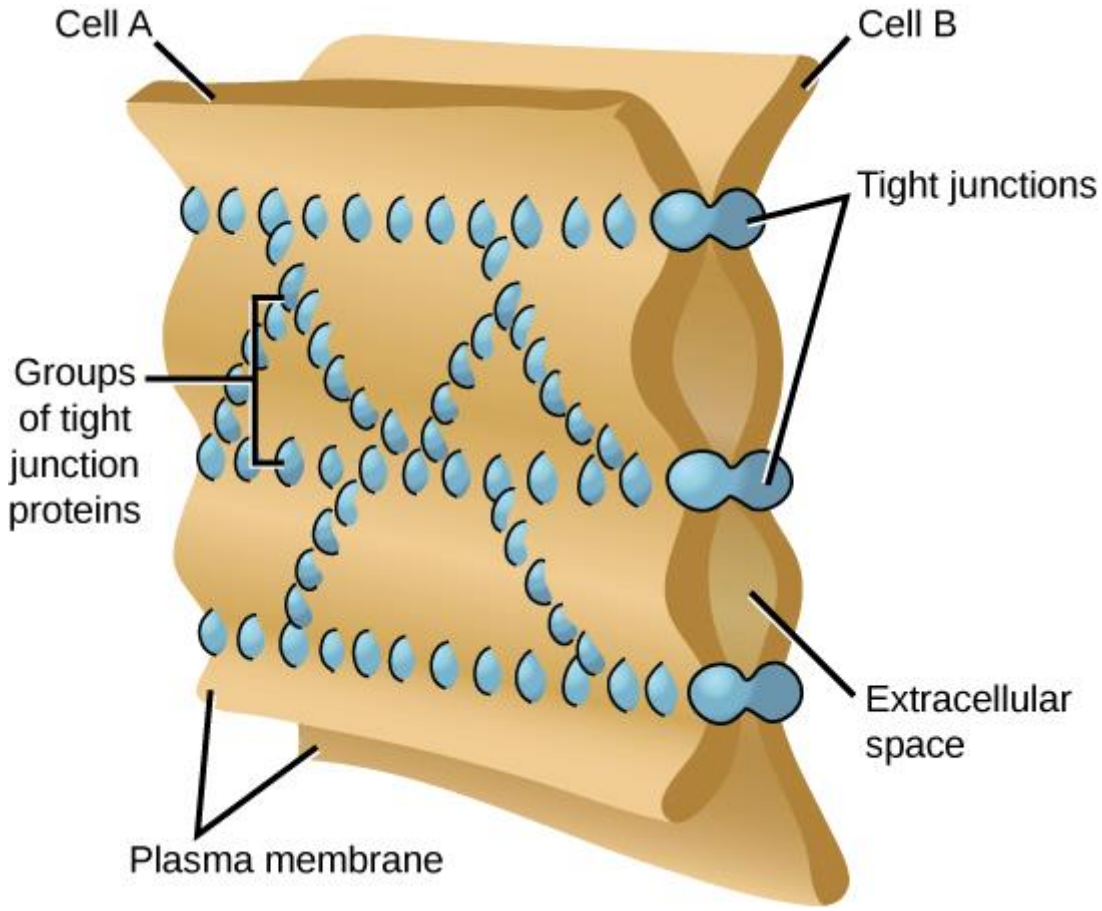
Tight junctions

Not all junctions between cells produce cytoplasmic connections. Instead, **tight junctions** create a watertight seal between two adjacent animal cells.

ليست كل الوصلات بين الخلايا تنتج اتصالات السيتوبلازم. وبدلاً من ذلك، تخلق الوصلات الضيقة حاجزًا مانعًا للماء بين خليتين حيوانيتين متجاورتين.

At the site of a tight junction, cells are held tightly against each other by many individual groups of tight junction proteins called **claudins**, each of which interacts with a partner group on the opposite cell membrane. The groups are arranged into strands that form a branching network, with larger numbers of strands making for a tighter seal .

في موقع الوصلة الضيقة، يتم تثبيت الخلايا بإحكام ضد بعضها البعض بواسطة العديد من المجموعات الفردية من بروتينات الوصلة الضيقة التي تسمى كلودين، والتي تتفاعل كل منها مع مجموعة شريكة على غشاء الخلية المعاكسة. يتم ترتيب المجموعات في خيوط تشكل شبكة متفرعة، مع وجود أعداد أكبر من الخيوط مما يجعل الختم أكثر إحكامًا.



The purpose of tight junctions is to keep liquid from escaping between cells, allowing a layer of cells (for instance, those lining an organ) to act as an impermeable barrier. For example, the tight junctions between the epithelial cells lining your bladder prevent urine from leaking out into the extracellular space.

الغرض من الوصلات الضيقة هو منع السائل من الهروب بين الخلايا، مما يسمح لطبقة من الخلايا (على سبيل المثال، تلك التي تبطن العضو) بالعمل كحاجز غير منفذ. على سبيل المثال، تمنع الوصلات الضيقة بين الخلايا الظهارية المبطنة للمثانة البول من التسرب إلى الفضاء خارج الخلية.

Adhesion Junctions (Desmosomes)

Animal cells may also contain junctions called **desmosomes**, which act like spot welds between adjacent epithelial cells. A desmosome involves a complex of proteins. Some of these proteins extend across the membrane, while others anchor the junction within the cell.

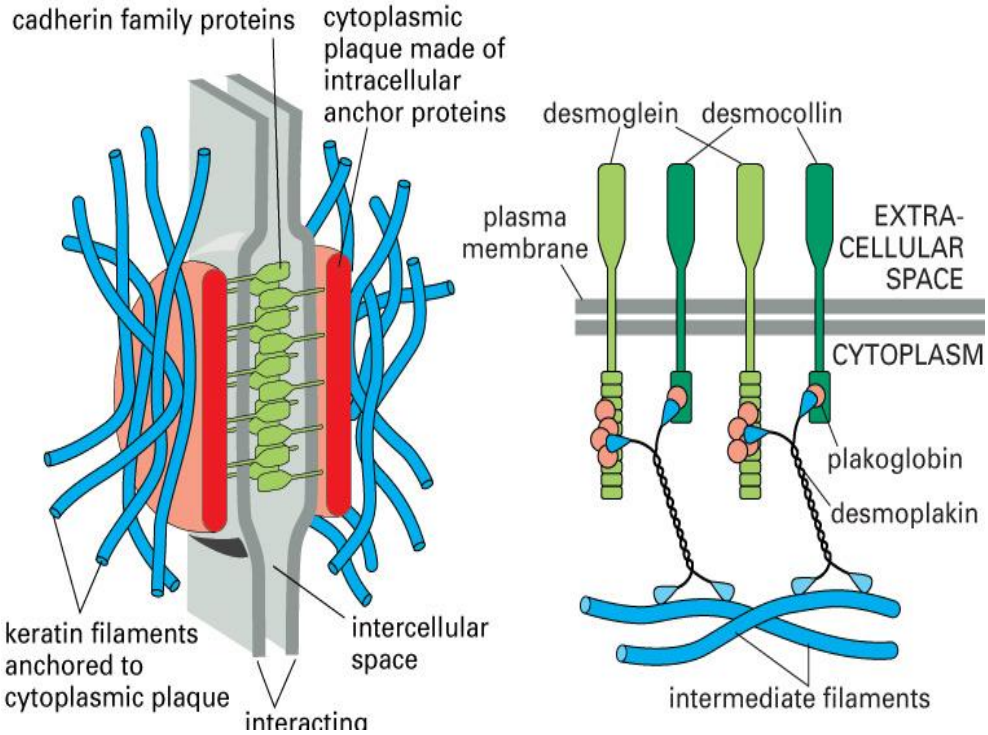
قد تحتوي الخلايا الحيوانية أيضًا على وصلات تسمى الديسموسومات، والتي تعمل مثل اللحامات الموضعية بين الخلايا الظهارية المجاورة. يشتمل الديسموسوم على مجموعة معقدة من البروتينات. تمتد بعض هذه البروتينات عبر الغشاء، بينما يقوم البعض الآخر بتثبيت الوصلة داخل الخلية.

Cadherins, specialized adhesion proteins, are found on the membranes of both cells and interact in the space between them, holding the membranes together. Inside the cell, the

cadherins attach to a structure called the cytoplasmic plaque (red in the image), which connects to the intermediate filaments and helps anchor the junction.

توجد بروتينات الكادهيرين، وهي بروتينات التصاق متخصصة، على أغشية كلا الخليتين وتتفاعل في الفراغ بينهما، مما يحافظ على تماسك الأغشية معًا. داخل الخلية، ترتبط الكادهيرينات ببنية تسمى اللوحة السيتوبلازمية (باللون الأحمر في الصورة على اليمين)، والتي تتصل بالخيوط الوسيطة وتساعد في تثبيت الوصلة.

Desmosomes pin adjacent cells together, ensuring that cells in organs and tissues that stretch, such as skin and cardiac muscle, remain connected in an unbroken sheet.



General principles of cell signaling lec 5

Introduction

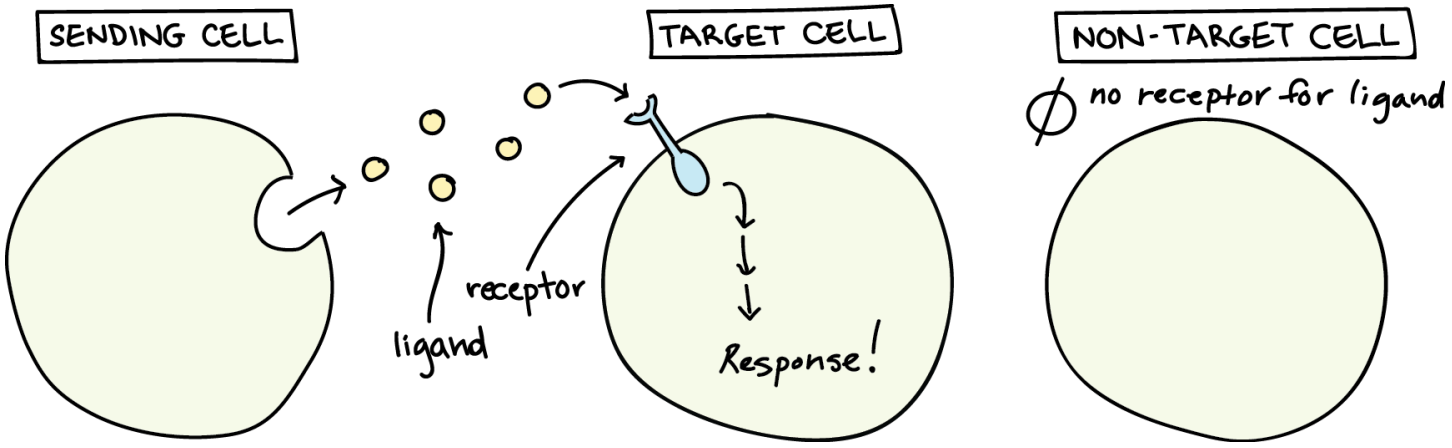
Think your cells are just simple building blocks, unconscious and static as bricks in a wall? If so, think again! Cells can detect what's going on around them, and they can respond in real time to cues from their neighbors and environment. At this very moment, your cells are sending and receiving millions of messages in the form of chemical signaling molecules!

مقدمة

هل تعتقد أن خلاياك هي مجرد وحدات بناء بسيطة، غير واعية وثابتة مثل الطوب في الجدار؟ إذا كان الأمر كذلك، فكر مرة أخرى! يمكن للخلايا اكتشاف ما يجري حولها، ويمكنها الاستجابة في الوقت الفعلي للإشارات الواردة من جيرانها وبيئتها. في هذه اللحظة بالذات، ترسل خلاياك وتستقبل ملايين الرسائل على شكل جزيئات إشارات كيميائية!

Cells typically communicate using chemical signals. These chemical signals, which are proteins or other molecules produced by a **sending cell**, are often secreted from the cell and released into the extracellular space. There, they can float – like messages in a bottle – over to neighboring cells.

تتواصل الخلايا عادة باستخدام الإشارات الكيميائية. هذه الإشارات الكيميائية، وهي عبارة عن بروتينات أو جزيئات أخرى تنتجها الخلية المرسلة، غالبًا ما يتم إفرازها من الخلية وإطلاقها في الفضاء خارج الخلية. وهناك، يمكنها أن تطفو – مثل الرسائل الموجودة في زجاجة – إلى الخلايا المجاورة.



Not all cells can "hear" a particular chemical message. In order to detect a signal (that is, to be a **target cell**), a neighbor cell must have the right **receptor** for that signal. When a signaling molecule binds to its receptor, it alters the shape or activity of the receptor, triggering a change inside of the cell. Signaling molecules are often called **ligands**, a general term for molecules that bind specifically to other molecules (such as receptors).

لا تستطيع جميع الخلايا "سماع" رسالة كيميائية معينة. من أجل اكتشاف إشارة (أي أن تكون خلية مستهدفة)، يجب أن يكون لدى الخلية المجاورة المستقبل الصحيح لتلك الإشارة. عندما يرتبط جزيء الإشارة بمستقبله، فإنه يغير شكل المستقبل أو نشاطه، مما يؤدي إلى حدوث تغيير داخل الخلية. غالبًا ما تسمى جزيئات الإشارة بالإشارات، وهو مصطلح عام للجزيئات التي ترتبط بشكل خاص بجزيئات أخرى (مثل المستقبلات).

Signalling by soluble extracellular molecules is by 3 ways:

Endocrine--- When cells need to transmit signals over long distances, they often use the circulatory system as a distribution network for the messages they send. In long-distance **endocrine signaling**, signals are produced by specialized cells and released into the bloodstream, which carries them to target cells in distant parts of the body. Signals that are produced in one part of the body and travel through the circulation to reach far-away targets are known as **hormones**.

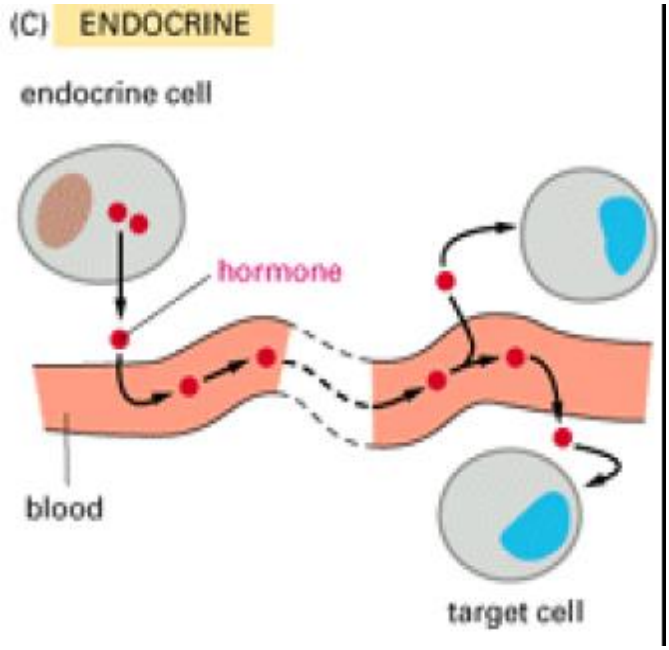
عندما تحتاج الخلايا إلى إرسال الإشارات عبر مسافات طويلة، فإنها غالبًا ما تستخدم الجهاز الدوري كشبكة توزيع للرسائل التي ترسلها. في إشارات الغدد الصماء لمسافات طويلة، يتم إنتاج الإشارات بواسطة خلايا متخصصة ويتم إطلاقها في مجرى الدم، الذي يحملها إلى الخلايا المستهدفة في أجزاء بعيدة من الجسم. تُعرف الإشارات التي يتم إنتاجها في جزء واحد من الجسم وتنتقل عبر الدورة الدموية للوصول إلى أهداف بعيدة بالهرمونات.

In humans, endocrine glands that release hormones include the thyroid, the hypothalamus, and the pituitary, as well as the gonads (testes and ovaries) and the pancreas. Each endocrine gland releases one or more types of hormones, many of which are master regulators of development and physiology.

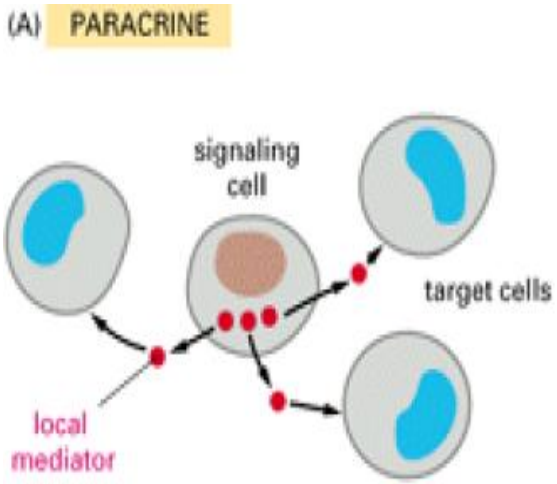
في البشر، الغدد الصماء التي تفرز الهرمونات تشمل الغدة الدرقية، تحت المهاد، والغدة النخامية، وكذلك الغدد التناسلية (الخصيتين والمبيضين) والبنكرياس. تفرز كل غدة صماء نوعًا واحدًا أو أكثر من الهرمونات، العديد منها عبارة عن منظمات رئيسية للنمو وعلم وظائف الأعضاء.

For example, the pituitary releases growth hormone (GH), which promotes growth, particularly of the skeleton and cartilage. Like most hormones, GH affects many different types of cells throughout the body. However, cartilage cells provide one example of how GH functions: it binds to receptors on the surface of these cells and encourages them to divide

على سبيل المثال، تفرز الغدة النخامية هرمون النمو (GH)، الذي يعزز النمو، وخاصة الهيكل العظمي والغضاريف. مثل معظم الهرمونات، يؤثر هرمون النمو على العديد من أنواع الخلايا المختلفة في جميع أنحاء الجسم. ومع ذلك، توفر الخلايا الغضروفية مثالًا واحدًا على كيفية عمل هرمون النمو: فهو يرتبط بالمستقبلات الموجودة على سطح هذه الخلايا ويشجعها على الانقسام.



Paracrine--- Often, cells that are near one another communicate through the release of chemical messengers (ligands that can diffuse through the space between the cells). This type of signaling, in which cells communicate over relatively short distances, is known as paracrine signaling.



في كثير من الأحيان، تتواصل الخلايا القريبة من بعضها البعض من خلال إطلاق رسائل كيميائية (روابط يمكن أن تنتشر عبر الفضاء بين الخلايا). يُعرف هذا النوع من الإشارات، الذي تتواصل فيه الخلايا عبر مسافات قصيرة نسبيًا، باسم إشارات نظير الصماوي

paracrine signals are especially important during development, when they allow one group of cells to tell a neighboring group of cells what cellular identity to take on.

إلا أن إشارات نظير الصماوي مهمة بشكل خاص أثناء التطور، عندما تسمح لمجموعة واحدة من الخلايا بإخبار مجموعة مجاورة من الخلايا بالهوية الخلوية التي يجب أن تتخذها.

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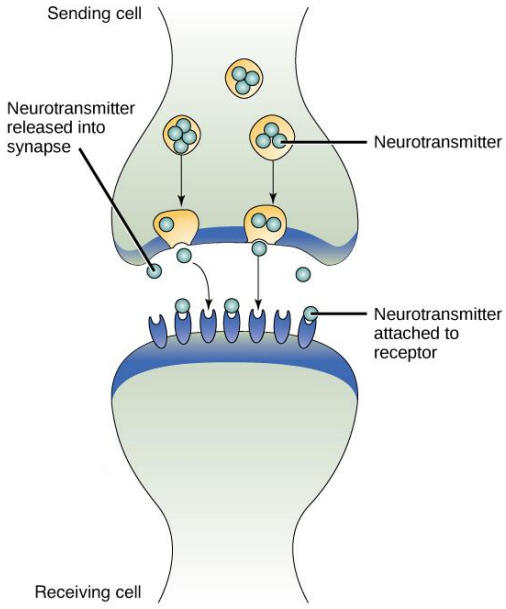
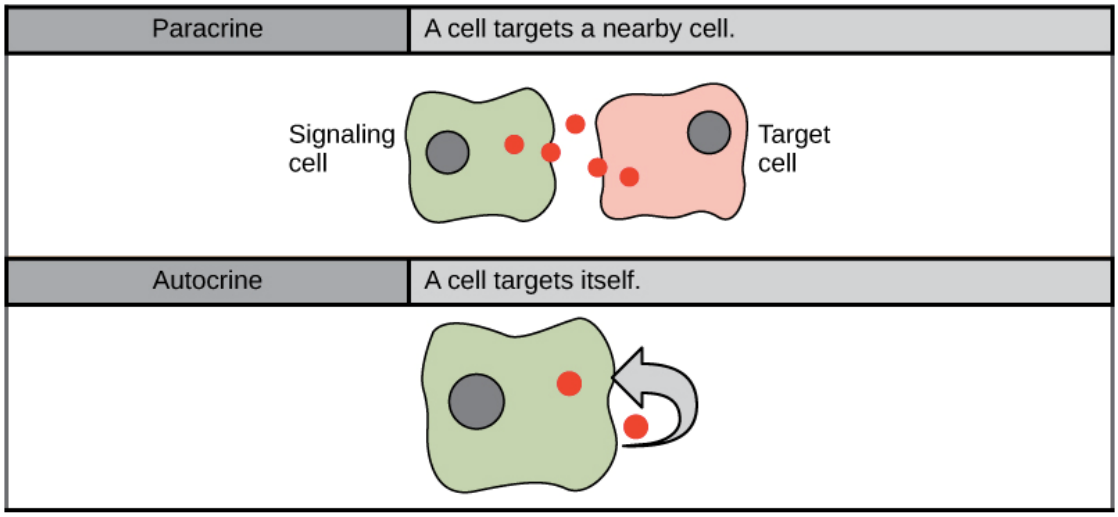


Autocrine---In autocrine signaling, a cell signals to itself, releasing a ligand that binds to receptors on its own surface (or, depending on the type of signal, to receptors inside of the cell). This may seem like an odd thing for a cell to do, but autocrine signaling plays an important role in many processes.

في الإشارات الذاتية، ترسل الخلية إشارات إلى نفسها، وتطلق الاشارة ترتبط بمستقبلات على سطحها (أو، اعتمادًا على نوع الإشارة، إلى مستقبلات داخل الخلية). قد يبدو هذا أمرًا غريبًا بالنسبة للخلية، لكن الإشارات الذاتية تلعب دورًا مهمًا في العديد من العمليات.

For instance, autocrine signaling is important during development, helping cells take on and reinforce their correct identities. From a medical standpoint, autocrine signaling is important in cancer and is thought to play a key role in metastasis (the spread of cancer from its original site to other parts of the body).

على سبيل المثال، تعتبر الإشارات الذاتية مهمة أثناء التطور، حيث تساعد الخلايا على اتخاذ هوياتها الصحيحة وتعزيزها. من وجهة نظر طبية، تعتبر الإشارات الاستبدادية مهمة في السرطان ويُعتقد أنها تلعب دورًا رئيسيًا في النقيلة (انتشار السرطان من موقعه الأصلي إلى أجزاء أخرى من الجسم).


Paracrine
A cell targets a nearby cell.
Signaling cell
Target cell
Autocrine
A cell targets itself.

The cytoplasm

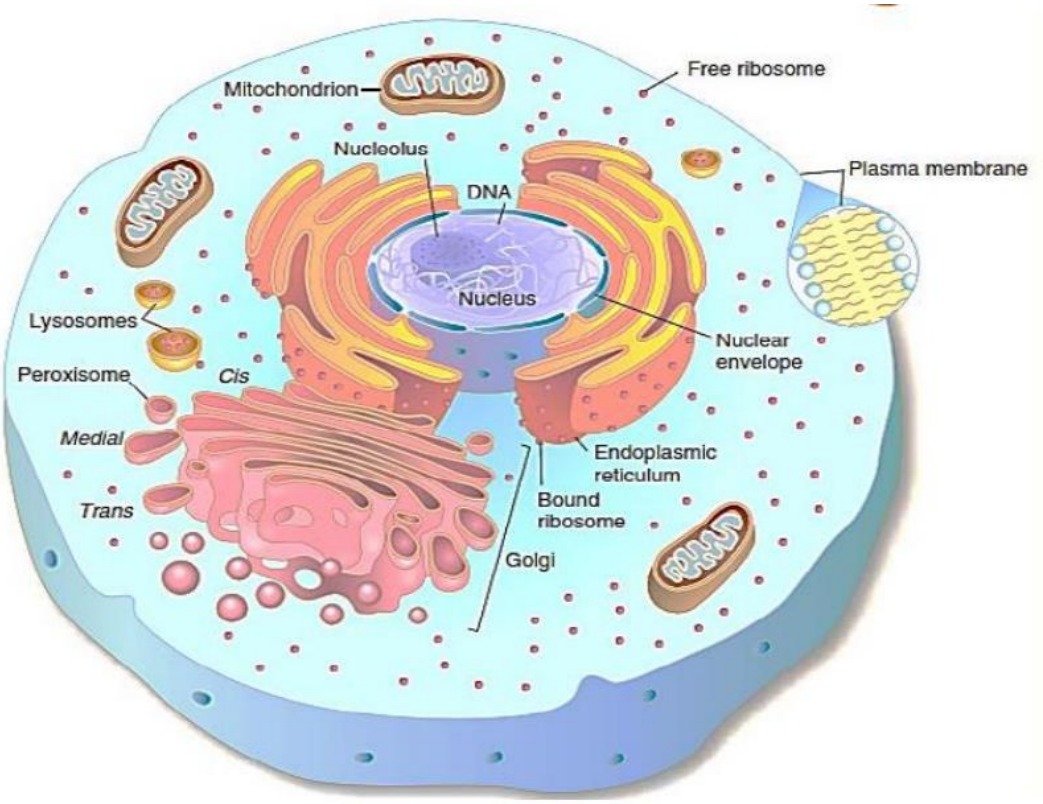
The cytoplasm is the part of the cell located outside the nucleus filling the space between nuclear envelop and plasma membrane. It consists of:

1. Cytosol is a large fluid component of the cytoplasm.

2. Organelles ("little organs") are swimming metabolically active structures, which may be membranous (such as mitochondria) or non membranous protein complexes (such as ribosomes and proteasomes).

3. Cytoskeleton is protein component of the cytoplasm which determine the shape and motility of eukaryotic cells.

4. Inclusions are the minor cytoplasmic structures that are not usually surrounded by a membrane. They consist of such diverse materials like crystals, pigment granules, lipids, glycogen, and other stored waste products



(Figure:1 Structure of the cell)

Cytosol

Cytosol is an aqueous gel called the cytoplasmic matrix. The matrix consists of a variety of solutes, including inorganic ions (Na+, K+, and Ca2+) and organic molecules such as intermediate metabolites, carbohydrates, lipids, proteins, and RNAs (ribonucleic acids). The cell controls the concentration of solutes within the matrix, which influences the rate of metabolic activity within the cytoplasmic compartment. Cytosol also contains hundreds of enzymes, all the machinery converging on the ribosomes for protein synthesis, O2, CO2, electrolytic ions, low-molecular-weight substrates, metabolites, and waste products. All diffuse through cytosol, either freely or bound to proteins, entering or leaving organelles where they are used or produced

Cytoplasmic Organelles (part1)

All cells have the same basic set of intracellular organelles, which can be classified

into two groups:

1. **Membranous organelles** with membranes that separate the internal environment of the organelle from the cytoplasm.

2. **Non-membranous organelles** without membranes.

* The membranes of membranous organelles form vesicular, tubular, and other structural patterns within the cytoplasm that may be convoluted (as in smoothsurfaced endoplasmic reticulum) or plicated (as in the inner mitochondrial membrane). In addition, each type of organelle contains a set of unique proteins.

* **In membranous organelles**, these proteins are either incorporated into their

membranes or sequestered within their lumens. For example, the enzymes of

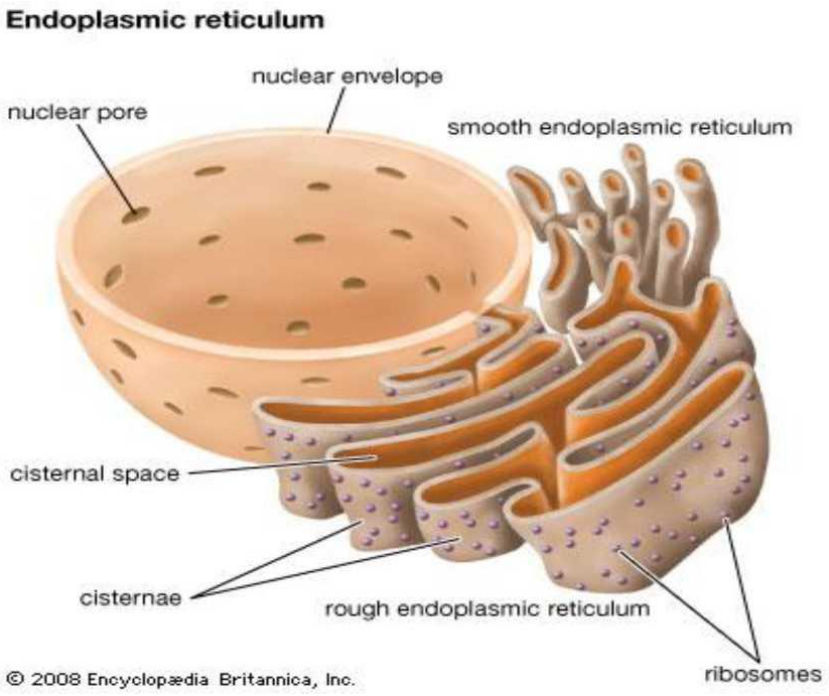
lysosomes are separated by a specific enzyme resistant membrane from the cytoplasmic matrix because their hydrolytic activity would be harmful to the cell.

*__In Non-membranous organelles__, the unique proteins usually self assemble into polymers that form the structural elements of the cytoskeleton.

Endoplasmic Reticulum - Structure and Function

The **endoplasmic reticulum (ER)** is an important organelle in eukaryotic cells. It plays a major role in the production, processing, and transport of proteins and lipids.

The ER produces trans-membrane proteins and lipids for its membrane and for many other cell components including lysosomes, secretory vesicles, the Golgi apparatus, the cell membrane, and plant cell vacuoles.



- The ER is Complex network of transport channels,Two types:

1. **Smooth**- ribosome free and functions in poison detoxification.
2. **Rough** - contains ribosomes and releases newly made protein from the cell.

Functions of Endoplasmic Reticulum (ER)

1. It is mainly responsible for the transportation of proteins and other carbohydrates to another organelle, which includes lysosomes, Golgi apparatus, plasma membrane, etc.
2. They provide the increased surface area for cellular reactions.
3. They help in the formation of nuclear membrane during cell division.
4. They play a vital role in the formation of the skeletal framework.
5. They play a vital role in the synthesis of proteins, lipids, glycogen and other steroids like cholesterol, progesterone, testosterone, etc.

Golgi Apparatus

*Also known as the Golgi complex or Golgi body, the Golgi apparatus is an organelle in eukaryotic organisms that moves molecules from the endoplasmic reticulum to their destination, and also modifies products of the endoplasmic reticulum to their final form.

*The Golgi apparatus is comprised of a series of flattened sacs that extend from the endoplasmic reticulum outward, into the cytoplasm.

*This gives the Golgi apparatus the ability to deliver vesicles, or packets of various cell products, to different locations throughout the cell.

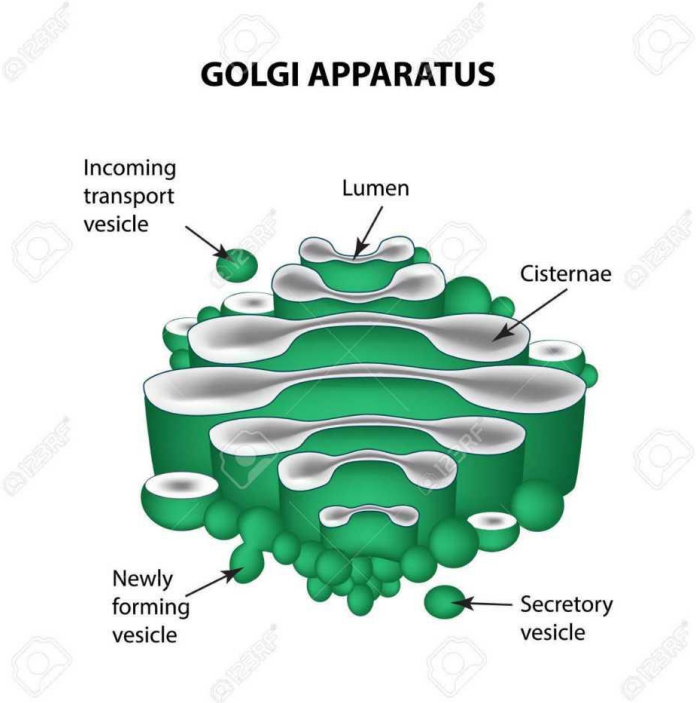
Why is the Golgi Apparatus the most important organelle?

*A major organelle in most eukaryotic cells is the structure of membrane-bound sacs called the Golgi apparatus. It acts to process and package the macromolecules such as proteins and lipids that are synthesized by the cell. A major function is the processing of proteins for secretion.

*Directing the carbohydrates and proteins required by the body to their correct destination is the primary job of Golgi Apparatus. The main function of Golgi

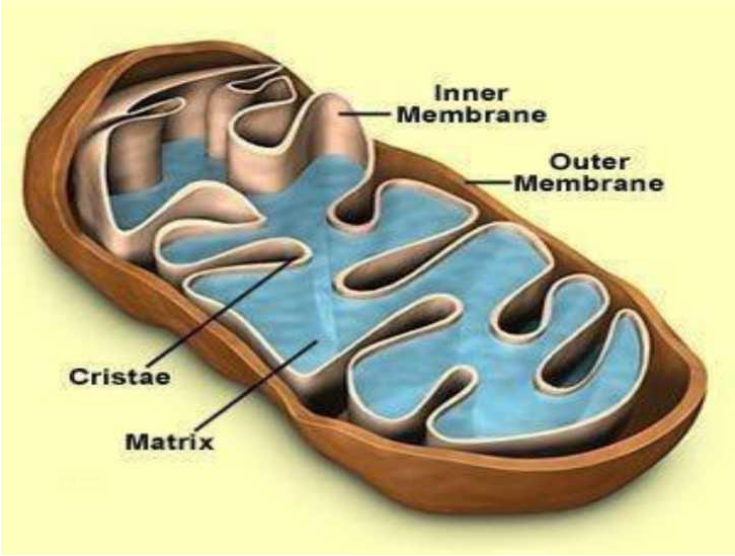
*apparatus is to carry out the processing of proteins generated in the ER. Golgi apparatus also transports protein to the different parts of cell.

*Cells synthesize a large number of different macromolecules required for life. The Golgi apparatus is integral in modifying, sorting, and packaging these substances for cell secretion or for use within the cell. It primarily modifies proteins delivered from the rough endoplasmic reticulum, but is also involved in the transport of lipids around the cell, and the creation of lysosomes.



Mitochondrion

Mitochondria are considered the "power houses" of eukaryotic cells. **What does it mean to say that mitochondria are the cell's power producers?** These organelles generate power by converting energy into forms that are usable by the cell. Located in the cytoplasm, mitochondria are the sites of cellular respiration. **Cellular respiration** is a process that ultimately generates fuel for the cell's activities from the foods we eat. Mitochondria produce the energy required to perform processes such as cell division, growth, and cell death. Mitochondria have a distinctive oblong or oval shape and are bounded by a double membrane. The inner membrane is folded creating structures known as **cristae**. Mitcohondria are found in both animal and plant cells. They are found in all body cell types, except for mature red blood cells. The number of mitochondria within a cell varies depending on the type and function of the cell. Muscle cells, on the other hand, may contain thousands of mitochondria needed to provide the energy required for muscle activity. Mitochondria are also abundant in fat cells and liver cells.



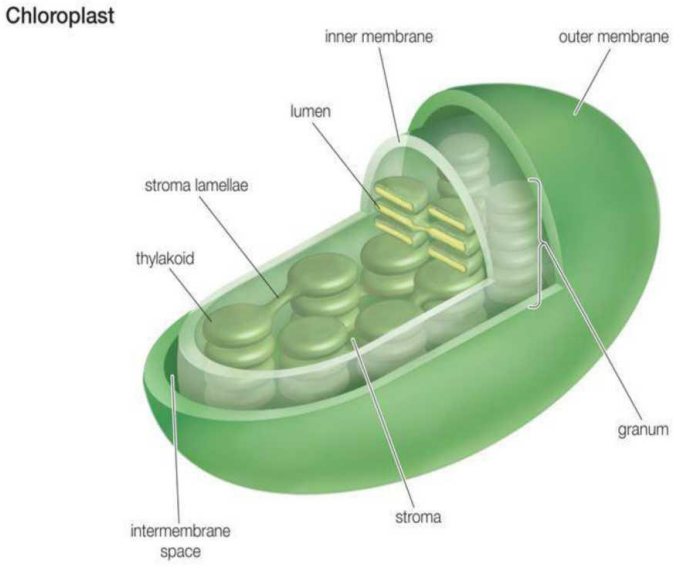
Mitochondrial DNA

Mitochondria have their own DNA, ribosomes and can make their own proteins. Mitochondrial DNA (mtDNA) encodes for **proteins** that are involved in electron transport and oxidative phosphorylation, which occur in cellular respiration. In oxidative phosphorylation, energy in the form of ATP is generated within the mitochondrial matrix.

Proteins synthesized from mtDNA also encode for the production of the RNA molecules transfer RNA and ribosomal RNA. **Mitochondrial DNA differs from DNA found in the cell nucleus** in that it does not possess the DNA repair mechanisms that help prevent mutations in nuclear DNA. As a result, mtDNA has a much higher mutation rate than nuclear DNA. Exposure to reactive oxygen produced during oxidative phosphorylation also damages mtDNA.

Chloroplast

Chloroplasts are the site of photosynthesis in eukaryotic cells. They are only present in photosynthetic cells like plant cells and algae. There are no chloroplasts in animal or bacterial cells.



Parts of Chloroplasts

■ Outer membrane - It is a semi-porous membrane and is permeable to small molecules and ions, which diffuses easily. The outer membrane is not permeable to larger proteins.

■ Intermembrane Space - It is usually a thin intermembrane space about 1020 nanometers and it is present between the outer and the inner membrane of the chloroplast.

■ Inner membrane - The inner membrane of the chloroplast forms a border to the stroma. It regulates passage of materials in and out of the chloroplast. In addition of regulation activity, the fatty acids, lipids and carotenoids are synthesized in the inner chloroplast membrane.

■ Stroma- Stroma is a alkaline, aqueous fluid which is protein rich and is present within the inner membrane of the chloroplast. The space outside the thylakoid space is called the stroma. The chloroplast DNA chlroplast ribosomes and the thylakoid sytem, starch granules and many proteins are found floating around the stroma.

■ Thylakoid System- The thylakoid system is suspended in the stroma. The thylakoid system is a collection of membranous sacks called thylakoids. The chlorophyll is found in the thylakoids and is the sight for the process of light reactions of photosynthesis to happen. The thylakoids are arranged in stacks known as grana. Each granum contains around 10-20 thylakoids.

Functions of Chloroplast

- Absorption of light energy and conversion of it into biological energy.
- The chloroplast is very important as it is the cooking place for all the green plants. All heterotrophs also depend on plasts for this food.
- The chloroplasts with the nucleus and cell membrane and ER are the key organelles of pathogen defense.
- The most important function of chloroplast is to make food by the process of photosynthesis.

Lecture 7

Smooth endoplasmic reticulum

Jaundice denotes a yellowish discoloration of the skin and is caused by accumulation in extracellular fluid of bilirubin and other pigmented compounds, which are normally metabolized by smooth endoplasmic reticulum (SER) enzymes in cells of the liver and excreted as bile. A frequent cause of jaundice in newborn infants (physiological jaundice) is an under developed state of SER in liver cells, with failure of bilirubin to be converted to a form that can be readily excreted.

Mitochondrial disorders

A maternally-inherited mutation in the mitochondrial genome is leading to defective synthesis of respiratory chain proteins which can produce structural abnormal in muscle fibers especially skeletal muscle fibers are very sensitive to mitochondrial defect (muscular dysfunction) and other cells. (This called mitochondrial disorders)

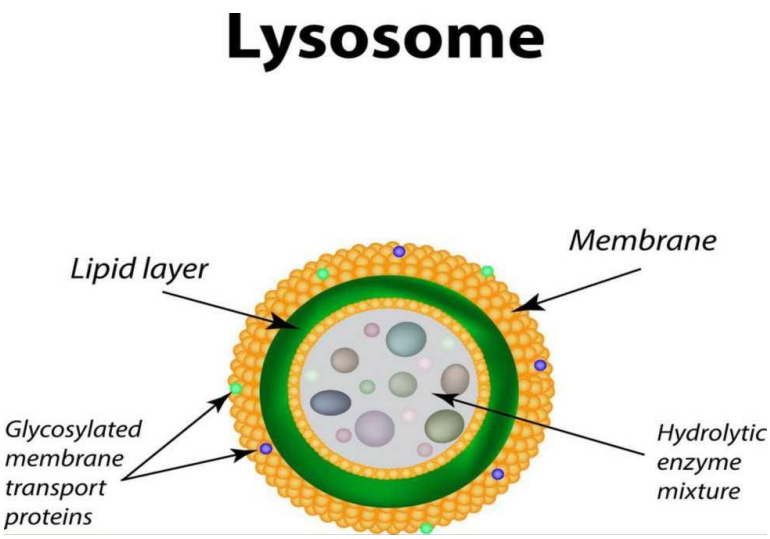
(Why the mtDNA is inherited solely from the mother?)

Lysosome

A lysosome is a membrane-bound organelle found in nearly all animal cells. They are spherical vesicles that contain hydrolyticenzymes that can break down many kinds of biomolecules. A lysosome is a type of vesicle with specific composition, of both its membrane proteins, and proteins of its lumen. The lumen's pH (4.55.0) is optimal for the enzymes involved in hydrolysis, analogous to the activity of the stomach. Besides degradation of polymers, the lysosome is involved in various cell processes, including secretion, plasma membrane repair, cell signaling, and energy metabolism.

The lysosomes also act as the waste disposal system of the cell by digesting unwanted materials in the cytoplasm, both from outside the cell and obsolete components inside the cell. Material

from outside the cell is taken-up through endocytosis, while material from the inside of the cell is digested through autophagy.



***Diseases categorized as lysosomal storage disorders stem from defects in one or more of the digestive enzymes present in lysosomes. In cells that must digest the substrate of the missing or defective enzyme following auto phagocytosis, the lysosomes cannot function properly. Such cells accumulate large secondary lysosomes or residual bodies filled with the indigestible macromolecule. The accumulation of these vacuoles may eventually interfere with normal cell or tissue function, producing symptoms of the disease.**

The Vacuole

A vacuole is a cell organelle found in a number of different cell types. Vacuoles are fluid-filled, enclosed structures that are separated from the cytoplasm by a single membrane. They are found mostly in plant cells and fungi. However, some protists, animal cells, and bacteria also contain vacuoles. Vacuoles are responsible for a wide variety of important functions in a cell including nutrient storage, detoxification, and waste exportation.

Non membranous organelles

 The non-membranous organelles are cytoplasmic organelles lacking of a membrane a round their internal

structure, such as the ribosome, centrioles, microtubules, and microfilaments.

The Ribosome

1. The ribosomes are small (20-30 nm) non-membranous particles assembled in the nucleus by association of ribosomal ribonucleic acid (rRNA) synthesize in the nucleus and proteins synthesize in the cytoplasm.

2. The ribosome particles are transported out the nucleus through nuclear pores of the nuclear envelope to be in many types.

3. Present in cytoplasm, mitochondria, chloroplast & also found attached to rough ER & nuclear membrane.

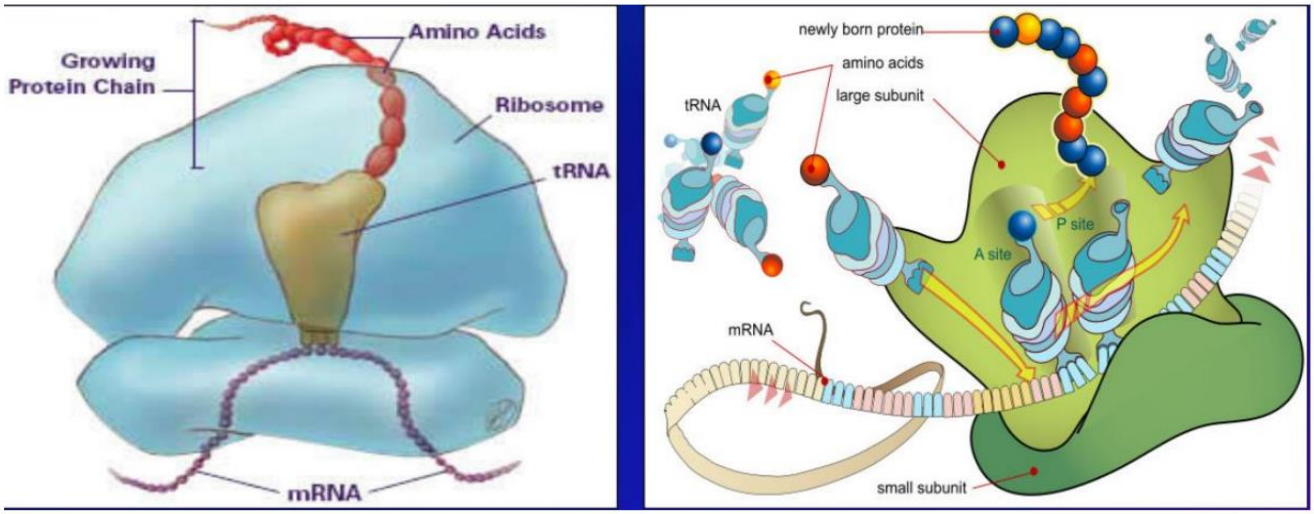
4. They exist in two sizes: 70s are found in all Prokaryotes, chloroplasts and mitochondria.

5. 80s found in all eukaryotic cells – attached to the rough ER.

6. Ribosome particles found as either free single granules, cluster polysomes of granules, or attached granules to the cisterna of rER.

7. Ribosome particles are the sites where amino acid molecules are incorporated into protein molecules, either to be used by the cells or secreted out the plasma membrane of the secretory cell, as that of the granular tissue (salivary glands).

The Ribosome



Proteasomes

Proteasomes are very small abundant protein complexes composed of three subunits : two regulatory particles and one core particle .Non membranous organelle that degrades some protein molecules.

They function to destroy protein infected by viruses. Whereas lysosomes digest organelles or membranes by autophagy, proteasomes deal primarily with free proteins as individual molecules.

Failure of proteasomes or other aspects of a cell's protein quality control can allow large aggregates of protein to accumulate in affected cells. In the brain this can interfere directly with cell function and lead to neurodegeneration.

Alzheimer disease and Huntington disease are two neurologic disorders caused initially by such protein aggregates.

The Cytoskeleton, Cell Movement, and Cytoplasmic inclusions

The Cytoskeleton is a network of tiny protein filaments and tubules that extend throughout the cytoplasm. It serves the cell's structural framework, helps maintain a cell's shape and either anchors the organelles or assists in the movements of organelles and cytoplasmic vesicles, and also allows the movement of entire cells.

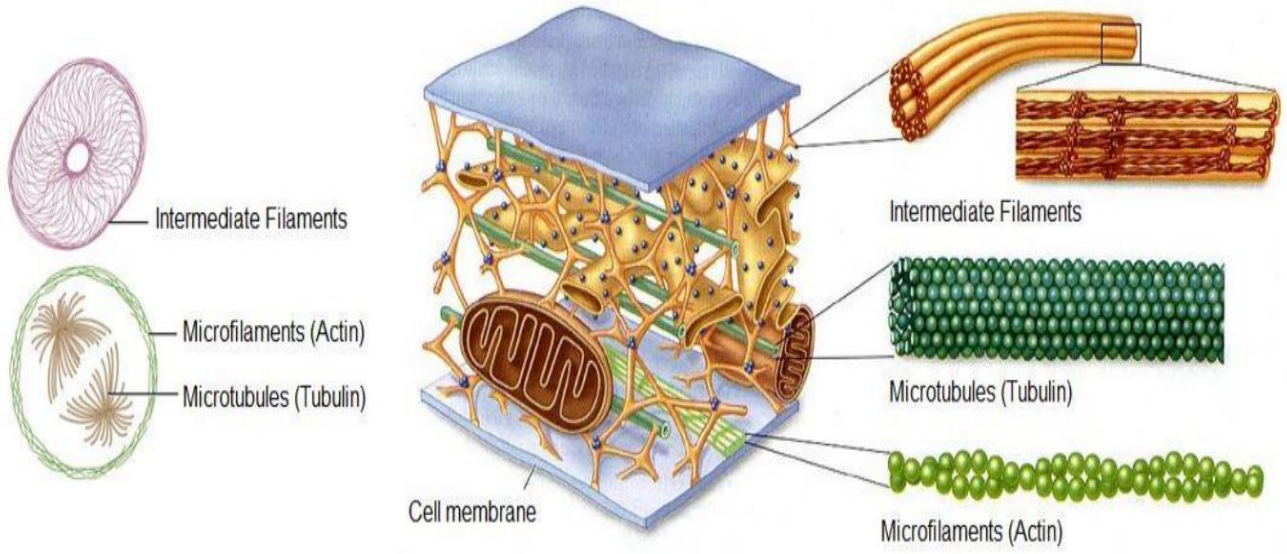


Figure16: Types of cytoskeletons

- Microtubules (MTs)
- Microtubules are found in almost all eukaryotic cell types except red blood cells.
- They are the largest elements of the cytoskeleton.
- Microtubules are non branching and rigid hollow tubes of protein that can rapidly disassemble in one location and reassemble in another.
- All microtubules originate from the microtubule-organizing center (MTOC) called centrosome, has gamma tubulin (γ).

 Centrosome is an area of the cytoplasm located near the nucleus

 Microtubules are elongated polymeric structures composed of equal parts of α tubulin and β tubulin.

 Microtubules grow from γ tubulin rings within the MTOC that serve as nucleation sites for each microtubule.

 The length of microtubules changes dynamically as tubulin dimers are added or removed in a process of dynamic instability.

 In the centrosome, the tubulin subunits polymerize and from two types of microtubules:

Dynamic microtubules are continuous assembly and disassembly (reshaping of cell) determine cell shape and function in intracellular movement of organelles and secretory granules and form spindles that guide the movement of chromosomes during cell division or mitosis

Stable microtubules form walls of centrioles, cilia and flagella. They are responsible for the beating movements

 Microtubules are involved in numerous essential cellular functions:

1. Intracellular vesicular transport (e.g., movement of secretory vesicles, endosomes, and lysosomes).
2. Movement of cilia and flagella.
3. Attachment of chromosomes to the mitotic spindle and their movement during

mitosis and meiosis.

4. Cell elongation and movement (migration).

5. Maintenance of cell shape, particularly its asymmetry.

 Several inhibitory compounds used by cell biologists to study details of microtubule dynamics are also widely used in cancer chemotherapy to block activity of the mitotic spindle in rapidly growing neoplastic cells. Such drugs include vinblastine and vincristine.

Centrioles:

Centrioles are non membranous organelles. Small cylindrical structures composed of highly organized microtubules located within centrosome, perpendicular to each other. Each centriole consists of nine evenly spaced clusters of three microtubules arranged in a circle. The microtubules have longitudinal orientation and are parallel to each other.

Before mitosis, the centrioles in the centrosome replicate and form two pairs. During mitosis, each pair moves to the opposite poles of the cell, where they become microtubuleorganizing centers for mitotic spindles that control the distribution of chromosomes to the daughter cells.

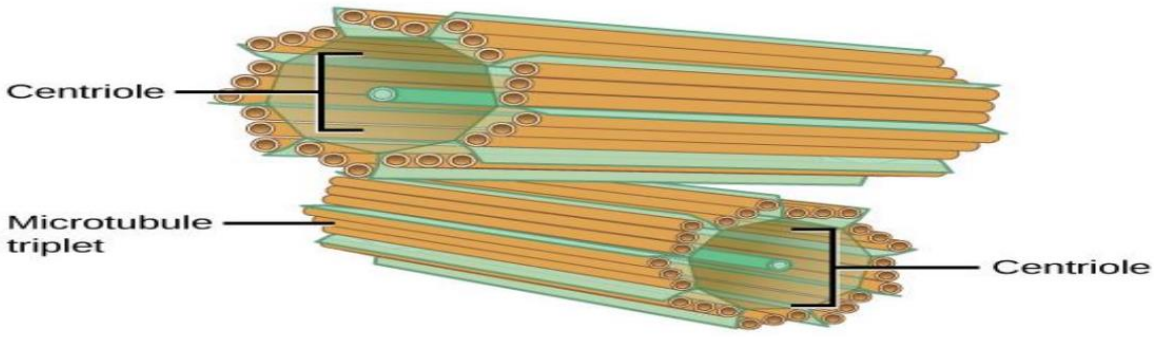


Figure17: Diagram of centrioles structure

Cilia:

 Cilia (sing., cilium) are involved in movement. Motile structure use to move something like the ciliated cells that line our respiratory tract sweep debris trapped within mucus back up the throat. This helps keep the lungs clean by rhythmic beating. Similarly, ciliated cells move an egg along the oviduct, where it will be fertilized by a flagellated sperm cell.

 Origin of cilia from centrioles, each centrioles give only one cilium, so ciliated cells have many centioles embedded in cytoplasm under cell membrane called basal body. Basal bodies associated structures firmly anchor cilia in the apical cell cytoplasm.

 Cilia have another function; act as receptor in special cells (rods and cones cells of the eyes retina).

Flagella

Flagella (sing. Flagellum) is motile projection use to move cell itself, like tail of sperm. Have an inner core of microtubules within a covering of plasma membrane. Flagellum is the same structure of cilium but always single and extremely longer.

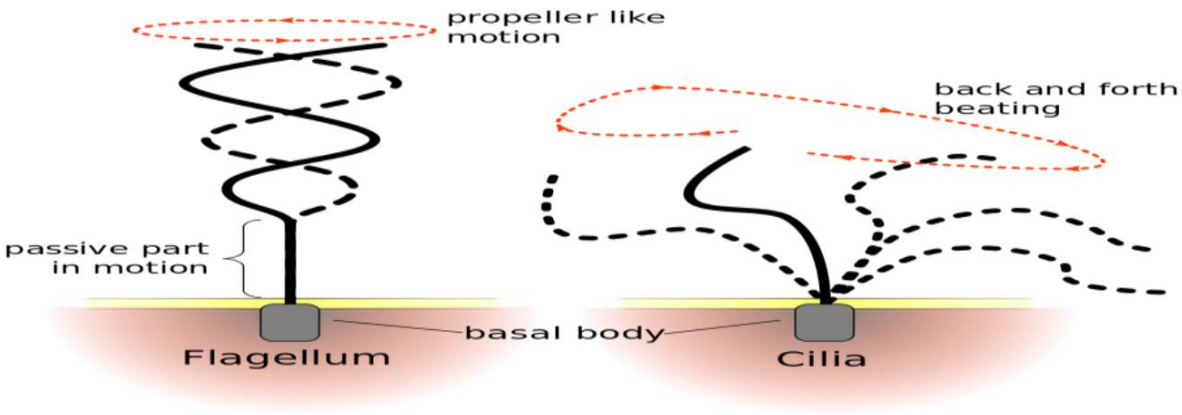


Figure 18: show the different between cilia and flagellum motion

Clinical application

The importance of normal cilia and flagella is illustrated by the occurrence of a genetic disorder. Some individuals have an inherited genetic defect that leads to malformed microtubules in cilia and flagella. Called immotile cilia syndrome

1. These individuals suffer from recurrent and severe respiratory infections. The ciliated cells lining respiratory passages fail to keep their lungs clean. (chronic respiratory infections)

2. They are also unable to reproduce naturally due to the lack of ciliary action to move the egg in a female or the lack of flagella action by sperm in a male. (Immotile sperm).

 Filaments

Each cytoskeletal filament type is formed by polymerization of a distinct type of minute protein subunit and has its own characteristic shape

and intracellular distribution.

There are three types of filaments:

Microfilaments, intermediated filaments and thick filaments

Microfilament (thin filament or known as actin filaments):

 Microfilaments are the thinnest structures of the cytoskeleton usually occur in bundles or other groupings.

 They are composed of the protein actin and are most prevalent on the peripheral regions of the cell membrane.

 Structure of actin protien is fine strands of globular actin (G-actin).

 These structural proteins shape the cells, and are involved in cell movement and movement of the cytoplasmic organelles. The microfilaments are distributed throughout the cells and are used as anchors at cell junctions. The actin microfilaments also form the structural core of microvilli (non motile cellular membrane protrusions that increase the surface area for diffusion and minimize any increase in volume such as the epithelial cells of small intestines) and the terminal web just inferior to the plasma membrane.

Intermediate filaments, as their name implies, are intermediate in size between microtubules and actin filaments.

Several cytoskeletal proteins that form the intermediate filaments have been identified and localized.

Their structure and function differ according to the type of cell.

1. Keratin filaments. In skin cells, these filaments terminate at cell junctions, where they stabilize the shape of the cell and their attachments to adjacent cells.

2. Vimentin filaments are found in many mesenchymal cells.

3. Desmin filaments are found in both smooth and striated muscles.

4. Neurofilament proteins are found in the nerve cells and their processes.

5. Glial filaments are found in astrocytic glial cells of the nervous system.

6. Lamin intermediate filaments are found on the inner layer of the nuclear membrane.

The presence of a specific type of intermediate filament in tumors can often reveal the cellular origin of the tumor, information important for diagnosis and treatment of the cancer. Identification of intermediate filament proteins by means of immunocytochemical methods is a routine procedure. One example is the use of Glial Fibrillary Acidic Proteins (GFAP) to identify astrocytomas, the most common type of brain tumor.

Finally the thick filaments in muscle tissues are the actin filaments fill the cells and associated with myosin proteins to induce muscle contractions.

Cytoplasmic inclusions

In addition to the living organelles found in the cytoplasm, other cellular components are found. Inclusions, considered to be nonliving components of the cell that do not possess metabolic activity and are not bounded by membranes. The most common inclusions are glycogen, lipid droplets, crystals and pigments. These may be synthesized by the cell itself or taken up from surrounding.

Inclusions

The cytoplasmic inclusions are temporary non-living structures that accumulate in the cytoplasm of certain cells not able to carry out any metabolic activity and are not bound by membranes. Inclusions are stored nutrients, secretory products, and pigment granules. Examples of inclusions are:

Glycogen: Glycogen granules is the most common form of glucose in animals and is especially abundant in cells of muscles, and liver

Lipids: Lipids are triglycerides in storage form the common form of inclusions not only are stored in specialized cells (adipocytes) but also are located as individuals droplets in various cell type especially hepatocytes. These are fluid at body temperature and appear in living cells as refractile spherical droplets.

Crystals: Crystalline inclusions have long been recognized as normal constituents of certain cell types such as Sertoli cells and Leydig cells of the human testis, and occasionally in macrophages.It is believed that these structures are crystalline forms

of certain proteins which is located everywhere in the cell such as

in nucleus, mitochondria, endoplasmic reticulum, Golgi body, and free in cytoplasmic matrix.

Pigments: The most common pigment in the body, besides hemoglobin of red blood cells is melanin, manufactured by melanocytes of the skin and hair, pigments cells of the retina and specialized nerve cells in the substantia nigra of the brain. These pigments have protective functions in skin and aid in the sense of sight in the retina but their functions in neurons is not understood completely. Furthermore, cardiac tissue and central nervous system neurons shows yellow to brown pigment

called lipofuscin, some believed that they have lysosomal activity.

This type of inclusion called Endogenous pigment because is formed by the cells, while other type of inclusion come from outside called exogenous like tattoo marks, carotene and dust

the epithelial surface of lung alveoli where it ingests inhaled particulate matter known as dust cells.

Nucleus

 The nucleus (nuclei, plural) the largest component of a cell, frequently appears as rounded, oval, flat, kidney shape, horse shoe shape, segmented or lobulated structure.

 Position of nucleus often near the center of the cell but in some cells the nucleus located eccentric, basal or peripheral.

 Found in all eukaryotic cells except mature red blood cells of mammals do not have a nucleus, or are nonnucleated.

 Most cells have a single nucleus called mononucleated, some cells have two nucleus called binucleated as in liver cells (hepatocyte) or other cells may exhibit multiple nuclei called multinucleated as
osteoclast and skeletal muscles.

 The nucleus stores genetic information. Every cell in
the body contains the same genes.

 The nucleus of a non dividing cell consists of the
following components:

 The nucleus consists of the following parts:

1. Nucleolemma or nuclear membrane (karyotheca)
2. Nuclear sap or karyolymph or nucleoplasm
3. Chromatin network or fibres

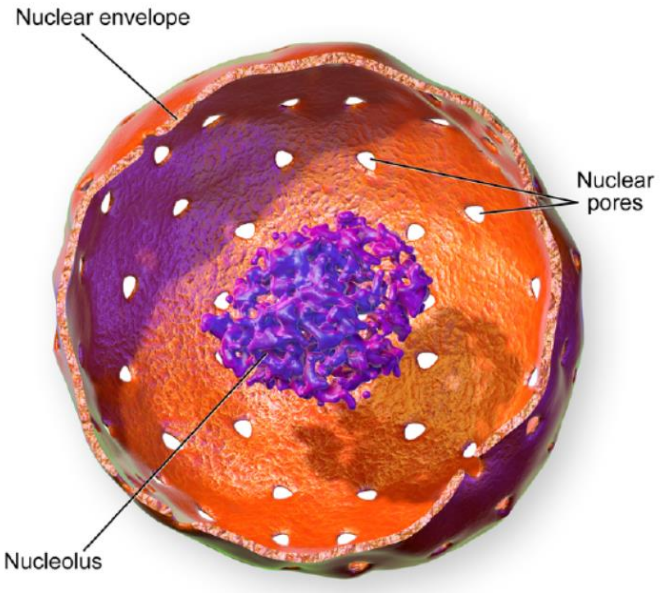
4. NucleolusThe nucleus is composed of four parts:

1-nuclear envelope

2-nucleoplasm

3- chromatin

4-nucleolus



1-Nuclear Envelope:

The nuclear envelope forms a selectively permeable barrier (double membrane)

between the nucleus and cytoplasmic compartments. Electron microscopy reveals that the envelope has two concentric membranes the outer one is called ectokaryotheca and inner one is termed endokaryotheca

separated by a narrow perinuclear space. This space and the outer nuclear membrane are continuous with the extensive cytoplasmic network of the rough endoplasmic reticulum. Closely associated with the inner nuclear membrane is a highly organized meshwork of proteins called the nuclear lamina which stabilizes the nuclear envelope.

Major components of this layer are the class of intermediate filament proteins called lamins that bind to membrane proteins and associate with

chromatin in no dividing cells.

The inner and outer nuclear membranes are bridged at nuclear pore complexes.

Various core proteins of a nuclear pore complex called nucleoporins. Although

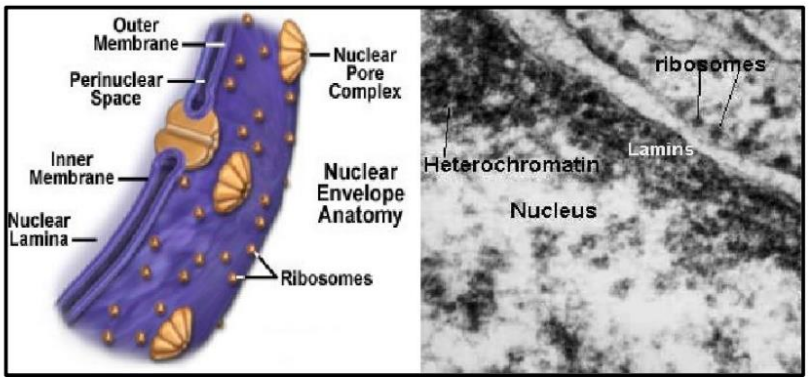
ions and small solutes pass through the channels by simple diffusion, the pore

complexes regulate movement of macromolecules between the nucleus and

cytoplasm. Macromolecules shipped out of the nucleus include ribosomal subunits

and other RNAs associated with proteins, while inbound traffic consists of

chromatin proteins, ribosomal proteins, transcription factors, and enzymes.



Medical Application Certain mutations in the gene coding for lamin A are associated with a subtype of the disorder progeria, which causes premature aging.

Functions of nuclear envelop are regulate the entry of proteins (histone and

hormones) to the nucleus and export of RNAs from nucleus to the cytoplasm.

Also encloses the nucleus and separates the genetic material of the cell from the

cytoplasm of the cell. And it serves as a barrier to prevent passage of macromolecules freely between the nucleoplasm and the cytoplasm

2 The nucleoplasm,

karyoplasm or nuclear sap is a fluid filling the inside of the nucleus. Within this fluid both nucleolus (or sometimes nucleoli) and the chromatin are found.

3- Nucleolus:

Nucleolus appears as a small dense body immersed in the nucleoplasm. Two nucleoli are sometimes present in the nucleus. The nucleolus is considered as the ribosomal factory as it consists of RNA and protein (ribosomal subunits) in the process of maturation. These subunits are synthesized in the nucleolus and then move through the nuclear pores to the cytoplasm, where they assemble. Ribosomes serve as the site of protein synthesis.

4- Chromatin:

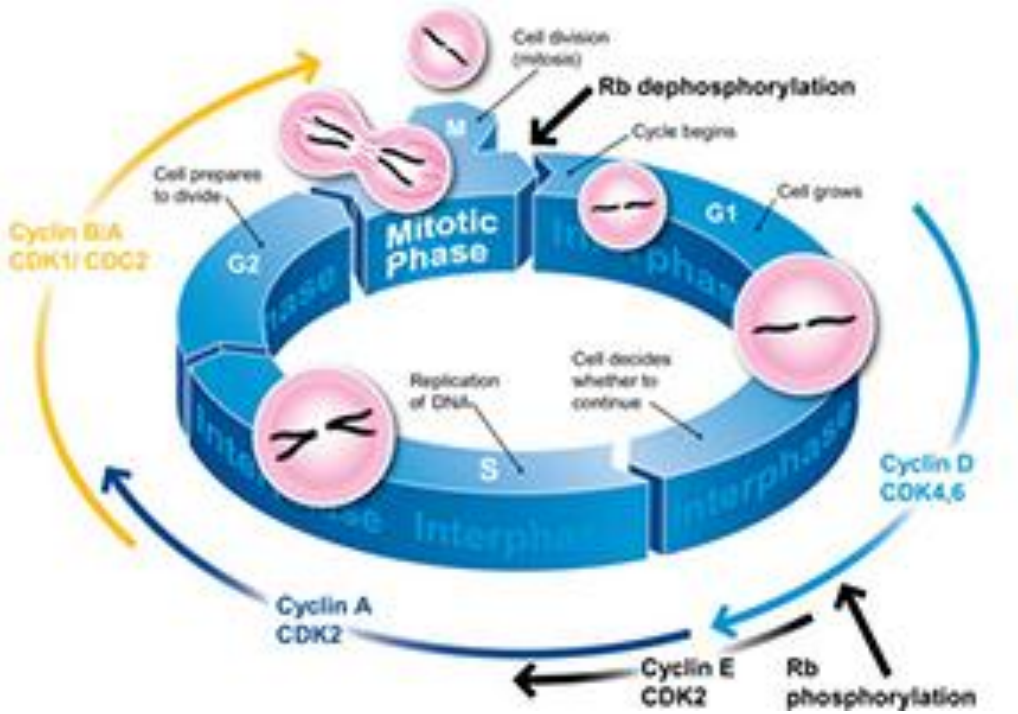
The chromatin is the nuclear material which is made up of DNA and large protein molecules (histones). This is basophilic in staining. It can be distinguished into two types:-

A- Euchromatin or noncondensed chromatin which is loosely packed and thus is very lightly basophilic. This is metabolically active with regard to RNA synthesis.

B- Heterochromatin or condensed chromatin which is tightly packed and thus is intensively basophilic. This is relatively inactive metabolically and consists of chromosomes

“ CELL CYCLE ”
Lec.10

First stage cell biology Dr. Omar Qahtan Yaseen



MSc. Mays jassim

Introduction

- The cell is the basic unit of life.

- The growth and development of every living organisms depend on the growth and multiplication of its cell .

- Organisms grow and repair themselves through the process of cell division .

Cell cycle :

- The cell cycle is a sequence of cell growth and division.

- The cell cycle is the period from the beginning of one division to the beginning of the next.

- The time it takes to complete one cell cycle is the generation time.

- The cell cycle is divisible in to two phases :
  - Inter phase
  - Mitotic phase

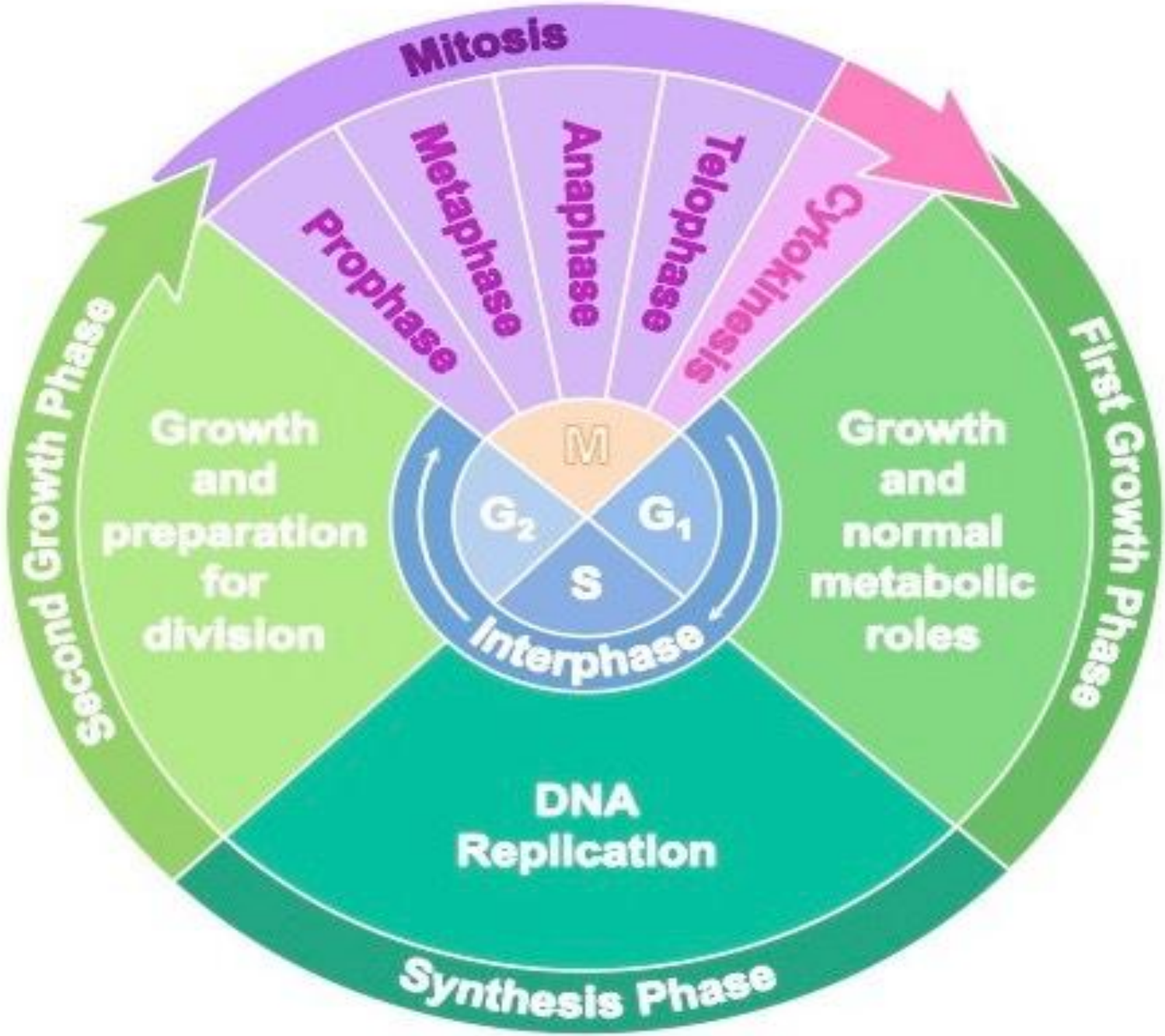
(1) Inter Phase :

• Inter phase is the interval period between two successive cell division .

• The cell prepare for cell division .

• The biologist divide inter phase in to three distinct period .

1) G1 phase :
2) S (synthesis) phase :
3) G2 phase :


Mitosis
Prophase
Metaphase
Anaphase
Telophase
Cytokinesis
M
G2
G1
S
Interphase
Growth and preparation for division
Growth and normal metabolic roles
DNA Replication
Second Growth Phase
First Growth Phase
Synthesis Phase

1) G1 Phase :

• It is the longest phase and is the period of maximum growth of cell .their is no changes in Dna contents of the cell during this phase .

2) S Phase :

• In this phase **DNA** molecules of each chromosome replicate by the synthesis of new **DNA** molecules .

3) G2 Phase :

• It is pre mitotic phase .This phase is characterised by increase in nuclear volume .

• The synthesis of **RNA and Protein** continues in this phase and cell
prepare it self to go in to the mitotic phase .

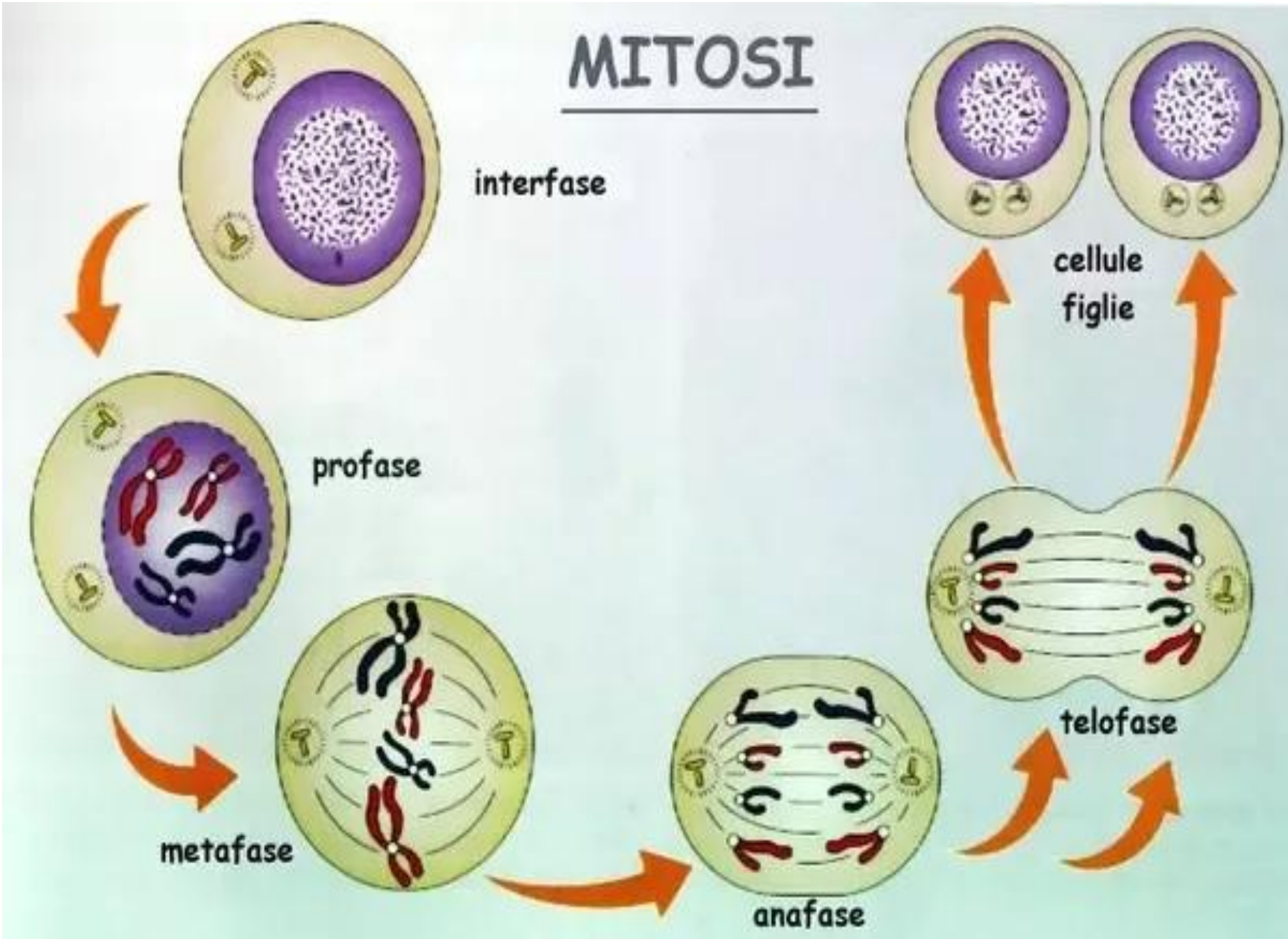
(2) Mitosis Phase :

- The process of cell division which results in the production of two daughter cells from a single parent cell.

- The daughter cells are **identical** to one another and to the original parent cell.

- There are **mainly 4 phases** in to the Mitosis process :

- - Pro phase :
- - Meta phase :
- - Ana phase :
- - Telo phase :


MITOSI
interfase
profase
metafase
anafase
telofase
cellule figlie

(3) Meiosis :

- One parent cell produces four daughter cells.

- Daughter cells have half the number of chromosomes found in the original parent cell.

☐ **During meiosis, DNA replicates *once*, but the nucleus divides *twice*.**

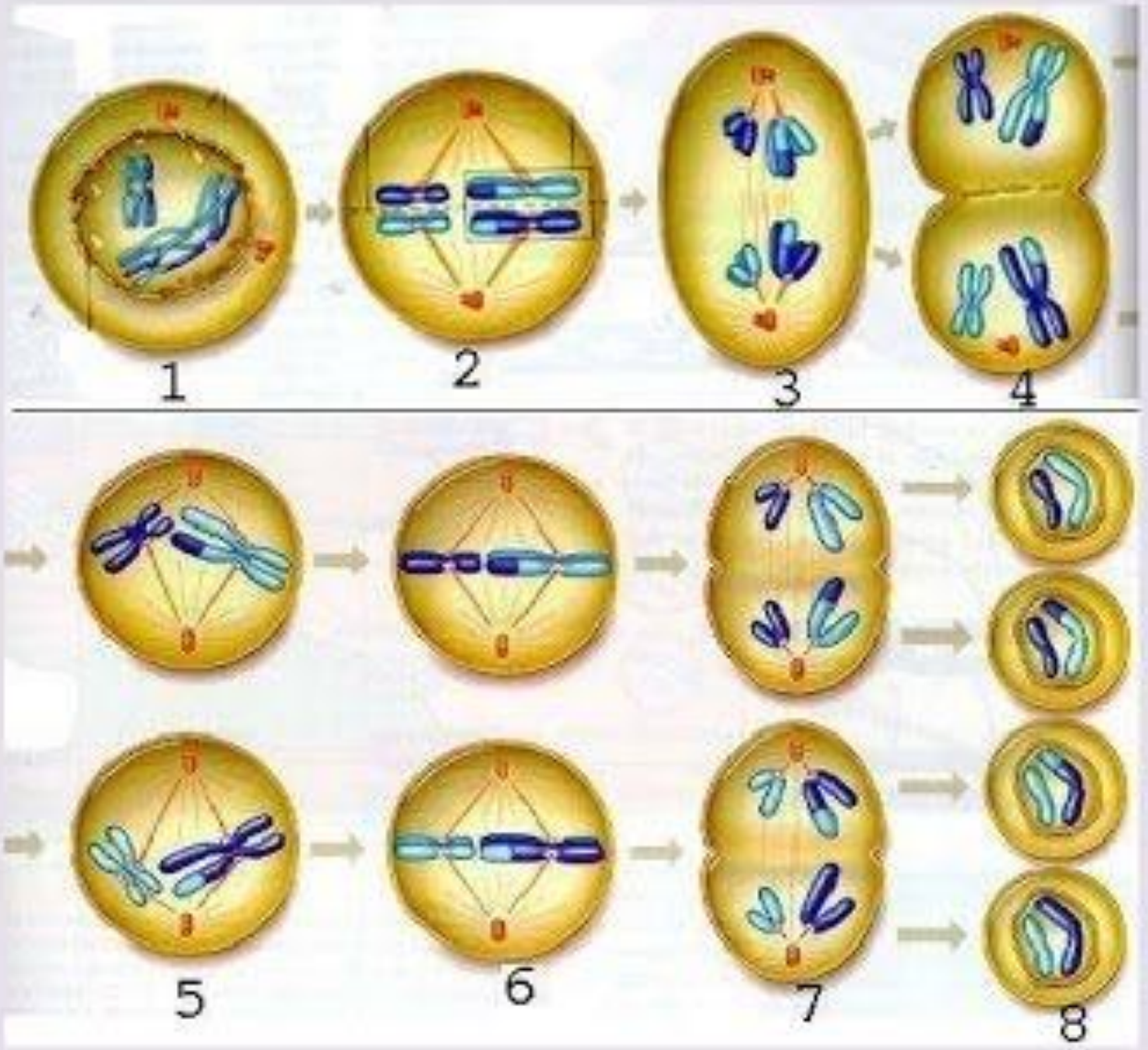
STAGES OF MEIOSIS:

MEIOSIS I

1. Prophase I
2. Metaphase I
3. Anaphase I
4. Telophase I

MEIOSIS II

5. Prophase II
6. Metaphase II
7. Anaphase II
8. Telophase II



First division of Meiosis :

- **Prophase I:** Each chromosome duplicates and remains closely associated. These are called sister chromatids.

- **Metaphase I**: Chromosomes align at the center of the cell.

- **Anaphase I**: Chromosome pairs separate with sister chromatids remaining together.

- **Telophase I**: Two daughter cells are formed with each daughter containing only one chromosome of the chromosome pair.

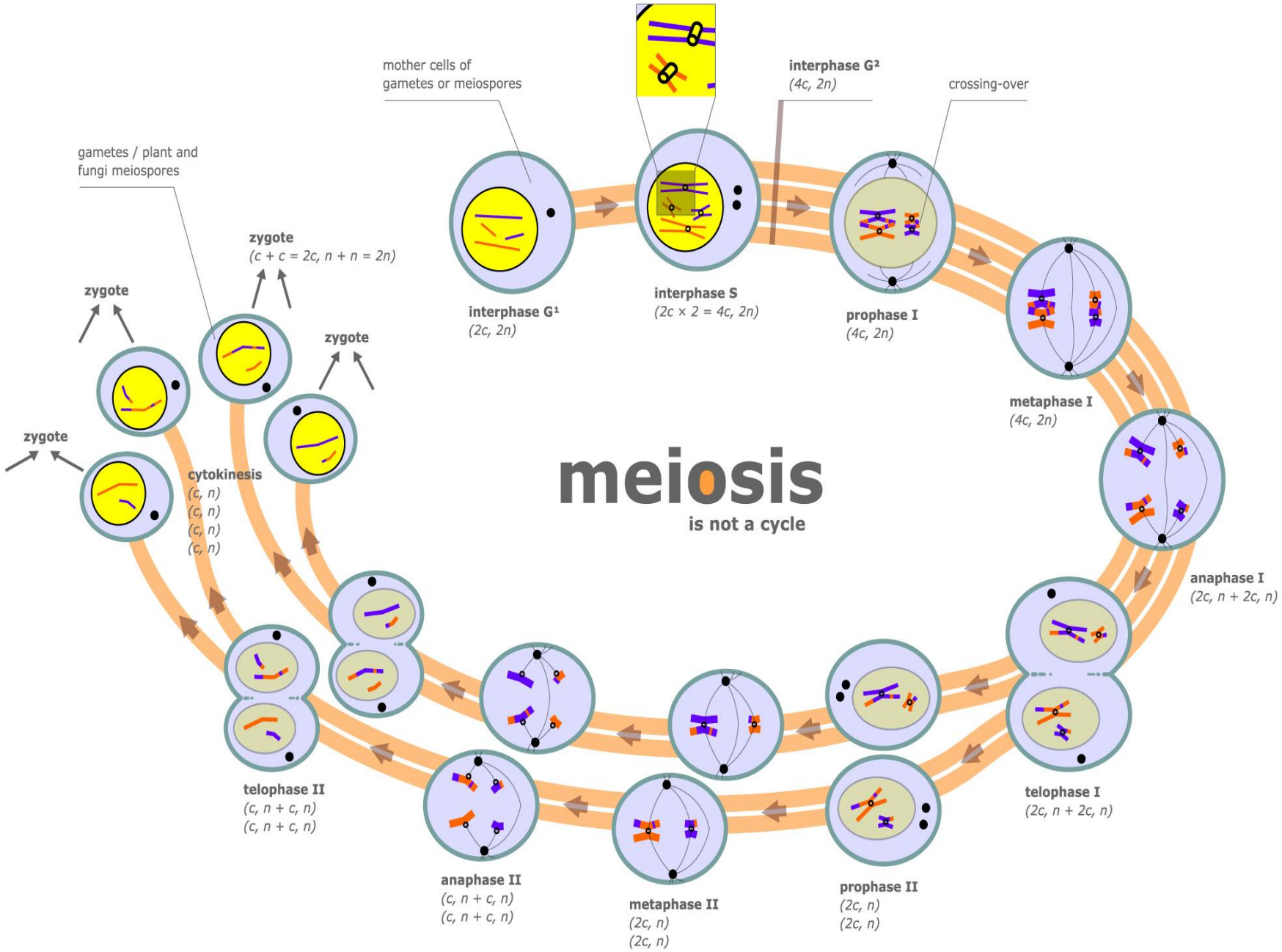
Second devision of Meiosis :

- **Prophase 2**: DNA does not replicate.
- **Metaphase 2**: Chromosomes line up at the center of the Cell.
- **Anaphase 2:** Centromeres divide and sister chromatids

move separately to each pole.

- **Telophase 2**: Cell division is complete.

Four haploid daughter cells are formed.


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

Meiosis Vs Mitosis

	Meiosis	Mitosis
Type of Reproduction	sexual	Asexual
Occurs in	Humans, animals, plants, fungi.	All organisms. Identical .
Genetically	Different	Identical
Crossing Over	Yes, mixing of chromosomes can occur.	No, crossing over cannot occur.
Number of Divisions	2	1

Meiosis Vs Mitosis

	Meiosis	Mitosis
Number of Daughter Cells produced	4	2
Chromosome Number	Reduced by half.	Remains the same.
Cytokinesis	Occurs in Telophase I and in Telophase II.	Occurs in Telophase.
Creates	Sex cells only: female egg cells or male sperm cells.	Makes everything other than sex cells.
Discovered by	Oscar Hertwig	Oscar Hertwig


Thank You

CELL DIVISION

Every living body is composed of cell. Some living bodies are made of only one cell. They are called **unicellular** organism, e.g. Bacteria, Amoeba Plasmodium, some Fungi and some Algae. Some living bodies are made of more than one cell. These are called **multicellular** organism. There are many. living bodies, which are made of millions of cells. Living bodies like human beings or mango tree etc. are composed of millions of cells. Unicellular organisms increase their number (multiply) by cell division. In this process one cell divides into two, two to four and so on. In multicellular organisms, a large body consisting of millions of cells develops by cell division from the embryo which also develops from a single fertilized egg. A young seedling developed to a large tree by cell division. Again new generation is created from male and female gametes formed by cell division. But all these divisions are, not alike the processes of division are of different types and the results are also different. The process of a parent cell dividing into daughter cells is known as cell division. Human somatic cells (any cell other than a gamete) have **23 pairs** of chromosomes.

Types of cell division

1-Mitosis

2-Meiosis

1- mitosis:

Mitosis is a form of eukaryotic cell division that produces two daughter cells with the same genetic component as the parent cell. Chromosomes replicated during the S phase are divided in such a way as to ensure that each daughter cell receives a copy of

every chromosome. In actively dividing animal cells, the whole process takes about one hour.

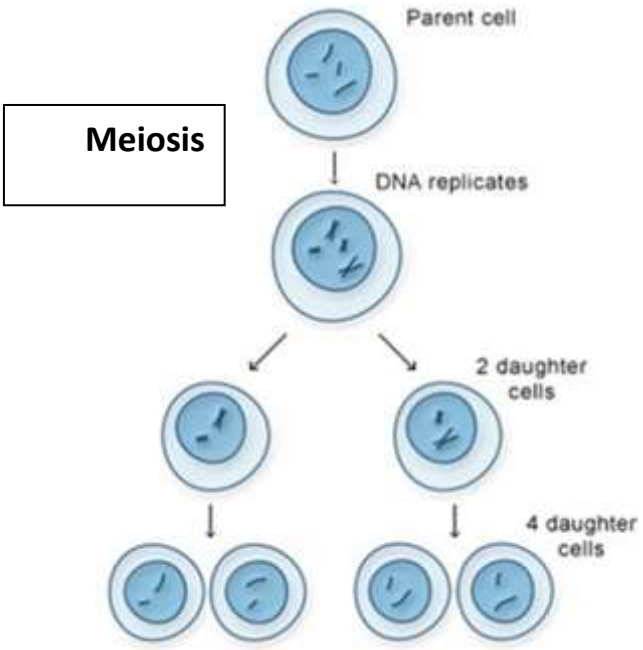
the parent cell divides into two identical daughter cells, which are in turn capable of dividing again ((**Mitosis is the process of cell division in which the daughter cells receive identical copies of DNA (chromosomes), which are also identical to that of the mother cell**)).

The replicated chromosomes are attached to a 'mitotic apparatus' that aligns them and then separates the sister chromatids to produce an even partitioning of the genetic material. This separation of the genetic material in a mitotic nuclear division (or karyokinesis) is followed by a separation of the cell cytoplasm in a cellular division (or cytokinesis) to produce two daughter cells.

2-meiosis: Meiosis is the form of eukaryotic cell division that produces haploid sex cells or gametes (which contain a single copy of each chromosome) from diploid cells (which contain two copies of each chromosome). The process takes the form of one DNA replication followed by two successive nuclear and cellular divisions (Meiosis I and Meiosis II). As in mitosis, meiosis is preceded by a process of DNA replication that converts each chromosome into two sister chromatids.

the cells get permanently transformed into a gamete and may undergo further division only after fertilization.((Meiosis is the process of cell division that results in the formation of cells containing half the amount of DNA (chromosomes) contained in the parent cell and having different copies of DNA from one another)).

In meiosis homologous chromosomes separate leading to daughter cells that are not genetically identical. In mitosis the daughter cells are identical to the parent as well as to each other.



Meiosis differs from mitosis in three fundamental ways:

1- Mitosis results in each daughter cell having a diploid chromosome (46). Where complement as in meiosis the mature gamete have a haploid complement of (23) chromosomes.

2-Mitosis takes place in somatic cells and during the early cell divisions in gamete formation. Meiosis occurs only at the final division of gamete maturation.

Cell Cycle

The cell cycle is the series of events that occur in dividing cells between the completion of one mitotic division and the completion of the next division.

The genetic material and gene action and protein synthesis :

Deoxyribonucleic Acid (DNA); the genetic material of all cellular organisms and most viruses. DNA is a genetic material, it carries genetic information's from cell to cell and from generation to generation.

DNA is in a double helix structure made up of **nucleotides**. Nucleotide : building block of nucleic acid. **Nucleotides**: ring shaped structures composed of,
1- Nitrogenous base: these bases are classified into two groups, **Purine** (Adenine and Guanine) and **Pyrimidine** (cytosine and thymine). **2- sugar 3- Phosphate group**

What is a gene ?

gene is sequence of nucleotides encoding functional RNA molecule or the amino acid sequence of a polypeptide. The sequence of bases that encodes a functional protein molecule is called a **gene. The gene;** it is a segment within a very long strand of DNA**. Genes** are the basic units of hereditary. **Genes** located on chromosome on its place or locus. Allele; a variant of the DNA sequence at a given locus. Each allele inherited from a different parent.

DNA contained in genes provides instructions for making protein. DNA A molecule, composed of a huge number of nucleotides, that provides the information for the construction of proteins and RNA. DNA can replicate itself, and it carries genetic information between cells and between generations**.**

DNA →transcription ⟶ mRNA → translation ⟶ protein⟶phenotype

Replication : DNA → DNA *

Gene action : Gene action refers to the way in which certain genes exert their effects on the body (tissues or processes). They could be dominant, or recessive, or they could be sex-linked or being absent or be involved in chromosomal aberrations. A combination of such gene actions results in the observable phenotype of an organism.

There are three broad types of gene actions :

1- Dominant gene action

The one pair of allele that masks the effect of the other when present in the same cell.

2- Recessive gene action

The one pair of allele that is masked by the other when present in the same cell and capable of producing its characteristics phenotype in the organism only when two alleles is present and identical.

3- Epistatic gene action

In this type of gene action, the presence or absence of an allele in one locus affect the expression of another allele in a different locus. Epistasis can either exert additive effect or dominance.

RNA is a single stranded; the pyrimidine base uracil (U) replaces thymine and ribose sugar replaces deoxyribose.

Protein Synthesis

Transcription: making a mRNA from 1 side of DNA (acts as a template) by RNA polymerase. Information from a specific section of DNA is first transcribed to produce a specific molecule of RNA. (Occurs at the ribosomes).

Translation: production of a protein by aligning and joining mRNA and tRNA. RNA attaches to a ribosome where the information is translated into a corresponding sequence of amino acids.

DNA contained in genes provides instructions for making protein.

steps of protein synthesis :

1- Information from a specific section of DNA is first transcribed to produce a specific molecule of **mRNA** (messenger RNA).

2- mRNA moves to cytoplasm, then ribosome (3 bases at a time).

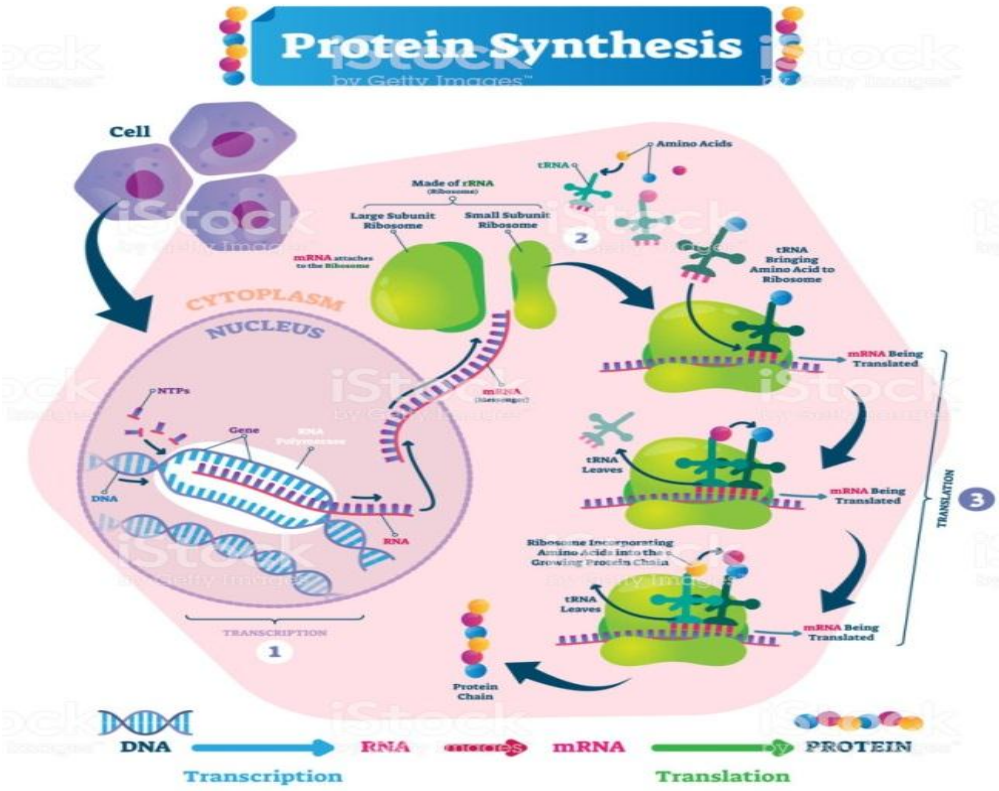
3- RNA attaches to a ribosome where the information is translated into a corresponding sequence of amino acids

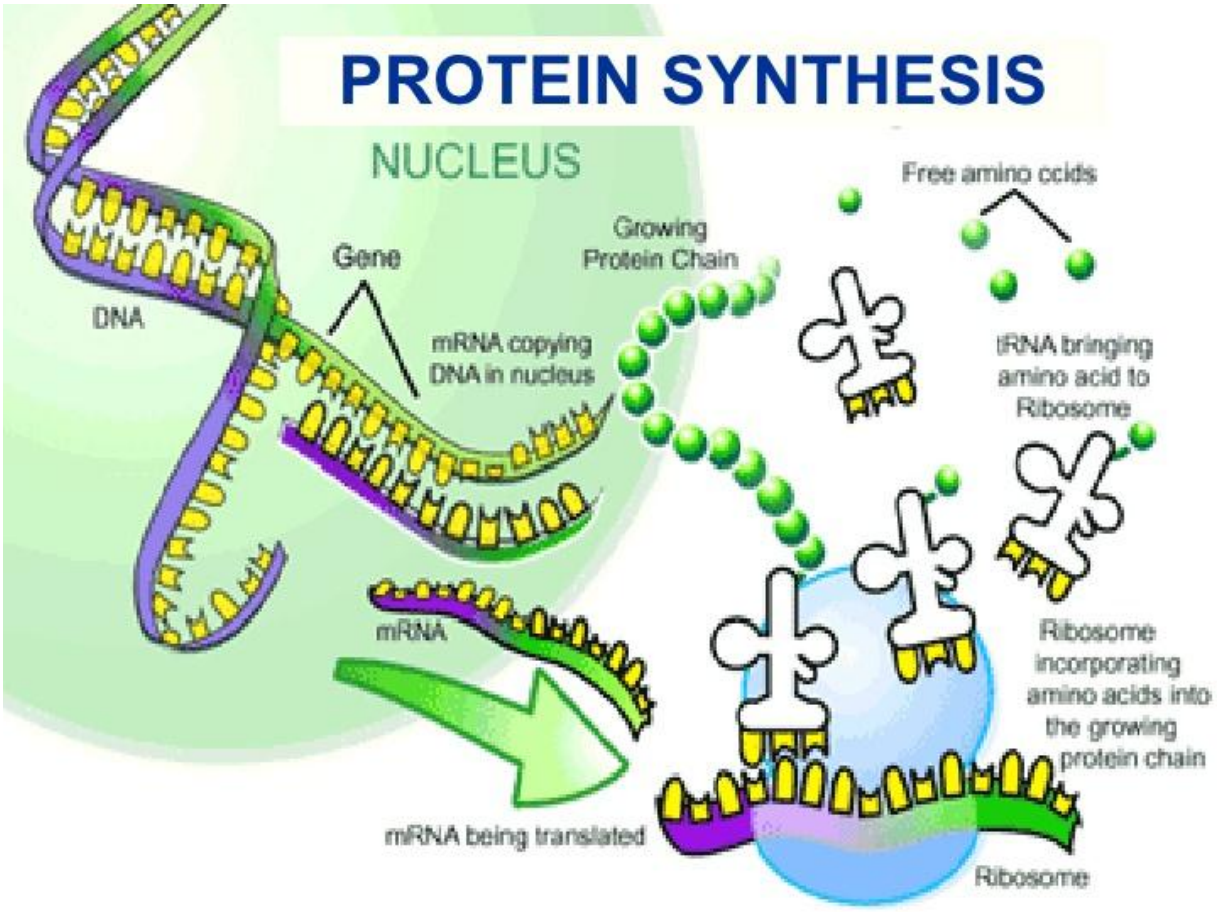
4- transfer RNA (tRNA) matches up with the open DNA bases.
5- tRNA releases the amino acid at the top, which joins the chain of amino acids being produced, and the new protein detaches, the tRNA detaches.

Codon : a sequence of three successive mRNA nucleotides that correspond with a base triplet.

Promoter : a special sequence of DNA nucleotides near the beginning of a gene that tell the RNA polymerase where to begin reading.

Terminator : a specific sequence of DNA nucleotides that signals the end of the gene.




PROTEIN SYNTHESIS
NUCLEUS
Free amino ccids
Growing
Protein Chain
Gene
DNA
mRNA copying
DNA in nucleus
tRNA bringing
amino acid to
Ribosome
mRNA
Ribosome
incorporating
amino acids into
the growing
protein chain
mRNA being translated
Ribosome

Cell Death Pathways

- For every cell, there is a time to live and a time to die. There are two ways in which cells die:
  - They are killed by injurious agents.
  - They are induced to commit suicide.
- Cell death by injury [necrosis] can be due to
  - Mechanical damage
  - Exposure to toxic chemicals
- Cell death by suicide [Apoptosis/Programmed Cell Death]
  - Extrinsic pathways
  - Intrinsic pathways

Necrosis

- Cells that die as a result of injury, typically swell and burst and they spill their content all over the surrounding cells.
- They (and their organelles like mitochondria) swell (because the ability of the plasma membrane to control the passage of ions and water is disrupted).
- There is leakage of cell contents, leading to inflammation of surrounding tissues.
- This process is named as cell necrosis, and it causes inflammatory response in animals.
- Uncontrolled process affecting large groups of cells.
- Considered as a toxic process where the cell is a passive victim
- Energy independent process.
- Oncosis is the more preferred term now. [as necrosis is considered to pertain to events following cell death].
- Mediated by 2 main mechanisms
  - Damage to cell membranes

- Interference with energy supply of the cell.

Major morphological changes during necrosis

- Disrupted organelle membranes; disruption of the cell membrane
  - Distended endoplasmic reticulum; swollen / ruptured mitochondria; disaggregation and detachment of ribosomes; swollen and ruptured lysosomes
- Cell swelling; formation of cytoplasmic vacuoles
- Release of cytoplasmic contents into surrounding tissue
- Chemotactic signalling with eventual recruitment of inflammatory cells

Apoptosis

- The cells of multicellular organisms are members of highly organized community.
- Controlling the rate of cell division and of cell death strictly regulates the number of cells in this community.
- If cells are no more needed, they die by activating intracellular death program, for this reason this process is named as programmed cell death (PCD) and more commonly apoptosis.
- In contrast to necrosis a cell that undergoes apoptosis dies without damaging neighbors.
- *Apoptosis, or programmed cell death, is a normal occurrence in which an orchestrated sequence of events leads to the death of a cell.*
- *Apoptosis or programmed cell death, is a carefully coordinated collapse of a cell, protein degradation , DNA fragmentation followed by rapid engulfment of corpses by neighbouring cells*
- It is a neat, safe and orderly process
- Apoptosis might be compared to the controlled implosion of a building using carefully placed explosives as compared to simply blowing up the structure without concern for what happens to the flying debris

Morphological changes during apoptosis

- **Conserved across all species**
  - Chromatin condensation [pyknosis]and nuclear fragmentation [karyorrhexis]
  - rounding up of the cell
  - reduction in cellular volume [shrinkage] of cell
  - Blebbing of the cell or fragmenting of cell into apoptotic bodies by budding.
    - Apoptotic bodies consist of cytoplasm with tightly packed organelles with or without a nuclear fragment and surrounded by a plasma membrane.
  - The cytoskeleton collapses.
  - Nuclear envelope dissembles and nuclear DNA breaks up into fragments.
- Apoptotic bodies that are formed during apoptosis are engulfed by specific macrophages.
- Thus complete elimination of the cell occurs
- Macrophages quickly phagocytose apoptotic bodies. So intracellular contents [lytic enzymes oxidising molecules, cationic proteins] are not released into surrounding tissue; hence no inflammation.
- If the remnants of apoptotic cells are not phagocytosed such as in the case of an artificial cell culture environment, they will undergo degradation that resembles necrosis and the condition is termed secondary necrosis.
- Several hours are required from the initiation of cell death to the final cellular fragmentation. However, the time taken depends on the cell type, the stimulus and the apoptotic pathway
- Why do our bodies have unwanted cells, and where do we find cells that become targeted for elimination? The short answer is: almost anywhere you look. It has been estimated that 10^{10}–10^{11} cells in the human body die every day by apoptosis.

- For example, apoptosis is involved in the elimination of cells that have sustained irreparable genomic damage. This is important because damage to the genetic blueprint can result in unregulated cell division and the development of cancer.

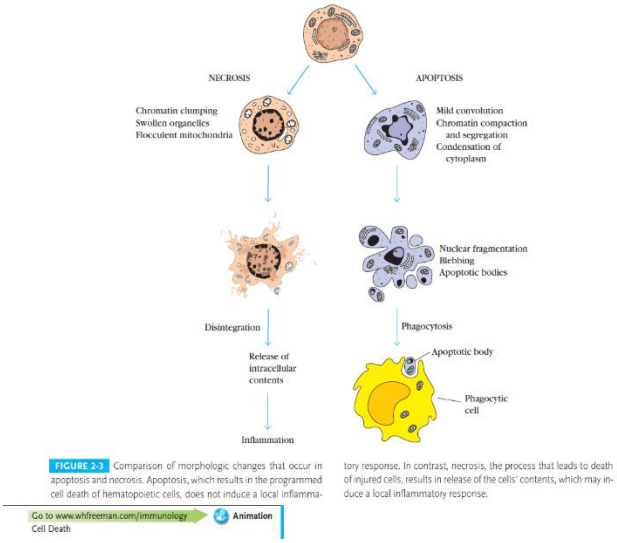
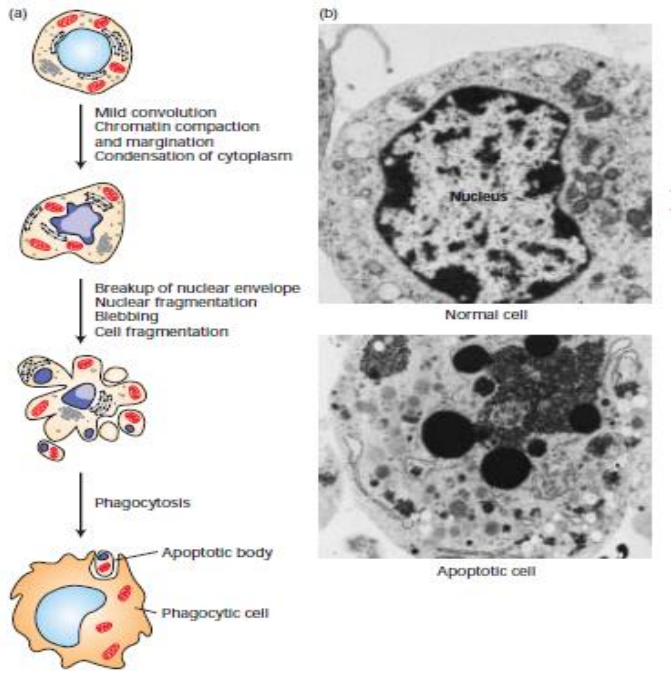


FIGURE 2-3 Comparison of morphologic changes that occur in apoptosis and necrosis. Apoptosis, which results in the programmed cell death of hematopoietic cells, does not induce a local inflammatory response. In contrast, necrosis, the process that leads to death of injured cells, results in release of the cells' contents, which may induce a local inflammatory response.

Go to www.whfreeman.com/immunology Animation Cell Death



	Apoptosis	Necrosis
Pattern of death	Single cells	Groups of neighboring cells
Cell size	Shrinkage	
	Fragmentation	Swelling
	Preserved continuity	
Plasma membrane	Blebbed	Smoothing
	Phosphatidylserine on surface	Early lysis
	Increased membrane permeability	
Mitochondria	Contents released into cytoplasm	Swelling Disordered structure
	Cytochrome c; Apaf1	
	Structure relatively preserved	
	Contracted	Swelling
Organelle Shape	"Apoptotic bodies"	Disruption
	Chromatin:	
Nuclei	Clumps and Fragmented	Membrane disruption
	Fragmented	
	Internucleosomal cleavage	
DNA Degradation	Free 3' ends	Diffuse and Random
	Laddering on electrophoresis	
	DNA appears in cytoplasm	
Cell Degradation	Phagocytosis	Inflammation
	No inflammation	Macrophage invasion

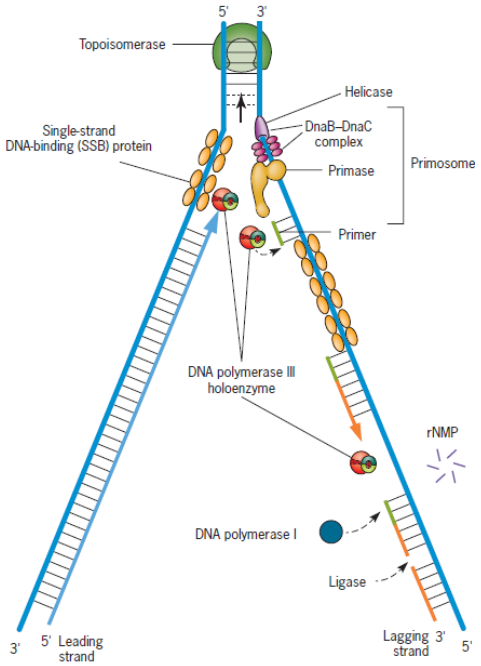
Senescence

- Senescence ---- aging /growing old.
- Observed that mammalian cells in culture undergo a finite number of cell divisions [“mortal”]and after that they stop dividing and no longer proliferate [even when carefully nourished]-------- cell senescence/replicative senescence.
- Some cells get transformed, escape senescence and divide indefinitely and can be maintained as cell lines [immortal].
- Senescent cells become large, flat, multinucleate and vacuolated.

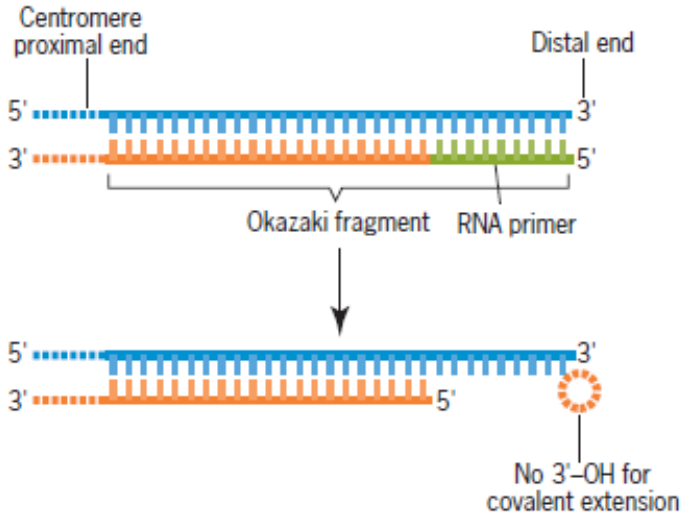
Mechanism of cellular senescence

- Hayflick’s theory----shortening of the telomeres or the inability to maintain normal telomere length is thought to play an important role in this process.
- When a cell divides these sequences are not replicated in the same manner as the rest of the genome but are synthesized by an enzyme, telomerase.

- Telomerase is a low fidelity enzyme and creates random variation in the number of repeats of the telomeric DNA sequence.
- Cell senescence is closely correlated with a progressive reduction in the number of these repeats.
- This suggests that senescence may be caused by failure to maintain the length of telomeres, perhaps because the somatic cells (in contrast with germ-line cells) are deficient in telomerase.



The telomere lagging-strand primer problem.



- Because of the requirement for a free 3’-OH at the end of the primer strand, DNA polymerases cannot replace an RNA primer that initiates DNA synthesis close to or at the terminus of the lagging strand

Premature senescence

- Induction of senescence by a variety of conditions in the absence of any detectable telomere loss ---- premature senescence.
- Invitro premature senescence can result from
  - Inadequate culturing conditions
  - Mutations in oncogenes or tumor suppressor genes